

Identity Development of Preservice Elementary Teachers of Mathematics
From Teacher Education Program to Student Teaching

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ABSTRACT

Drawing on Lave and Wenger (1991) this study explores how preservice elementary teachers develop themselves as teachers of mathematics, in particular, from the time of their teacher education courses to their field experiences. This study also researches the critical experiences that contributed to the construction of their identities and their roles as student teachers in their identity development. The stories of Jackie, Meg, and Kerry show that they brought different incoming identities to the teacher education program based on their K–12 school experiences. The stories provide the evidence that student teachers' prior experience as learners of mathematics influenced their identities as teachers, especially their confidence levels in teaching mathematics. During the mathematics methods class, student teachers were provided a conceptual understanding of math content and new ways to think about math instruction. Based on student teachers' own experiences, they reconstructed their knowledge and beliefs about what it means to teach mathematics and set their goals to become the mathematics teachers they wanted to be. As they moved through the program through their student teaching periods, their identity development varied depending on the community of practice in which they participated. My study reveals that mentor relationships were critical experiences in shaping their identities as mathematics teachers and in building their initial mathematics teaching practices. Findings suggest that successful mentoring is necessary, and this generally requires sharing common goals, receiving feedback, and having

opportunities to practice knowledge, skills, and identities on the part of beginning teachers. Findings from this study highlight that identities are not developed by the individual alone but by engagement with a given community of practice. This study adds to the field of teacher education research by focusing on prospective teachers' identity constructions in relation to the communities of practice, and also by emphasizing the role of mentor in preservice teachers' identity development.

DEDICATION

Dedicated to my family in Korea:

Mom and Dad, thank you for your priceless love and support for me.

Your endless love serves as a forceful motivation to keep up the work and never give up. I would like to thank you for my sister and brother who understand me the most and always show their love to me.

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CHAPTER 1

INTRODUCTION

Major Premises in Teacher Education Program

Ever since the release of the National Council of Teachers of Mathematics (NCTM) Standards in 1989, a cognitive approach in school mathematics has dominated the field. This perspective emphasizes that understanding concepts equates to knowledge and that the ability to reason and problem solve demonstrates cognitive ability (Greeno, Collins, & Resnick, 1996). This focus on conceptual understanding in teaching mathematics requires teacher education programs to substantially shift their strategies in ways that include changes in important cognitive constructs related to the beliefs, knowledge, and attitudes of how math has traditionally been taught (Swars, S. L., Smith, S. Z., Smith, M. E., and Hart, L. C. 2008). When discussing the importance of such constructs, many research studies emphasize the central role of prior knowledge and beliefs of both in-service and preservice teachers and their impact on the development of mathematics teaching practices (Borko et al, 1996, Thompson, 1992; Feimennemser, 2001, Swars et al, 2009; Wilson & Cooney, 2002).

There are some common premises to this approach. The first premise concerns the fact that prospective teachers typically enter teacher education programs with traditional views of mathematics, of teaching and learning mathematics, and of the role of teachers, which contrasts with reform-based

perspectives. (Cady, Meier & Lubinski, 2006; McDiarmid, 1990; Ebby, 2000; Ball, 1990). A second premise assumes that preservice teachers come to teacher education programs with a lack of content knowledge; hence, teacher education programs need to provide them with strong subject matter knowledge and pedagogical content knowledge to make up for this deficit (Feiman-Nemser & Buchmann, 1986; Ball, 1990, Borko & Eisenhart, 1992, Brown and Borko 1992) Thirdly, a large number research studies point out that there is a lack of connection between preservice teachers' experiences and the transitions from university classrooms to the social environment of K–12 classroom situations and the curriculum as it is enacted in these real settings (Cook, L. S., Smagorinsky, P., Fry, P.G., Konopak, B., Moore, C., 2002; Eisenhart and Borko, 1993; Kagan, 1992; Korthagen and Kessels, 1999; Grossman 2000). The last premise concerns the fact that prospective teachers' prior beliefs and self-images pertaining to what it means to be a teacher of mathematics play a pivotal role in methodology of beginning teachers (Ensor, 2001; Kagan, 1992; Feiman-Nemser, 1983; Feiman-Nemser & Buchmann, 1989; Raymond, 1997).

Based on these premises, one can begin to describe a typical teacher candidate's journey of learning to teach. Teacher candidates enter their teacher education program holding traditional views of teaching mathematics and possessing limited content knowledge. During their university program, the preservice teachers' traditional views are challenged by reformed-based teaching mathematics curriculum and methods. As teachers moves into their teaching

career, they face a disconnect between what they learned from the teacher education program and what they experience in their real classroom settings. Teachers' practices will be characterized differently depending on their beliefs about teaching mathematics and how they view themselves as teachers. Such characteristics may determine whether a teacher "bucks the system," or succumbs to the constraints and affordances of the setting.

To understand this journey more completely, Brown and Borko (1992) argued that the process of being a teacher should be considered as a continuous journey that includes preservice, induction, and in-service experiences. These authors clearly articulated this continuum in this way:

[B]ecoming a teacher is a life-long process; that is teachers begin to learn about teaching long before their formal teacher education begins (Wright & Tuska, 1986) and continue to learn and change throughout their careers (Sprinthall & Thies-Sprinthall, 1983) (p.210).

The long-term characteristic of teacher learning is also emphasized by Feimennemser (1983). She highlighted that we need to understand how the effects of teacher preparation programs go beyond the student-teaching period because the first year in the classroom is the critical time for adaptation and inquiry for beginning teachers. Further, the first year of teaching greatly determines not only whether someone remains in teaching but also what kind of teacher he or she becomes.

Despite these arguments, little research has been conducted on the long-term effect of teacher learning after candidates leave their teacher education program

(Borko and Eisenhart, 1992; Brown and Borko, 1992; Grouws and Schultz, 1996; Thompson, 1992; Zeichner, 2005). Part of this problem revolves around the fact that the teacher education literature tends to focus on preservice teachers' *individual* knowledge and beliefs rather than how their knowledge and beliefs develop over time through *interaction* in a real social context. Recently, the *situative* perspective has added to our understanding of teaching alongside our longer tradition of cognitive research. The situative perspective argues that to understand teacher-learning, we must study it within the multiple contexts in which teachers do their work, taking into account both the individual teacher-learners and the physical and social systems in which they are participants (Putman and Borko, 2000; Peressini and Borko, 2006).

These issues are compelling and play a pivotal role in the success of beginning teachers. In the following chapters, I explore them in greater detail. Chapter 2 examines the relevant research in mathematics teacher preparation and early induction by focusing on the impact of university classroom experiences and field experiences. Taking these multiple contexts into consideration, I classify the studies into three broad constructs related to teachers' beliefs, their developing knowledge, and their identity. I apply key hypothesized transitions to these constructs in a sequential order—examining the research conducted in mathematics methods courses, student teaching experiences, and in the first year of teaching. Next, I investigate how these literatures addressed what shapes such construction.

I particularly focus on several topics: 1) the role played by prior mathematical experiences, especially the influence of a key mathematics teacher in molding a candidate's beliefs, knowledge, and identity as a potential mathematics teacher; 2) the role of the methods course; and 3) the role of first-year experiences in simultaneously shaping teachers' identities and their development of mathematical practices. It will be shown that the role of the instructor—teacher, professor, mentor—and sometimes the parents or other influential adults is critical for initiating important beliefs and knowledge in potential teachers in both of these critical periods of a teacher's development. Moreover, young, potential teachers draw on their memories of these influential adults and emulate those they see as “good” as defined by their existing beliefs. These relationships are critical determinants of beginning teachers' identities as mathematics teachers.

This dissertation will examine, in detail, these relationships in the lives of prospective teachers. I investigate how novice teachers design and deliver students' mathematics lessons as a result of these experiences and how these influences are incorporated into students' understanding of mathematics teaching. By doing this longitudinally, following prospective teachers for several semesters and documenting their transitional moments, I will pinpoint how these relationships influence their professional identity as a mathematics teacher and show how these growing and dynamic identities frame their teaching practices.

CHAPTER 2

LITERATURE REVIEW

Theoretical Framework

Learning to teach involves becoming attuned to different situations of practice (Peressini & Borko, 2004) and developing new identities (Sumara & Luce-Kapler, 1996). This development includes the identities that teacher-candidates bring with them into teacher-education and the transition into their new teaching identities. It also includes the identities that develop while doing university coursework and student-teaching practicum while, continuously connecting to the school environments. Due to these multiple contexts and the fact that teacher education is an on-going phenomenon, the situative perspective is necessary to understand the complexity of learning to teach.

Traditional teacher-education research tends to focus on teacher learning from a cognitive perspective (Peressini & Borko, 2004). From this perspective, research typically describes learning as an individual's acquisition of knowledge, conceptual understanding, or change in belief structure. The cognitive perspective emphasizes teachers' development of epistemological beliefs, knowledge bases, and action plans that will help them to make decisions productively (Greeno, 1998). Knowledge, in a situative perspective, is distributed among people, and their environments and the communities in which they are members (Greeno, Collins, & Resnick, 1996). According to Greeno, Collins, &

Resnick (1996, p.17), a situative analysis suggests different ways to focus on teacher learning, with emphasis on “processes of interaction of individuals with other people” and learning, in this perspective, involves “becoming attuned to constraints and affordance of social system which they interact.” Hence, how an individual engages with the goals of a community through participation is important for teacher learning.

Essentially defining the situative perspective, Lave and Wenger (1991) characterized the learning of practices as a process of participation in some kind of community that works together. This participation is the root of the process of apprenticeship. This process, also called “legitimate peripheral participation,” (p.27) involves beginners who are peripheral in the community of practice, but as novices they get experiences especially tailored to help them move to more central and sophisticated participation that is attuned to the practices of others considered to be masters of the communal knowledge and skills. Lave and Wenger (1991) also emphasized how an apprentice’s identity derives from the process of becoming part of the community of practice. From this point of view, a novice teacher’s identity is developed in the community where they find themselves (e.g., the methods classroom, their field setting, etc.,) and is based on the goals of this community and how they adjust themselves to these goals within the given social context. This aspect of teacher-education is of critical importance in shaping identity.

Therefore, actions taken by individuals are most effective within a community whose members share common experiences and understanding. In this study, it means that student teachers construct their knowledge by participating in a common culture of novice teachers and by sharing an understanding about what it means to learn to teach. This knowledge is then further shaped in each subsequent transition into teaching by the more experienced others who are more centrally situated in the field, such as professors in their teaching program, mentor teachers in their field experiences, and their colleagues and administration in their in-service community.

Hence, I adopted a situative perspective for my study because it would me to focus on an individual's learning process in relation to one's participation in a community, with the mentor teacher's classroom, the students, the schools, and so on.

Among various features of situative learning that are relevant to teacher learning, I focused my attention on two constructs that are particularly applicable to teachers' instructional practices. These are the professional identity and the development of relationships in the community of practice. The construction of professional identity here means how one defines one's self as a mathematics teacher in negotiation with other participants in the community. The development of relationships is important because student teachers encounter numerous influential people as they move along the path of learning to teach. For example, during the mathematics methods courses, student teachers are exposed to the

community of teacher-candidates. Thus, their relationships with instructors and peers become dominant. When they move to the student-teaching practicum, the relationships with mentors emerge as critical and they face an opportunity to experience real mathematics teaching practices. These relationships play a pivotal role in developing professional identities because this is the community that prospective teachers engage in everyday life.

The ultimate goal of this study is to investigate how prospective teachers construct their professional identity as mathematics teachers and how these multiple relationships contribute to such development. I now elaborate on the critical theoretical constructs for the present study.

Identity

In this study, I adopted the concept of identity because it serves as a pivot between the social and the individual, so each can be talked about in terms of the other (Wenger, 1998). Identity is a complicated concept with many definitions and interpretations (Enyedy, 2004). Holland et al. (1998, p.68) state “the way in which a person understands and views himself and is often viewed by others—a perception of self that can be fairly constantly achieved.” According to this perspective, constructing identity is an on-going process, and it involves both the student-teacher him/herself and the other people around. Student teachers have their own image of who they are as mathematics teachers. They also have a professional identity as perceived by their mentors, students, colleagues, and

principals. For instance, mentors might view the beginning teacher as a novice, as a protégé or even as a content expert.

Wenger (1998) similarly defined identity as a learning trajectory, “we define who we are by where we have been and where we are going” (p.149). He states “building an identity consists of negotiating the meanings of our experience of membership in social communities.” (p.149). Similar to Holland, Wenger views identity as on-going process, but he stresses the negotiation process in the community. When prospective teachers enter in their community of practice, they start their negotiation to build identity as a mathematics teacher based on their prior experiences and by their instructional practices (Bang, 2008).

Wenger (1998) stated that identity is related to one’s personal history, and he emphasized the importance of social context. He explained how one teacher experiences her job, how she interprets her position, what she understands about what she does are not only related with her personal history but also connected with the community of they belong. From Wenger's perspective, “identity is shaped by belonging a community but with a unique identity. It depends on engaging in practice but with a unique practice” (p.146). In other words, one teacher brings her incoming identity to the community that she belongs and this prior experience is important to shape her identity in the community. It means preservice teachers’ prior beliefs, knowledge, and experiences, and the community where the teacher belongs are important factors of identity construction. Prospective teachers have personal aspirations of what it is to be a

mathematics teacher when engaged in their teacher education program. When they encounter a real classroom setting, such as mentor's classroom or their own classroom, there are multiple internal and external demands that novice teachers must deal with to negotiate the meaning of their experience. If a young teacher believes a teacher's role is facilitating students' learning rather than showing and telling, he or she might face boundary dilemmas to achieve his or her goal. For example, a novice educator might face a dichotomy between the ideal and the real model of a mathematics teacher (Brown 1999), a difference in philosophy between one's content and pedagogical knowledge, or the introduction of some new ideal model of teaching from their mentor or peer teachers. Hence, prospective teachers' personal history and self-images of a mathematics teacher are practiced through experiences of participation in *their* specific communities. They are constantly going from their current model of what a teacher is and practicing their identities during student teaching, even while teaching is modeled by their mentor teachers. When they move into their own career, teachers are constantly constructing their identities as mathematics teachers through their negotiations within the community of practice (Battey, 2008).

Hence, Wenger (1998) argued that viewing identity as self-image or image of how other people think about the subject area is not enough. Rather, identity-in-practice is defined socially. When addressing identity construction, it is necessary to consider both the student teachers' personal views and their social environments at the same time. My definition of identity stems from the situative

perspective and relies on Wenger's perception of identity. I believe that professional identity is an on-going personal perspective of how the candidates interpret their job as mathematics teachers and how they practice it in relation to their everyday participation in a specific community. In other words, a professional identity as a mathematics teacher means how teacher candidates view the role of mathematics teachers based on their personal history and how this specific view is continuously developed through experiences. Specifically, this study focuses on the teachers' identities that are constructed in three areas: 1) their mathematics methods courses; 2) during their student teaching phases; and 3) the first year of teaching experiences.

Preservice teachers come to teacher education programs with their early experiences with mathematics and their perceptions of themselves as mathematics learners and teachers (Drake, 2006). These early experiences are mainly traditional based on how they learned. During the university methods program, under the mathematics reform movement, prospective teachers tend to be exposed to reform-oriented teaching models. Prospective teachers need to understand what it is to participate in the world of reform pedagogy, learn models of identities for the world of reform pedagogy, and negotiate new constructions of mathematics (Horn, Nolen, Ward, and Campbell, 2008).

A recent study (Borko & Peressini, 2009) reported how teachers' identities as mathematics teachers influenced their teaching practices. This study found that student teachers' norms and expectations about mathematics teaching practices

were fundamentally different depending on whether they saw themselves as teachers or students. Other studies emphasize that having a clear self-image as a teacher is critical for translating what has been learned from the teacher education programs into real classroom practices (Bullough, 1992; Kagan 1992; Mewborn, 1999). These studies document that prospective teachers struggle with their teaching practices when they don't have secure self-images as teachers, even though they had support from both university and mentor teachers in coherent ways. Whether they see themselves as a traditional mathematics teacher (image from early experiences) or a new-model teacher (provided by teacher education program), their teaching practices will look fundamentally different.

In sum, my study explores how preservice teachers construct their professional identities as a mathematics teacher as they move from their earlier image of teachers—which is in many cases traditional—to new models of teachers, and how they struggle to reconcile their identities as a mathematics teacher with these two opposing images. In order to understand identity construction, I look at preservice teachers' prior experiences and relationships with mathematics and mathematics teachers as a personal history that shapes identity. In addition, I focus on other constructions of relationships with their cooperating teachers, with their teaching practices, and their relationships with students. The first relationship is about relationship to mathematics, as a discipline or focus of activity.

Relationships to Mathematics

A large number of teacher education studies address the fact that students come to programs with a traditional image of mathematics, which means mathematics is typically rule bound, utilizing drill-and-practice and practice for tests, finding answers and so on (Schram et al., 1998; McDiarmid, 1990; Vacc and Bright, 1999; Cady et al., 2006; Raymond, 1997). However, this traditional perception of mathematics is challenged by contemporary accounts of what it means to know, learn, and teach mathematics that undergird new models of teacher education programs (Raymond & Santos, 1995). Raymond and Santos (1995) found that during their teacher education program, prospective teachers learned why equations work, understood concepts, problem solving, multiple strategies, cooperative learning, and began to see different ways to do mathematics (Raymond & Santos, 1995). Raymond (1997) found that teachers' views of mathematics strongly shaped their mathematics teaching, and they saw the teachers' roles as telling and transmitting knowledge to students. It is often stated that as novice teachers moved into their first year of teaching, these teachers relied on their own experiences more than newly learned experiences from their teacher education programs (Ensor, 2001; Kagan 1992. Wang & Odell, 2002).

However, despite the centrality of relationships between mathematics teachers and their teaching practices, there have been few, if any, longitudinal studies that have investigated how prospective teachers' perceptions toward

mathematics change over time. Thus, as a part of identity construction, I focus how prospective teachers' relationships within mathematics communities change over time and how they influence their teaching practices.

Relationships with Cooperating Teacher

The first theoretical relationship I discuss here is the relationship between a student teacher and a mentor teacher. Even though several researchers (Ball and Cohen, 1999; Mewborn, 1999; Eisenhart and Borko, 1993; Kagan, 1992) have articulated the critical role of mentor teachers in the learning-to-teach trajectory, a limited number of research studies have investigated this relationship. To explore the relationship between the student teacher and the cooperating teacher, I adopted the apprenticeship metaphors from Lave and Wenger (1991). This construct frames the mentor teacher as a master who is a full member of a community and knows the dynamics of the community very well. Meanwhile, the student teacher is a novice who is a peripheral member of the community but is developing an "identity of master[ing]" (p.41) through participation in the teacher education program. How much authority the student-teacher has during the student-teaching period, how the novice teachers move from legitimate to full participation, how negotiation with the given context influence their learning and identity construction, what the master's modeled teaching looked like, and how they communicate with each other are all part of master-novice relationship.

Wenger (1998) documents the fact that "practice entails the negotiation of ways of being a person in that context" (p. 140). He defines practice as "a

negotiation of meaning in terms of participation and identity as negotiated experience of self (p.150)”. In this sense, negotiation is important in learning and developing identities because learning to teach is a continuously negotiating process. Prospective teachers begin the journey of learning to teach, utilizing the frame of their prior beliefs and experiences. As the journey goes on, they are challenged by various moments of negotiations, such as encountering new ways of teaching, examining their mentor teachers’ teaching practice, immersion in various school cultures and curriculum, attempting to manage a classroom, meeting test pressures, reflecting on students’ mathematical thinking etc. Student teachers have to negotiate what to adopt or what not to adopt from their masters and how to balance these when teaching moment to moment in the environment into which they have been thrust by their program. Through these processes, student teachers build their identity as mathematics teachers. The next type of relationship focuses on how prospective teachers engage with mathematics teaching practices.

Relationships with Teaching Practice

Student teachers enter into their field experiences with their own images of teaching mathematics. Ideally, they are offered an effective model of teaching by the methods course and by a mentor (master) during student teaching (Battey, 2008). Student teachers come to the teacher education program with certain images of mathematics teaching practices mostly based on their own school experiences. Some students describe mathematics teaching as heavily drawing on

showing and telling, working on paper-and-pencil tasks, rote memorization of formula and procedures, and finding answers. Other students think of mathematics teaching more generally as group work, sharing ideas, problem solving, using manipulatives, and the discussion of mathematics concepts. The former image falls into the description of the so-called traditional pedagogy (Hiebert & Stigler, 1999), and the latter is similar to reform-based mathematics teaching (Senk & Thompson, 2003). Students' images of teaching mathematics may be challenged and modified by the methods course and by the mentor teachers' teaching practices during field experiences (Battey, 2005)

However, as Ensor (1995) reported, learning best practices and implementing them into the classroom is a different story. In her study, student teachers were able to recognize and evaluate best practices from methods courses but were not able to implement best practices in the classroom. Research studies reported many different reasons for this, such as lack of content knowledge, inconsistency with school policy, test pressures, and curriculum. When considering construction of identity as a social process, it is important to explore what the social environment allows or disallows them to do. According to Wenger's notion of identity, identity is practiced and constructed through negotiating the meaning of experiences. Hence, to understand teachers' construction of professional identity it is crucial to explore how teachers practice their mathematics teachings in their everyday life and how they negotiate with the given social settings in order to be the mathematics teacher they want to be.

Enyedy (2006) criticized that there is very little research that focuses on teachers' teaching practices in relation to the construction of their identities. Hence, I explore how novice teachers' everyday teaching practices influences their professional identity and at the same time how prospective teachers' self image as mathematics teachers explain their teaching practices. With respect to mathematics teaching practices, I particularly focus on how student teachers' teaching practices change in relation to the social settings such as mentor teacher's teaching and the school environment.

Relationships to Students

Research assumes that student teachers lack an understanding of classroom student's mathematics knowledge because of limited experience with it (Ball 1990). Field experiences provide student teachers the opportunity to learn more about how students' learn mathematics in a real classroom setting. During the student-teaching period, student teachers observe how mentor teachers teach mathematics, and they have an opportunity to observe how students learn mathematics. When teachers move into their first year of teaching, they view everyday how students learn mathematics. They also become fully responsible for students' learning of mathematics. New teachers come to understand the students' difficulties, misconceptions, and commonly made mistakes. They learn how students engage with mathematics, how they share their ideas, how students participate, and how they interact with a teacher. Throughout these experiences, student teachers reconstruct their beliefs about how students learn mathematics,

and these experiences in part, contribute to their beliefs about the students' roles in learning mathematics and their role in helping students learn mathematics (Enyedy 2005).

Enyedy (2006) investigated two middle school teachers' identity and teaching practices for implementing new science curricula in relation to their beliefs about learning and the goals of science instruction. In this study, one teacher believed students' active participation through discussion is important in learning science. This teacher's self-image was as a learner and questioner. This teacher's teaching practice was centered on students' reflections and discussions. The other teacher believed students learn best with social interaction, and she tried to reach her goal by making students feel comfortable and highly ready to learn. This teacher evaluated her teaching practice being successful when students' high engagement was observed. Enyedy concluded that how teachers framed student learning in the classroom influences their teaching pedagogy.

Drawing on the importance of teacher-student relationships, I investigate how novice teachers frame students' learning mathematics and how their notions of their own relationships influence their professional identities as mathematics teachers. I also focus on how mentor teachers build relationships with in-service teacher and how this relationship plays out in the student teacher's own classroom teaching during the student teaching period. Then, I discuss how student teachers perceive their relationships and their bearings on their images of what their

relationships with their own students should be. I further investigate the connection between this relationship and their teaching practices.

So far, I have described the notion of identity construction of preservice teachers in relation to several important relationships. As alluded to earlier, the development of student teachers' identities involves multiple stages, such as mathematics methods classes and student teaching, and they continuously refine their identity in the first year of teaching. Thus, it is important to understand the role of the teacher education program in this developmental process. Moreover, because at least one previous scholar (Wenger, 1998) has argued that identity development is an on-going process, it necessary to review the literature that focuses on first-year teachers' learning in relation to their teacher education. Hence, in the section below, I review related research studies and classify them in a sequential order based on the developmental trajectory preservice and in-service teacher go through: 1) methods course; 2) student teaching; and the 3) first year of teaching. I then connect how these experiences are related with the identity development of student teachers.

Teacher Knowledge and Beliefs: The Role of the Teacher Preparation Program

Teacher knowledge

The majority of the literature on teacher education focuses on preservice teachers' development while they are in the university program. Most of these

studies document that teacher preparation courses are typically designed based on reform-oriented principles and curricula. Preservice teachers' knowledge and beliefs are the major constructs of interest, but some research has focused on teacher identity. In discussing the importance of such constructs, a considerable number of research studies emphasize the central role of prior knowledge and belief on teaching practices (Borko et al, 1996, Thompson, 1992; Feimen-Nemser, 2001, Thompson, 1992; Swars et al, 2009; Wilson & Cooney, 2002). Feimen-Nemser argued that preservice teachers don't come to the program with a blank canvas, so their learning takes place through the process of combining the knowledge they bring to their program and what their programs offer. Thus, preservice teachers' mathematics beliefs, attitudes, and knowledge influence their classroom practices. This is also important because mathematics educators have assumed that if teachers experience mathematics differently as learners, they will reconstruct their beliefs, assumptions, and ultimately their practices (Schifter & Fosnot, 1993; Simon, 1994).

With respect to teachers' knowledge, a large number of studies argue that teacher education programs need to provide preservice teachers with strong subject matter and pedagogical content knowledge. (Feiman-Nemser & Buchmann, 1986; Ball, 1990, Borko & Eisenhart, 1992, Brown & Borko 1992); Livingston & Borko, 1990; Borko & Putnam, 1996; Schifter & Fosnot, 1993). These studies argued that teachers, in general, who had greater knowledge with a particular subject placed more emphasis on conceptual explanations and problem

solving, and they drew more connection between topics than did their colleagues with less deep knowledge. Thus, they suggest that teachers need to have rich and flexible knowledge of subject matter to accord with current reform efforts that emphasize the development of students' conceptual understanding as a primary goal of mathematics instruction (Borko and Putnam, 1996). Ball and Cohen (1999) summarized two types of knowledge that teachers should know. First, teachers need to develop subject matter knowledge that is quite different from that they typically learned as students. A recent study done by Hill, Schilling and Ball (2004) documented that content knowledge for teaching mathematics consists of more than the knowledge of mathematics that well-educated people hold. These studies imply that the mathematics content knowledge that teacher candidates possess following university training may not be enough to teach mathematics. In particular, their knowledge of how to generate representations, interpret students' work, and analyze students' mistakes is not a simple function of teachers' mathematics knowledge. Second, teachers need to generally know how their students learn mathematics and where they are developmentally in math. Brown and Borko (1992) noted, "without adequate content knowledge, student teachers spend much of their limited planning time learning content, rather than planning how to present the content to facilitate the student's understanding" (p.220). They also cited Shulman and Grossman (1999) and explained the important role that mathematical knowledge plays as preservice teachers select mathematics topics for teaching.

Despite the centrality of content knowledge, Ball (1990) criticized that prospective teachers come to programs without adequate mathematical knowledge. To assess this, Ball conducted a study that focused on the subject matter knowledge of preservice elementary and secondary teachers. To examine their prior knowledge before entering their teacher education programs, she distributed questionnaires and interviewed 252 teacher candidates at the time they entered their formal teacher education programs. These prospective teachers were given mathematics problems that required them to divide fractions. Throughout the interviews, most of the elementary and secondary teacher candidates approached these problems with a rule-bounded approach; that is, they inverted and multiplied the fractions. These candidates had difficulty finding the underlying meaning beneath the procedure. Surprisingly, even secondary teachers who majored in mathematics did not seem to connect the underlying meanings and concept and struggled with making sense of division with fractions. The only observed difference between elementary and secondary groups, on the items Ball assessed, was that secondary teacher candidates showed less anxiety about mathematics.

Ball's findings suggested that the mathematical understanding that the teacher candidates brought to the program was not adequate to teach students to have a conceptual understanding. Furthermore, the subject knowledge of mathematics majors was not enough to teach some elementary topics conceptually. In Ball's conclusion, she argued that mathematics teacher-educators need to emphasize the pedagogical content knowledge of mathematics teacher-candidates

in addition to their subject matter knowledge. However, there is a limitation to these studies. As Ball and Bass (2000) have pointed out more recently, teacher educators lack an adequate understanding of what and how mathematical knowledge is used in practice. They bring attention to the fact that we need to research beyond the teacher education program to understand how the knowledge obtained during methods courses is used and developed during student teaching and how it changes and adapts during in-service teaching practices.

Teacher beliefs

Another major construct in teacher education concerns preservice teachers' beliefs about mathematics content and about the learning and teaching of mathematics. As briefly mentioned as one of the premises, it is shown in many studies that preservice teachers tend to hold traditional views of teaching and learning mathematics. (Schram, P., Wilcox, S., Lanier, P., & Lappan, G., 1988; Cady, Meier & Lubinski, 2006; McDiarmid, 1990; Ebby, 2000; Ball, 1990). For instance, preservice teachers' common beliefs about mathematics are that it is rule-bound, static, and linearly ordered. In addition, some research has found that preservice teachers generally hold the following beliefs: 1) they think learning mathematics is based on remembering algorithms (Schram et al., 1998; McDiarmid, 1990); 2) they view the teacher's role as a technician to implement curriculum (Schram et al, 1988) utilizing show-and-tell with student practice for the test (McDiarmid); and 3) they believe teachers should have all the authority and answers for the problems (Cady et al. 2006).

Ball (1990) explained that these traditional beliefs are shaped through teachers' own school experiences before they entered their teacher education programs. Richardson and Placier (2001) reviewed research studies that showed how difficult it is to change a person's beliefs and epistemic understanding after years of consistent reinforcement of traditional views. Despite this difficulty, there is a good amount of research in teacher education that focuses on how prospective teachers' entrance beliefs change within a short period of time (such as during one year of methods courses or two years of methods course and student teaching) (Borko & Eisenhart, 1992; Cady et al. 2006; Ensor, 2001; McDiarmid, 1990; Schram et al. 1988; Steele, 2006; Swars et al. 2008, Vacc & Bright, 1999). All of these studies described their philosophical goals as either reform-based or cognitive based. I consider these two perspectives to be roughly synonymous, as described in Chapter 1.

The common result of these studies was that the majority of preservice teachers included in the study moved away from their initial traditional beliefs to a more reform-based perspective when they left the program. For instance, the pilot study of Schram et al. (1988) found that the majority of preservice teachers came to the university program holding many traditional notions about teaching and learning mathematics. During their teacher education programs, the preservice teachers engaged with the mathematics method classes that focused on problem solving, group work, and discussions about mathematics concepts. At the end of the class, the researchers utilizing reflective journals and personal

interviews to examine how the traditional notions of the teachers had changed as a result of their methods courses. This study indicated that as a result of the courses, a majority of students reported that they started to raise questions about the traditional notion of teaching mathematics that they brought to the program; consequently, they began to appreciate the value of teaching methods they engaged with their university methods classes. Based on these findings, they argued that the mathematics methods class provided a new model of teaching mathematics to the preservice teachers and facilitated a change the teacher candidates' incoming beliefs about traditional teaching methods in mathematics.

Vacc and Bright (1999) researched changes in preservice teachers' beliefs about teaching and learning mathematics using both qualitative and quantitative methods, particularly focusing on cognitive guided instruction (CGI) practice. The student teachers took a mathematics methods class that were designed to focus on how children think about mathematics. They also participated in a weekly workshop led by both university faculty and CGI-experienced teachers. As a survey tool, this study adopted the mathematics belief instrument (MBI), which was developed by CGI researchers (Carpenter et al, 1989). Utilizing repeated-measure analysis of variance, the researchers measured the student teachers' beliefs about learning to teach mathematics. This study found that the mean scores of 34 participant teachers on the belief scale increased significantly during their methods courses and continued across student teaching experiences. The high scores on this measure indicated that student teachers became strong

believers of these categories: 1) children are able to construct their own knowledge; 2) skills should be taught in relationship to the understanding of mathematics; 3) the sequencing of topics should be based on children's natural development of mathematics; and 4) the role of teachers should be facilitators rather than presenter of the knowledge. This study argued that the mathematics method class and the workshop based on CGI practices helped student teachers to change their beliefs to a more constructivist orientation and to be able to develop a view of instructions that are different from simply telling students what to do. This study also revealed that the use of CGI principles varied for each teacher in the ways that instruction was carried out in the classroom.

With respect to elementary prospective teachers' mathematics belief, Swars et al (2009) conducted the similar study. Using a longitudinal study, they investigated the effects of teacher education programs on important constructs related to prospective teachers' beliefs in teaching mathematics. The researchers adopted four instruments to gather quantitative data, which are the MBI, mathematics teaching efficacy beliefs instrument (MTEBI), mathematics anxiety rating scale (MARS), and learning mathematics for teaching instrument (LMT). The result of the MBI revealed that there was a significant shift in the measure of student teachers' beliefs toward a cognitive orientation, increasing from 3.21 to 3.64 (initial to final). This is consistent with what Vacc and Bright (1999) found in their study. In addition to the MBI scale, Swars et al (2009) adopted the LMT (Hill et al., 2004) to measure prospective teachers' subject content knowledge

(SCK) growth and its relation to MBT scales. They concluded that teachers' subject content knowledge and beliefs were positively correlated and also interrelated with other measures such as MARS and MBEI. This means that prospective teachers' beliefs about a cognitive teaching approach, mathematics content knowledge, math anxiety level, and self confidence are all interwoven. The result showed that prospective teachers in this study who were able to develop a better understanding of mathematics content appeared to take on more cognitively oriented pedagogy, and the results showed they had more confidence in their skills. The result of this study highlighted the role of content knowledge to help student teachers be able to teach mathematics that are aligned to methods provided in the teacher education program and to sustain such teaching practice further.

So far, I have discussed the teacher education literature that addresses the role of preservice teachers' knowledge and beliefs in teaching mathematics. The common result of these studies was that preservice teachers come to the teacher education program with limited mathematics content and pedagogical content knowledge, and they hold traditional beliefs about teaching mathematics. These studies highlighted that the university mathematics, methods classes provided innovative knowledge for teaching mathematics, which is reform-oriented and aligns to the constructive perspective. Thus, they argued that the methods classes were able to change preservice teachers' incoming beliefs into a more reform-oriented perspective.

Although these studies argued that preservice teachers' traditional beliefs were changed by reform-based method courses, I am hesitant to conclude that the participating teachers' beliefs were changed enough to be practically relevant because, as McDiarmid (1990) stated in his study, "the only reliable test of changes in belief is what these prospective teachers do in their classrooms" (p.16). Hence, despite evidence that many prospective teachers reframed their initial beliefs, it is difficult to determine the degree of practical change unless we examine their teaching practices. The difficulty of practical change is well illustrated in the study done by Feiman-Nemser and Buchmann (1989). They conducted a two-year, case study of six elementary student teachers from Michigan State University. The central focus of this study was how the prospective teachers coped with the methods curriculum when they were placed in the school context where they were student teaching. This study identified major contributing factors that hindered or helped the transition of these candidates to pedagogical thinking such as personal capacities, dispositions, and entering beliefs. It was noted that during the transition period, the case teachers interpreted the issues of equity and diversity differently depending on their personal histories. The authors argued that if these entering beliefs remained unchallenged, it might result in misleading beliefs or missed opportunities for the teachers to learn.

Additionally, as Thompson (1992) pointed out, it is problematic that research studies try to measure changing beliefs in such a short period of time,

beliefs being a continually updated register of personal experience in an area (Middleton & Toluk, 1999). Brown and Borko (1992) and Grouws and Schultz (1996) showed there is a lack of longitudinal teacher education studies because few studies examined prospective teachers' changed beliefs or attitudes over a long period of time. It brings attention to the fact that there is a need to investigate the change of preservice teachers' knowledge and beliefs beyond the university setting. Hence, in the section below I describe studies that illustrate how student teachers learn to teach during field experience then describe how beginning teachers' beliefs and knowledge influence their teaching practice.

Field Experiences

Ball and Cohen (1999) considered field experiences to be a critical time for prospective teachers. They argued that teachers can certainly learn subject matter, pedagogical content knowledge, and other types of knowledge from a variety of courses, but the use of such knowledge in actual teaching cannot be learned in advance or outside of practice. It must be learned *in* practice, and field experiences are the first opportunity to do so. In that sense, Mewborn (1999) focused primarily on the importance of field experiences. This study examined the problems of four prospective fourth-grade math teachers and how they dealt with these problems. The mentor teacher was a veteran mathematics teacher whose classroom was consistent with national councils of teacher of mathematics NCTM standards. With the mentor teacher, the university instructor set up the goals of this field experience, which included an inquiry approach, a cohort group,

and a school-university collaboration. After each observation, the mentor teacher and university instructors helped the participant teachers articulate their developing ideas about mathematics teaching and learning and probed them to provide reasons for their ideas. Here, the role of teacher educator has shifted from supervising to helping prospective teachers to reflect on their teaching practices. As a result of this collaborative work, the prospective teachers benefited from field experiences in conceptualizing what they had learned from their methods courses. This study advocated that it is important to define the exact goals of field experiences and the role of university instructors during field experiences. Further, it is important to think about how these goals are connected to, and are supported by, methods courses.

However, one of the critiques of most teacher preparation programs is that there are not enough opportunities for preservice teachers to experience classroom teaching that is consistent with their university programs where reform teaching is central (Eisenhart and Borko, Feiman-Nemser, 2001; Zeichner, 2005). Eisenhart and Borko (1993), for example, argued that the contrast between many teacher candidates' field experiences and their methods courses induces them to question the usefulness of university programs. This study demonstrated that student teachers had limited opportunities during their placements to observe or participate in mathematics classrooms that were consistent with the reform-based approach, which demonstrates the need for university instructors to work together with placement schools to reduce this discrepancies and support teachers in

transition. It brings attention that, as argued in a study by Schultz, Jones-Walker and Chikkatur (2008), teacher preparation programs need to help teacher candidates learn how to negotiate with varied experiences in the given contexts of practice.

McDiarmid (1990) specifically studied how field experiences that employ nontraditional teaching practices challenged teacher candidates' beliefs about mathematics instruction. In this study, a group of his student teachers observed four classes taught by Deborah Ball, an instructor who used unconventional teaching practices. His study found out that this observation forced the students to reconsider their views of learners, particularly those views about young learners' learning processes in relation to teaching practices. McDiarmid argued that this experience led his students to reconsider what it means to teach mathematics. The preservice teachers were impressed by the third-grade students' use of mathematical representations and by the teacher's role in facilitating students' learning instead of just explaining the material to them.

Eisenhart and Borko (1993) also noted the critical role of the mentor teacher during the student teaching transition period by following a young teacher named Ms. Daniels. They found that Ms. Daniels' practice was more procedure-oriented when she was with the teacher who stressed procedures in her teaching. Meanwhile, Ms. Daniels' interests in her students' thought processes motivated her to try conceptual instruction; however, counterbalancing factors, such as assessment pressures and the need to get through the curriculum overwhelmed her

attempts. At one point, when her mentor teacher supported her in this effort, Ms. Daniels did attempt to place a greater emphasis on conceptual teaching.

Whenever Ms. Daniels had conceptual questions, her mentor teacher consulted with her. Overall, teaching practices among student teachers have been found to vary greatly, depending on the characteristics of the mentor teacher. This study shows the evidence that field experiences hold great potential for prospective teachers to construct their professional identity as well as to reflect teaching practice; but left unchecked, they can also contribute to a legacy of conceptions and practices.

Bullough (1992) conducted a case study about the relationships between curriculum decision-making and teacher development in the first year of English major teachers. He examined two first-year teachers. This study examined contextual factors and internal factors of how novice teachers use the given curriculum in their classrooms. In one of his cases, Lawrence's mentor teacher was allowed him to develop a curriculum that was as flexible as he wanted; hence, the student teacher was able to modify curriculum. However, Lena's mentor teacher tended to push her to follow the prescribed way. As a consequence, Lena had less chance to learn to adjust curriculum with her own teaching philosophy and consequently adopted the methods of her mentor teacher. He concluded that the mentor teacher who was more flexible and open appeared to have a greater impact on beginning teachers' identity construction (in the positive sense of the construct) than the teachers who held more traditional ideas about the role of the

student teacher. As Lawrence's mentor teacher gave him the autonomy to try out his teaching philosophy, Lawrence had an opportunity to practice his identity as the mathematics teachers he wanted to be, but that was not the case for Lena. Bullough pointed out that in addition to the autonomy level, the student teacher's self-identity was a critical factor to create differences. Lawrence, who appeared self-assured and settled in much of his role as a teacher, was able to use the curriculum concomitantly to satisfy his teaching role. Meanwhile, Lena, who possessed an uncertain conception of herself as a teacher tended to follow the curriculum and adopt the teaching philosophy of her mentor teacher.

This fact makes it clear that student teaching placement decisions are crucial. It is vital to provide preservice teachers with field experiences that focus on conceptual knowledge and demonstrate a model of teaching strategies that are consistent with effective pedagogies. When this does not occur, student teachers are likely to confront gaps between theory and practice and fall back on their own previous learning experiences, which can impede their willingness to consider new approaches to effective teaching (Agee, 1997).

I have, thus far, discussed the influence of mentoring practices, and I have stressed the influence of match or mismatch of teaching practices between novices and mentors. However, we know little from the literature about what mentor teachers do to make their knowledge accessible, how they think about their work, what novices learned from them specifically, and so forth (Feiman-Nemser, 2001). Furthermore, it is important to explore how these experiences

from methods classes and student teaching play out when in-service teachers become a first-year teacher.

Teacher Belief and Knowledge—The Role of Belief and Knowledge in the First Year of Teaching

Teacher Beliefs

The last premise of teacher education literature discussed earlier was the critical role of teachers' prior beliefs in framing and interpreting the outcomes of a beginning teacher's teaching practice. (Ensor, 2001; Kagan, 1992; Feiman-Nemser, 1983; Feiman-Nemser & Buchmann, 1989; Raymond, 1997). Raymond (1997) addressed why the beliefs of beginning teachers are important:

[F]irst, beginning teachers reveal much about their beliefs as they struggle to develop their teaching practice; second, beginning teachers' beliefs about mathematics and mathematical pedagogy are likely to be challenged during the first few years of teaching because their pedagogical beliefs are pitted against the realities of teaching (p. 551).

She asserted that despite the importance of beginning teachers' beliefs, they are often overlooked in current education research. The related research emphasizes how beginning teachers tend to transform what they have learned during their teacher education programs to the classroom setting in which they belong

The transformation of learning is well described in a number of studies. Ensor (2001), for instance, conducted a two-year, longitudinal qualitative study that tracked seven secondary mathematics teachers from their methods courses to

the first year of teaching. She focused primarily on the participants' first year of teaching. Her article identified how the pedagogy that all seven teachers held from the same methods courses was recontextualized throughout their first-year teaching experiences. One of the examples is the case of Mary. Mary, one of the participant teachers, created her own meaning of "visualization". During her teacher education program, visualization was characterized as allowing students to explore and discover of meaning mathematics content through the use of multiple concrete tools. However, visualization, to her, meant providing students with an overhead projector so students were able to see the process of solving problems. Ensor surmised that Mary's limited understanding of teaching practices appeared to cause this transformation. Another example of transformation of knowledge was observed with all seven teachers. The seven participating teachers obtained their first-year teaching positions in multicultural contexts. Each went from all-white, well-equipped, government-funded schools to very poorly resourced, schools with entirely African American enrollment. Ensor found that although these teachers all taught in very different school environments, the characteristics of their learners were considered as constraints for all of them. For example, when they taught lower-performing students, they drew largely on teaching of rules and procedures, but with higher-performing students they emphasized the importance of teaching for conceptual understanding. Only one teacher, Alexandra, focused consistently on teaching that was based on conceptual knowledge. The result of this study implied that even though the prospective

teachers began the teaching with changed beliefs, depending on the classroom context, their beliefs played out in different ways. This study confirms how difficult it is to change preservice teachers' deep beliefs that have a profound influence on their real classroom teachings.

A study done by Raymond (1997) investigated relationships between beginning teachers' beliefs and mathematics teaching practices. She examined personal factors that influence teachers' beliefs, practices, and the degree of inconsistency between them. The participant teacher, Joanna, held incoming beliefs about mathematics that were traditional due to her personal school experiences. Meanwhile, she developed less traditional beliefs about mathematics pedagogy as a result of her university program. However, Joanna failed to implement her less traditional beliefs about teaching pedagogy in the classroom because she confronted overarching constraints in the culture within her community of practice. Joanna explained that she had to vary her teaching practice according to the topic at hand and the behavior of students in the classroom. She said the time constraints, scarcity of resources, and concerns over standardized testing were potential causes of inconsistency; but the biggest obstacle was the students' behavior because she struggled with classroom management when she taught math using a base 10 block. Raymond pointed that Joanna did not divide the class into groups and used base 10 block again after this lesson even though she believed this was the ideal way to teach the content conceptually. Raymond noted that Joanna's cases represented a teacher who

might fall into a traditional teaching practice naturally because of limited time, resources, and lack of classroom management skills. According to her argument, without changing deeply held beliefs, it is going to be very difficult to expand the number of nontraditional mathematics classrooms. Ms. Hence, it is essential to focus on beginning teachers' incoming beliefs to yield substantial changes.

In addition to beginning teachers' personal beliefs, their lack of knowledge (especially pedagogical content knowledge) has been cited as another major obstacle that must be dealt with. As alluded to earlier, it is generally accepted that beginning teachers come to the classroom with a lack of knowledge, especially pedagogical content knowledge (Borko and Eisenhart, 1993; Ensor, 2001; Hollingston, 1989; Kagan, 1992; Steele, 2001; Wilcox et al., 1992).

Teachers Knowledge

Steele (2001) pointed out that beginning teachers' lack of knowledge of both key mathematical concepts and critical pedagogical moves plays a critical role in implementing what they learn from their university courses. For example, Ann who was a beginning teacher, believed that cooperative learning was important and that memorizing rules is not an effective way to teach; however, her lack of confidence about mathematics did not allow her to pose open-ended conceptual problems to her students. For Dawn, another beginning teacher, it was her lack of pedagogical knowledge that made it difficult for her to connect CGI with her teaching practices, even though she had majored in mathematics.

Brown and Borko (1992) show that when beginning teachers do not have adequate content knowledge they have less time to spend reflecting on students' thinking strategies and must utilize cognitive and temporal resources based on their *own* understanding of the content. Kagan (1992) highlighted how this problem is compounded when there is a lack of pedagogical content knowledge pertaining to classroom management. Classroom management is one of the most pressing concerns for beginning teachers (Kagan, 1992; Raymond, 1997).

Because they need to maintain behavioral and social norms, novice teachers who lack this knowledge tended to plan instructional design not to promote learning primarily, but to control students' behavior. Their inadequate knowledge of the classroom was found likely to lead beginning teachers to use procedural instructions to make the classroom function effectively. Until such standard procedures are routinized and fairly automated, novice teachers will probably continue to rely on their traditional approach to teaching merely as a function of cognitive resources and time restrictions.

The described studies so far showed that the teachers' knowledge and beliefs played an important role in the implementation of what they had learned in their teacher education programs. It is well documented in these studies that first year teachers often struggle to implement what they have learned in the university program, and these studies presented different reasons: 1) the impact of entering belief (Ensor, 2001); 2) lack of content knowledge (Brown & Borko, 1992), 3) lack of pedagogical content knowledge (Steele et al, 2001), and 4) concerns about

classroom management (Raymond, 1997). The finding of these studies explained the reason for first-year teachers' struggles was the individual teacher's beliefs and knowledge. However, an extensive amount of teacher education research has argued that it is critical to investigate first-year teachers' school environments because there is lack of connection between the university program and the real school settings (Cook, L. S., Smagorinsky, P., Fry, P.G., Konopak, B., Moore, C., 2002; Eisenhart and Borko, 1993; Kagan, 1992; Korthagen and Kessels, 1999; Grossman 2000). Hence, in the section below, I review the literature that explores the impact of school culture in teachers' learning to teach.

School Environment: The Role of Social Environment in the First Year of Teaching

With respect to the role of the school environment in the teacher education field, Cook et al. (2002) refer to Zeichner and Tabachnik (1981) and indicate that the effects of teacher education are washed out in the school because university professors' instruction is inconsistent with the pedagogy teachers espouse in classrooms. Similarly, Grossman (2000) argues that conceptual tools offered in methods courses need to be exemplified by practical strategies for teachers to be able to appropriate them more fully. Without concrete strategies, the theories presented in methods courses are inadequate to achieve that goal. Grossman further emphasized that "theory becomes real only through practice" (p.29).

Cook et al. (2002) conducted a case study of one teacher, Tracy, from her student teaching through her first full-time job teaching a multiage kindergarten

and first grade class. The main focus of this study was to examine how Tracy conceptualized constructivism-based teaching for reading that she learned from her methods class and student teaching. Tracy embraced constructive philosophy from the beginning and showed a strong desire to implement it into her own teaching. When she tried to implement constructivism in her teaching, there were two reasons that seemed to hinder her. The first one was that the school setting was not supportive and not connected with the university program. As a teacher in the school, she wanted to adopt curriculum that adhered to a constructivism approach, but what was given to her was far from this philosophy. In addition, she didn't have a mentor from the university who was able to provide support and guidance to her that aligned with the constructivism approach. This environment did not reinforce Tracy's teaching as a constructivist. The second reason was her limited understanding of the notion of constructivism. Her understanding of constructivism was superficial. This study argued that it is necessary to find a way to provide teachers with practical reinforcement to implement the core notions of university, teacher education programs.

Eisenhart and Borko (1992) also described the tension that existed between a student teacher, Ms. Daniels, and the school context. The school structure where Ms. Daniels was placed for student teaching contrasted with the ideas she had learned in her methods courses. As a student teacher, Ms. Daniels felt pressure to meet her university professors' expectations, which were reform-based teaching practices, and she also had to meet the daily responsibilities of her

placement classroom. Korthagen et al. (1999) noted that these tensions came from the “poor transfer of theory to practice as a lack of integration of the theories presented in teacher education” (p.5). In other words, the rather abstract and general theory of teacher educators was quite different from the student teacher’s theory, which focused more on concrete problems.

Overall, results from these studies suggest that teacher education has a dilemma in terms of teaching durable concepts, especially in methods courses that contrast with actual school settings. Student teachers leave the university classroom with an understanding based on teaching theory, a repertoire of teaching strategies, and knowledge, but they often need support to implement what they have learned within their particular classroom settings (Liston, Whitcomb, and Borko, 2006). As Korthagen (1999) suggested, teacher educators need to develop a theory about learning and teaching mathematics that is directly relevant to classroom practices. In addition, it seems obvious that beginning teachers are likely to struggle during this shift in experiences, so it is necessary to help them to be prepared for such a transition.

Another constraint that beginning teachers often confront comes from the school environment, which can include pressures from the district, the classroom, testing pressure, the curriculum, the principal, and so on (Cook et al., 2002; Grossman, P., Valencia, S., Evans, K., Thompson, C., Martin, S., Place, N., 2000; Steele et al., 2001; Wilcox et al., 1992).

Steele's (2001) case study described the characteristics of teachers who were not able to sustain CGI practices after they left the program. Her cases illustrated that only two of four students in the study sustained CGI and incorporated it into their teaching practices during the first two years of full-time teaching experiences. The common features of the teachers who sustained what they had learned from the methods courses included flexibility in using the given curriculum, planning the lesson, preparing the students' assessments, and as discussed earlier, their image of teachers as learners. In particular, what distinguished Mary and Vanessa, the two students who sustained CGI, was that they attempted to decide—and not just follow—the curriculum. The difference between these two teachers was that Mary seemed to be the most comfortable with test preparation while Vanessa went back and forth among conceptual teaching and drill and practice for the test. Dawn and Ann, the other two teachers, did not weave CGI into their teaching practices because compared to Mary and Vanessa, Dawn and Ann tended to draw on test, drill, and practice for assessing students, and they were dependent on the textbooks.

Steel's work articulated how school contexts influenced first-year teachers' teaching practices. Among Mary, Vanessa, and Dawn who held more CGI oriented beliefs, only Mary and Vanessa retained the same conception because there was less pressure from the school and district. For Dawn, the pressure from her school, especially the assigned curriculum, was her biggest obstacle. Further, she was the only teacher who had complied with the policy of her school district.

Steel further showed the evidence that sustaining CGI was a function of the participants' teacher-as-learner identities, and that the school setting is very influential in the development of new teachers. Despite the centrality of the school context, we know little about the complexity of this context. For instance, what is a supportive school context, how do student teachers interact with school contexts such as the given curriculum, the principal, the district, and their relationships with colleagues? Steel's study brings attention to the need for broad-based support for young teachers, increasing reform-based professional development and curriculum, sufficient content knowledge, and most of all, teacher education that helps preservice teachers deal with possible sources of pressure and the dilemmas they are likely to face as they move through their own profession.

Focusing on these complex school contexts, Grossman's (2000) study revealed, in particular, the impact of curriculum on beginning teachers. In it, she conducted a longitudinal study of ten beginning teachers. Grossman followed those teachers from their university programs of language arts through their first two years of full-time teaching. They adopted a sociocultural framework to understand how beginning language arts teachers develop pedagogical goals while engaged in activities in particular settings, such as school context, mentor teachers, peer relationships, and the given curriculum. The second goal was to identify the problems these teachers confronted, how they negotiated the situations, what kind of pedagogical tools they used, and how these pedagogical

tools developed differently as beginning teachers moved from their first to their second years.

The most striking finding from the first year of full-time teaching was the teachers' high dependency on the curriculum. For instance, first-year teachers in Grossman's study were trained how to teach English using cooperative integrated reading and composition (CIRC) during teacher education program, and they wanted to implement this in their classrooms. However, CIRC requires three-day blocks to conduct, and this time constraint hindered the beginning teachers from transferring their subject knowledge of writing to the students. Moreover, combined with the school-wide emphasis on other reading programs, CIRC became a major issue in the teaching of writing. Even though all the teachers prepared for pedagogy in their methods courses, when their classroom setting did not support the approaches they learned, such as reform-oriented pedagogy, it became no longer practical, and teachers tried to find sources from outside. As a result of this study, Grossman asserted that first-year teachers were struggling to put pedagogical tools into practice and the lack of support from their schools and from their university settings was the biggest reason.

However, in Grossman's study, some university instructors actively helped prospective teachers to implement what they had learned in the school context. When this occurred, the other factors in the situational context, besides the curriculum, such as cooperating teachers and the learning community, were not as big of an issue for them. Unfortunately, this rarely occurs. With respect to

this issue, Grossman and McDonald (2008) argued that in their field experiences, novice teachers infrequently have opportunities to receive immediate feedback after they experiment with important pedagogical concepts. They asserted that developing skills in complex teaching practices through rehearsing is necessary for novice teachers. These studies highlight again how continuous support from the teacher education program is crucial in the first year of teaching if reform-oriented pedagogical knowledge is to be sustained.

Brief summary of multiple context of learning to teach

With respect to studies of first-year teachers, the difficulties in the first years of teaching are commonly documented. Teacher-education research often describes beginning teachers as survivors or flounders (e.g., Kagan, 1992; Feimen-Nemser, 1983). Such descriptions imply that learning to teach is not a simple phenomenon that can be easily figured out. At the same time, studies of multiple contexts point out the complexity of this critical transition period for novice teachers and the central elements that preservice teachers commonly face during their first year: 1) preservice teachers' knowledge and beliefs; 2) their lack of or inconsistency between pre and post concepts; 3) the role of field experiences and mentor teachers; 4) the transitional gap between theory and practice; 5) the contrasts between methods courses and real classrooms; and 6) various contextual pressures from schools and districts.—It can be said that learning to teach is interwoven with individual characteristics and the social environment. To have a better understanding of this complexity, this study adopted the notion of teacher

identity because, as stated earlier, identity connects the individual and social (Wenger, 1998).

Teacher Identity

Kilgore et al. (1990) argued that individual teachers plays an active role to decide what kind of teacher they want to be, but their agency is limited within their given social contexts, so it is necessary to investigate both the individual's learning process and the given culture to more fully describe the complexity of learning to teach. To look at the individuals' learning within their social frameworks, I adopted the notion of identity from Lave and Wenger. Wenger argued that identity explains an individual's development in terms of other relationships—with other teachers, with their mentors, and with the larger context of mathematics teaching as a profession. On the individual level, looking at the development of teacher identity helps us to understand how teacher candidates learn how to teach mathematics in terms of their beliefs, knowledge, and relationships. On the social context level, examining teachers' identity development helps us to understand how preservice teachers adjust themselves to their mentor teacher and school contexts because identity is continuously negotiated and constructed in relation to the community of practice in which they belong (Wenger, 1998).

Drawing from the work of Wenger, I define teacher identity as follows: how they define who one is in relation to others. In other words, how student teachers define who he or she is as a mathematics teacher in relation to his/her

prior experience, to his/her teacher education program, to his/her students and their mentor teacher.

In studying process of becoming a mathematics teacher, I hope to shed light on the influences of the University program and the local school culture. I also hope to uncover how we might improve the experiences for new teachers as they try to implement a more reform-oriented, pedagogical identity. Kagan (1992) stressed that preservice teachers' prior beliefs and how they see themselves as a mathematics teacher is critical in shaping their initial teaching practices. For instance, if one sees him or herself as a mathematics teacher who believes that repetition and practice is important to teach mathematics, one will tend to engage in practices that embody that identity. These beliefs stem from teachers' prior experiences as a student of mathematics, and they progress as teachers' grow through their experiences in their teacher education programs. This study, in particular, focuses on identity development while teachers are in their student-teaching periods.

Teacher identity development during student teaching

Overall, studies that have emphasized preservice teachers' knowledge and beliefs tend to take a constructivist perspective. This is true for research on identity as well. Ebby (1999), for example, explicated how student teachers made sense of a constructivist teaching perspective throughout their own methods classes and field experiences and how they incorporated those ideas into their identity as beginning teachers. She conducted a case study of three prospective

teachers to see if their methods courses and field experiences helped the teachers develop new identities as learners. She found out that those student teachers who perceived their roles as learners during student teaching were more successful at making sense of the constructivist perspective for teaching mathematics.

However, the methods courses did not change the identity of one student teacher, Michelle. Ebby reasoned that Michelle's strongly negative orientation toward mathematics from her own experiences might have caused this result. She confirmed that whether or not the student teachers adopt the constructivist identity for their own mathematics teaching practices has much to do with their prior beliefs, dispositions, and experiences that they bring with them. She concluded that to implement the new model of teaching emphasized by the methods courses, the goal of the courses should be on developing a self-image and identity as learners. Considering the importance of teachers' roles, Kagan (1992) noted that novices who entered the classroom without having a clear self-image as a teacher tended to face difficulty sustaining their beliefs and what they had learned. These studies argued that developing a new identity as a mathematics teacher is critical in a teacher education program.

Boaler and Greeno (2000) adopted the figured-world framework in their study to explore how high school students' identities were developed under two different mathematics-teaching methods, didactic (traditional) and discussion-based (reform). Traditional pedagogy in this study was characterized by a routine of presenting a procedure, modeling an example of a problem, and then asking

children to practice similar problems (Hiebert & Stigler, 1999). In the traditional classroom, the classroom routine typically consists of the teacher presenting the procedures and students practicing these procedures. Reform pedagogy entails designing and posing tasks that call upon children to reason about quantities, invent their own strategies, and discuss their thinking. This study does not directly relate to the identity development of preservice teachers, but it shows how prior identities are developed by different teaching methods and different math teachers.

Boaler and Greeno also found out that in a traditional classroom, students considered successful students to be receivers of knowledge and they developed identities that are compatible with a procedure-driven, figured world. The students who succeed in such classes attributed their success to obedience, compliance, the ability to follow directions, and the dismissal of their own decisions. Another striking result was the reason why a large portion of students gave up pursuing mathematics careers. The students reported that the image of a passive learner does not match with their identity, which is more creative, narrative, and human. On the contrary, in discussion-based classrooms, more students identified learning mathematics as a thoughtful process in which they developed connections and relational understandings. Partly because of this study, learning mathematics is no longer considered a matter of preference in the field. It is a matter of establishment of identities (Boaler and Greeno, 2000). The findings from this study support the research done by Holland et al. (2008) on

how previous identities play a role in the adoption of new identities in teacher education program.

With respect to preservice teachers' identity development, Holland et al. explored how they identified themselves as mathematics learners and doers within the frame of figured worlds. Holland and her colleagues defined a figured world as "a socially and culturally constructed realm of interpretation in which particular characters and actors are recognized, significance is assigned to certain acts, and particular outcomes are valued over others" (p.52). For instance, in the figured world of a reform pedagogy, mathematics classroom, invented strategies are valued over the formal algorithm. Students are supposed to explain their thinking when they solve the problems. Holland and colleagues assigned two different roles of identity to the college students in the teacher education program. One group of students took the role of children who were learning mathematics in the reform-based classroom, and the other students acted as teachers who taught mathematics to the children. When students acting as children were asked to solve multidigit addition problems without using a formal algorithm, they struggled. This was partly because they lacked experiences using different strategies other than the traditional way they had been taught. It is also because some of students believed that breaking the traditional way would confuse children; hence, they tried to modify the given problems so that they were familiar to them. Meanwhile, those who took on the role of the teacher understood that student thinking is important, but they faced difficulties asking questions

regarding how to move them, and still hold to their view of teachers as those who must prescribe a series of steps of what to do for children. This study highlighted that implementing reform pedagogy is difficult for both mathematics teachers and mathematics learners due to their lack of experiences and their prior beliefs of teaching and learning mathematics. Reform pedagogy consists of new concepts and practices for prospective teachers. Consequently, they inevitably face confusion and conflict from the world they experienced in their own schools as children and the new world provided by their teacher education program. As a conclusion of the study, Holland et al. (2008) argued that teacher education programs needs to support teacher candidates to build new identities of being mathematics teachers in a reform-based world.

The routine, therefore, looks a little bit different in the reform classroom. Students often work as groups, and the teacher's role is more like a facilitator rather than the transmitter. Teachers in reform classrooms tend to encourage students' invented strategies. The mathematics content is more centered on core concepts, and the lessons are built based on students thought processes and what the students bring to the classroom (NCTM Standards, Senk & Thompson, 2003; Stein, 2007; Tarr, 2006; Trafton et al., 2001; Weiss, 1987).

With respect to identity development during teachers' field experiences, Bullough (1991) noted that field experience is important period because student teachers experienced the dual roles of a student and a teacher simultaneously. Bullough mentioned that novice teachers first seek to confirm their self-images as

teachers apart from their previous images as students. His study revealed that the beginning teachers who did not have a clear self-image of themselves as teachers found it difficult to sustain consistent classroom skills.

Field experiences are the time that preservice teachers typically have to develop their own initial identity and set of signature practices. Teacher candidates learn teaching theory from teacher preparation programs, and they experience an exemplar of “good” teaching along with an understanding of teacher learning from their mentors (Fieman-Nemser, 2001). Students develop an image of good teachers and knowledge about teaching in realistic classroom situations throughout their field experiences (Moore, 2003). In addition to the mentor’s influence on teaching practices, how student teachers construct their professional identities as math teachers during this period is equally important to understanding the complexity of learning to teach. As we shall see, this identity is also influenced heavily by the mentor teacher.

There still exist some agendas that teacher educators need to know to better prepare preservice teachers. Zeichner (2005) pointed out that much of the existing research has focused on how methods courses and field experiences influence teachers’ beliefs and attitudes, but relatively little research has paid attention to their influences on teachers’ knowledge and practices. Further, emphasis has typically been placed on measuring these factors instead of understanding the process. For instance, the studies cited above explained the theoretical perspectives of methods courses, but none of the studies provided a

detailed curriculum of these courses. Without detailed content of the methods courses, it is difficult to explore exactly how methods courses impact novice teachers. In addition, there are few longitudinal studies that examine the effects of preparation on teachers over time. Although a teacher's transition is a continuous trajectory of learning, the research studies are rather fragmented and isolated. Studies on methods courses, field experiences, and the first year of teaching have rarely connected teachers and teacher educators. Few beginning teachers are able to receive support from university professors during their transition.

It seems obvious that the mentor teachers, the learning community, and the university faculty would play a pivotal role in prospective teachers' learning. However, the studies cited only briefly mention this leaving the relationships between mentors and their student teachers virtually unexplored. Further, the literature does not discuss in detail the importance of how student teachers are placed in schools. This is necessary information for examining how student teachers resist, comply with, or modify their beliefs and practices within given environments.

There is also the issue of classroom management. Wilson, Floden, and Ferrini-Mundy (2002) pointed out the importance of the management routine. Classroom management was addressed as one of the major concerns for beginning teachers because managerial routines have to be emphasized before prospective teachers can focus on teaching subject matter. Regardless of subject-

matter preparation, preservice teachers who failed to standardize discipline and management were not able to focus on students' thinking (Wilson et al., 2002). This suggests a need for additional research that focuses on the relationships between classroom management and students' learning. Given the complexity of teacher education and its connection to various aspects of teacher learning, it is essential to employ multiple methods and theoretical approaches to provide the necessary support for novice teachers (Ziechner, 2005). This statement reflects the idea that researchers in teacher education may need to reach outside their community altogether in order to address problems of organizational complexity (Grossman et al., 2008; Wilson et al., 2002).

Research Questions

Taken together with previous research, my study focuses on the development of preservice teachers' identities as they grow and change through key transitional periods in their teacher education programs. In particular, I examine the role of central individuals in preservice teachers' mathematical and education-related experiences. Specifically, I address the questions below by following a small set of aspiring elementary teachers through their mathematics methods courses, through their student teaching semester, and into their first year of instruction:

1. How do aspiring elementary teachers construct their professional identity?
Specifically, in what ways do they develop an identity related to

mathematics teaching during the critical period when they engage in the mathematics methods courses and through student teaching?

2. What are the critical experiences, people, knowledge, and skills that contribute to the construction?
3. How do the contexts of student teaching and the school environment impact teachers' identities and teaching practices?

CHAPTER 3

METHODS

Description of Study

This study is about how teachers construct their professional identities as mathematics teachers during two critical periods of their teaching careers. The first critical period is the time spent as a teacher candidate enrolled in mathematics methods courses. The other milestone is the stretch of time spent as a student teacher. I also followed up with my subjects in their first year of teaching, but this dissertation will only describe the first two transitional periods in their identity development.

My cases were students who were enrolled in the teacher preparation program at Arizona State University. The study was conducted between August, 2009, and December, 2010. I followed five elementary teacher candidates from the last year of their mathematics methods courses into their student teaching periods. I began with all the teacher-candidate students in the program (Fall 2009) and selected five prospective teachers based on high engagement, good content knowledge, and commitment to their work in spring, 2010. This selection process will be described in the following section.

I observed my case teachers' mathematics methods courses, their student teaching placements. In addition to observations, I interviewed the student teachers regarding their identity construction as mathematics teachers. As key

informants, I interviewed their methods class instructors and mentor teachers regarding their approach to mathematics teaching and learning. The following table is a summary of the participant groups and the time frame.

Table 1

Participant Groups and Time Frame of Collecting Data

Participant group	Time frame	Description
Prospective teachers (n=27)	15 weeks Fall 2009	<ul style="list-style-type: none"> • Observed undergraduates enrolled in their mathematics methods courses: Mathematics methods and management course for elementary school (EED 480) • Required class to earn certificate for elementary school • Characterized reform-based teaching
Practicing teachers (n=5)	spring 2010 fall 2010	<ul style="list-style-type: none"> • Observed 5 of these prospective K–8 teachers in their student teaching field experiences. • Observed case teachers into their first year of teaching (not reported in this manuscript).

The purpose of this study is to investigate how student teachers practice their professional identities as mathematics teachers through apprenticeships with a methods instructor and their mentor teachers. Furthermore, I look at how novice-teachers construct their identities within a given community of practice. Identity construction is a complicated phenomenon not only because it relates to many other factors such as a person’s beliefs, the specific social settings, and historical experiences, but also because it is an ongoing process (Holland, 1998).

Hence, how teachers construct their identities may vary depending on the social settings that surround them. Instead of looking at what the general patterns of constructing professional identity of student teachers are, my study investigates the unique situations that contribute to such development.

Given the complexity of the social environment, and given how little we actually know about identity development, qualitative methods are appropriate to generate a working model of the phenomenon. Erickson (1985) stated that qualitative methods are best at answering such complex questions. Borrowing his notion of fieldwork, the practical questions of my study can be framed this way. What is specifically happening in the social action that takes place in a particular setting (e.g., in the methods course, in a field classroom)? What do those actions (the relationships between mentor teacher and student teacher) mean to the actors involved in them, at the moment the actions (interaction between those two) take place? How is what is happening in this setting as a whole related to happenings in other system levels outside and inside the settings (e.g., the school building, the school system, district, etc.)?”

Hence, use of the qualitative approach will help me to understand the complexities of student teachers and their learning and teaching contexts and their relationship to their development of teachers’ professional identities. In particular, I adopt case study methods that draw on the strengths of this method as demonstrated in Erickson (1986), Merriam (1998), Stake (1995), and Yin (1994).

Yin (1994) defines a case study in terms of the research process. “A case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident” (p.13). The strength of the case study method is addressed as its ability to examine in-depth, real life, contexts (Yin, 2006) and in-depth, analyses of complex issues (Stake, 1995).

Stake (1995) described that a case study is a study of the particular; we conduct a case study as we are more interested in a specific phenomenon than its generality. To understand the causal network in the case of a teacher’s developing identity, we must reveal the issues that *may* have bearing upon other cases. But a plausibility argument needs additional evidence to provide justification of generality across cases or transportability to new contexts and new actors (Middleton, Gorard, Taylor, & Bannan-Ritland, 2008). My study is focused on the particular cases of student teachers who graduated from one specific teacher education program and who began their own teaching career in the same area. As the teachers’ identities are bounded with their own historical backgrounds and personal stories (Drake, 2006), the particular characteristics of each case teacher will help understand what is happening in their personal identity construction. This approach also helps focus on individuals’ perspectives as they engage in activities within a given social context and on the meanings individuals draw from these experiences. Because I have three cases that have common experiences in mathematics learning and mathematics teacher preparation, the

patterns of identity development uncovered in each case can be compared across cases to provide initial evidence of plausibility of a more general model of identity development. Thus, following the description of each case, I will discuss these commonalities and propose issues that may determine the development of identity for any elementary mathematics teacher.

Case Selection

Stake (1995) emphasized the importance of selecting cases by stating that “understanding critical phenomena may depend on choosing the case well” (p.243). It was necessary to select a limited number of cases to understand the specific context of identity construction and to maximize what we can learn about each case. As my research design is a case study, the case selection needs to be defined. Merriam (1998) and Yin (2009) noted that purposeful sampling is commonly used in case studies when the researchers want to discover, understand, and gain insight from the sample. According to them, some common types of purposeful sampling are typical, unique, maximum variation, convenience, snowball, chain, network, and theoretical. They asserted that to begin purposeful sampling, it is necessary to determine what selection criteria are essential in choosing participants. The following is the criteria that I used for my case selection.

Mathematics Method Class

I chose to observe a required mathematics methods course at Arizona State University prior to selecting my elementary teacher candidates. This provided me with an example of the teaching methods my participants were taught in their teacher-education courses. In addition, the instructor of the course was a veteran teacher, and her class was aligned with reform-based teaching methods, including a general constructivist approach, use of manipulatives and technological tools, and an emphasis on children's mathematical thinking, especially CGI. The *Principles and Standards for School Mathematics* (NCTM, 2000) was a required textbook, and the Principles and Standards was one of the major foci in this class. During this methods course, preservice teachers were engaged with manipulatives, group work, the development of conceptual understanding of content, and problem solving. Students in the class were also always asked to justify their mathematical thinking to the rest of the classmates. The teacher candidates often shared their mathematical ideas among the groups and compared strategies for solving the same problems. In sum, during this mathematics methods class, student teachers were engaged with mathematics knowledge and skills in a manner that is consistent with the NCTM principles and standards.

Student Teachers

I selected my sample of student teachers according to their participation in the methods course. During the course (fall, 2009), I observed every week (three

hours per session) for the entire class period and took notes on how the teacher candidates interacted with peers, shared their mathematical thinking in public, and how they participated in the class activities. In the classroom observation, I looked for evidence of their knowledge about teaching mathematics what they thought was important in mathematics, and what they knew about teaching mathematics. This helped me to know what they might do in a class as a teacher of mathematics. I also considered that when teacher candidates publically stated their opinion that this was evidence of their confidence. I looked for this evidence because confidence is related to their ability to learn and to teach mathematics (Graven, 2004). Based on these observational field notes, I first selected eight student teachers who made a commitment to do their work and exhibited high engagement. Four showed low confidence, and four showed high confidence.

The other selection criteria was gaining access to the local school they were placed and obtaining the consent form from the cooperating teachers. Based on these criteria, three participant teachers were dropped, and the remaining five teacher candidates constituted my pool of cases. Detail on each of my case teachers is included below in Chapter 4.

Mentor Teachers

I followed the remaining five teacher candidates into their student teaching field placements and incorporated their five mentors as participating mentor teachers. Detail on each of the mentor teachers is also included in Chapter 4.

Data Collection

The main data formats for my case study were interviews at multiple time periods and the consistent classroom observations, as a participant observer.

Interviews

Pattson (1990) explained that the main purpose of an interview is to find out what is in someone's mind. As he explains:

We interview people to find out from them those things we cannot directly observe.... We cannot observe feelings, thoughts, and intentions. We cannot observe behaviors that took place at some previous point in time. We cannot observe situations that preclude the presence of an observer. We cannot observe how people have organized the world and the meanings they attach to what goes on in the world. We have to ask people questions about those things. The purpose of interviewing, then, is to allow us to enter into other people's perspective, (p.196)

Therefore, interviews are important for my study because they gather evidence concerning teachers' beliefs about teaching mathematics and can also provide me with a deeper understanding of the construction of identities as a result of engagement with the given social structure. Since identities involve ever-changing and ongoing processes (Holland et al., 2003), interviews at different time periods allowed me to obtain: 1) participants' interpretations of their experiences at each time; 2) their understanding of the world in which they worked, which differs for each transitional period, and perhaps as events transpire within these periods; and 3) personal knowledge and beliefs about mathematics teaching practices in relation to their identities. Multiple interviews enabled me to see how teacher candidates' identities developed or changed and the possible

interpretation embedded in such change. I interviewed each mentor teacher one time at the end of the semester because the interview focused on the mentor teacher's beliefs and teaching philosophy in general—not on how these beliefs changed over time.

The major themes of the interviews were: 1) the participants' prior experiences with mathematics and their teacher education program; 2) the teachers' beliefs about teaching mathematics; 3) the teachers' engagement with the given social contexts; and 4) the teachers' relationships with students. If there was time to have a casual conversation before or after the observation, I conducted a mini-interview focusing on the mathematics topics/activities of the lesson, or the teacher's reflection on the lessons and so on. The detailed questions for each theme are described later. All interviews were semistructured and in-depth, and interview questions and answers were audio recorded and transcribed. In this set of data, I looked for evidence of how their prior experiences and beliefs influenced their current approach to teaching mathematics, their identity as a math teacher, and also how the student teachers negotiated themselves within the current social context, especially in their relationships with their mentors—noting conflicts as well as conformance.

Observations

Merriam (1998) stated that observation is a research tool when it: 1) serves a formulated research purpose; 2) is planned deliberately; 3) is recorded systematically; and 4) is subjected to checks and controls on validity and

reliability. Classroom observations allowed me to record mathematics lessons in each classroom, including the teacher's behavior, decisions, interactions, and discourses that were occurring from moment to moment. These provided the background I needed to capture the character of the teachers' identities and beliefs. This also allowed me to make a comparison of responses during the methods course versus during student teaching and make assertions regarding the change that occurred, when it occurred. The major focus of classroom observations were: 1) the teacher's (both student and mentor) engagement with the given social cultures; 2) the teacher's mathematics teaching practices; and 3) the teacher's interaction with students in the classroom. As my research focus is teacher's identity construction, which can hardly be captured visually, I did not video-record the classroom observations. Instead, all classroom observations were recorded in written field notes.

I recorded observations in steno notebooks divided in two columns to generate data. Upon arrival at the classroom, at the top of the page, I noted general background observations, including the specific location, date, time, and mathematics content that the students were engaged in. In the left-hand column, I wrote down what mentor teachers were doing in the classroom, and on the right-hand column I noted what student teachers and children were doing in the classroom. For example, I wrote down the moves mentor teachers made in relation to what the student teachers did using a different color of pen. This approach provided me with information about relationships between student

teachers and mentors and the degree of participation of student teacher. I also focused on the role of mentors and how much opportunity the participants had to teach mathematics because I wanted to know what occasioned the opportunity for teachers to become who they wanted to be. These factors included what kind of teaching model they were engaged in with the mentor teacher, how the student teachers taught mathematics, and how this compared to their beliefs and goals. These were major markers of participation in the studied cases.

Regarding the second theme, teachers' mathematics teaching practices, to understand the chronological order of events and the extent to which they were prevalent in the classroom, I recorded the time when one event was finished or when a transition occurred to a different topic or activity. For instance, I recorded how much time was spent on teacher explanations, transitions, homework checking, sharing ideas, using manipulatives, how many problems were taught during the math time, and so on. I copied down all the problems that students solved during the instructional period and collected extra copies of problems as evidence of instruction material. This provided me with consistent information about what teaching materials they drew on, the typical routine of the mathematics class, and the characteristics of the teachers' mathematics teaching practice.

Lastly, concerning the teacher's interaction with students, I focused on how student teachers encouraged students to engage with mathematics, such as asking them to share strategies or answers, explaining students' thinking, or

encouraging them to use manipulatives. In particular, interaction with students and utilizing manipulatives were major foci during the university methods course; hence, this observation allowed me to know how much of the university methods program the teachers implemented in their actual teaching practices. Also, it helped me to understand how their teaching practices aligned with what they believed to be the best practice for *their* students.

Collecting data using multiple sources, often referred to *triangulation*, is important in qualitative research because it confirms the emerging findings and deals with validity threats. The major foci of the observations and interviews of the methods course, and for the observations and interviews of the student teaching experiences were identical. But, the detailed focus varied slightly depending on the two experiences. All the data were collected at two different periods of time—at the end of methods class and during student teaching. At the end of the observations, I wrote down my reflections based on what I observed and questions to help me record, store, organize, and access the wealth of data I generated. I observed each mentor teacher once a week, and the duration of each observation was approximately 40 minutes. The detailed schedule of data collection is described in the following table.

Table 2

Time Schedule of Data Collection

Time of year	Data source	Duration
Fall 2009 (methods class)	Observation	<ul style="list-style-type: none"> • Once per week • 3 hours per week • Total 15 weeks
	1st interview with student teacher	<ul style="list-style-type: none"> • At the end of semester • Approximately 30 minutes
Spring 2010/Fall 2010 (field experience)	Observation of field experience	<ul style="list-style-type: none"> • Once per week • Ave. 40 min/week • Total 11 weeks
	2nd interview per student teaching including self survey	<ul style="list-style-type: none"> • Approx. 40 minutes • Middle of semester
	1st interview per mentor	<ul style="list-style-type: none"> • At the end of semester • Approx. 30 min

Role of the Researcher

While collecting information as an observer, it is necessary to think about what stance I took. Merriam (1998) restated Gold's (1985) classic typology of four possible stances, which are: 1) a complete participant; 2) participant as observer; 3) observer as participant; and 4) complete observer. My research role during the study was a participant observer. Basically, I observed the classroom and took notes on the interactions between mentor teachers and the student teachers. Merriam (1998) restated Gans (1982) assumption that there is always the temptation to become involved. Also, subjectivity and interactions are assumed in qualitative terms where the researcher is the primary instrument of

data collection (Merriam, 1998; Marshall, 1989). Merriam emphasized the point that research can identify the effects of these pitfalls and account for them in interpreting the data. For my study, problems due to researcher intervention was certainly possible and could have impacted the causal relationships among key persons and variables with respect to the construction of teachers' identities. I attempted to decrease this impact by interacting minimally during class sessions, only interjecting when there was need for clarification from a participant. In order to deal with this threat, I made consistent and multiple classroom observations to record data on a regular basis.

Period 1: Student Teaching Experiences (Spring, 2010)

Observations

As Feiman-Nemser (2001) stated, “new teachers have two jobs—they have to teach and they have to learn to teach” (p.1026). She also addressed that prospective teachers must think about the reciprocal relationship between teaching and learning. With this in mind, the student teachers' roles and their growing identities are as learners and teachers. Thus, they are likely to hold multiple identities as learners and teachers at the same time. Wenger (1998) stated that identity is shaped by belonging to a community but that an individual plays a unique role *in* that community, and thus, one's identity is also distinct from that of others. From this perspective, student teachers develop their identities by negotiating their agendas (and that of others) in the course of doing

their jobs and interacting with others. Thus, the foci of classroom observations were: 1) the relationships between student teachers and their mentors; 2) the mentor's mathematics teaching practice; and 3) how mentor teachers engaged with students in the classroom. The followings examples represent the foci of each observation.

Observation focus

- 1) The relationship between cooperating teachers and student teachers:
 - What specific feedback or comments does the mentor provide to student teacher's mathematics instruction (how or in what direction does the mentor guide the student teacher)?
 - What is the degree of participation of the student teacher (e.g., full participation or peripheral participation)? For example, who leads the class activity? Who delivers the whole class instruction? Who checks homework? Who takes the teacher's role and at what time(s)? What do student teachers do in terms of what the mentor teachers do during math instruction?
 - Who holds the authority for teaching (whose ideas are more likely to be accepted)?

This helps me to understand where student teachers' teaching ideas come from—from their own teacher education program, from mentors, or school curriculum.

- How often do student teachers teach mathematics? Does the mentor teacher let them teach mathematics from the beginning as a full time teacher or let them teach as assistant? How is participation structured?
 - What do student teachers get to do when they actually teach? Are they encouraged to try new things? If so, how does this negotiation play out?
- 2) The mentor teacher's mathematical teaching practice:
- What content do they cover? What are the major teaching materials? How does the teacher utilize mathematics curriculum? Is there any difference in teaching practice depending on the topics?
 - What kind of question does the mentor ask to the class? (e.g., yes or no, answer-oriented vs. concept-oriented, why and how questions?)
 - How often do student use tools such as manipulatives, drawings, hands-on activity etc?
- 3) The cooperating teacher's relationships with students
- How often do students share their ideas, present multiple strategies, work as a group, work on the designed problems? How do teachers solve problems? (procedure, rule-based vs. concept, multiple strategy)

The observations of the mentors' mathematics teaching practices helped me to understand the mentor teachers' teaching philosophies. Through the interviews, I understood how student teachers interpreted their teaching practices as compared to their prior experiences, including those in their teacher education program. For instance, utilizing manipulatives and hands-on activities were

emphasized during the teacher education course, so I wanted to know how student teachers interpreted this when they observed mentors' teaching mathematics with or without hands-on activities. My focus on mentors' engagement with students in the class was important because teachers' beliefs about what or how children need to learn may lead teachers to spend considerable time on certain topic or methods (Barr, 1988).

Interview

I conducted interviews with the student teachers to ask them about their prior school experiences, their methods courses, their expectations about their field experiences, and their identity as a part of a teaching community. The interview was semistructured, which means it had some overarching main questions. The follow-up questions were developed based on the interviewee's original responses. The interview for student teachers was conducted at two different time periods—at the end of methods class and at the end of student teaching. Additionally, I regularly had informal conversations to ask questions about what I saw during the observations. When possible, these conversations were conducted during lunch or specials. The remaining questions were asked during the formal interview. When I interviewed student teachers at the end of the methods class, I wanted to discover the student teachers' general perspectives toward the mathematics methods class and to know their expectations about their upcoming student teaching experiences. At the second interview after student teaching, I asked them about their experiences student teaching. I interviewed the

mentor only one time at the end of field experience, and this framed my conversation with mentors to understand their expectations and experiences with student teachers. Similar to the student teacher interview, I was able to approach to the mentor during specials or break time to ask questions about what I've observed in class. As such, I could use the mentor interview to confirm or disconfirm my take on the student teachers' responses.

The interview questions were divided into five themes: 1) participants' prior school experiences; 2) relationships between the student teacher and mentor; 3) identity as a mathematics teacher; 4) perspectives on mathematics teaching practices; and 5) their relationships with students. A considerable amount of research indicates that it is important to focus on prospective teachers' personal experiences when they are in the process of framing their own teaching practices (Ensor, 2001; Kagan, 1992; Feiman-Nemser, 1983; Feiman-Nemser & Buchmann, 1989; Raymond, 1997). In addition, Drake (2006) argued that utilizing teacher's mathematics life stories provides a more contextualized and integrated view of teachers' beliefs and knowledge than paper-and-pencil beliefs measures. He adopted story-telling methods to understand teacher's belief within the context. Other themes were based on the literature addressing social contexts that contribute to the shaping of identity. I wanted the responses to these questions to illuminate teachers' beliefs regarding multiple domains and relationships. Appendix 1 shows the interview questions for the student teaching period.

In summary, I interviewed two different types of participants; student teachers and their mentor teachers. Each interview focused on a small set of themes, some of which were similar across student teachers and mentors. The following tables, Tables 3 and 4, summarize the main theme of each interview. Participants' prior experiences were covered in the first interview, and the rest of them were explored in their second interview. If I did not finish all the interview questions due to time constraints, I asked for more time to finish all the questions.

Table 3

Summary of Theme of Data Collections for Student Teachers

Theme	How does this relate to identity construction?
<p><u>Prior experience</u> -mathematical background -teacher education program</p>	<ul style="list-style-type: none"> • Story telling is a part of identity (Drake, 2006) • Personal history is important to identity construction (Wenger,1998) • How this program influences participant’s prior belief of teaching mathematics
<p><u>Current social context</u> - relationship with mentor and mentor’s teaching practice</p>	<ul style="list-style-type: none"> • How identity is practiced by the master teacher (Wenger, 1985) • How they interpret/evaluate the master’s teaching practice? How is this model of teaching close to their image of the mathematics teacher they want to be? (Brown et al, 1999) • What degree of autonomy and participation is evident? (Wenger, 1985) • What did they learn during these experiences?
<p><u>Relationship with student</u></p>	<ul style="list-style-type: none"> • What they believe influences their mathematics teaching practice (Thompson 1992) • What they observe about student’s learning mathematics in a real classroom may influence their teaching philosophy (Ebby, 2000)

Table 4

Summary of Theme of Data Collection for Mentor Teachers

Theme	How this relates to identity construction
<p><u>Prior experience</u> -mathematical background -teaching background</p>	<ul style="list-style-type: none"> • Story telling is a part of identity (Drake, 2006) • Personal history is important for identity construction (Wenger,1998) • The extent to which the mentor is strong/positive toward mathematics might influence student teacher’s teaching practice and learning opportunity.
<p><u>Current social context</u> - relationship with student teacher and student teacher’s teaching practice</p>	<ul style="list-style-type: none"> • How the master may influence the apprentice/novice teacher (Wenger, 1998) • degree of autonomy and participation of student teachers is important (Wenger, 1985) • Identify who they are as a math teacher and identify how other people view them as a mathematics teacher is a part of identity (Holland, 1998) • How mentor’s teaching practice influences student teacher’s learning
<p><u>relationship with student</u></p>	<ul style="list-style-type: none"> • What they believe influences their mathematics teaching practice (Thompson 1992) • What they observe about student’s learning mathematics in a real classroom may influence their teaching philosophy (Ebby, 2000) • What they do with students may influence student teacher’s learning

CHAPTER 4

ANALYSIS

For the analysis of data, I adopted pattern coding from Miles and Huberman (1994).

As an early step in the analysis, I carefully read through all the observation field notes and interview transcripts within the cases five times, in search of emerging themes or patterns that appeared repeatedly across the data. While repeating this process, I looked for evidence of identity development through participants' responses to my interview questions regarding identity and beliefs and through my field notes where I recorded social behaviors within the context within which they were situated. As a part of my evidence, I looked for the frequency and consistency of emerging themes in the data to determine, in part, the impact of their experiences on their identity development.

Data Grouping

When reading the data, I first categorized events in the lives of the student teachers in chronological order: 1) their comments about their experiences in K–12 schools; 2) their mathematics methods class; and 3) their field experiences. I then looked for themes that pertained to identity. This process allowed me to be able to characterize the student teacher's prior identity before coming to the teacher education program. It allowed me to directly analyze how this identity was reinforced or suppressed as student teachers participated in the teacher

education program. This process helped me to identify the particular events or experiences that contributed to such construction.

Data Coding

I then coded emergent leitmotifs or patterns that I discerned through the interview transcripts and field notes of the classroom observations. I summarized each segment of data and categorized the common themes then related these themes to identity construction. Regarding the identity statement, I considered three characteristics. First, drawing from Drake (2006), who feels that one's personal story is part of one's identity (Drake 2006), I looked for the teacher candidates' descriptions of their personal experiences with mathematics or mathematics teachers as evidence of their incoming identities while analyzing the teacher candidates' K–12 school experiences. Secondly, I searched the statement from the interview about preferences and beliefs because these influence behavioral decisions about how identity is enacted. At the same time, I looked for reasons why they believe that way. For example, as a part of her identity, one student teacher believed that hands-on is the best way to teach mathematics because she had a good experience with this in a geometry class in high school. She also enjoyed learning mathematics with hands-on activities during her mathematics methods class. Lastly, statements used for evidence of identity were descriptions of being a teacher. For instance, "I want to be a teacher who teaches math. My goal as a teacher is.... I want to teach like Ms. P. When I have the opportunity to teach, this is what I want to do. As a teacher, I liked that, and I didn't like that" and so on. With respect to the behavior of identity, I looked at

their discourse and actions, such as the questions they asked, the problems they posed, what materials they used to teach mathematics, and so on. I also looked for consistency and inconsistency between what they said and what they did in the classroom.

Next, I analyzed the time line of the data, the type of data, its relevance to identity construction, and the frequency and consistency of the appearance of data. The data and the initial themes were carefully examined to determine counter examples that were not appearing consistently throughout the whole body of the data. For example, one student teacher mentioned two contrasting ideas with respect to being successful in doing mathematics and not successful at the same time. I then compared the level of consistency and frequency that successful outcomes were mentioned during the interview. The successful experiences for this student teacher were dominant and occurred throughout observations as well. An unsuccessful experience occurred only once. I looked carefully at what the student teacher did with this unsuccessful experience and how this experience related to their identity construction. If the counter example seemed temporary and irrelevant to identity construction, I marked it as a counter example, noted the reason, and dropped it. However, there is always the possibility that what participants said did not appear in their teaching practices. To make a stronger claim, I searched for counter examples that would disprove the emerging theme and checked whether the supporting evidence outweighed the evidence against it.

As an example, the student teacher whose experiences are represented in Tables 3 and 4 repeatedly expressed her mathematics identity in negative ways

and attributed most of them to her K–12 school years. Yet, among the negative experiences, there was one positive event that stood out. Her high school geometry teacher taught mathematics, in her belief, in a fun way; and this experience is described in the results section on page 70. In addition to this event, the mathematics methods instructor provided what this particular teacher candidate felt were innovative experiences that influenced her goals as a future mathematics teacher. Her lack of confidence in teaching mathematics was frequently observed during student teaching and she was trying to actionalize her desired identity by attempting to teach mathematics utilizing hands-on materials. These patterns were accounted for by her earlier experiences in K–12 schools and her beliefs about what it means to become a mathematics teacher. This provided the evidence that this student teacher’s K–12 school experiences heavily influenced her then current identity, but that there were important ways in which her teacher education program and practicum experiences changed her core beliefs. This process was done repeatedly for the other two student teachers. I started analyzing data from all five students, but two of the cases had overlapping themes with others in this study. Consequently, I focused on three student teachers that represent all of the themes.

Table 5, shown below, provides an example of how I analyzed the data for one case.

Table 5

Analysis Codes and Description of Data for One Case Teacher

Emergent leitmotiv	Description	Source of data
Negative experience (no fun, lack of confidence, no enjoyment)	Lack of confidence in learning mathematics Did not enjoy mathematics—attributed to K–12 experiences <ul style="list-style-type: none"> • Not successful in doing mathematics—attributed to K–12 experiences • Lack of content knowledge (e.g. fraction)—attributed to K–12 experiences 	K–12/Interview K–12/Interview K–12/Interview
Positive experience (hands on, manipulatives, fun math)	<ul style="list-style-type: none"> • High school geometry teacher = best math teacher —attributed to K–12 experiences • Math method class = role model attributed to methods instructor • Desire to be a math teacher who teaches math with hands-on, in a fun way—attributed K–12 experience • Children learn math the best with hands on—attributed methods 	K–12/Interview Methods/Interview goal/Interview belief/Interview
Practiced identity / social context /	<ul style="list-style-type: none"> • Partial understanding of method class—attributed to student teaching • Hesitate to teach mathematics—attributed to student teaching • Lack of confidence in teaching math—attributed to student teaching • Delivering incorrect fraction lesson—attributed to student teaching 	S.T/Observation S.T/Observation S.T/Observation S.T/Observation S.T/Observation S.T/Observation

-
- Attempt to teach math with hands on (probability lesson)—attributed to student teaching
 - Lack of receiving feedback from mentor—attributed to student teaching
 - Goal of community of practice—attributed to student teaching
-

Data Analysis Across Cases

Miles and Huberman (1994) articulated the important function of pattern coding. “For multiple case studies, it lays the groundwork for cross-case analysis by surfacing common themes and directional process” (p.69). Drawing on this idea, I then extended the analysis to generalize the patterns codes. For instance, regarding prior experiences in mathematics, I found the lack of confidence doing mathematics to be common across cases. Accordingly, I created one thread of cross-case comparison. I made great effort to avoid generalizing themes too quickly or in a biased manner; yet, there are some important threats I need to attend to.

Internal Validity

In my study, I looked at factors that contribute to identity development as well as at potential threats to internal validity. For instance, if I theorized that preservice teachers’ identities changed traditional reform-based and I wanted to infer one cause as the interaction with their mentor teachers who taught their own classes in accordance with reform-based methods, how could I infer that the

change actually originated from the mentor teacher's teaching examples? To tackle this very important methodological issue, I collected multiple sources of data, such as observations and interviews at different time points. I interviewed the preservice teachers and mentors at different time periods. I also followed them from their methods classes to their field experiences to see if their actual teaching practice was consistent with what they reported in the interviews. These methods of triangulation helped me to deal with internal validity issues because it allowed me to cross-check what participants reported they thought about identity as mathematics teachers and how they interpreted those thoughts as they engaged in different experiences.

External Validity

External validity indicates that the researcher claims that the findings of the study are true somewhere else. My study necessarily, then, faced external validity threats. However, the purpose of a case study is not to generalize the phenomenon but to understand it in more complexity than a larger study could capture. The details of my study and explanations of interaction among variables provides new constructs, concepts, and understandings for research going forward across studies rather than providing generalization in a strict sense of the word. Yet, consistencies in the cross-case analysis provide a plausibility argument regarding the potential for generalization of the themes constructed in this study to other cases of mathematics teacher preparation.

Reliability

I have also thought about the reliability of my study. Erickson (1984) argued that reliability in the social sciences is problematic because the social context around a phenomenon changes from moment to moment as a result of social engagement. Further, I had to keep the “Hawthorn effect” in mind, which means subjects’ behaviors improve simply in response to the fact that they’re being studied. I think continuous and frequent observations, coupled with triangulation of data helped build reliability. In addition, a second coder, Dr. Middleton assisted to help avoid biased analysis by discussing coder agreement. So, reliability in this qualitative study concerns the replicability of the methods, as opposed to the generalizability of the findings. Another scholar should be able to replicate the methods of my study in any traditional teacher preparation program, and apply the same methods to pattern coding and cross-case comparison. If such a researcher were to find similar results, the strength of my plausibility argument regarding the generality of influences on mathematics teachers’ identity development, would be strengthened.

Construct Validity

Construct validity asks “does the test measure what it is supposed to measure?” When applied to this study, the question would be “how do I determine if my study design is really measuring the development of identity and teaching practice?” This has been challenging for me because identity is not something readily measurable. I had to characterize what I mean by teacher identity and

what behaviors and verbalizations constitute evidence of identity construction. To deal with these issues, I conceptualized identity as participant teachers' ongoing relationships, behaviors, and personal thoughts about their self-images as math teachers. I then designed my methods and analytic structure to capture changes occurring within a longitudinal framework. With respect to teaching practice, I empirically focused on teachers' mathematical engagement with students and school cultures. I physically observed their live action in the classroom and had participants reflecting on their behaviors. This helped me to conceptualize teaching practice and reduce this threat.

CHAPTER 5

RESULTS

Below, I present findings of the cases of Jackie, Meg, and Kerry separately and all names used in this study are pseudonym. Each case is organized in the chronological order from their experiences before beginning the teacher education program through their time as student teachers. Each story shows how they developed their identity as a mathematics teacher over time and how it related to their experiences across multiple settings, including their own mathematics experiences, beliefs and knowledge, their mathematics methods class, their mentors, and their teaching practices. This structure gives a detailed picture of development of identity and specific events or experiences that emerged across settings. Based on the story of three student teachers, I discuss their incoming identities and how they developed over time as well as the critical experiences that contributed to their formation. Then, I describe the salient features of their identity development. Following these individual cases, I present the general case of identity development based on the experiences the three teachers shared in common. Lastly, I discuss how findings from this study add to the current field of teacher education and the implication and the directions of future study.

Jackie's Story

When I met her in the mathematics methods class, Jackie was a senior in her early twenties and white American lady. During the methods class, she was a

little shy and quiet. She seemed to enjoy mathematics methods class, but it was rarely observed that she volunteered to publically share her mathematical ideas. When asked to work as a group, she was a listener rather than a talker or a leader of the discussions. Her passive and shy attitude in the class gave me the impression that she might not be confident in mathematics. As math anxiety, lack of confidence, and least favorite of mathematics is often observed with teacher candidates, I selected her as a typical student teacher who was not confident in the beginning of her teacher preparation program.

Earlier Experiences

When asked about her earlier K–12 experiences with mathematics, Jackie remembered that mathematics had not been her favorite subject. She expressed her negative views of mathematics several times during the interview. Jackie said that she never really liked mathematics during her school life. She seemed to relate such negative experiences to her own mathematical ability. When mathematics became harder for her to understand, Jackie noted that she began to view mathematics as an irrelevant subject and tried to avoid math all together.

For instance, Jackie said:

For the most part, mathematics is kind of average subject for me, I was okay with it when I was growing up, but when I got older I started to struggle as mathematics got harder. When we got to fractions and decimals, those were the hardest for me to understand. I couldn't understand it. I thought, 'whatever,' I am not ever going to use this, who really cares, and I was just escaping by it. (ST 1st Interview–May 14, 2010)

This statement suggested that Jackie didn't have strong mathematical knowledge, and she was not confident with the subject. Her lack of confidence in mathematics seems to have influenced her self-confidence in teaching mathematics later in life.

Instead of putting more effort into overcoming her struggles, Jackie chose to escape from the situation. She recounted a poignant experience when she was in college. On the first day, a college math professor told the whole class that they had to take the same class three or four times to pass it. Jackie immediately dropped the class, and it was the only college course she ever dropped. When mathematics became difficult to her, avoiding the situation seems to have been her way to cope with it. This experience highlights Jackie's limited conceptual understanding of mathematics and her lack of confidence in doing mathematics.

Another experience that stood out during her K–12 school years was the way in which she learned mathematics. When asked to reflect on K–12 school experiences with mathematics, Jackie recalled that her mathematics classes were traditional and that it was no fun. She said:

When I was growing up I very rarely used manipulatives in class. It was very much like, 'here is the examples on the overhead and here is the worksheets' I think a lot of teachers teach that way. It wasn't necessarily bad, but it just wasn't as fun (ST 1st interview–May 14, 2010).

Her idea of a traditional mathematics classroom consisted of a teacher at the board, students working at work sheets, going home with homework, and very rarely using manipulatives. This gave her the impression that learning mathematics is not fun. In other words, it seems that she did not enjoy learning

mathematics with the traditional method of teaching. Thus, Jackie described her overall experience with learning mathematics as difficult, irrelevant, a lot of repeated work, and no fun. Drake (2006) argued that identities are evidenced in practice and in stories; and these experiences revealed that Jackie's earlier identity in relation to learning mathematics was quite negative. This negative experience was a prelude to less active engagement with teaching mathematics later in life for Jackie.

In contrast to the majority of her impressions of learning mathematics, Jackie recalled a positive experience she had with one specific teacher. Jackie said that she never liked mathematics during her K–12 school years, but geometry was an exception because she loved the geometry teacher very much. Jackie described the geometry teacher as a great person who made the class a lot of fun because the teacher often used hands-on materials, and there were a lot of visual representations. As a result, Jackie was able to enjoy the math class. This experience contrasts with her earlier impression of learning mathematics. As noted above, she mentioned that her traditional experience learning mathematics was no “fun,” but she enjoyed geometry class because the class was a lot of fun and very delightful. It is noticeable that the ability to have fun seems to be an important component of her ideal image of mathematics instruction. Throughout the interview, Jackie frequently conveyed this perspective by citing types of mathematics classes and mathematics teachers she liked. She recalled a specific teacher that she admired:

I remember this teacher at the college. He was super enthusiastic. He was excited and loved math, and it made you realize that it can be fun. I really liked the teachers that not just explained it on the board, but tried to have you do something with it, use manipulatives to get you to understand it. That would make you an ideal teacher (ST 1st interview–May 14, 2010).

This statement reflects Jackie's favorite mathematics teacher, and she explained why she liked this teacher. With respect to the notion of fun math, Moyer (2001) studied the relationships between fun math and the use of manipulatives in the mathematics classroom. Teachers in this study described "fun" math as the part of the lesson where students found enjoyment with manipulatives as math "games," "enrichment," "an extra-time activity," and "a reward for behavior" (p.185). They also noted that students saw mathematics as fun an "activity-based sense" (p.186). Similar to what Moyer found, Jackie's perception of fun math seems to have meant using manipulatives, hands-on activities, and playing games because in many cases, she mentioned such words at the same time as the word fun. Yet, students' engagement with mathematics, problem solving, or conceptual understanding of mathematics content was not framed as fun. More importantly, in this view, teaching mathematics in a fun and enjoyable way and utilizing manipulatives seems more important for Jackie than an understanding of mathematics. In sum, fun math to Jackie appears to mean the use of manipulatives rather than the understanding of the concepts that such exercises represent. Her ideal image of fun math seemed to start with her favorite teachers from past experiences. Jackie entered the teacher education program with this experience, and her perception toward learning and teaching mathematics was

restructured because the methods class provided Jackie with innovative teaching practices and perspectives of what it means to teach mathematics.

Mathematics Method Course

Jackie's experience in her mathematics methods class is characterized by two factors, her persistent desire to teach mathematics in a fun way and her limited understanding of reform-based teaching. When Jackie was a senior at the university, she took a mathematics methods course, which was required to become an elementary school teacher. At the same time, Jackie had to complete 72 hours of internship; she was placed in a 5th grade classroom for an entire semester. During the methods course, most of the time preservice teachers were engaged with manipulatives, group work, conceptual understanding of content, and problem solving. Students in the class were always asked to justify their mathematical thinking to their classmates. Jackie recalled that the methods taught in the class were very different than the way she was taught as a child. In the methods class, they were instructed to use various kinds of manipulatives. The following is what she explained regarding her experience of this class:

I would say it is very different than when I was growing up. I would say the biggest thing I applied from the methods course was the fact that Ms. P [methods course instructor] stressed using manipulatives so much. Every day we did hands-on mathematics, the thing that I didn't even think we can do or use manipulatives, we were using it. The class was three hours long but I felt like it went by very quickly and that is how I knew it was a very good class. If I was bored, I felt like it was eight hours long (ST 1st interview–May 14, 2010).

In the above-mentioned methods class, Jackie articulated that the emphasis on manipulatives was the most valuable experience she had learning about how to

teach mathematics. She also noted that this course was good because she never felt boredom during this class. Apparently, Jackie's ideas about what would be the best model for teaching mathematics entails the use of hands-on activities and manipulatives and an enjoyable time in class.

While taking this methods course, Jackie also took 72 hours of teaching internship in a 5th grade classroom. During this time Jackie had the opportunity to experience how mathematics is taught in real classroom settings. Jackie felt her internship teacher was also a positive role model as a mathematics teacher. When asked how her placement teacher's teaching practice influenced Jackie, she replied:

I really liked the way she did it. She usually did, she usually had some kind of manipulatives. She tried always to play some kind of game when it came to math and just then she had them to do group work and individual work to solidify the information. I would say, I would adopt most of her teaching style. It seemed very practical to me. As much as I would like to have manipulatives in everything for every single lesson, she utilizes manipulatives when she could and where she could, but if she didn't have that, she would find another way to make it fun. She really tries to make math fun for her students (ST 1st interview–May 14, 2010).

This statement provides further evidence that Jackie valued her internship teacher's teaching methodology, especially because of the way she used manipulatives and games to make learning mathematics fun. On several occasions during the interview, she clearly indicated the importance of teaching mathematics in a fun way. Here, Jackie clearly emphasizes the broader goal of teaching mathematics as enjoyable, articulating that she found it to be a particularly attractive feature throughout the method course. One possible

explanation is that because she considered fun an important component of mathematics, she looked for such an experience from the methods course and from her intern teacher.

In addition to her focus on enjoyment—fun— Jackie expressed her view that teaching mathematics has much to do with remembering facts. During the observed semester, she taught three mathematics lessons and recalled that “it was terrifying experience.” She figured that the reason why she was not able to remember how to teach it was because she graduated elementary school a long time ago. She continued by saying that when she saw what students were doing, she remembered the content and how she learned it when she was in elementary school, but she did not know how to teach it. For example, Jackie said:

in order to teach mathematics, I have to remember everything, I need to go back and study because I have graduated a long time ago. I have to go back and remember how to do those simple steps. That is what I most worried about teaching mathematics (ST 1st interview–May 14, 2010).

From this statement, I assumed that Jackie thought teaching mathematics is more like memorization or remembering facts or steps. It seems that Jackie views her mathematics methods course rather superficially by looking at fun methods, overlooking the conceptual understanding of learning mathematics embedded in those games. One possible reason why she seemed to look for such fun learning mathematics is due to her own lack of enjoyment when she learned mathematics as a student.

Bringing together how Jackie talked about her experience with learning and teaching mathematics, it is clear that teaching mathematics with hands-on

tasks and manipulatives as tools is an integral idea of Jackie's teaching practice. Before taking the mathematics methods course at the university, she viewed mathematics as boring, not practical, and hard to understand. While taking the methods class, Jackie experienced new knowledge and ways to practice teaching mathematics, and she started to realize mathematics can be taught in a fun way. She has now reconstructed her identity based on new knowledge of how to teach mathematics from Ms. P's teaching practice. She has also had the opportunity to observe how mathematics is taught in a fun way from her internship teacher. These experiences challenged her earlier view of mathematics as boring, and it facilitated her goal to become a mathematics teacher who teaches mathematics with fun.

In sum, by taking the mathematics method course and the internship, Jackie's negative perspective toward learning mathematics shifted to become more positive. Based on this experience, she started realizing mathematics could be fun, and she wanted to learn how to become a mathematics teacher who teaches mathematics in a fun way.

Goal and Aspiration of Mathematics Teacher

What is noteworthy from the analysis of Jackie's K-12 school experience is that her earlier experiences with math contributed to the perception of her ideal mathematics teacher. When asked about a role model of a mathematics teacher, Jackie pointed out Ms. P, the methods instructor, and expressed her desire to be a mathematics teacher like Ms. P. Jackie liked two things the most from Ms. P.

First Ms. P really made the class interesting by utilizing all the resources possible across different mathematics contents. Secondly, she enjoyed being highly engaged during Ms. P's class. Jackie reflected that students' high engagement and the fun math lesson based on the use of manipulatives were the highlighted mathematical goal in Ms. P's class. In particular, Jackie clearly conveyed the importance of teaching mathematics with hands-on material. In her interview, when asked "how do you believe children learn mathematics best?" She explained:

I believe children learn the best with hands on, anytime they can do hands on, that is one of the best ways. Whole-group participation on the white board or telling me the answers to the problem, or working this out, those are also great assessment but when students can participate as a class and also get their hands involved, kids will do better on by themselves, and work on their space. I think it is really beneficial when they can do hands-on but I think most of them, hands-on are the best, I think (ST 2nd interview–December 16, 2010).

This statement is evidence of how strongly Jackie wanted to teach mathematics with hands-on methods. Reflecting on her initial teaching experience with her placement teacher, she realized that there were two areas that she needed to develop to reach her goal, time management and content knowledge. She reflected from experience that it takes longer to plan the lesson and teach the math in a fun way, so she needed to find the realistic time frame to teach mathematics within a given time structure. Thus, she said she expected to learn from her mentor in the following semester how to make lessons fun and make them interesting during her field experiences but within a realistic time frame.

Additionally, she expressed her concern about building an understanding of the content she teaches. Jackie saw herself as a mathematics teacher who

needs to learn and needs to build more content knowledge. In the beginning of the interview, I was not quite sure if the content knowledge she meant was mathematical content knowledge, pedagogical content knowledge, or practical knowledge around the games and manipulatives. Jackie reflected that taking the mathematics method course was not enough to help her build adequate content knowledge alignment with her goal to become a fun mathematics teacher. She mentioned that to meet her goal she wanted to take more outside classes to make sure she gets the most up-to-date ways of teaching methods with different kinds of games and manipulatives.

Jackie's goal of teaching mathematics in a fun way was consistently noticed throughout the semester. An extensive amount of literature states that when student teachers encounter a difficult situation, they are more likely to fall back to the way they were taught mathematics. However, Jackie showed a strong desire to teach mathematics with fun. When Jackie had the chance to teach mathematics during her internship period, she attempted what she wanted to do. But when she found it was difficult to reach her goal, instead of giving up on her desire and falling back to the way she was taught, she sought opportunities to build more practical knowledge that would help her to reach her goal. This is what Wenger (1998) mentioned as the negotiation process. Jackie attempted to practice her identity as a fun mathematics teacher when the opportunity was given even though the opportunity was very limited during the methods class and

internship. Her lack of opportunity to practice is also evident in Jackie's experiences in student teaching.

Field Experience

In the following semester, Jackie started student teaching in a local elementary school. Here she met Mr. Brown, a 5th grade teacher, who was her mentor. During her field experience, Jackie was an apprentice to the mentor and started to practice her identity as a mathematics teacher. In this section, I describe first why field experience is important in one's identity construction. I then illustrate the background of Mr. Brown and his mathematics teaching practice. Next, I illustrate several mathematics instructional episodes that seemed to impact Jackie's identity construction.

Why does this matter?

Wenger (1998) viewed identity as negotiated experience, which means, we are becoming who we are through negotiation in terms of participation and reification. He also mentioned that the community where the participants belong is also critical because the participant is engaged with practice in a certain experience based on what the community pays attention to. It means that, depending on the goal of the community, a student teacher learns particular knowledge and skills that are valued in that community of practice. The master teacher, who holds knowledge and skills in the community of teaching mathematics, helps structure teacher candidates' experiences towards those valued by the community. For instance, if procedural knowledge and

computational skills are valued as best practices in teaching mathematics and the master teacher is an expert in using them to teach mathematics, a novice teacher is more likely to practice that same knowledge and skills as a mathematics teacher in alignment with the master teacher's best teaching practices. Thus, to understand how Jackie practiced her identity as a mathematics teacher, it is important to investigate the goals of teaching mathematics in this community and what knowledge and skills are provided as best practices as represented in Mr. Brown's classroom.

Background of This Community: Mr. Brown's Classroom

Mr. Brown was a veteran 5th grade teacher who had been teaching for 11 years. He was very confident in teaching mathematics and stated that mathematics is his strongest subject area to teach. The general description of the mathematics classroom routine is illustrated below.

The mathematics lesson was normally around 9:15 depending on the specials, and lasted between 60 and 80 minutes. The mathematics lesson usually started with 10 problems, which were written on the board. Most of them were simple computation operations based on the content that students were previously taught. While solving the 10 problems, students worked individually on paper. During this time, Jackie walked around to help students. One of the routines of this class was that during the math lessons, Mr. Brown called students who needed help to work with him in the back of the classroom. Students who finished early were allowed to read books.

After the ten practice problems, Mr. Brown posed one central problem. This was usually a story problem. For this problem, students worked with a partner and recorded their strategies on a white board. When they were ready, the students lifted up what they had on the board and showed their work. They were expected to explain how they solved the problem. Most of time, Mr. Brown asked the class for a different strategy to solve the problem, or he picked a student who demonstrated a different approach to the problem. This pattern of teaching was consistently observed in Mr. Brown's classroom.

Goal and Demonstrated Practice of Teaching Mathematics in Mr. Brown's Classroom.

From the analysis of classroom observations and interviews, three distinct patterns emerged as major foci in Mr. Brown's teaching practice; higher order questioning skills, the emphasis of problem solving, and multiple methods of instruction.

First, Mr. Brown consistently uses questions that get students' thinking about the how and why of learning rather than simply encouraging memorization of isolated facts. Some examples are:

- How many of you did the same ways as John?
- Did anybody solve it differently?
- How did you know?
- What did you do first?"
- Why did you do that?"

- What if you did this instead of that?
- What would you do?"

Wimer et al. (2001) identified these types of questions as higher-order questions that elicit higher-level cognitive responses, such as analysis, verification, and mathematics argument. These questions are distinguished from lower-level questions that rely on simple recall of information. Mr. Brown said in the interview:

When kids come up with answer and I am not really sure why so I am always getting kids to explain their answer so I can figure it out, okay what did they wrong, so that the way I could make sure their understanding in future (Mentor Interview–December 10, 2010).

The given examples of higher order questions are consistently and frequently observed during Mr. Brown's teaching instruction.

The second pattern was the emphasis on the problem solving. The interview with Mr. Brown explains why problem solving is so important to him.

When asked what the goal for teaching mathematics was, he stated:

When I teach, what I really stress with my kids is to solve the problem, how to solve, what are the steps, what is the key information because life is so much about problem solving. I want to give them those kinds of skills. If I am able to get all the students to logically solve problems, and to think logically, and to understand problem solving, I think that is probably my biggest goal (Mentor Interview–December 10, 2010).

He also mentioned that he always tries to find the time and topic that makes students think "when would we ever need to use problem solving in our real world?" To him, problem solving is important because it is connected to the real world. His view of problem solving is similar to the meanings of "problem

solving as context” that Stanic and Kilpatrick (1989) identified. They stated that “problem solving as context means problems are employed as vehicles in the service of other curricular goals” (p.13). He also mentioned that some problems are related to real-world experiences, and such real-life application convinces students and teachers of the value of mathematics. With a similar reason as the cited above literature, Mr. Brown heavily emphasized problem solving.

Lastly, Mr. Brown’s strong belief toward multiple methods of instruction was expressed many times in his interview. His belief was easily discernible during the observations. He believes that students learn mathematics the best with multiple methods and that finding different ways to help students is the fun part of the teaching.

There is no one method that works best for kids. In our classroom, we will have mixture of multiple methods, visual aids, manipulatives and giving them many examples, and different kinds of examples so they can see how it can be solved differently. I wouldn’t say there is one good method and I am a really strong believer that multiple methods, showing them multiple ways teaching them at their ability level, then getting them using math, seeing math in their everyday lives, seeing that math is important.

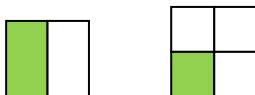
I would say finding those students who just aren’t getting it, finding the method that is going to make sense to them and to me, that is the challenge and that is the fun part about teaching. I am not a believer that there is just one way to solve it if they can solve any way they can and get the right answer that is the most important thing for me (Mentor Interview – December 10, 2010).

Here is one example from my observation field notes. This excerpt provides a clear snapshot of Mr. Brown’s teaching mathematics. It was one of the 10 problems of a day and students were asked to compare the following fractions.

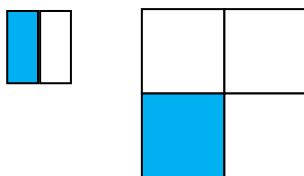
Vignette 1. *Mr. Brown's teaching mathematics*

Compare $\frac{1}{2}$ ○ $\frac{1}{4}$

- 1 **Brown:** what do we have here? Which is bigger?
- 2 **Students:** $\frac{1}{2}$ is bigger
- 3 **Brown:** Thumb up or thumbs down?
(majority of the students showed thumbs up)
How do you know? Who wants to tell me? Student 1, okay, what did you do first?
- 4 **Student 1:** I changed $\frac{1}{2}$ into 4th so it is the same is $\frac{2}{4}$ and $\frac{2}{4}$ is larger than $\frac{1}{4}$
- 5 **Brown:** Good. How do you know $\frac{1}{2}$ is the same as $\frac{2}{4}$?
- 6 **Student 1:** because 1 out of 2 is half and 2 out of 4 is still half so they are the same.
- 7 **Brown:** Great. How many of you did the same way as student 1?
(many students raised hands)
- 8 **Brown:** Did anybody solve it differently?
(one girl raised her hand and show him what she did as illustrated below)



- 9 **Brown:** I love she used pictures but I have one problem with her picture. Can anyone tell me?
- 10 **Student 2:** Yes, I know, it is not equal sized
- 11 **Brown:** That is a good point. Take a look at this. What if I drew this way (shown below), which one is bigger?



- 12 **Students:** $\frac{1}{4}$ looks bigger.
- 13 **Brown:** Yes, using drawing is an excellent idea but, in fraction, especially when you compare fraction you have to very careful that it has to be equal size.

(Observed field notes–September 15, 2010)

In this excerpt, it is shown that Mr. Brown tended to ask students to justify their answers to the class. He tried to elicit students thinking further, and he emphasized critical ideas for understanding the topic.

Drawing on the interview and the vignette, it can be said that problem solving and using multiple methods of teaching in mathematics lessons are the goals in this community of practice. Additionally, higher-order questioning skills appeared to be his expertise in teaching mathematics. Although the ideas of teaching mathematics with fun and with hands-on tasks were obviously important for Jackie's teaching preparation in mathematics, it was not one that was highlighted by the mentor teacher.

Thus, in this community of practice, Jackie was engaged with specific mathematics knowledge and skills pertaining to problem solving, multiple methods, and asking questions that promote students' mathematical understanding as important. However, it is important to attend to the ways in which Jackie participated in this community to practice such knowledge and skills to develop her identity. This will be described in the following section. While engaging with the above characterized practices, Jackie, a novice teacher, had to interpret the master's teaching practice and negotiate what to adopt from her master, what not to adopt, and how to balance teaching from moment to moment. Wenger (1998) stated that this process shapes one's identity and as a novice teacher acquires the knowledge and skills needed as a mathematics teacher through participation in a community. Thus, the structure of the mentor-student teacher

relationship and how the student teacher participates is an important factor that contributes to the construction of a student teacher's identity as a mathematics teacher.

The next two sections cover the form of mentoring and the opportunity to practice. The section that covers the form of mentoring draws from the master teacher's descriptions of his work with the students, which he describes in the interview, and the observations I made in the classroom. The opportunity to practice is also central because student teachers' learning occurs when they increase their participation in their community of practice (Lave and Wenger, 1998). To be a master teacher who is knowledgeable about the required skills, it is necessary to participate in doing and trying out the tasks she or he is attempting to teach.

Form of Mentoring

In the beginning of the semester, Jackie's role was mostly as a student and an observer watching how the master teacher taught. It was Mr. Brown who led the mathematics instruction, and Jackie worked with students who asked for help. When students were engaged with problems, Jackie walked around to help students individually. As the semester went by, Jackie took over some of the simple tasks of the mathematics lessons, such as collecting homework, checking answers, preparing materials, and walking around the classroom to help the students. Jackie mentioned during the interview that there were sometimes co-planning sessions before the class, but it seemed more common that the mentor

teacher took the lead in designing the lesson. Mr. Brown described the typical mentor-student teacher relationship as follows:

At the beginning she was observing and asking questions, and I was giving her feedback. When she started doing her lessons, I provided her a lot of feedback mostly after the lesson. And then as she started teaching full time, she was comfortable enough and I was comfortable enough that if I need to interject something for the benefit of kids or for the benefit of her I was able to interject, and she welcomed that. (Mentor Interview– December 10, 2010)

One notable aspect of this statement is the fact that Mr. Brown's primarily provided his feedback after the class. Schwille (2008) conceptualized the forms of mentoring based on their characteristics, and one of the characteristics was when the mentoring occurs. If a mentor provides feedback when the students are present, Schwille called this type of mentoring "inside action" (p.155). When mentoring occurred in the pre or post phases when students are not present (e.g., during lunch, specials, after or before class), it is called "outside action" (p.155). Schwille (2008) pointed out that inside action is beneficial for student teachers to learn complex skills of teaching in a real context because it provides "reflection-in-action" (p.157) strategy. She continued that the reflection-in-action strategy is particularly helpful when facilitating student discussions that lead to conceptual understanding. This is not only because this strategy offers "opportunity to learn ways to think and act that are attuned to pupils' understandings at the moment" (p.157) and also because it is hard to gain while being away from the actual context. As guiding and managing discussion requires complex intellectual skills

(Schwille, 2008), student teachers need to have prompt feedback and support from the mentor to obtain such skills and knowledge.

Based on the description of the above study, Mr. Brown's mentoring structure of is similar to the outside of action style. Actually, during the classroom observations, Mr. Brown's interjections were sometimes observed, but it was more common that Mr. Brown let Jackie finish her instruction without interruption. It was mentioned earlier that one of the strengths of Mr. Brown's teaching strategy was higher-order questioning skills that elicited conceptual understanding. The observed outside of action mentoring did not seem to allow Jackie to obtain the best knowledge of questioning skills from of her mentor. Jackie's lack of questioning skills was often observed during her teaching. An example is described in the vignettes of her mathematics teaching practice in a later section of the paper.

What stood out next in this relationship is that the focus of feedback that Mr. Brown provided to Jackie. Mr. Brown reflected on the time when he student-taught. He recalled that he learned more about what teaching is really about in a week of student teaching than he probably learned in four years of college. Based on his experience, he considered what he had to do to help Jackie build her teaching skills in general rather than provide the content-specific feedback. He stated "my job is to help her to prepare for that to show all those little things they don't teach you in school about." Based on this experience, Mr. Brown explained his goal of mentoring.

Honestly, my major focus, it is not necessary even the content, content you can get, it is an attitude, it is the relationship of the kids, it is relationship with the other teachers, it is being able to handle the little things that teaching throws at you. We've talked many times about how the school prepared you, they help you with the lessons but they don't teach you how to do the fire drill, they don't teach you how to get your kids to physical education. All those things take up a good chunk of your day so it was really just kind of helping her with those, she was very flexible and she was very good with going with flow of things, which I try to encourage because that is so important to teaching and being a successful teacher (Mentor Interview – December 10, 2010).

In this statement it is seen that Mr. Brown's placed more emphasis on teaching strategy than specific content, such as mathematics. This type of feedback is certainly very helpful for the student teachers, but it seems that Jackie also needed content specific support and feedback from Mr. Brown, especially with teaching mathematics. Jackie's lack of confidence in teaching mathematics was noticed 16 times during the interview and the classroom observations. When I called Jackie to set up an appointment to discuss the observation schedule, she told me that mathematics would be the last subject she would be taking over. So if I wanted to come to observe mathematics teaching, it wasn't going to happen soon because she was not comfortable teaching it. Mr. Brown was also aware that mathematics was not a strong subject for Jackie to teach. During the interview he mentioned that he knew Jackie was a little bit hesitant to teach mathematics, and as he saw it was typical that preservice teachers do not have full content knowledge of mathematics. He said he wanted to wait for her to feel comfortable teaching mathematics.

During the classroom observations, there was a real sense of Jackie's insecurity with mathematics. Jackie's opportunity to teach mathematics did not happen until the last three weeks of the fifteen-week semester. Until that week, Jackie's role in teaching mathematics was more supplementary and secondary to Mr. Brown.

Jackie told me during the interview that she and Mr. Brown got together in the mornings and planned the lessons together. Mr. Brown gave her specific feedback such as what part of the lesson went well, how to change the lesson for the next time, and how to make the lessons beneficial for the students. Jackie's comments indicate that Mr. Brown provided some feedback usually in the morning before the lesson started, but it seems like it didn't occur immediately during the lesson. As stated earlier, this type of mentoring structure didn't seem to allow Jackie to practice questioning skills. She expressed that she was dependent on him and needed extra help especially with mathematics just because it was the hardest subject for her to teach. She said,

I guess for me, I feel like the reason math is tough for me is because I don't have experience yet to know what the kids are going to mess up on, one thing that was really great with Mr. Brown was he is like 'make sure you say this because they will do this wrong'. Because I am not quite experienced yet, haven't been in the classroom long enough to be like Mr. Brown. I feel like I see more students overall who will obviously struggle with mathematics. With reading or writing, it is more of hidden struggle but with mathematics it is like right or wrong so I think math is more obvious to see their struggles (ST 1st Interview–May 14, 2010).

Here, Jackie admits that she finds math difficult to teach. Jackie felt that the reason was first because of her lack of experience teaching and second from her

view toward learning mathematics, which for her stems from a traditional approach in which there is a right or wrong answer. This statement reflects her lack of confidence in teaching mathematics, and it seems to relate her delay in taking responsibility for teaching mathematics during student teaching. Her insecurity with mathematics stems from her K–12 school experiences. Because she was not a successful learner of mathematics, she was hesitant to teach mathematics. Taken together, it led her to feel mathematics is the hardest subject to teach. Jackie’s lack of confidence and mathematics knowledge stood out when it came time to teach mathematics.

Opportunity to Teach

When investigating the participating student teachers’ teaching practices, I emphasize three areas. I first compare student teacher’s teaching practices to their mentors. Secondly, I look at how they teach mathematics in relation to their goals. Third, I look at their mathematical identity.

Jackie vs. Mr. Brown

Comparing the teaching practice between Jackie and Mr. Brown, there were similarities and dissimilarities at the same time. What stood out the most as similar practice was the way that Jackie structured her lessons. For instance, they both started the lesson with 10 problems, used white board and markers, adopted the format of *I do* (showing how to do), *we do* (practice together), *you do* (solve their own), had them talk to neighbors, and asked for different strategies. This pattern of teaching practice was the routine of Mr. Brown’s math instruction,

which was already established when Jackie arrived. As a novice teacher, Jackie started developing her teaching practice by adopting the structure of her mentor's lesson. However, the discourse patterns between Mr. Brown and Jackie during the mathematics lessons were very different. When Mr. Brown led this type of lesson, I frequently observed that he posed many questions about mathematical ideas, processes, and multiple strategies. He also engaged students with mathematical inquiry. On the contrary, Jackie more frequently taught her mathematics lessons focusing on memorizing mathematical facts and procedures, applying rules, and defining correct or incorrect answers. Jackie simply checked the answers with the class and asked them to show a thumbs-up or a thumbs-down to see how many of them got the correct answer. If the majority of the class showed a thumbs-up, she moved to the next problem without asking students to justify their answers.

With respect to Jackie's teaching practice, three aspects emerged. These were her lack of conceptual understanding, lack of questioning skills, and her attempt to make the lesson fun. The first vignette is the example that shows her lack of conceptual understanding and different discourse pattern in questioning skills. The second vignette shows how she attempted to teach mathematics in a hands-on, fun way.

Vignette 2. One day, Jackie had a chance to lead the math lesson. She started with the 10 problems of a day. These were simple arithmetic problems,

such as; 1) $4 \times (7 \times 6) = (4 \times n) \times 6$, find n , 2) $11582 \div 36$, 3) $1 = \frac{(\quad)}{3}$, 4) $6 \times 5 = 2$ and so on.

One of the 10 problems was about the fractions, $1 = \frac{(\quad)}{3}$. The majority of the class provided an incorrect answer. Jackie wanted to show how to solve this problem because many of the students were confused. In order to represent this fraction visually, first she drew one circle and divided it into six sections and shaded the half, see figure 1 below.

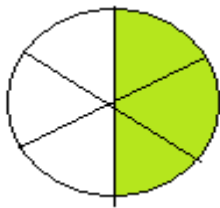


Figure 1. Jackie's representation of $1 = \frac{1}{3}$ on September 22, 2010

She asked the class how many more she needed to color and some students answered three. Then she asked the class to show thumbs up if they think 3 is the correct answer, and less than half of the class gave a thumbs up. Without asking any further questions or explanation, she proceeded to the next problem.

Based on my observation of Jackie teaching the lesson described above, it is apparent that she knew that the answer was three. She wanted to represent the fraction visually to show the class $\frac{3}{3}$ makes one whole because that is what Mr. Brown often used for the fraction instruction. During the student teaching period, Jackie observed many times how to represent fractions with pictures. Mr. Brown used visual representations often, so Jackie wanted to draw the diagram to

represent fractions. However, she did not represent the fraction correctly or make the conceptual connection between the diagram and the fraction.

It seemed that she was not sure how to represent $\frac{3}{3}$ with pictures. Thus, she struggled with the conceptual explanation of what a *whole* means in a fraction and the relationships between the concept and the picture representation. This lesson provided an example of Jackie's limited knowledge. Rather than making an explicit connection between the answer of the problem and the picture representation, Jackie jumped quickly to the next problem. It seems that she did not recognize that her illustration was not a correct representation for the problem. Nor did she attempt to provide a conceptual explanation or ask for help from her mentor.

In addition, it appears that Jackie's approach to leading the 10 problems of the day contrasted sharply with Mr. Brown's teaching style. Problem solving in relation to a real world application, providing multiple methods of instruction, and asking questions to promote students' justification of answers—the focus of Mr. Brown's teaching practice—were not observed in Jackie's teaching. This matches what Ensor (1995) reported in her study. Ensor mentioned that learning best practices in a teacher preparation program and implementing them in the classroom is a different story. Jackie learned from the methods course and from her mentor how to use visual representation of fractions, but she was not able to teach it to her students. She confessed that fractions were one of her weaknesses

when she learned mathematics, so she wanted to try a different teaching method with visual representation; however, it didn't turn out the way she planned.

Secondly, I describe Jackie's teaching practice in relation to her identity and goal as a mathematics teacher. It has been frequently expressed that Jackie wants to teach mathematics through fun games or activities and that students' engagement is very important to her. She also wants to build her teaching practice differently from her own early learning experiences as a child. She expressed her intention to not use her past experiences when she taught as a student teacher. During her student teaching experience, Jackie told me that the most challenging thing in teaching mathematics was "not letting how I learned affect how I am going to teach it." She added, "If I only taught how I learned, I think a lot of kids would not understand it." Here she confirmed her belief that she wanted to teach mathematics based on the newly provided methods rather than the way she was taught. She has her own reason to explore different teaching methods, and she tries to learn more about new methods. Jackie sees herself as a math teacher who is still learning. She really tries to give pictures and examples to the students. The following vignette is an example of her teaching practice and how it is aligned to her aspiration and her identity as a mathematics teacher.

Vignette3. This time, she was leading the beginning part of the mathematics class, and it was a probability lesson. To increase students' engagement, Jackie brought two bags of M & Ms, so students were very excited

about this activity. One of the bags was for the experiment, and the other bag was for treats after the experiment. Jackie gave the following instructions.

- 1 **Jackie** : Let's do some activities. (showing the brown paper bag)
 Inside this bag, there are M & Ms.
- 2 **Students**: Hooray!
- 3 **Jackie** : In this bag, there are 3 browns, 2 yellows, 2 oranges, and
 1 red M & M.
 What I want you to do is as a group, predict which M & M
 will be pulled out the most often. After pulling out M & Ms,
 record your answers of how many times you pulled out red,
 yellow, or red on the white board.
 Like this, (drawing tallies on the board)
 B /// Y // R ////.
 Are you ready? Go!

Students started pulling out M & Ms from the bag and recording the outcomes.

During this activity, as usual, Mr. Brown called a couple of students to the back of the room to help them. Because Jackie's instructions were unclear, some of the groups put the M&Ms back into the bag after pulling them out and other groups didn't. Mr. Brown noticed this and interrupted.

- 4 **Mr. Brown** : Class, do we need to put it back after you pull it out? Yes
 or no? Raise your hand
 (It was about half and half)
 You have to put it back after you pull it out because the
 order does not matter. Are we going to look inside to pick
 the color?
- 5 **Students** : No
- 6 **Mr. Brown** : You have to do this at least 50 times.
- 7 **Students** : What?
- 8 **Mr. Brown**: I know it is a lot. Why is that? Why isn't it 15 times or 5
 times, why is it 50 times?
 (no one answered)
 If we pulled out 5 times and pull out all red, does this mean
 that all M&Ms in the bag are Red?
- 9 **Students** : No.
- 10 **Mr. Brown**: The more you pull, the more information the data brings

The activity continued and Mr. Brown noticed that one of the groups was pulling out three M&Ms at a time and he explained to the class why they were supposed to pull out only one at a time. After a little while, Jackie pulled the class together and started recording outcome group by group. She counted all the tally marks of the first group, and the result was that orange had been pulled the most.

- 11 **Jackie:** Why do we have more oranges?
12 **Students:** Because we have more oranges
13 **Jackie:** Did they do wrong? Do they have to pull out Brown the most?
It could happen.
Even though I have one red and other colors I could pull red every time. Okay, let's do another one.
(Observation field notes – October 26, 2010)

As seen from this excerpt, Jackie conducted most of this lesson by herself. She told the class that she wanted to do the lesson with M & Ms because she thought it was going to be fun. As she expected, students were very excited about this activity and the rewards they would get after the experiment. As with the lesson on fractions, Jackie didn't quite deliver the lesson in a way that conveyed an understanding of the concept. Jackie focused on the fun part of this activity; thus, the lack of detailed directions confused the students and she had difficulties to connect this activity to the important concept of probability. She didn't seem to anticipate how children would do this activity or how to draw a conclusion from the activity. Additionally, Jackie's explanation for the rule of the activity didn't seem clear to the student and she encountered with classroom management issues. It seemed that Jackie was not comfortable enough to realize what was going on clearly and to provide additional directions for the activities. Her attempt to teach

mathematics in a fun way, in align to her desired identity, didn't come out successfully for two reasons. The first reason seems to be based on her limited conceptual knowledge of how to teach probability and the other is her inexperienced classroom management. Jackie had learned how to teach probability from the methods class but didn't have opportunity to practice with classroom management. Thus, when the classroom management came in play she was less successful in teaching mathematics.

Overall Summary

“Teaching mathematics with fun,” was a notion that consistently emerged as Jackie's goal as a mathematics teacher. Jackie's engagement with mathematics across multiple contexts—K–12 schooling, her mathematics method class, and her student teaching experiences—shows why she felt that fun mathematics was so important. Drawing on her own experience, especially K–12 school, Jackie's incoming identity with mathematics was mostly negative. Later, from her favorite geometry teacher, Jackie found out that mathematics can be fun when it is taught with hands-on tasks and manipulatives. The idea of teaching math with fun arose as Jackie's mathematical goal, and she created a desire to build her identity as a fun mathematics teacher. This desire became stronger as she was taking the mathematics methods class from Ms. P. at ASU. In the mathematics methods class, Jackie engaged with new knowledge and skills for teaching mathematics that are close to her goal and her identity. Jackie's experience in the mathematics methods class seemed critical because that class provided her with a

mathematical goal and a clear image of what kind of mathematics teacher she wanted to be. It can be said that the social context of her mathematics methods class allowed her to develop her identity and reach her goal.

Even though the overall experience of the math methods class allowed Jackie to reformulate her identity it did not actually move Jackie towards enacting her newly formed identity as a mathematics teacher. This may be because Jackie entered the mathematics methods class with limited content knowledge but the method class was more focused on how to teach mathematics. Hands-on teaching practice was new to Jackie so it is always needed to practice but Jackie had to learn and understand the content first to be able to practice the methods of teaching. Additionally, the way she learned mathematics was very different from how she wanted to teach mathematics; thus, she had to negotiate between her incoming identity and her desire to become a different type of mathematics teacher. Last, as Jackie focused on fun mathematics teaching, including hands-on activities, she appeared to miss other important parts of the math methods class, such as conceptual understanding, students' mathematical thinking, and problem solving. Thus, her newly gained knowledge was still limited, her new knowledge was still hypothetical, and she had not had opportunity to practice a lot.

Coming into student teaching, Jackie's field experience was not consistent with what she had prepared for methodologically and she was not able to quite implement her self-identity in the way she hoped she would. During this time, Jackie had a variety of experiences of teaching mathematics from her mentor, Mr.

Brown. These practices included higher-order questioning skills, including “why” and “how” to emphasize problem solving while effectively delivering multiple methods of instruction. Even though Mr. Brown encouraged problem solving and students’ engagement hands-on mathematics was not highlighted in his community of practice. Thus, Jackie had limited opportunity to observe the modeled teaching practice that is align to her goal to be a fun mathematics teacher. One experience that made it difficult for her to realize her goal was her lack of opportunity to teach, which directly resulted *from* her lack of confidence. The other experience that played a role in her identity development is that lack of specific feedback with respect to her mathematical goal. This hindered her ability to incorporate reform-based pedagogy into her repertoire of skills. Both resulted in lack of feedback around particular knowledge and skills she wanted to practice

As stated at the beginning of this section, Wenger (1998) argued that learning is increasing participation. Student teachers expand their participation from peripheral to more full participation as they practice their identity as a mathematics teacher. To increase participation, student teachers need to practice their identity as a real mathematics teacher, but it seemed that Jackie didn’t have enough participation over a long enough period of time to secure her identity as a fun mathematics teacher. In sum, Jackie’s identity as a mathematics teacher emerged as a fun mathematics teacher. When Jackie becomes a full-time teacher, she will finally have the opportunity to learn and grow as a mathematics teacher, and with time and practice, she will be able to realize her dream of becoming a

fun math teacher. In the meantime, university and schools need to get on the same page because the disconnection creates difficulty for incoming teachers to develop effective long-term identities.

Meg's Story

Meg was senior in her early twenties and white American female student. She was talkative, and she was willing to share her stories, not only about her school life but her personal narrative about her mother and grandmother. She was the student who showed strong confidence in doing mathematics because she was very actively engaged with mathematics problems, she led discussions, and she did not hesitate to share her mathematical ideas with the class. She typically was one of the students who finished the given problems first and helped colleagues in the same group. When she explained her thinking in public, it was evident that she conceptually understood the mathematics content she was talking about. All these demonstrations showed her confidence in doing mathematics, so I wanted to select her as a case that contrasts with Jackie. What was different about Meg was the elementary school she was placed in during student teaching. Meg chose an elementary school for interning and student teaching that was quite far from the university because that was the school Meg attended as an elementary student. Thus, she was very familiar with school environment from the beginning of the student teaching. The cooperating teacher had been working for the same school for more than 20 years, so Meg had known her since she had attended even though Meg had not actually been in one of her classes. Taken together, this

particular context seemed to help Meg to feel comfortable during most during internship and student teaching, and this special relationship played a critical role in Meg's identity development.

Earlier Experiences

When asked about her K–12 experiences with mathematics, Meg recounted that mathematics was always her favorite subject. She expressed her confidence in doing mathematics. Meg was always one of the top students in mathematics. She remembered one particular moment when she worked really hard in mathematics.

One thing that really sticks out for me was my conference when I was in 4th and 5th grade, which is the same teacher I had for these two years, I heard from my mom saying that my teacher told her that I wasn't good at problem solving. I don't know why but I always remember that and I always ever since I heard that, I kept trying to get better at word problems. My teacher said that was my biggest weakness and that really affected me because I don't like to have weakness in math. Going through high school still and I always remember that and try to work extra hard (ST 1st Interview–March 31, 2010).

My first impression based on this statement is that Meg liked mathematics growing up, and she held a strong desire to be successful in learning mathematics. When she found out that problem solving was her weakness, she tried her best to overcome it by making extra effort.

Another experience during her K–12 school years was the way she learned mathematics. When asked to reflect on K–12 school experiences with mathematics, Meg recalled that even though her experience varied depending on the teacher, they were traditional experiences in general. She said she did not

have any specific memory of teachers from the elementary schools, but she remembered some traditional teachers from high school.

I had some teachers there were very traditional in my high school, like geometry teacher, they would know that none of us understand the concept but they would say “come after school and go find out tutor”. It was not just one or two kids, it was an entire class who didn’t understand but he moved to the next concept. So I had to get a tutor every morning in order to survive in that class (ST 1st Interview–March 31, 2010).

What is interesting from her statement is how she framed traditional mathematics teachers. Drawing on her experience, Meg characterized the teachers who did not help students understand the concepts as traditional teachers. She pointed out in particular the geometry teacher as very traditional because students in the class did not understand the concepts from his teaching. Meanwhile, Meg recalled the calculus teacher from high school as the teacher she liked. She said she loved this calculus teacher because he asked the class how students were doing everyday and helped the class understand the concept instead of moving on the next topic every day. She described the traditional mathematics classroom as one in which students work individually with paper and pencil following the textbook to cover the standards of the year. Testing and the scores are emphasized most of time in the traditional mathematics class. She thought that the geometry teacher was very traditional because he moved so fast without focusing on students’ conceptual understanding. Meg liked the calculus teacher because he placed emphasis more on understanding the concept rather than following the given schedule. This statement shows the evidence that her notion of traditional mathematics is tied to

the teaching style in which the teacher does not focus on whether students have a conceptual understanding.

During her K–12 schooling period, Meg recalled one middle school algebra teacher as the “best” mathematics teacher. Meg enjoyed learning mathematics most of times, but she especially liked this teacher the most. She said,

in middle school, I had a good algebra teacher. She did a lot of overhead things that a lot of people would think boring, but for me, it was the way I learned the best. It was lecturing style and that way might seem boring to other people, but I liked it. I definitely learned more in lecture format so she would be my favorite teacher just because I understood it best (ST 1st Interview – March 31, 2010).

Based on her description, her algebra teacher’s teaching methods seem to be rather traditional and focused on worksheets and a lot of practice with the overhead projector. Nevertheless, Meg remembered her as the best math teacher because she understood algebra very well with that method. This quote shows that understanding mathematics seems an important criterion in learning and teaching mathematics for her. However, in this quote, it is not clear what she meant by “understanding mathematics.” Meg remembered this algebra teacher in particular because she understood the algebra the best, but the way this teacher taught mathematics seemed to focus on procedural knowledge. She mentioned that the geometry teacher was her least favorite teacher because the teacher moved so fast without providing an understanding of geometry. It is noticeable that when she reflected on her favorite or least favorite teachers, Meg seemed to focus more on the understanding rather than the method of teaching instruction. It

seems clear that understanding of mathematics in general is a key notion for Meg with respect to mathematics teachers.

Similar to Jackie, Meg noted that her K–12 experience with mathematics was more traditional, but their interpretation of traditional teaching was slightly different. Jackie’s notion of traditional teaching methods in mathematics depends on the lack of usage of hands-on activities and manipulatives as methods and tools. Meg perceived learning mathematics without understanding as traditional. The notion of understanding mathematics emerged as an important theme during her interview, but a clear definition was not provided. It seemed that Meg’s perception of understanding mathematics was often mixed with both procedural and conceptual understanding.

With the mathematical idea of conceptual understanding, Eisenhart and Borko (1993) suggest that “conceptual knowledge refers to knowledge of the underlying structure of mathematics—the relationships and interconnections of ideas that explain and give meaning to mathematics procedures” (p.9). They point out that conceptual knowledge means to be able to use concrete or semiconcrete models like drawing a representation. It also means that the teacher is able to discuss mathematical ideas embedded in the given problem. For instance, when dividing a fraction, a teacher should be able to discuss how the division of the fraction is related to the proportion or scales. Eisenhart and Borko also defined the meaning of procedural knowledge as “mastery of computational skills and knowledge of procedures for identifying mathematical components,

algorithms, and definitions” (p. 9). Drawing on the definition of Eisenhart and Borko, Meg’s perception of understanding mathematics seems to have meant interconnections of both procedural and conceptual knowledge. In some cases she mentioned conceptual understanding along with procedural knowledge, such as repetition, or drill, and practice to master the necessary skills. Discussing mathematical ideas and connecting mathematics concepts across different contexts were not framed as conceptual understanding. Meg’s mixed notion of conceptual understanding is further discussed later in Meg’s goal as a mathematics teacher.

In sum, looking back into Meg’s earlier experiences with mathematics provided the evidence that she was successful in mathematics during her school years, and she enjoyed learning mathematics even though there she mainly learned through the traditional approach to teaching mathematics. She had a strong desire to be good at mathematics with a conceptual understanding, so she put more effort in to overcome her weakness in problem solving. With this experience, she entered the teacher education program at a university. Her identity as a learner of mathematics then started to shift to a teacher of mathematics.

Mathematics Method Course

Meg recalled her confidence in doing mathematics during the mathematics methods class. Whenever challenging mathematics problems were given to the class, Meg was always one of the students who quickly and correctly solved the

given problems. She also actively volunteered to share her mathematical ideas in the class. Meg's experience in the mathematics methods class is characterized two ways: 1) as a completely different experience from the way she learned in K-12, so she had to reconstruct what it meant to teach mathematics; and 2) it confirmed to her the importance of teaching mathematics with conceptual understanding.

Meg and Jackie reported similar stances on participating in Ms. P's class, which challenged their earlier ideas about teaching mathematics. However, how Meg interpreted this class was different from the way Jackie interpreted it. Similar to Jackie, Meg recalled that the methods course was very different than the way she was taught, especially in regard to the use of manipulatives and the emphasis of conceptual understanding. Meg said she couldn't remember ever using manipulatives as a student, and she was surprised by the way Ms. P used hands-on materials across many different mathematics topics. Meg also said that before taking Ms. P's class, she never thought about the conceptual meaning of the mathematical topics she learned. For example, Ms. P introduced the meaning of multiplication as groups of objects and used unifix cubes to represent each group. In addition, Ms. P also had the class engaged with multiple strategies for multiplication, such as repeated addition, using base ten blocks, area models, and so forth. Meg reflected that that was a totally new teaching method of multiplication. The following is what she explained about her experience in this class.

This is what I learned from her class. She would teach us ways to do elementary math that I never learned as a kid. For example, I never thought about the meaning of division or multiplication before, never thought about it that way, what I did was just memorization. So after all these years, I understand the concept and it almost clicked for me like ‘oh, that is what I am supposed to be learning.’ I think it is a bad sign that you can’t get a click this far in life (ST 1st Interview–March 31, 2010).

In this statement, Meg recalled that she came to understand the concept of mathematics content in Ms. P’s class, and that she learned with rote memorization during her elementary school years. She further criticized that it is unfortunate that students didn’t understand what they learned from elementary school until they went on to the college more than a decade later. It seemed that this experience was one of the most valuable and influential experiences for Meg because she repeated how much she was impressed by how the class focused on conceptual understanding in learning mathematics. She stated:

Ms. P explained concepts I learned when I was in elementary school. Then it made more sense to me all of sudden the way she did it. So I think her class is very innovative, it is not something I knew in the past (ST 1st Interview–March 31, 2010).

Meg considered Ms. P a reform-oriented teacher because Ms. P always had very creative ideas, and that was so new to her. This statement illustrates that Meg valued Ms. P’s teaching mathematics, especially in the way Ms. P explained the mathematical concepts and how much understanding Meg got from her class. Among various experiences during the mathematics methods course, she clearly indicated on more than one occasion the importance of teaching mathematics with conceptual understanding.

Before the taking mathematics method class, Meg's incoming identity was as a successful but mostly traditional learner of mathematics. She reflected that she rarely engaged with conceptual understanding during her K–12 school mathematics experience. Yet, Meg was always successful and confident in doing mathematics.

Meg's understanding of mathematics was not articulated clearly. It seems that Meg's emphasis on teaching mathematics with understanding means two things. First, she interpreted the presence or absence of conceptual understanding in the lesson as the criteria for the traditional or reform way of teaching mathematics. Second, conceptual understanding is tied to her perception of good teaching. When she reflected on her K–12 school experiences, Meg described the mathematics class that focused little on mathematical concepts as traditional teaching mathematics. On the contrary, the middle school, algebra teacher, regardless of his teaching practice, was Meg's best teacher because Meg understood the class the best with his teaching practice. Thus, based on her K–12 school experiences, Meg's view of good teaching consistently appealed to the teachers who teach mathematics with conceptual understanding and this belief became stronger through the method course.

Meg highly valued Ms. P's teaching methods, and she expressed that she wanted to adopt Ms. P's teaching approach for her teaching style. How she adopted Ms. P's teaching practice is described later in this paper.

In sum, throughout this experience, Meg considered Ms. P as her role model of a mathematics teacher and began to see herself as a reform teacher who focuses on conceptual understanding. During her K–12 school experience, Meg liked learning mathematics and her favorite math teacher was the one who helped her understand the concept. Her preference toward teaching mathematics conceptually became stronger since Meg engaged with the knowledge and skills provided by Ms. P. Examples of her favorite teachers, her ideal model of teaching, and implementation from Ms. P's class appear to influence her mathematical goal as a mathematics teacher.

Goal and Aspiration of Mathematics Teacher

Based on her prior experience and the influence of Ms. P's teaching practice, Meg clearly expressed her goal to take on Ms. P's identity as a mathematics teacher. In particular, she wanted to focus on teaching math with conceptual understanding and emulate Ms. P's innovative ways of teaching mathematics. Meg stated that she wanted to become like Ms. P because Ms. P is a very reform-style teacher who teaches math in an innovative way.

What I am aiming toward is that I want to be the teacher they go like 'she is different, she is creative,' and I guess that is how I interpret reform, the new way, like Ms. P. I think new way is like someone who is welcoming change and always trying to learn and it is okay to try completely new things.

The central idea of reform is to go back and check if students really have, really, really have deep understanding rather than giving them surface information and make sure that you cover all year contents (ST 2nd Interview – May 2, 2010).

What is evident with this statement is how strongly Meg wants to teach mathematics with a conceptual understanding. She stressed the word “really” three times. Meg also articulated here that she wanted to be a reform teacher who is willing to change, learn, and be open to trying new things. This statement is reflected in Meg’s teaching practice. I often observed that Meg tried out new knowledge she learned from Ms. P’s class, and she used smart board which was totally new to her. Thus, Meg was able to attempt new teaching methods from the beginning of her student teaching.

As seen in this statement, Meg was pretty clear about her goal of teaching mathematics, so she was able to describe how she saw herself as a mathematics teacher. Meg saw herself as a mathematics teacher who emphasizes concepts the most, but she still expressed her desire to use a little bit of traditional methods such as repetition to master necessary mathematical skills. Meg’s desire to integrate both conceptual and procedural knowledge is well reflected in her belief of how children learn math best.

There are two. I want to say, in the long run, repetition. At first, that is not important but in the end, repetition is very important because once you understand multiplication you just need to know your multiplication facts. It would help you in the future it needs to be in your head know the answers so repetition is definitely later on important.

Before that, I thought children learned best by applying the real world. I think the biggest struggle as a kid was ‘how does this help me at all in my life, I don’t need this.’ You can connect math with something that they can relate to it and math would become so much important for them that they want to learn about it (ST 2nd Interview–May 2, 2010).

Meg thinks repetition is necessary to master certain skills when learning mathematics, but it is important that conceptual understanding should precede repetition. This comment is once again connected to her past experiences as a student. For instance, Meg reflected that she was successful in doing mathematics by memorizing all the multiplication facts, but she didn't learn the meaning of multiplication until she took Ms. P's class. This experience was so impressive to her. Thus, it can be said that she feels conceptual knowledge is important, but some aspects of math benefit from procedural knowledge acquired through practice, such as repetition. She also addressed children's difficulty in finding motivation to learn mathematics, so it is important to teach mathematics in a way that students can connect with their everyday life. Thus, it seemed that teaching mathematics with conceptual understanding and real world application is her mathematical goal as a teacher.

Field Experience

After the mathematics methods class, Meg was placed in a 1st and 2nd grade multiage class in a local elementary school. She met Mrs. Green as her mentor teacher. During this semester, Meg was apprenticed by the mentor, and she started to practice her identity as a mathematics teacher. In this section I first describe Mrs. Green's background, and her mathematics teaching practice, and I illustrate several mathematics instructions that seemed to have an impact on Meg's identity construction.

Background of This Community: Mrs. Green's Classroom

Mrs. Green is a veteran teacher who had been teaching more than 20 years. Most of her teaching experiences had been in Kindergarten and 1st grade. This was Mrs. Green's first year teaching a 2nd and 3rd grade combination class. The general description of the classroom routine is illustrated below

Mathematics was generally taught sometime between 8:45–10:30 am. The duration of math lesson varied depending on the schedules of the specials, such as music and physical education and other school events. The maximum length of math class was 50 minutes, but it was sometimes less than 30 minutes. The math class usually started with checking homework from the previous day, and either Meg or Mrs. Green started math lesson.

One salient feature of this classroom was that Mrs. Green handed over the math class to Meg from the beginning of the semester, and Mrs. Green allowed Meg to teach the mathematics lesson by herself as long as it covered the district standards. The detailed background of this form of teaching is explained later in the section. During the whole semester, Meg taught the majority of mathematics lessons, and Mrs. Green taught very few lessons. Due to this particular situation, it is difficult to describe the routine of Mrs. Green's mathematics class. Thus, I focused more on Mrs. Green's interview, and the classroom materials that she chose to engage the students with to have better understanding of Mrs. Green's mathematical teaching practice.

Mrs. Green stated that the textbook *Everyday Mathematics* and a smart board were provided by the school district, but that she did not use either for two reasons. First, Mrs. Green was unfamiliar with *Everyday Mathematics*, and she believed that a lot of the content in the textbook was not aligned with the standards at the time. Consequently, Mrs. Green and the other multiage teachers developed their own 2nd and 3rd grade curriculum including homework packages.

The teachers pulled all the standards for 2nd and 3rd grade and made up their own mathematics book to develop procedural knowledge. Secondly, Mrs. Green also said she is not a fan of *Everyday Mathematics* because she doesn't feel that the kids have enough repetition or a real solid understanding or mastery of the skills. She feels that *Everyday Mathematics* moves content so fast that kids do not have enough opportunity for repetition and practice. Figure 2 represents a sample of classroom material that Mrs. Green used instead of *Everyday Mathematics*. The similar forms of work sheets were given to the students every day for the homework.

NAME _____

Lesson 1.5 Adding 2-Digit Numbers (with renaming)

Add the ones.
Rename 12 as 10 + 2.

37	7	37
+25	+5	+25
		2
		2

Add the tens.

37	oddend	
+25	oddend	
		62
		sum

Add.

	a	b	c	d	e	f
1.	$\begin{array}{r} 23 \\ +18 \\ \hline \end{array}$	$\begin{array}{r} 76 \\ +15 \\ \hline \end{array}$	$\begin{array}{r} 13 \\ +77 \\ \hline \end{array}$	$\begin{array}{r} 36 \\ +16 \\ \hline \end{array}$	$\begin{array}{r} 19 \\ +62 \\ \hline \end{array}$	$\begin{array}{r} 29 \\ +19 \\ \hline \end{array}$
2.	$\begin{array}{r} 27 \\ +36 \\ \hline \end{array}$	$\begin{array}{r} 52 \\ +39 \\ \hline \end{array}$	$\begin{array}{r} 36 \\ +28 \\ \hline \end{array}$	$\begin{array}{r} 30 \\ +50 \\ \hline \end{array}$	$\begin{array}{r} 56 \\ +27 \\ \hline \end{array}$	$\begin{array}{r} 59 \\ +13 \\ \hline \end{array}$
3.	$\begin{array}{r} 54 \\ +27 \\ \hline \end{array}$	$\begin{array}{r} 53 \\ +28 \\ \hline \end{array}$	$\begin{array}{r} 28 \\ +17 \\ \hline \end{array}$	$\begin{array}{r} 13 \\ +19 \\ \hline \end{array}$	$\begin{array}{r} 39 \\ +17 \\ \hline \end{array}$	$\begin{array}{r} 56 \\ +14 \\ \hline \end{array}$
4.	$\begin{array}{r} 62 \\ +19 \\ \hline \end{array}$	$\begin{array}{r} 27 \\ +18 \\ \hline \end{array}$	$\begin{array}{r} 26 \\ +55 \\ \hline \end{array}$	$\begin{array}{r} 18 \\ +13 \\ \hline \end{array}$	$\begin{array}{r} 72 \\ +18 \\ \hline \end{array}$	$\begin{array}{r} 37 \\ +17 \\ \hline \end{array}$
5.	$\begin{array}{r} 23 \\ +57 \\ \hline \end{array}$	$\begin{array}{r} 29 \\ +16 \\ \hline \end{array}$	$\begin{array}{r} 25 \\ +16 \\ \hline \end{array}$	$\begin{array}{r} 38 \\ +14 \\ \hline \end{array}$	$\begin{array}{r} 26 \\ +28 \\ \hline \end{array}$	$\begin{array}{r} 76 \\ +15 \\ \hline \end{array}$
6.	$\begin{array}{r} 29 \\ +17 \\ \hline \end{array}$	$\begin{array}{r} 34 \\ +27 \\ \hline \end{array}$	$\begin{array}{r} 43 \\ +27 \\ \hline \end{array}$	$\begin{array}{r} 25 \\ +26 \\ \hline \end{array}$	$\begin{array}{r} 48 \\ +12 \\ \hline \end{array}$	$\begin{array}{r} 45 \\ +46 \\ \hline \end{array}$

Spectrum Math Grade 3 Chapter 1, Lesson 5 Adding and Subtracting 1- and 2-Digit Numbers (with renaming)

Can you find these answers in just one minute?

$9 \div 3 =$ _____	$2 \div 2 =$ _____	$8 \div 4 =$ _____
$45 \div 5 =$ _____	$24 \div 3 =$ _____	$25 \div 5 =$ _____
$18 \div 6 =$ _____	$56 \div 7 =$ _____	$48 \div 8 =$ _____
$27 \div 3 =$ _____	$64 \div 8 =$ _____	$9 \div 3 =$ _____
$21 \div 7 =$ _____	$18 \div 3 =$ _____	$24 \div 8 =$ _____
$12 \div 4 =$ _____	$16 \div 8 =$ _____	$54 \div 6 =$ _____
$16 \div 8 =$ _____	$40 \div 5 =$ _____	$20 \div 4 =$ _____

20

Figure 2. Sample worksheet from Mrs. Green's class on March 18, 2010

Mrs. Green's teaching practices and emphasis on appropriate materials shows that for her, drill and practice and repetition seem to be central in teaching mathematics. Mrs. Green often mentioned that students need to have repetition and practice to master the skills. For Mrs. Green, procedural knowledge seems to have been more important than conceptual understanding when teaching mathematics. This perspective was clearly expressed when she talked about her teaching goals, which I will discuss in the following section.

The other noticeable aspect of this class was the limited usage of technology. Although Mrs. Green had a smart board for a couple years, she rarely used it. She acknowledges that she is not good with technology. However, I

frequently observed that Meg used the smart board in her teaching practice, and this played a critical role in changing Mrs. Green's teaching practice later on.

Goal and Demonstrated Practice of Teaching Mathematics in Mrs. Green's Classroom

When asked about her teaching goals, Mrs. Green mentioned two objectives. The first aim was to help students be confident doing mathematics, so they wouldn't get turned off. She described her own experience as a student.

When I was a kid, I was almost afraid of math, because teachers didn't make it easy to understand. I think it is important to show them it is needed in everyday life and they will use it someday and they enjoy it.

I did not like math. And until now, I still don't because of the way we learned growing up, it was very textbook and very dry. We did not use a lot of manipulatives, hands on, real life application so I just thought it one way, and I wasn't provided different ways to learn. It moved very fast for me, I felt as a child that I had to have a lot of help at home from my parents. So I developed as a child, kind of "un, I don't like math" (Mentor Interview–April 30, 2010).

This statement reflects Mrs. Green's own identity with mathematics. When growing up, Mrs. Green didn't have a positive experience learning mathematics, and she struggled at it. It seems that Mrs. Green's challenge with mathematics as a student still influences her identity as a teacher. Mrs. Green stated that due to her earlier experiences, mathematics had not been an easy subject to teach. Mrs. Green said that she had to work really hard to adopt a totally different teaching approach than the way she learned in order to teach mathematics. After much effort and many experiences teaching mathematics, she is now comfortable teaching the subject; although it is still not her favorite subject to teach. She

acknowledged that the reform ways of teaching mathematics is very beneficial to the children. She characterized reform teaching as interactive, hands-on, and applicable in real life. At the same time, she expressed her concern regarding the testing pressure and the expectation of the *No Child Left Behind Act* of 2001. She believed that because of that, she wanted to keep the traditional way of teaching mathematics. Mrs. Green described that traditional methods for teaching mathematics is better for making better test scores. This is what Mrs. Green said.

You know, with the testing pressure and the expectation of *No Child Left Behind*, I don't feel that you can move more to the reform way of teaching, my personal feeling is that, because kids have to know the fact like this (snapping fingers to show fast) and test and sometimes some of them by rote, some of them by traditional way, you do have to do that. The number one thing for them to learn is understanding concepts for real life but there is quite a bit a pressure on test scores, so I feel like you got to hold on to a little of traditional teaching (Mentor Interview–April 30, 2010).

In this example, Mrs. Green clearly showed that her idea of teaching mathematics is rooted in the traditional way of teaching. What is also noticeable from these statements is that Mrs. Green pretty clearly states her identity as a mathematics teacher who teaches to achieve good test scores. From her earlier experience as a student, Mrs. Green knows that reform methods are better for kids, yet she still wants to hold on to traditional teaching approaches to mathematics due to testing pressures.

The analysis of her interview shows that traditional teaching methods as modeled by Mrs. Green was considered the best teaching practice. Thus, in this community of practice, Meg was engaged with specific mathematics skills

focused on procedural knowledge, repetition, and test preparations. When considering the given information of Meg's goals and belief of teaching mathematics, Meg seemed to have a different approach to teaching mathematics. While engaged in this contrasting teaching practice, Meg had to decide what to adopt from her mentor's methods and how to balance her teaching from moment to moment. The relationship between Mrs. Green and Meg played an important role in the way Meg adjusted her mathematics teaching practice.

Form of Mentoring

Mrs. Green described the typical internship trajectory as follows. Student teachers come in and observe quite a bit and pick up on mentor's teaching style while they get to know the curriculum. Then the mentor has student teachers start teaching and takes a more responsibility as semester goes by, so they can be ready to take on a full lesson and the full responsibility of teaching.

However, this was not the case for Meg. Meg started taking over the teacher's role from the beginning of the semester, with mathematics in particular. Meg's role was more like an actual teacher and her mentor's role was supplementary. The biggest reason that Meg was able to do this was that Meg had an internship with Mrs. Green during the previous semester; so they had already built a mentor-student relationship. Thus, Meg was able to feel more comfortable

I actually knew her for a long time and I feel kind of like a friend and a mentor, that is different than other mentors. I started teaching early since I was here from last semester so when I started my student teaching I already knew my students and I've taught way more than all other student

teachers have because I have been teaching since last semester (ST 2nd Interview–May 10, 2010).

Meg's statement gave the information that she has been in Mrs. Green's classroom for two consecutive semesters, almost a year. This situation was only observed in Meg's case. During the interviews and the classroom observations, Meg looked very comfortable being in the classroom and confident in teaching mathematics. It appears that such a long relationship with her mentor brought her extra confidence.

With respect to Mrs. Green's teaching mathematics, Meg considered Mrs. Green as a great mentor because she helped her every step of the way in teaching, and Mrs. Green has so many teaching materials. She continued, owing to Mrs. Green's abundant teaching resources, she didn't have to spend a lot of time to prepare classroom materials. Additionally, Meg stated that she learned a lot from Mrs. Green regarding classroom management. Meg said that feedback from Mrs. Green helped her change her idea about classroom management greatly.

I think in the beginning, my idea of management was different than Mrs. Green's. Now that I've seen that I have adopted more of her techniques and that kind of changed my teaching philosophy in a sense that 'okay, you can't give them so much freedom'. In terms of classroom management we are a lot closer than in the beginning (ST 2nd Interview–May 10, 2010).

Meg remembered that in the beginning, she was like a friend of the students rather than their teacher because she had an internship in the same class before starting her student teaching. She felt that some of the students treated her as their friends

or baby sitters. When it came to classroom management as a teacher, Meg had a really hard time controlling the class because the students didn't think Meg had the same authority that Mrs. Green had. Thus, Meg tried to adopt the same methods in managing the class. She found that she was much closer to Mrs. Green in terms of classroom management. Thus, upon entry into Mrs. Green's classroom, Meg began to change her orientation toward learning classroom management towards Mrs. Green's methods.

However, it seemed that Mrs. Green provided practice of teaching mathematics to Meg in different ways because she said "I would definitely adopt her management skills but not in mathematics". She gave the following reason.

She would probably not teach mathematics in relation to how I would like to teach because she is a big fan of work sheet and packets and reinforcement, which is good in a small amount but I am not a fan of that every day. I feel like I am honestly going off of what I am learning from method class more than I am learning from her. I would definitely adopt her management skills but not in math. In math, I think I can stick to my ways, I like what I am doing, and all I need to do is management (ST 2nd Interview–May 10, 2010).

In this statement, it is clearly expressed that Meg only wanted to adopt the part of Mrs. Green's practice that involved classroom management. With teaching mathematics, Meg made an explicit identity statement. "I am not a big fan of worksheets every day" and "I feel like I am honestly going off of what I am learning from the methods class more than I am learning from her." As consistently appeared across her statements, Meg wanted to become a mathematics teacher who focuses on conceptual understanding and real world application. As Mrs. Green had a more traditional teaching style Meg opted to

stick with her own reform style but Meg found that using Mrs. Green's management skills allowed her to implement math the way she wanted. What is interesting in Meg's case is how Meg navigated their differences in teaching style. As mentioned earlier, the relationship between Mrs. Green and Meg was not a typical mentor-student relationship in which the mentor teacher models how to teach and the student teacher tries to reproduce it. From the beginning of the semester Mrs. Green handed over her mathematics class to Meg, and Meg had almost a full responsibility of teaching mathematics.

Throughout the classroom observations, I had a real sense that Meg had confidence when teaching mathematics. During the whole student teaching period, Meg received an extensive amount of teaching time. Even though Meg planned the lesson together with Mrs. Green, Meg was allowed to try anything she wanted to do during the lesson as long as it covered the standards. Unlike the traditional mentor-student structure, I observed that from the beginning of the semester Meg's role was mostly that of a lead teacher during mathematics lessons. Mrs. Green allowed Meg to teach the class solo while she took care of other activities such as preparation for other lessons. Even though it was Mrs. Green's class she chose to give this privilege to Meg. Meg remembered a particular moment and reflects on how this relationship started.

When I first started teaching mathematics, Mrs. Green pretty much gave me work sheets and said 'here, teach this' then I was like 'can I try something I did in class one day?' I taught the lesson and I had such a good reaction out of students. So Mrs. Green wants me to continue with it (ST 2nd Interview– May10, 2010).

As the quote above suggests, when Mrs. Green gave worksheets to Meg, she preferred another method. Meg expressed her desire to try something that she learned in Ms. P's class, and Mrs. Green allowed her to do so. Meg described the lesson as follows.

The lesson was two-digit by one-digit division problems. Mrs. Green tried to use worksheets, but no worksheet was ready that day so I asked her if I can try something I learned from Ms. P's class. I remembered Ms. P introduced a division problem using a story so I wanted to try that. So I posed the story problem something like this. 'There are 15 apples and 5 bears, if 5 bears share the apples equally how many apples does each bear get?' Then using the smart board, I pulled out drawings of apples and bears and shared the apples equally with the bears and found out the answer was 3. Students really liked it, and they found the answers so easily and quickly. I was so happy for that (ST 2nd Interview–May 10, 2010).

Based on this experience, Meg decided to continue teaching mathematics. It is possible that the effective delivery of the lesson gave Meg the confidence to continue doing other things. Meg believed that this lesson was a turning point because after her success with the lesson, Meg was able to have continuous opportunities to try her out her ideas. Later, Mrs. Green began teaching her division lessons this way too. Zeichner and Tabachnik (1981) argues that beginning teachers are very likely to fall back to the traditional way of teaching mathematics even though they are not fond of the method because that is how they were taught. Meg reflected that the opportunity helped her not to fall back to the traditional methods she was taught with as a child and to become more confident as a mathematics teacher.

The analysis of interviews about Meg's teaching experiences gives the evidence that she was very confident in teaching mathematics with reform methods even though that was new to her. There are two reasons that possibly explain why Meg felt more confident with reform methods: 1) Meg's confidence with mathematics; 2) her desire to adopt Ms. P's teaching method; and 3) her mentor-student relationship.

First, the analysis from the interview and the classroom observation consistently showed her positive and confident experience in mathematics. She was a successful learner of mathematics during her K–12 years, and it helped her actively engage with Ms. P's mathematics method class. Both experiences appeared to provide a solid foundation from which she could explore new teaching styles.

Second, Meg clearly valued Ms. P's teaching methods because Meg believes Ms. P's teaching practice is very useful. Meg explained that she liked Ms. P's class and how she incorporated Ms. P's teaching methods into her teaching practice.

I loved it. I loved Ms. P. She was great. I learned so much from her. I have her book here, actually the binder is her book. I bring it to the class, and I use it. This is not a just a note book that I would sell back and you would not use it and I actually use it. I found it so helpful because she would have the work sheet for it. Then she would tell us how to teach it, and I would take notes on that so now I have work sheets to go with it in the future, and I have notes in case I forget how to teach something. I got from her book and pretty much everything that she was teaching us we were doing in this class (ST 1st Interview–March 31, 2010).

This statement evidently shows that Meg really valued Ms. P's teaching instructions. In addition to her confidence in doing mathematics, I frequently observed that she volunteered to teach mathematics and to try new methods based on what she learned from the methods class.

Ms. P's teaching practice not only challenged Meg's identity as a good teacher, but it provided the resources for changing that identity and expanding her definition of "good" teaching.

I found the last but primary reason for the unique relationship between Meg and Mrs. Green. Unlike other student-mentor relationships, Meg and Mrs. Green seemed to have a closer personal relationship because Meg has personally known her mentor for a long time, and she has spent relatively larger amount of time in Mrs. Green classroom. Taken together, Meg felt very comfortable with her mentor, and she was able to ask her to do what she really wanted to do. When Meg expressed her desire, the mentor accepted her request, but this might not always be possible. Meg also received positive feedback about her teaching practice from her mentor.

Mrs. Green is great teacher. She trusts me work on my own now, we are working together and she always says she wouldn't know what she would do without me because we work there for each other. I have so many resources from Ms. P, and she has resources from other teachers so it is very smooth (ST 2nd Interview–May 10, 2010).

This quote shows that Mrs. Green trusted Meg's teaching and their relationship worked very well. But here Meg confirmed one more time that she values Ms. P's teaching methods for mathematics.

The reason why Meg was allowed to have so much freedom in the relationship is clearly expressed in Mrs. Green's mentoring goal. It evidently shows that she encouraged Meg to teach mathematics in relation to her own goal. She stated:

I try to give Meg more autonomy because if I see something really isn't working I would tell her, but I think it is important for her to have the experience to try whatever she wants to try, and that way she can really justify if that works or if it doesn't work, what she would do differently.

I think if she gets just the way that I want to do it she is not getting the true experience for herself and then that first year will be even harder because eventually people always go back to their way I think, and I think if she doesn't get to do it her way now, I would rather have her stumble a little bit with me here to help, and kind of see 'oh, maybe I don't like to do it that way or maybe I am more traditional than I thought'. So I think it let's her be her own, and I think it is good for me and good for children to see different ways (Mentor Interview–April 30, 2010).

Mrs. Green's goal of mentoring explains why Meg was able to try her own ways of teaching mathematics. As described earlier, it is important to attend to the fact that the first lesson where Meg tried something new gave Meg leverage to try more new things. During the interview, Meg also agreed that she had freedom to try new things because Mrs. Green allowed her to as long as it covered the standards as Mrs. Green wanted to provide enough opportunity for Meg to practice her own way of teaching. Everston and Smithey (2000) conceptualized the forms of mentoring based on its characteristics and one of the characteristics

was a *guiding* versus *evaluating* type of mentoring. They described in the study that the guiding type of mentor tends to guide student teachers to use *self-inquiry* or *self-discovery* so student teachers learn from their reflection on the lesson. It is different from the evaluating type of mentor who often evaluates student teachers' lessons and provides advice for improvement. Everston and Smithey pointed out that self-inquiry or self-discovery also provide feedback but more in general terms and nonspecific advice.

Based on the description of the above study, the mentoring structure of Mrs. Green is similar to the self-inquiry type. Compared to the mentoring structure with Mr. Brown and Jackie, this type of relationship is similar to out-of-action because little feedback was provided while students were present. Actually, during the classroom observation, Mrs. Greens' interjection was rarely observed, and it was more common that Mrs. Green let Meg teach the lesson with high autonomy. From her interview statement, Mrs. Green seems to believe it is important for student teachers to stumble a little bit because that is the part of the learning process to become the type of teacher they wanted to be. Mrs. Green said she would tell the student teacher if what she is doing is not really working.

With respect to this type of mentoring, Meg mentioned during the interview that it had both good and bad aspects.

She is good about letting me do what I want to do, but at the same time, that is probably the hardest thing because that makes me wondering if she is okay with what I am doing because she would never tell me (ST 2nd Interview–May 10, 2010).

What she said implicitly shows that Meg didn't have much verbal feedback about her teaching even though Mrs. Green said she would tell her if something needed to be improved. So, the fact that Mrs. Green let her continue teaching with little verbal feedback is confirmation that she was successful. Drawing on this mentoring structure, Meg was able to practice teaching mathematics extensively, and as a result, Meg gained a lot of confidence in teaching mathematics. Gaining confidence and building knowledge from experience is certainly very helpful for student teachers, but it seems that Meg also wanted content specific support and feedback from mentor to reach her goal of conceptual teaching mathematics. However, little verbal feedback in relation to teaching mathematics was given to her, Meg didn't seem to build the best knowledge of teaching mathematics from her mentor.

This apprenticeship resulted in two aspects. First, Meg was able to have extensive amount of opportunity to teach mathematics, and she developed her reform math instruction skills and knowledge. Such experience allowed Meg to secure her identity as a mathematics teacher that was in alignment with her goal of teaching mathematics with understanding. This is discussed further below. Secondly, Meg's teaching mathematics influenced her mentor's, Mrs. Green's, teaching practice. This is illustrated in the later section with the vignette.

Opportunity to Teach

With respect to the opportunity to teach, it is evident that, during this particular period of time, Meg's participation in teaching mathematics was much

more extensive than that of Jackie's. Meg actively taught mathematics. Sometimes Meg used what she learned from Ms. P's class in her teaching practice. During the interview on three occasions—children learn math the best, goal of teaching mathematics, and why mathematics is important – Meg clearly articulated that her teaching goal was to help the students understand real world applications. She felt that Ms. P's teaching methods would help her accomplish this goal. Additionally, Meg said what she needed to reach her goal is building more experience.

Meg vs. Mrs. Green

Although Meg's teaching style is very different from Mrs. Green's, their classroom management styles are similar. As a student teacher, Meg didn't have experience managing classrooms, so she built her management skills based on those of her mentor. Some examples include the following;

- Ringing the chime bell when the classroom became noisy,
- Finishing the math class with a homework assignment,
- Keeping strict rules, and
- Giving students think time for their misbehavior.

During the interview, Meg said that ringing the chime bell was extremely helpful to get children to stop talking. This is because students were used to the classroom rules and expectations, so it was easy for her to adopt the method. As I briefly mentioned earlier, Mrs. Green's classroom materials are oriented to procedural knowledge and repetition of mathematical facts, and this contrasts

with Meg's perspective. However, it was one of the routines of the classroom that was already set up. Meg was allowed to create her own lesson most of the time, but assigning homework prepared by Mrs. Green and checking the homework the next day was one of the routines Meg had to do every day.

So far, I have described how Mrs. Green's teaching practice has influenced Meg building knowledge and skills in teaching mathematics. What I observed was unique to Meg's case in which the student teacher seemed to influence the mentor's teaching mathematics. Similar experience was not observed in any other student teaching model in this study. The following vignette illustrates an example of Mrs. Green's teaching that is influenced by Meg.

Vignette 1. One day, I was able to observe Mrs. Green's teaching mathematics. The lesson's objective was to learn multiplication and division. The lesson started with the review of multiplication and division facts. For example, when Mrs. Green asked the class "what is 3×5 ?" the students said "it is 15." It was similar for the division facts, and she moved through this activity very quickly. After repeating this practice several times, Mrs. Green told the class that memorizing all the facts is very important. Next, she passed out some flash cards that contained multiplication and division facts. She had each person in the class work with a partner and practice the facts using flash cards. The early part of the lesson focused on the drills and rote memorization, and this pattern of teaching practice was frequently observed. What follows next is the evidence of Mrs. Green's newly adopted method from her student teacher, Meg.

The next activity was called *division bears*. Using Microsoft Power Point, Mrs. Green showed a picture of six bears and three children. She then asked “how can we share these bears equally among three students?” The students answered as one voice “three.” She complimented the students and then handed out some counters and a piece of paper to have students practice further. Mrs. Green asked the class to solve the following division problems using the given counters. The sample problems were $12 \div 2$, $12 \div 4$, and $12 \div 6$. The students didn’t seem to have difficulties solving these problems.

After Mrs. Green finished the division bear activity, she pulled out one lesson from the smart board, which was titled “division as equal sharing.” Mrs. Green told the class “we just did division practice. What is division? To divide means to separate into equal groups.” Then she demonstrated one problem: 25 blocks divided by 5 people equally, so each person got 5 blocks each. The key point of this lesson was to approach division as sharing items equally. Mrs. Green posed some sample problems from the smart board lesson, and they were as follows.

Mom brought 12 candy canes for my brother and me to share. How many candy canes can we each have?’ Five children are going to share 25 blocks equally. How many blocks does each child have? Write a number sentence that represents the ants in the circle.

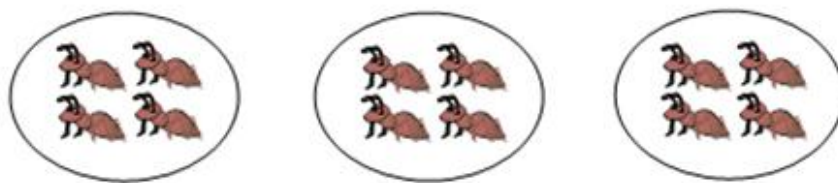


Figure 3. Mrs. Green's division problem on April 28, 2010

Mrs. Green assigned these sample problems and asked students to work individually. After a while, Mrs. Green called the class back together and checked how students solved these problems. When the student who raised a hand presented the answer, she moved to the next problem without having them explain the way he or she solved the problem. It was observed that quite a few students were struggling to write a number sentence for the ant problem. Mrs. Green explained the steps for division on the board.

1. Figure out how many in all (in this problem there are 12 ants)
2. Figure out how many equal groups you need (3 groups)
3. Divide the total number by how many equal groups you need.
4. Thus, for this problem the number sentence is $12 \div 3 = 4$.

This excerpt highlights three aspects. The most noticeable aspect is that this lesson is an example of Meg's influence on Mrs. Green's teaching practice, which is mentioned earlier in this section. Connecting the division problem to the sharing story problem was reminiscent of what Meg introduced to the class based on Mrs. P's methods. The second aspect is that Mrs. Green attempted to use a new method for teaching mathematics that involved manipulatives and the smart

board. In addition, Mrs. Green used power point that contained visual representations, and it was first time for Mrs. Green to use the smart board for her math lesson. In the beginning of the semester, Mrs. Green mentioned that she rarely used the smart board because she was not good with technology. During the interview, Mrs. Green also stated that Meg's teaching style influenced her especially with using technology and the smart board. Mrs. Green said she loved to learn from Meg and get new ideas from her. With respect to Mrs. Green's attempt for the new method, Meg stated:

Um I think Mrs. Green has changed since the last interview. When she was teaching the division again probably two weeks ago, all I have noticed was she didn't have worksheet or stuff. They were really great. I was happy she started using smart board. I would like to think I have a little influence on that. She didn't know how to use it before and I kind of showed her how. I love her teaching mathematics now more than the beginning (ST 2nd Interview–May 10, 2010).

Meg observed Mrs. Green didn't use worksheets anymore for her division lesson and felt that happened because of her. It appears that this was possible because Mrs. Green allowed Meg to teach the mathematics lessons on her own and try new approaches that she learned in teacher education classes. Mrs. Green was also willing to learn from Meg. Although Meg did not receive specific feedback about her teaching from Mrs. Green, the fact that Mrs. Green adopted Meg's teaching method indicates that Mrs. Green approved and felt that what Meg was doing was appropriate for the class. It also seemed to increase Meg's confidence in teaching mathematics further. At the very least, *Meg* felt like Mrs. Green respected her abilities as a mathematics teacher, and this reinforced her identity as

a teacher who developed lessons for conceptual understanding—similarly to her other role model, Ms. P.

The other aspect that is highlighted here is the shift in discourse pattern in Mrs. Green's teaching. Following Meg's example, Mrs. Green adopted a different teaching method of teaching that used power point, hands on activities, and smart board lessons. While the overall approach was similar to the format that Meg used, Mrs. Green's discourse during this lesson was similar to her own earlier lessons. For example, Mrs. Green often focused on students' answers and procedures but did not invite students to reason out mathematical ideas. Further, the manner in which she initiated discussion by defining correct and incorrect answers seemed to eliminate any opportunities for students to engage in mathematical inquiry.

The interview analysis shows that the goal of teaching mathematics for Meg is conceptual understanding and its application to the real world. Meg expressed that she wanted to adopt the teaching method from Ms. P. The next vignette demonstrates how Meg tried to attempt conceptual understanding when she was teaching mathematics. The second vignette gives an example of how Meg attempted to achieve conceptual understanding of Ms. P's teaching method.

Vignette 2. On another occasion, Meg attempted to provide a lesson on conceptual understanding. The math objective of the lesson was fractions, especially the equivalent fraction. Meg tried to start the lesson with the terminology of fractions. It went like this.

- 1 **Meg :** Who can tell me what a numerator is?
 2 **Students:** It is the top number.
 3 **Meg:** What is the bottom number?
 4 **Students:** Denominator.
 5 **Meg :** What is the difference?
 6 **Students:** One number is bigger than the other.
 7 **Meg :** Which one?
 8 **Students:** ...
 9 **Meg :** In a normal fraction, the denominator is bigger than the numerator.
 Today we are going to learn about equivalent fractions.
 Does anyone know what equivalent mean?
 10 **Students:** ...
 11 **Meg :** It means the same. We are going to do an activity to learn about this. (she handed out a rectangular shape of paper)

Meg started the lesson by checking to see if the students had the terminology for fractions, and students seemed to know the language. However, she did not make any explicit connection between what the students said and the real meaning of the numerator and denominator. She continued the lesson.

- 12 **Meg:** Now, fold your paper into half.
 (A couple of students asked for some help to fold the paper, and she helped them.)
 13 **Meg:** With your pencil, shade $\frac{1}{2}$.
 14 **SS :** Doesn't matter what side?
 15 **Meg:** Correct, it doesn't matter (Meg gave the class time to shade their fractions and showed the class how she did it.)



- 16 **Meg :** Now, fold the paper one more time
 (one student jumped in and said)
 17 **S1:** I know, it makes four sides so now I have $\frac{2}{4}, \frac{1}{2} = \frac{2}{4}$, is that correct?
 18 **Meg :** Yes, that is right. Can anyone explain why?
 19 **S2:** If you colored more (Meg jumped in before the student finished her explanation.)

20 **Meg :** No, we didn't color it more. If you colored right and fold it correctly, it should be two sides shaded out of four. Okay, fold one more time and raise your hand if you know what an equivalent fraction it is.

21 **S3 :** $\frac{4}{8}$

22 **Meg :** Good, how did you know?

23 **S3 :** There are eight sections and four are shaded

24 **Meg :** Good, let's write on the board (She wrote the following.)

$$\frac{1}{2} = \frac{2}{4} = \frac{4}{8} = \frac{5}{10}$$

25 **Meg :** What is the pattern in bottom number?

26 **Ss :** They are all even number

27 **Meg:** What is the next even number?

28 **Ss:** 12

29 **Meg:** Yes, so half of 12 is 6 and next even is 14 and half of 14 is 7. (As she explained, she continued writing the equivalent fraction on the board)

$$\frac{1}{2} = \frac{2}{4} = \frac{4}{8} = \frac{5}{10} = \frac{6}{12} = \frac{7}{14}$$

30 **Meg :** You can do the same thing for 3th and 4th because we can count by three. Let me show you the examples. (She wrote the following examples on the board, and explained how to find denominators.

$$\frac{1}{3} = \frac{2}{6} = \frac{3}{9} = \frac{4}{12}$$

31 **Meg :** To find out the next denominator, think about $3 + 6 = 9$ so the next number is 9. The next is, $9 + 3 = 12$ so the next number is 12. You can continue this fraction as counting by three. Okay, let's practice more. I am going to pass out a worksheet for finding equivalent fractions with many other fractions. (She passed out the worksheet and gave the class to work on the problems. A couple minutes later, Meg gathered the class). Okay, who wants to share how you solve this problem? (Meg chose two students, and they came up to the front and explained how they did it)

32 **S4 :** This is how I did it. I wrote numbers 1, 2, 3, 4.... All the way to 17 on top and on the bottom, I counted by three.

$$\frac{1}{3} = \frac{2}{6} = \frac{3}{9} = \frac{4}{12} \dots \frac{16}{48} = \frac{17}{51}$$

33 **Meg:** Okay, good. How did you do it, can you tell us how you did?

34 **S5 :** What I did is similar to what S4 did. I counted by ones for the top number and counted by 4 for the bottom number.

$$\frac{1}{4} = \frac{2}{8} = \frac{3}{12} = \frac{4}{16} = \frac{5}{20} \dots \frac{24}{96}$$

The first impression of this excerpt is that Meg attempted to teach conceptual knowledge, to some extent, but it didn't come out successfully. She tried to pose "why" questions and ask them to explain their thinking. She attempted to connect the concept of equivalent fractions with the paper folding ideas. However, her discourse often involved giving directions, telling what to do, or yes or no questions. Meg rarely asked questions that challenged students' thinking, such as "how can we make this fraction," "who can show $\frac{1}{2}$," and "what should be done next." It seemed that Meg had content knowledge to understand the concept of equivalent fraction, but she didn't have pedagogical content knowledge of how to explain that concept to the students. For example, she used the idea of folding a paper in half so the denominator would go 2, 4, 8, 16, and 32. When following this pattern, $\frac{5}{10}$ cannot be made by the paper folding activities that students were engaged with. However, Meg didn't realize this error and maybe because has not practiced his activity before conducting the lesson.

The other noticeable aspect of this lesson is Meg's limited conceptual understanding of equivalent fractions. When Meg explained how to find the denominator for the equivalent fractions, she found the answer by adding numbers. This approach is mathematically limited because this method only works for the unit fraction and not for the other fractions. When engaged with fractions, Meg

showed her additive thinking approach rather than multiplicative thinking. What is noticeable in this vignette is that what Meg did was not what she learned from Ms. P.

In the methods class, Ms. P taught how to find the equivalent fraction using the identity property of multiplication. For instance, Ms. P explained that students could find equivalent fractions by multiplying $\frac{2}{2}, \frac{3}{3}, \frac{4}{4}$ because $\frac{2}{2}, \frac{3}{3}, \frac{4}{4}$ are the same as 1 and multiplying by 1 does not change the value of the fraction. Ms. P also explained that this is why students have to multiply the same number by the numerator and denominator to find out the equivalency. Ms. P emphasized in the class that students often learn the rule but rarely understand why this rule works all the time, so teacher candidates had to understand this to teach their future students. Although Meg believed in the value of teaching for conceptual understanding, she was not quite yet able to give a precise description of her conceptions of fractions and mathematics. Eisenhart and Borko (1993) stated that there are some factors that affect student teachers' abilities to teach conceptual knowledge, such as their knowledge of mathematics and mathematics pedagogy related to the specific topic, the curriculum, their perceptions of students' ability, and so on. Among these factors, Meg's limited conceptual knowledge and lack of experience might have played a role. This excerpt also reveals students' high reliance on Meg's method of teaching when they worked on the problem. When Meg shared how students solved the problem she encouraged students to come in front of the class and share their mathematical ideas. However, what students

shared was the exactly same method that Meg taught. Both of the students explained that they counted top numbers by 1, 2, 3... and the bottom numbers counted by either 3 or 4 and that was how they found equivalent fractions. As can be seen on the above excerpt, students made mistakes when they counted by three, $\frac{16}{51} = \frac{17}{54}$ is supposed to be $\frac{16}{48} = \frac{17}{51}$. However, students went back to their seats after sharing their answers and strategies and the lesson continued without any further comments about the incorrect answers or discussions of other strategies. During this lesson, Meg didn't ask for help from her mentor, and Mrs. Green did not interject.

On another occasion, I observed that Meg attempted to implement what she learned from Ms. P's class. The following vignette is one example. The math objective was comparing fractions of unlike denominators. The students were asked to compare the given fractions.

$$\frac{1}{3} () \frac{3}{7} \qquad \frac{3}{6} () \frac{1}{2} \qquad \frac{5}{8} () \frac{3}{4}$$

The majority of students didn't know how to compare the first fraction because the denominators 3 and 7 are not the friendly numbers. Meg helped the class find the equivalent fraction of $\frac{1}{3}$ because it was something similar to what students did in the previous class. Students came up with $\frac{1}{3} = \frac{2}{6} = \frac{3}{9}$ pretty quickly, but they still seemed unsure how to compare $\frac{3}{9}$ and $\frac{3}{7}$ because the denominators were not easy to compare. Meg brought the idea of fair sharing. She provided the context

to the class, “Think about this. There are three pizzas to share among 7 people and 9 people. Which one would get the bigger piece?” One boy said $\frac{3}{7}$ is bigger because there are less people with the same amount of pizza. She complimented the boy and told the class that “I know that this is hard to get in the beginning, but I don’t want to discourage you. Yes, this is difficult; but it will come to you sometime. What about the next one?” The majority of students replied that they are the same because both of the fractions mean half.

Meg moved to the last problem and asked “which fraction is bigger?”

About half of the class said $\frac{5}{8}$ is bigger, and other half replied that $\frac{3}{4}$ is bigger. To help students, Meg drew a picture of each fraction and shaded not the shared part but the leftover part (shown below). She asked the class which shaded piece is smaller. Students replied that $\frac{1}{4}$ is smaller. Meg said, “yes, you are right. $\frac{1}{4}$ is smaller and that means $\frac{3}{4}$ takes more space than $\frac{5}{8}$. Also what you can think about is $\frac{3}{4}$ is $\frac{1}{4}$ away from the one, but $\frac{5}{8}$ is $\frac{3}{8}$ away from one so $\frac{3}{4}$ is bigger.”



During this lesson, Meg attempted to adopt the fair sharing concept and benchmark fractions to explain ordering fractions. Connecting benchmark fractions and fair sharing contexts was reminiscent of what happened in Ms. P’s classroom. Ms. P taught comparing fractions using bench mark fractions, such as

$\frac{2}{7} () \frac{2}{9}$, $\frac{3}{11} () \frac{4}{7}$, $\frac{8}{9} () \frac{6}{7}$. For instance, $\frac{4}{7}$ is bigger because it is more than

half, but $\frac{3}{11}$ is less than half; and the last one is $\frac{8}{9}$, which is bigger because it is closer to one. It is possible to see that Meg tried to use the same approach as Ms. P with her students, but Meg's explanations for comparing fractions using benchmark numbers seems to have confused her students, especially the last one. Meg's goal was to show the difference between $\frac{1}{4}$ and $\frac{3}{8}$ by drawings and by explaining how far those fractions are away from 1, but it seems that her limited pedagogical content knowledge made her struggle with providing answers while the children were waiting. One of the reasons is that in the case of Ms. P's fraction, the numbers were easy to compare, $\frac{1}{9}$, $\frac{1}{7}$. This was not the case for Meg's fractions. Although students didn't seem to understand Meg's explanation, she closed the math lesson without any further probing questions or explanation. Meg's demonstration of the fraction lesson was designed to result in conceptual knowledge of fractions, yet she moved on in the lesson without considering students' understanding.

As seen from this excerpt, Meg conducted most of the lessons by herself. Meg attempted to teach with methods similar to what she learned from Ms. P's class. She also tried to ask questions to probe student's mathematical understanding. She didn't anticipate how students would engage with the lesson or how to connect students' answers with important mathematical concepts. Thus, in Meg's teaching, a disconnect emerged between her lack of pedagogical content knowledge and her desire to teach mathematics conceptually. As a result, she adopted some key aspects of her methods class, some aspects of Mrs. Green's

class, and layering these on top of her prior knowledge and understanding of mathematics and mathematics teaching. All three periods of her growth as a mathematics learner and teacher contributed significantly to her growing identity as a mathematics teacher.

Overall Summary

Meg's engagement with mathematics across multiple contexts, such as K–12 schooling, mathematics methods class, and student teaching, gives a detailed picture of the development of her identity and mathematics teaching practice. Looking back into her earlier engagement with learning mathematics demonstrates of why understanding of mathematics is so important for developing a frame for mathematics teaching practice. Her experience with Ms. P at ASU brought her some conceptual understanding that she didn't have during elementary school, and she admired Ms. P's creative methods of teaching mathematics. She even adopted methods from Ms. P's repertoire. Within the mathematics methods class, Meg engaged with the new knowledge and skills of teaching mathematics. As a result, teaching mathematics with conceptual understanding arose as Meg's mathematical goal. Thus, she started to build her identity as a reform-oriented mathematics teacher who teaches math with emphasis on concepts and creative methods of instruction. The data shows that the mathematics methods class provided Meg with the environment that was consistent with her goal as a mathematics teacher. Also Meg's confidence in learning mathematics and the content knowledge she brought to the class from her

K–12 experiences reinforced her confidence as a reform-oriented mathematics teacher. However, the knowledge and skills provided in the methods class was new and still hypothetical to her because Meg needed to practice her knowledge and skills to develop her new identity as a mathematics teacher.

Coming into student teaching, Meg's identity as a mathematics teacher was reinforced in one aspect, but it was also suppressed to some degree at the same time. For instance, because of Meg's confidence when teaching mathematics and her positive experiences in her K–12 schooling, she had the most opportunities to teach mathematics of my three student teachers. In addition, the particular relationship with her mentor, Mrs. Green, allowed Meg to be able to practice what she had learned from Ms. P's class. She tried new things and hands-on games, and she actually had opportunities to practice her identity as a reform teacher. Using the smart board and what she learned from Ms. P's class, Meg attempted to teach math lessons conceptually on some occasions. In Mrs. Green's community of practice, Meg expanded her participation from peripheral to close to full participation, and this process is what Wenger (1998) defined as learning, which is increasing participation. Throughout her the participation, Meg was able to practice her identity as a mathematics teacher. But, her identity as a reform mathematics teacher was not secure yet. One possible explanation can be found in the goals and norms of the community in Mrs. Green's classroom.

The mathematics teaching practices of Mrs. Green contrasted with Meg's goals and the approaches that Meg wanted to pursue. This provided an

environment that was not consistent with Meg' incoming identity and provided limited opportunities for her to see reform teaching actually being modeled. Meg seemed to have been aiming toward becoming a mathematics teacher who emphasizes conceptual understandings and who tries creative methods of instructions. Nevertheless, I often observed that Meg did not ask why or how questions, invite the students to explain their thinking, check how many students understood the concept or got the correct answer, or ask for their problem solving strategies. Rather, she focused on telling the students what to do before moving to the next problem, which was consistent with the pedagogical norms established by Mrs. Green. Additionally, her lack of pedagogical content knowledge and her inexperience teaching mathematics contributed to this inconsistency. More importantly, it seems related to her lack of experience observing methods listed above and a lack of feedback from her mentor teacher regarding the particular knowledge and skills she wanted to practice.

Her mathematical goal was not highlighted in Mrs. Green's teaching practice, so she had limited opportunity to observe and engage with teaching practice modeled by her mentor. Meg is a representative case that research studies (Eisenhart and Borko, 1993; Feiman-Nemser, 2001; Zeichner, 2005) have criticized in the past. These researchers argued that there are not enough opportunities for preservice teachers to experience classroom teaching that is consistent with reform teaching. Mrs. Green's goal was focused more on helping Meg self-guided rather than on providing her content-specific feedback. Mrs.

Green's teaching practice was more traditional and it was not consistent with Meg's mathematical goal. Both of these issues resulted in lack of feedback that could have helped Meg to secure her identity as a mathematics teacher. In sum, Meg's identity as a mathematics teacher emerged as a reform teacher. She was able to practice her knowledge and skills as a reform teacher during field experiences, but she didn't have enough feedback to support her newly gained knowledge and practice to secure her identity as a reform teacher. When she becomes a full time teacher, it is possible that Meg is likely to struggle to build solid teaching practices that represent her identity as a reform teacher, unless her school has consistent opportunities to learn these practices and she is provided feedback regarding her attempts to implement them.

Kerry's Story

Like Meg and Jackie, Kerry was a senior in her early twenties. She was an athlete who played tennis. She told me that she tried really hard not to miss any classes except when she had to leave the state for a game or her required training schedule. From her statement, I was able to see her passion for education. She blended well with other student in the mathematics methods class. Because Kerry's case was not similar to Jackie's or Meg's, I selected her as a participant to increase variety in the study.

Earlier experience

When asked about her K–12 experiences in mathematics, Kerry reflected that she “absolutely loved mathematics.” Until 7th grade, she loved mathematics and was always successful. But when she took Algebra in 8th grade, she started to struggle. Kerry reflected that the teaching style of her algebra teacher confused her, because the teacher wanted students to figure out solutions first before he/she would explain the problem. It seems that the algebra teacher wanted the students to explore the problems using prior knowledge, but this method did not work effectively for Kerry. One possible reason could be that Kerry was not prepared for this type of method, so she didn’t have scaffolding experiences with similar teaching practices. Consequently, Kerry didn’t pass the class and had to retake algebra 1 the following school year. Kerry remembered that because of the setback, she worked extra hard to be successful in mathematics. She was, therefore, able to take further mathematics classes, such as algebra 2, geometry, precalculus and calculus. She noted that she enjoyed all of these classes. It is clear from her story that Kerry liked mathematics, was mostly confident in learning mathematics, and when confronted with difficulties she overcame her struggles by putting in more effort. Kerry’s earlier identity with mathematics sharply contrasts with Jackie’s in terms of how she dealt with a challenge. Both Kerry and Jackie encountered some hardships learning mathematics; but, while Kerry wanted to expend effort to be more successful, Jackie chose to withdraw from her situation to overcome her struggles. One noticeable aspect of Kerry’s

positive experience in mathematics consists of her parents' involvement. She recalled:

I remembered that I thought learning my numbers was important since I was young at home because my parents always did the fun activities like money and stuff and we had fake stores and practice with fake money etc. I think those are really important to help develop mathematics literacy and understanding of mathematical concepts from a young age. Actually my Dad, he taught geometry and algebra 2 in high school and he was really good at mathematics (ST 1st Interview–May 11, 2010).

Based on this statement, Kerry clearly considered mathematics important from a young age because her father, a high school math teacher, engaged her with mathematics at home early on. Further, it seems that the words mathematics literacy were central for her identity in mathematics. During the interview, Kerry mentioned the notion of mathematics literacy ten times when citing favorite mathematics classes, mathematics teachers, and in regard to learning and teaching mathematics. Based on this belief, she feels that mathematical literacy is a central characteristic of an ideal mathematics teacher, and she planned to make it the major focus in her future classroom.

With respect to the notion of mathematics literacy, Kerry gave her definition of this concept.

I guess that mathematical literacy is the ability to know how to use mathematics in the real world, and how to read it, and how to investigate it and understand it. I always use examples like percentage in the store. If you walk in the store and something is 30 % off, and do you know how much off that is? Or calculating you have a budget of 50 dollars to go grocery shopping with, do you know if you are going to have enough money with taxes? Just things of that nature like that you really do use mathematics every day. That is what I think mathematical literacy is. It is

the ability that solves real world problems related to mathematics (ST 1st Interview–May 11, 2010).

In this statement she defined mathematical literacy as “real world” application and provided concrete examples about how she viewed mathematics would be used in everyday lives. She talked about real life situations in a store and how to figure out the appropriate amount of money utilizing mathematical knowledge. Based on her statement, Kerry links mathematical literacy with practical situations in everyday life. Kerry’s belief and identity regarding mathematics literacy was discernible across interviews and classroom observations. The detailed analyses of which will be illustrated later.

Connecting Kerry’s notion of mathematical literacy—in other words, real world application—is very critical to understanding Kerry’s identity; and it is further discussed below with her mentor relationship and field experience.

Later, when asked to describe the best mathematics teachers from her experience, instead of reflecting on one specific teacher, she illustrated the best characteristics of a good mathematics teacher.

I think a good mathematics teacher is the one that applies real world situations within a class and explains the context of mathematics in and outside of the world. I think that is really important because a lot of times you see things in one dimensional viewpoint in mathematics, then you are not able to develop and understand that this is important for your actual life. I think that really helped students to get a grasp of why mathematics is important to learn and that is also why students always ask “why do we have to know this” and my answer is that is why (ST 1st Interview–May 11, 2010).

This statement clearly highlights that for Kerry, real world application is fundamental to becoming a good mathematics teacher because students discover and understand the reasons why they have to learn mathematics in real life. It is evident that Kerry's emphasis on real world application in learning mathematics related to her own early experiences. As she mentioned earlier, her parents engaged her in real world mathematics. Such experience possibly helped her to be more confident in mathematics and to realize why mathematics is important in her life.

Another notable experience in her earlier school life was that unlike Jackie and Meg, Kerry's mathematics education was not a traditional experience. Kerry characterized her own learning experience as in between traditional and reform-oriented. Her definition of the traditional mathematics classroom is a teacher at the board giving a lecture in which the major goal is test preparation. Contrarily, a reform-oriented way of teaching means that students work as a group, collaboratively, and with manipulatives while preparing students for standardized tests. Kerry reflected that her own mathematics experiences included both types of teaching practices, and that is why she placed her emphasis in the middle. Summarizing her reflections, Kerry didn't mention any impressive or specific teachers that served as a role model for her during her K-12 schooling period. Instead, mathematics literacy as a concept constituted her critical notion of identity as a good mathematics teacher. This ideal notion emanated from her

mathematical experiences at home. With this belief and experience, Kerry entered the university teacher education program.

Mathematics Methods Course

As described in the previous sections, Jackie and Meg reflected that their experiences in learning mathematics during their K–12 years were traditional, and Ms. P’s teaching method was so innovative that they were impressed by their new experiences. Both Meg and Jackie clearly showed how much they enjoyed Ms. P’s lessons and wanted to emulate Ms. P as mathematics teachers. However, this was not the case for Kerry.

When asked about her experience in the course, Kerry’s first statement was “I felt like it was a repetition of MTE 180 and 181, so sometimes it felt tedious and boring.” These courses, MTE 180 and 181, were mathematics courses taught in the mathematics department that provided specialized content knowledge for elementary teachers. Students typically take these courses as freshman or sophomores. In contrast, Ms’ P’s methods class focused on teaching methods in mathematics. Most students take this class at their senior level. Kerry recalled that the instructors of MTE 180 and 181 were very nice, and she learned how to use manipulatives and hands-on activities from those classes. She further noted, “I still kept the math book from those classes to use when I had a chance to teach mathematics because there are so many good tips in there.” What can be said here is that Kerry thought what she learned from MTE 180 and 181 classes was similar to what she learned from the methods class. Kerry seemed to value

teaching methods of MTE classes over the mathematics method class; thus, the mathematics methods class didn't appear to provide further influence that reinforced her earlier identity.

Kerry mentioned that in respect to Ms. P's teaching practice,

I would say Ms. P's teaching practice is somewhat traditional and reform at the same time. I remembered that I've experienced similar activities that Ms. P has done in the class so it was not something totally different experience for me (ST 1st Interview–May 11, 2010).

Kerry recalled that one traditional aspect of Ms. P's class was that she lectured sometimes, and Ms. P's major goal of teaching mathematics seemed to be to cover an entire year of curriculum in a math classroom. Yet, Kerry thought Ms. P showed a more reform-oriented way of teaching mathematics as well by providing good problems. Kerry particularly mentioned two problems shown below. She liked them because they allowed her to use different parts of her brain and made her look at the problems from different perspectives. Here are problem examples that Kerry mentioned.

Figure this !

- Is a discount of 30 % off the original price, followed by a discount of 50 % off the sale price, the same as a discount of 80 % from the original price?

Figure 4. Sample 1 of Kerry's favorite problem from Ms. P's class

A problem of the semester

A king sends for three prisoners. He has 3 black hats and 2 white hats. He blindfolds the prisoners and puts a hat on each. He then removes the blindfolds and allows them to look at each other. He tells them that if they can tell him the color of the hat they have on, he will set them free. If not, they will be killed. The first prisoner looks at the other two and says, "I don't know, I cannot tell." The second prisoner looks at the first and third prisoner and says, "I don't know, I cannot tell." The third prisoner is blind, but he says, "I have a black hat on." The blind prisoner is right and he wins his freedom.

Question: Was the blind prisoner lucky or did he really know what he was talking about?

Support your answer clearly by examining very well your thinking process and by providing any work you did: charts, tales, pictures, etc.

Figure 5. Sample 2 of Kerry's favorite problem from Ms. P's class

Kerry explained, the first problem directly relates to our everyday life, so it was a good example to show the kids how to use mathematics to solve the problem and why students need to learn mathematics. From Kerry's perspective, this type of problem is the example of what she meant by mathematical literacy, which as referenced above is how mathematics are used in real world.

The second problem was given to the class as the problem of the semester. Ms. P passed out this problem in the beginning and collected it at the end of the semester. Students were asked to solve it as a group and justify their strategy. Kerry recalled that this problem stood out the most because she had to spend a

long time figuring it out using very different strategies. She added, “If you are just continually doing the same types of problems and problem solving then you are not gaining experiences in a holistic way.” The consistency of the MTE courses and the methods class appeared to be a reinforcing experience for Kerry.

With respect to the most valuable experience from Ms. P’s class, Kerry stated there were two valuable experiences that influenced her notion of teaching mathematics; one focused on a deeper understanding of mathematical literacy, and the other concerned gender issues in teaching mathematics. Here is what Kerry mentioned.

I think one thing that I really came to understand more in Ms. P’s class was the ideas of mathematical literacy. I mean reading and even like scientific literacy, I knew they are important because you use them a lot. But then in math I never realized that you would also need to be literate in math. I want to take that idea and try to figure out the ways to implement it in my classroom and make it important for my students. That is probably very important in my future class (ST 1st Interview–May 11, 2010).

Kerry learned from her experience how important mathematics is and that it is a powerful tool just like reading because mathematics is used everywhere. In addition to her experience, Ms. P’s class provided an extensive amount of opportunity to engage with problem solving and concrete examples that she could utilize for her future mathematics teaching practice. As for the other critical experiences in Ms. P’s class, Kerry reflected:

I would say the biggest change before and after taking Ms. P’s class is my attitude towards mathematics, especially with the gender issue. One day Ms. P mentioned that how we teachers segregate and kind of differentiate our teaching mathematics to both genders. I never realized how much of

things you do and you say and how your questions have an effect on them. I wasn't aware of it before, but now I am. I came to think about the awareness of the need for equality in math, especially in your math teaching (ST 1st Interview–May 11, 2010).

Kerry said that before taking Ms. P's class, she never thought about gender issues in teaching mathematics for students. For instance, one day, Ms. P shared her research interest with the class, which focused on math anxiety and gender issues in learning and teaching mathematics. Ms. P talked about the fact that there are many students and teachers who face math anxiety. She then discussed misconceptions that people often hold about the mathematics achievement gap between boys and girls, and relayed the research-based suggestions for teachers. Based on these experiences, Kerry articulated that what she wanted to learn from her field experience is “new lesson ideas, probably how to incorporate real world application to math lessons.”

Throughout this experience, Kerry built up a strong belief and desire for teaching mathematics with real world applications. She aspired to be a teacher who focuses on mathematical literacy and gender equity. Thus, the methods course reinforced her projected identity as a teacher who emphasizes real life application of mathematical concepts and skills. Her early learning experiences in mathematics with her parents helped her develop a strong belief of what constitutes a good mathematics teacher. Ms. P's class further developed her identity by connecting her early notion of good mathematics teaching with insight into the practices of selecting and instructing meaningful problems, and for

challenging Kerry with research on the differential gender effects of instructional practices.

Goal and aspiration of Mathematics Teacher

The analysis of Kerry's K–12 school experiences suggest that her earlier experience with mathematics and learning mathematics at home helped her build an ideal image of a mathematics teacher as one who teaches math with real world applications. In other words, Kerry's major goal for teaching mathematics stemmed from her experience of doing mathematics at home, and it was continuously projected as she participated in the teacher education program. This goal of teaching mathematics is clearly expressed in the following statement.

As I mentioned earlier, the most important focus of teaching mathematics in my future would be real world application, communication, and then the development of mathematical literacy. Also I believe that children learn math the best by doing mathematics. What they are doing can vary such as doing mathematics with manipulatives, by practicing, by incorporating different methods of learning, by doing games, and by repetitions etc, but they learn math by doing it (ST 1st Interview–May 11, 2010).

Reflecting on her experiences learning mathematics at home, early school experiences, and those in Ms. P's methods course, Kerry realized that there were two aspects of her ability that she needed to develop to reach her goal, knowledge and more teaching experience. While taking the mathematics methods class, Kerry took an internship in a 3rd grade classroom and had some opportunities to teach mathematics. Kerry reflected that teaching students how to apply mathematics knowledge in everyday life has been the biggest challenge for her.

Kerry found out from her internship experience that she needed to research the different methods and ideas that help relate mathematics content to the real world, so students can connect with why they are learning mathematics and how to apply their skills. Thus, she said she expected to learn from her mentor how to make these connections during the field experience.

Kerry also expressed to me that she needed to get more teaching experience because she remembered how she was nervous when she started out teaching mathematics. She had to relearn the materials and figure out the way to explain them to her students. “A constant learner” is how Kerry described herself as a mathematics teacher.

I still remember the moment I started teaching mathematics. I was totally nervous at all times and I made so many mistakes. Sometimes, even my students pointed out my mistake during my teaching. As I progressed and as I taught more math I became more comfortable, and once I got over my fear of making mistakes then I just became better and more confident and my lessons became nicer. I would say, as a mathematics teacher, you can't be afraid to make mistakes because you learn from it. If you stop learning then you are not really helping yourself becoming a better teacher. So I would say I am a constant learner in teaching mathematics (ST 2nd Interview–December 15, 2010).

Despite Kerry's confidence and success in learning mathematics as a student, her identity as a mathematics teacher was not as secure. This statement provides evidence of how insecure she saw herself as a mathematics teacher—at least initially. But as she struggled to learn from her mistakes, her identity as a mathematics teacher became more secure. This trend is evident in Kerry's experiences in student teaching.

Field Experience

After the mathematics methods class, Kerry was placed in a 5th grade classroom in a local elementary school. Here she met Mrs. Olive as her mentor teacher. During this semester, Kerry was apprenticed by the mentor and started practicing her identity as a mathematics teacher in action. In this section, I first describe the background of Mrs. Olive and her mathematics teaching practice. I illustrate several mathematics instructions that seemed to impact Kerry's identity construction.

Background of This Community: Mrs. Olive's Classroom

Mrs. Olive was a teacher who had been teaching for eight years, all in the 5th grade. The time devoted to mathematics was typically in the morning between 8:00–9:25, and the duration of her mathematics lesson was typically around 80 minutes. The mathematics lesson usually started with journal problems of the day. There were four problems a day consisting of a mixture of computational and conceptual problems. The mathematical content was also mixture of topics. For instance, Figure 6 shows one of the examples of eight problems ranging from comparing fractions and long division to probability.

<p>Write > or < to compare.</p> $\frac{1}{8}$ <input type="checkbox"/> $\frac{1}{3}$ $\frac{1}{2}$ <input type="checkbox"/> $\frac{1}{10}$ $\frac{1}{4}$ <input type="checkbox"/> $\frac{1}{12}$	<p>Which is the best estimate for the length of a</p> <p>paper clip _____ dining table _____ bandage _____ railroad route _____ scissors _____</p> <p>A. centimeter B. decimeter C. meter D. kilometer</p>	<p>Write each number word.</p> $\frac{2}{8}$ _____ $\frac{5}{7}$ _____ $\frac{1}{2}$ _____	<p>***** ***** *****</p> $5 \overline{)17}$ XXXXX XXXXX XXXXX XX $3 \overline{)17}$	Day # 3																																																												
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Figure 6. Example of daily problem from Mrs. Olive's class on September 14, 2010

Typically, when problems were posed, students worked either individually or with a partner and were always asked to record how they solved the problems in their math journal. While students were engaged in problem solving, Kerry and Mrs. Olive walked around to help students. When it was time to check the answers, Mrs. Olive called on students and asked them to explain how they did the problems. After journaling and discussing the problems, the mathematics lesson started. What was consistently observed during the semester was Mrs. Olive's range of teaching methods. Sometimes she explained the concept on the board, showed a power point presentation to the class, engaged students with a partner or with a group, played mathematics games, or worked on a project, and so on.

Goal and Demonstrated Practice of Teaching Mathematics in Mrs. Olive's Classroom

From the analysis of classroom observations and interviews, three distinct patterns emerged as major foci in Mrs. Olive's teaching practice: 1) she focused on CGI—; 2) she used of a variety of modalities and materials; and 3) she differentiated group activity.

First, I frequently observed that Mrs. Olive's teaching practice is oriented towards CGI, especially in the way she asks students questions about mathematical thinking and multiple strategies. Cognitively Guided Instruction is a research-based project developed by Thomas Carpenter and Elizabeth Fennema (1999) at the University of Wisconsin, Madison. In their book, *Children's Mathematics: Cognitively Guided Instruction* (1999), CGI emphasizes instruction in which teachers use students' mathematical thinking to diagnose their development and then to provide appropriate problems, questions, or tools to help students gain a higher (or deeper) understanding. In terms of norms of practice, it emphasizes problem solving, exploring multiple strategies, and gaining deep conceptual knowledge. For instance, she often called up individual students to justify their answers and share their strategies. Also students were required to record their mathematical thinking in their math journal when they solved the problems. Mrs. Olive stated that her mathematics teaching practice had evolved in the last several years in response to district training based on CGI.

I actually would say my most recent training in CGI has probably been the most helpful and the most beneficial because I am able to see that you just

don't teach kids one way and force into them this way of doing something or that way of learning it because it may not make sense to them. Letting kids have their own way of thinking and then explaining that to other kids usually has more buy-in for the other kids in the room (Mentor Interview–December 15, 2010).

She continued:

Letting kids kind of evolve and take their understanding and moving forward with it, it just gives more of concrete example, it gives them more of base line to move forward and I think in the long run it will give them more exposure to high levels of math and will make more sense to them (Mentor Interview–December 15, 2010).

As clearly expressed in her statement, Mrs. Olive believes that exploring problems before the explanation by the teacher and engaging with multiple strategies are beneficial for students in learning mathematics. Mrs. Olive reflected that she learned mathematics in the traditional way in which the teacher tells you what to do; but now she is looking at the opposite way of teaching mathematics. The following is an example of how Mrs. Olive taught her lesson, and this vignette especially highlights one aspect of CGI—how Mrs. Olive encouraged students to use their intuitive mathematics knowledge. The following vignette 1 illustrate Mrs. Olive's ratio lesson using pattern block.

Vignette 1. For this lesson, students were given the worksheet in Figure 7 and a set of pattern blocks. Without modeling how to solve this problem, Mrs. Olive let students explore the given problems (see figure 6 & 7).

Determining the Relations

Use the online pattern blocks to answer the following questions.

1. How many  are in  ?

2. How many  are in  ?



3. How many  are in  ?

4. How many  are in  ?



5. How many  are in  ?

6. How many  are in  ?

Based on the above relations, figure out the ratios of the shapes below...

7. If  = 1,  = ___.

8. If  = 1,  = ___.

9. If  = 1,  = ___.



10. If  = 1,  = ___.

Figure 7. Sample worksheet of ratio problem from Mrs. Olive

on November, 9, 2010

Mrs. Olive told the class that she would give them 10 minutes to solve this problem and make an equivalent fraction. Students were allowed to discuss the problem with the group, but they were asked to be creative in making the equivalent fractions. When the time was up, Mrs. Olive asked one volunteer to share the answer with the class. She picked one boy and asked him how he did the problem. He said, “I need two triangles to cover one blue parallelogram so it is going to be 2 triangles.” Mrs. Olive complimented him and continued asking individual students to show the class how they solved the problem. Problems 1–5 seemed easy, and students clearly explained what they did. But the problems 6–10 were not easy for the students. A sample of the discourse they had is provided below.

Vignette 2. This lesson was about ratio lesson.

- 1 **Mrs. Olive:** Okay. Let’s look at the problem number 6, it is tricky. I have one blue parallelogram and how many do I need to fill the red trapezoid?
- 2 **Students :** (most of them) one
- 3 **Mrs. Olive:** okay, but it is not completed with one, but two can’t fit any more either.
Does anybody have some idea? Can you guess how many would I need?
- 4 **Students:** (no response)
- 5 **Mrs. Olive:** Okay, let’s leave that now. That’s okay. We are going to come back later.
(she moved to the next problem)
- 6 **Mrs. Olive:** What about number 7? Who can share how you did?
- 7 **Student 3:** I put it down 6 because I need 6 triangles to cover one hexagon
- 8 **Mrs. Olive:** How many of you did the same way? How many of you think it is 6?
(majority of students raised their hands)
Okay, let’s think about it together. How many triangle do I need to cover the hexagon?

- 9 **Students:** six
- 10 **Mrs. Olive:** Yes, that is right. Then, what if I have only one triangle, what portion of hexagon I can fill with one triangle?
- 11 **Students:** $\frac{1}{6}$
- 12 **Mrs. Olive:** What about the next one? How many do I need to fill?
- 13 **Students:** three
- 14 **Mrs. Olive:** what if I have only one triangle, what portion of trapezoid I can fill?
- 15 **Students:** $\frac{1}{3}$
- 16 **Mrs. Olive:** Can anybody explain number 9?
- 17 **Student 4:** I would need to 2 trapezoid to fill out the hexagon but I only have one trapezoid so I only can $\frac{1}{2}$ of the hexagon. So it is $\frac{1}{2}$
- 18 **Mrs. Olive:** Do you agree? (students nodded)
Okay, let's talk about the last one. Let's take a moment to think about this.
- (Mrs. Olive was walking around to see how students did on this problem.
Similar to problem number 6, students seemed to be confused)
- 19 **Mrs. Olive:** Okay, let's talk about it. What do you think? I saw student 5 did a great job, can you come up and show the class how you did?
- 20 **Student 5:** I kind of found out that the blue parallelogram can't fit evenly to the trapezoid so I tried to find the piece I can use for both parallelogram and the trapezoid and it was the triangle. Then I figured out how many triangle I would need to fill out the trapezoid and it was two, so the answer is $\frac{2}{3}$.
- 21 **Mrs. Olive:** That's great. Okay, let's move to the next one. Everybody put the blocks away.
(Observed field notes–November 9, 2010)

This vignette shows two things about her teaching. First, Mrs. Olive let the class begin the activity as soon as she handed over the worksheet and the pattern blocks. She read aloud the directions, and any further explanation or

modeling of what to do were not provided. What is also noticeable from this excerpt is that she provided an opportunity for the students to explore the problem by themselves. Then the teacher asked them to share how they solved these problems. Problems 1–5 seemed to be easy, and students clearly explained what they did. The majority of students, however, did not answer problems 6–10 correctly. When none of the students came up with the correct answer for number 6 she didn't attempt to explain further or teach the concept directly; instead, Mrs. Olive chose to move to the next problem. She told the class that it is okay, and she would come back later.

Secondly, what is notable from this excerpt is the level of her questioning skills. Based on her CGI training, Mrs. Olive tried to adopt such type of instruction but it seems that Mrs. Olive is still developing her practice. As seen on the lines 11, and 15, her follow up questions are not solid. She asks initial open questions, but when she gets the answer she wants she didn't ask follow up questions to articulate mathematical ideas, instead, she moves on to the next problem.

On problem 7, most of the students wrote down 6 for the answer instead of $\frac{1}{6}$. Mrs. Olive noticed that many students were not on the right track in terms of a technically correct answer, but she didn't focus on whether their answers were right or wrong. Rather, she had each student provide their reasons for choosing the responses they did. This practice is indicative of CGI. With respect to this lesson, Mrs. Olive stated "I know that it can be challenging for them, but I would

let them explore first then we are going to talk about it together. That is my expectation of this activity.” This vignette shows that Mrs. Olive really likes the approach of CGI and tries to implement it especially utilizing students’ mathematical thinking. However, as Mrs. Olive is a constant learner, she continues to hone her CGI skills while she works with her student teachers. Her particular practice is described below is new to her and she is still learning, Mrs. Olive is apprenticing new practice for herself and it influences the community of practice Kerry is apprenticing to, which will be described later.

Another important aspect of Mrs. Olive’s teaching practice is the differentiated group work. The interview with Mrs. Olive explains why this is so important to her. When asked what the goal for teaching mathematics was, she replied:

I would say my main goal is for kids to learn and feel successful in math at all different levels. Just helping them feel successful and helping them realize math can be fun. I do hear my kids saying ‘I am not good at multiplication but I am really good at division or vice versa or I am really good at measurement’. They know that there are different elements in math. I think they are starting to understand that there are parts of math that they are good and parts that they still need to work on, so feeling successful in some area of math so it is not such a negative connotation when they think about math (Mentor Interview–December 15, 2010).

Mrs. Olive believes that students learn mathematics differently, so she wants help them understand the different areas of mathematics and find the area in which they feel confidence. This belief is embedded in her teaching. When students work on the problem as a team, Mrs. Olive accepts the different math abilities within the groups. The following illustration highlights how Mrs. Olive

encouraged differentiated group work depending on students' mathematical levels by engaging them in the jumping frog project.

Smiley and Grumpy won the competition four years ago. This year, their jumping totals are as follows: when Smiley jumps three times and Grumpy jumps twice, their total is 48 steps, but when Smiley jumps four times and Grumpy jumps twice, their total is 56 steps (Problem used in the lesson by Mrs. Olive–October 7, 2010).

For this project Mrs. Olive divided the class into several teams. Each team consisted of 4–5 students. They were asked to find out the best jump of each frog, to record all the steps of how they solved the problem, and also to be ready to justify their answers. The lesson continued from the previous day. The teacher started the lesson by reviewing what they had done the previous day. Based on what students had written down, Mrs. Olive asked questions that were open-ended and facilitated students' ability to analyze and reason. For example, Mrs. Olive asked “how did we get 25 for Smiley and how did we get 23 for Grumpy?” She also asked “what did we do first, can anybody explain how you did it yesterday?”

After a short review, the teacher asked the students to go back to their teams and continue working on the project. The problem solving progress was different depending on the teams. For instance, some of them had already solved the problem, and some were close to finding the answers. In the meantime, other teams were still struggling with how to do it. Nevertheless, students were actively engaged while Mrs. Olive walked around and asked students how they did on the problems. During this project, getting the correct answer or not didn't seem to be

a major focus. Instead, the teacher focused on students' reasoning strategies. She told the class, "This is thinking time no matter what answer you have. You have to be ready to explain how you got it." These initial open-ended questions led the class to retrieve what they had done on a previous day and be ready to move on.

The strategies that students recorded varied as well. One team drew a number line and represented each jump of the frogs. Another team was using a trial and error strategy. One team made an equation of this problem. The teacher accepted these multiple strategies, and helped the groups while walking around.

After 20 minutes, Mrs. Olive gathered the teams and asked them to share how they solved the problem. When students explained what they did, the teacher demonstrated how each student solved the problem by restating their strategies to the class. During this time, the teacher actively created opportunities for students to justify their reasoning by asking questions. What stood out during this observation was how Mrs. Olive handled the students who had difficulties in working on the problems or justifying the answer. Instead of telling students what to do Mrs. Olive asked other students to help him or her or asked the struggling team to go talk to the other team who finished solving it. The teacher provided the class the opportunity to learn from each other and explain their thinking to other classmates at times. Examples of this interaction include:

- Amy thinks 12 is correct and Laura has 27. You need to justify your answers. Tell us how you got your answer.

- Can someone tell me why she has 9 combination? How she got 9×3 ?
What does 3 represent? Who can explain?
- Why this method is easier than the other one? Can you explain?
- Can anybody help him how he solved the problem?
- (for the group work) Team 1, why don't you go to team 3 and see how they did it and talk about it?

The above questions are some examples of how Mrs. Olive tries to engage her students' mathematical thinking during the instruction.

The last pattern was the use of a variety of modalities and methods. Mrs. Olive believed that students are all different in terms of their mathematical level, so it is important to accept such differences. In order to meet students' different needs, she feels that it is necessary to provide various methods of instruction. It was frequently observed that the teacher presented the information in a variety of ways with a variety of materials. For example, Mrs. Olive explained the concept on the board. Sometimes she used power point presentations or provided hands-on activities. She asked kids to work as a team or to move around to find out how others solved a problem. She also sometimes provided mathematical games. One example is a division lesson. First, Mrs. Olive explained the algorithm and meaning of division using a power point presentation that contained exciting pictures. Next, she demonstrated different representations of division problems on the board. Students also played a relay game to help them remember the procedure of division. Afterwards, students were engaged with both story-based

problems and the algorithm-based, division problems. During the transition time, after math but before lunch, Mrs. Olive played a multiplication game with the class. The emphasis of multiple methods of instruction is tied to her belief of how children learn mathematics the best.

When asked how children learn mathematics best, Mrs. Olive replied.

I think a lot of different ways, trying a lot of different things such as partner work, problem solving, connecting in real world scenarios, tying in algorithms because eventually kids are going to need to know how to solve problems and algorithms quickly. I would say real world group work, games obviously, and understanding the mathematics is important (Mentor Interview–December 15, 2010).

Mrs. Olive's division lesson shows that she sometimes emphasizes procedural knowledge. The focus of multiple representations and the games allows Mrs. Olive to focus on practicing procedural knowledge as well as conceptual understanding. With respect to Mrs. Olive's questioning skills, it seems that her identity is developing as a CGI teacher and here is a parallel that some part of her teaching is not practicing CGI. Among the various methods of teaching mathematics, it is notable that Mrs. Olive mentioned connecting real world scenarios as one of the major foci in her teaching. As mentioned earlier Kerry also believes that real world scenarios are the most important goal of teaching mathematics. Lave (1997) stated that learning develops in settings where the goals of the novice and mentor are consistent (Vigotsky, 1978). Thus, it is necessary to explore how Kerry interpreted Mrs. Olive's teaching methods and

whether or not Mrs. Olive provided teaching practices that are consistent with Kerry's vision of mathematics teaching.

In this community of practice, Kerry was engaged with specific mathematics knowledge and skills pertaining to CGI, multiple strategies, and differentiated instruction. While engaging in practices new to the novice, Kerry had to interpret the master's teaching practice and negotiate which aspects she would adopt and how to initiate these practices appropriately from moment to moment. Regarding student teaching experiences with Mrs. Olive, Kerry reflected that it was a great experience.

It was fantastic. Overall, my best experience in the college of education by far. I loved it. I loved Mrs. Olive, and I could collaborate with ideas, and I can always ask her questions, and it was a really comfortable environment for me to grow and develop as a teacher. So I loved it (ST 2nd Interview–December 15, 2010).

With respect to Mrs. Olive's mathematics teaching, Kerry stated,

I think she does a lot of things very well. She always gives students opportunities to practice within her lesson rather than it is on the board or on notebook so right away students got to apply what they just learned into their work. I thought that was really cool. She did a lot of games, math games, which I think they are great. I think she has a great balance between appropriate amount of homework and fun math. She just had a nice balance.

I think she teaches math the way I would like to teach math, just with the nice balance. Because I think that is critical in helping students learn to love mathematics and apply them in the real world like what we did for the department store mathematics (ST 2nd Interview–December 15, 2010).

Kerry clearly liked Mrs. Olive's teaching methods in mathematics. She observed that Mrs. Olive provided opportunities to the students to apply what they had

learned to their ongoing work. Kerry also noted that Mrs. Olive is very knowledgeable and able to balance the instruction between too much work and fun mathematics games.

One noticeable aspect in Kerry's comments about Mrs. Olive's practice is that Kerry does not address the development of student's mathematical thinking, which Mrs. Olive discusses a lot. Student's mathematical thinking and strategies were central in Mrs. Olive's teaching practice and her statement, but Kerry didn't mention it. As a developing CGI teacher it was sometimes observed Mrs. Olive asked questions that elicit students' mathematical thinking but Kerry didn't discuss the mentor's questioning discourse during the whole interview. Instead, Kerry gave an example of a mathematics problem she liked from her mentor, which was a department store math problem. "If you walk into and something is 10 % off of the original price. How do you figure out the amount off the price?" This example is very similar to the problem that Kerry mentioned as one of the favorite problems from the methods class. Kerry strongly believes that real world, real-life situations are very important to motivate students to learn mathematics. Thus, she wanted to develop and adopt real world applications of mathematics from her mentor. Although Kerry did not mention Mrs. Olive's questioning strategies, it may be that she was focused on aspects of her mentor's teaching style that reinforced her incoming identity. Kerry's novice questioning skills were later observed in one of her division lessons.

In addition, Mrs. Olive's application of differentiated group work made a big impression on Kerry. Kerry explained how Mrs. Olive assigns groups for mathematics activities. Kerry also like how Mrs. Olive gave students the opportunity to interact with different students by changing the groups around. Sometimes she assigned the students to groups based on their mathematical levels. Other times, she assigned the groups randomly. On Wednesdays, the gifted students go to Mrs. Olives' class during math instruction, and Mrs. Olive mixes the groups so students are able to see different ways to solve problems. Kerry praised this grouping rubric.

I liked how Mrs. Olive grouped the students because sometimes she would do it by ability and sometimes she would mix up the groups because then everyone gets a chance to experience different thinking. I love those groups too, which I would like to have in my classrooms, that means definitely more work because you have five different centers and need to plan basically plan 5 lessons for the day but it is nice for the kids, because kids really liked it (ST 2nd Interview–December 15, 2010).

What is evident in this statement is that Kerry wanted to adopt Mrs. Olive's practice of differentiated group work. From her experience with her mentor, Kerry learned that although differentiated group work requires more work as a teacher, it is more effective. Kerry expressed that this is something she really wants to adopt from her mentor.

In sum, Kerry's view of her mentor's mathematics, teaching practices is positive. What was highlighted the most in Mrs. Olive's teaching was a variety of teaching methods and differentiated group activities. As a CGI teacher, Mrs. Olive focused on students' mathematical thinking and their intuitive knowledge at

times. Mrs. Olive believes that real world scenarios are also important in teaching mathematics, and it was one of the other core aspects of her teaching perspective. Based on her vision of teaching mathematics, Mrs. Olive provided a variety of teaching methods. For instance, she provided context-based, story problems, various mathematics games, multiple strategies, discussions, and differentiated group work to actively engage students. As described above, those activities sometimes included real life related situations.

For Kerry, mathematical literacy is the core notion of teaching mathematics, and she perceives that mathematics literacy is equivalent to real world applications of math. As Mrs. Olive's teaching practice contains real world application problems, Kerry found a common teaching goal with Mrs. Olive's teaching practice and wanted to adopt it. Kerry also wanted to adopt her mentor's differentiated group work strategy in her future classes.

Even though Mrs. Olive's teaching practice and Kerry's goal and incoming identity are not completely consistent, there are some aspects they both share in common. These are real world applications of math and differentiated group work. Thus, it can be said that the community of practice in Mrs. Olive's classroom modeled teaching practices that were mostly consistent with Kerry's teaching goals and her incoming identity. In this community of practice Kerry chose what she wanted to develop as a mathematics teacher. Kerry's experience in this community of practice reinforced her identity as a mathematics teacher who wants to highlight mathematical literacy for her students. In the next section,

I discuss how Mrs. Olive mentored Kerry and how Kerry participated in this community of practice and its relationship to the development of her identity.

Form of Mentoring

The apprenticeship pattern of Mrs. Olive and Kerry is similar to the typical apprenticeship pattern (e.g., Lave and Wenger, 1991) in which student teachers initially observe their mentors and then gradually increase their role until they can assume full responsibility of some key aspect of practice. In the beginning of the semester, Kerry's role in teaching mathematics was limited to more mundane tasks, such as collecting homework, checking answers, preparing materials, and walking around the classroom to help the students who asked for some help. As the semester went by, Kerry began teaching more mathematics lessons. Mrs. Olive described the typical, mentor-student teacher relationships as follows.

A lot of it was just verbally after the lesson, during the special, or during the break we would like to talk, some of it would be written. We had weekly reflections we talked about went over together, too (Mentor Interview–December 15, 2010).

Compared to the mentor-relationships of the other two student teachers, Kerry's case highlights three different aspects of student teaching: 1) weekly reflection; 2) mentor's support during the lesson; and 3) Kerry's active participation and ability to seek feedback. What is similar about Mrs. Olive's mentoring style is that like the other teachers, Mr. Brown and Mrs. Green, she provided her feedback primarily after the class or during the time when students were not in the

classroom. As discussed above, Schwille (2008), asserts that this type of mentoring—outside of action—is less effective than inside of action of mentoring to help student teachers learn complex skills of teaching moment to moment. Although the other two mentor-teachers did not provide written feedback, Mrs. Olive provided written feedback and had reflection times on a regular basis. Collins et al (1987) articulated the importance of reflection in the apprenticeship structure. They mention that reflections are necessary to maximize one’s learning because reflections “enable students to compare their own problem solving processes with that of an expert, other students, and ultimately an internal cognitive model of expertise” (p.19). Thus, Collins is able to explain why reflecting on a regular basis with her mentor seemed beneficial for Kerry’s development as a teacher.

Another noticeable element of this relationship is the level of support Kerry received from Mrs. Olive when co-planning of the lessons. During the semester, I frequently observed that Mrs. Olive stepped in to provide support both to the class and Kerry while Kerry lead the class. For example, Mrs. Green and Mr. Brown tended to let the student teachers teach the lesson independently, and I rarely observed that the mentors jumped in while student teachers were teaching. Meanwhile, when Kerry was leading instruction of a math problem, Mrs. Olive occasionally jumped in to provide further explanations. Schwille (2008) defines this type of mentoring structure as *coaching*, in which the mentor “steps in” to teach or “steps out” so that the student teacher can resume the lesson. An

example of this style of collaborative teaching or coaching is provided in a subsequent vignette

The last and the most significant difference observed in their relationship was Kerry's active participation in planning the lessons and seeking feedback from her mentor. Co-planning was observed in the other two relationships, but it was different because Jackie's role was supportive in designing lessons, and Meg planned the lesson with little help from her mentor. What was different with Kerry was that Kerry took an active role in designing lessons and always asked for feedback from Mrs. Olive. Kerry mentioned during the interview that she actively participated in the lesson planning before and after class.

We have a curriculum map of what we are supposed to be teaching. I would say "this is my idea. How does it sound to you?" then Mrs. Olive would say "oh, that is great but you might want to think about this because in my experience of teaching, you may start out with basic ideas and then move on to the more advanced one" (ST 2nd Interview–December 15, 2010).

Kerry was not afraid to share her ideas with Mrs. Olive, and frequently asked Mrs. Olive for comments about her own lesson. Kerry also had the opportunity to participate in co-planning sections with other 5th grade teachers on a regular basis. The 5th grade teachers met as a team on Wednesdays to plan for the next week. They gathered different ideas about the lesson and then picked the best of them. Kerry reflected "I really liked it. It was just nice to have other ideas, and we could share a great lesson together."

With respect to Kerry's attitudes, Mrs. Olive mentioned the following.

Kerry was really good about asking for feedback and wanting to do better whether the lesson was great or good or excellent. She still always asked for feedback so that made it really nice for me. If I gave her any sort of feedback, it would be so much better next time. Kerry tried to find games, activities, power points, all different things to help kids take in a little better. She did all that really on her own (Mentor Interview–December 15, 2010).

This statement shows that Kerry actively asked for feedback to improve her teaching practice, and she tried to be an independent learner. According to Lave and Wenger (1998), learning occurs with increased participation. Schwille (2008) argues that the learner's active participation and his/her interaction with the environment results in growth in the learning process. Thus, Kerry's active participation played a critical role in learning to teach mathematics. Kerry participated in several ways. She planned and taught the lessons, with Mrs. Olive's support, and when the lesson was over, Kerry obtained feedback. Taken together, this apprentice structure helped Kerry master the skills she needed to be a mathematics teacher.

Kerry's active participation and ability to seek feedback may be the result of her self-identity as a constant learner and the mentoring goals of Mrs. Olive. As Kerry saw herself as a constant learner she was not afraid to make mistakes and always wanted to learn to improve her teaching. Kerry also felt very comfortable to ask Mrs. Olive anything she wanted. Mrs. Olive's goal was to make Kerry feel conformable. She explained:

I want her to feel comfortable, and that takes time. It definitely took several weeks for her to feel comfortable about what she was doing—being comfortable and still being creative at the same time and being

willing to trying new things—not being stuck in one way of teaching math or one thing, being willing to trying different things and she always was willing to do that I would say, that was really the goal for her (Mentor Interview–December 15, 2010).

Mrs. Olive’s comments about her mentoring goals clearly show that she tried to help Kerry feel comfortable while student teaching. Drawing on this mentoring structure, Kerry was able to share her ideas and ask for feedback from her mentor from the beginning. At the same time, she encouraged Kerry to teach mathematics with multiple methods, and try new things. When Kerry was allowed to try something new by herself, Kerry didn’t attempt what she learned from methods class. Most of Kerry’s practices were based on observing and emulating her mentor’s teaching practice, and this also can be the evidence of Kerry’s desire to take on mentor’s identity as a teacher.

This apprenticeship reveals that Kerry appeared to be the student teacher who was able to develop her identity in a way that most in aligned with her goals. It also reveals that to maximize student teachers’ identity development, novice and master should have common goals in teaching mathematics. Further, the community of practice in which they are placed should be consistent with the student teacher’s projected identity, and the novice and master should have a comfortable relationship so that the novice is able to ask any questions or try what they want. And more importantly, novices should get feedback about their teaching practices to solidify their identities as mathematics teachers. Taken together, her overall experience during student teaching reinforced Kerry’s

identity as a mathematics teacher. In the next section, I illustrate how Kerry's teaching practice reflected her identity and compare this to her mentor.

Opportunity to Teach

Three major foci have come to light in this investigation. First, we must consider how the novice teacher's teaching practice is similar to or different from that of the master's teaching style. Similarity of practices can be seen as evidence of influence of the master on the novice. In cases where student teachers come into the mentoring situation with well-developed practices, correspondence is not evidence of influence of the master teacher per se. Rather it serves as a reinforcing condition for the norms already established. Second, the extent to which a novice teacher's practices align with her identity as a mathematics teacher, or in relation to her goal of becoming a good math teacher, provides evidence of the development of identity and what situations contribute to the process. For example, what novice teachers say, and what they do as a mathematics teacher can show particular consistencies or inconsistencies with their professed identity as a mathematics teacher. Tying it all together is the fact that there are factors outside the teachers' control, the broader context that can work in conjunction or in opposition to the teachers' burgeoning identity and practical change.

It was mentioned earlier that Kerry's teaching experience was built under the guidance of Mrs. Olive's teaching practice. To better understand Kerry's teaching practice in relation to Mrs. Olive's teaching, here I offer up the following

vignette. This vignette shows how Mrs. Olive stepped in and helped Kerry when Kerry was leading a class.

Vignette 3. It was an algebra lesson and students were asked to represent the equation of each problem.

- 1 **Kerry:** A number minus 3? Who can you show me what it looks like?
- 2 **S1 :** $x - 3$
- 3 **Kerry:** Who agrees?
- 4 **Ss:** (most of them raised their hands)
- 5 **Kerry:** What about 3 less than a number? Who can write this for me?
- 6 **S2:** $\frac{3}{x}$
- 7 **Kerry:** What does less usually means? Is it adding? Subtracting? Multiplying? Who can help her?
- 8 **S3:** That is subtract
- 9 **Kerry:** Okay, so can you try again?
- 10 **S2 :** (she changed her answer from $\frac{3}{x}$ to) $3 - x$
- 11 **Kerry:** x goes on the front. It is the same thing as $x - 3$. This is super tricky
Okay, let's do the next one.
5 multiplied by a number? How can you write? One way is.
- 12 **Mrs. Olive :** (she jumped in) there is a lot of ways to representation this equation.
- 13 **S4:** 5×2
- 14 **Mrs. Olive:** I guess 4 different ways
- 15 **S5:** $5/Z$
- 16 **Kerry:** That is division, not multiplication
- 17 **S6:** $5 \cdot Z$
- 18 **S7:** $5xL$
- 19 **Kerry:** That is good. Does anybody else know other way?
- 20 **Ss:** (no response)
- 21 **Mrs. Olive:** (she jumped in to help students)
It is higher level and more sophisticated. You might have seen this before and I mentioned it last week. Can anybody tell what it is?
- 22 **Ss:** (no response)
- 23 **Kerry :** Okay, I will tell you the last two. It is $5n$
- 24 **Ss:** (many student said) Oh, that is what I was going to say.
- 25 **Kerry:** You can also write it as $5(n)$
- 26 **S8:** I know another way. It is 5^x
- 27 **Kerry:** That is exponential, but good thinking.

- 28 **Mrs. Olive:** If I have $5n$, is it different or the same $5n=n \times 5$?
Think about it and give me some comments.
- 29 **S9:** They are the same.
- 30 **Mrs. Olive:** How can we know? Let's plug in the numbers,
 $5 \times 2 = 2 \times 5$, are they the same?
- 31 **Ss:** Yes. They both are ten
- 32 **Mrs. Olive:** Yes, in multiplication you can flip around. When you write
this expression
 $5xL$ is least favorite way to use because $5xL$ can be
confusing if x means multiplication or a variable. $5(n)$ or $5n$
is more commonly used.
 $5xL$, $Lx5$, $5(n)$, $5n$, $5 \cdot n$ these are all the same way to
represent 5 times a number. You are going to see these in
advanced math.
(Observation field notes–September 21, 2010)

As seen in this vignette, Kerry started the lesson by herself, but Mrs. Olive then stepped in. What is noticeable from this lesson is the discourse they had. Lines 7, 11, and 16 show that Kerry focused on procedure, and she told students answers rather than asking questions that encouraged students' reasoning. When student 3 came up with an incorrect representation of "3 less than a number," Kerry told the class that x comes first and did not provide any further explanation except this is tricky problem (line11). Kerry then moved to the next problem without asking students' justification about student's answer. Until this moment Mrs. Olive didn't step in.

The next problem was "5 multiplied by a number," and here Mrs. Olive interjected, added more explanation, or helped students solve the problem. When Kerry attempted to show one way of representation, Mrs. Olive challenged students to think about a variety of representations of the expression, and she further connected to the lesson by discussing the commutative property. Mrs.

Olive's interjection helped students engage in challenging mathematics, but what Mrs. Olive provided was the explanations and multiple representations rather than asking follow up questions to elicit their reasoning. Mrs. Olive mentioned in the interview that she really wants to use CGI practices especially the practice that encourages students' mathematics thinking. However, as she was new to this form of practice, as shown in this vignette, Mrs. Olive's is still developing the questioning skills and practice her identity as well. During the semester similar patterns were observed on more than one occasion.

Kerry vs. Mrs. Olive.

Kerry's teaching style in mathematics showed extensive similarities with Mrs. Olive's especially with the structure of lessons. The primary evidence is that there were many occasions that showed how Kerry attempted to emulate Mrs. Olive's teaching practice. It stood out the most when I compared the structure of Kerry's teaching practice with that of Mrs. Olive's. Classroom routine is a good example of similarity. Mrs. Olive typically started the lesson with four problems of the day in which students recorded their mathematical thinking in math journals. During this time, she encouraged group work, shared strategies, and multiple modalities. These patterns are ones that were observed frequently in Kerry's teaching practice. As described earlier, Mrs. Olive utilized various methods of instruction to teach long division, and a similar structure was observed in Kerry's algebraic expression lesson.

Despite a similar overall structure, some differences were observed at a finer level. The biggest feature was the type of questions Kerry asked the class. When Kerry was leading the class, she attempted to ask various questions. Some were closed-ended (e.g., what is three less than a number, who can write this, what does less usually means?), and some were open-ended, such as how do you know or what do you think. But follow up questions to facilitate a higher levels of understanding was not observed in Kerry's teaching. For instance, when a student provided an answer or completed an action, Kerry did not follow up with extensions or clarification, and her feedback to students seemed perfunctory. As Ensor (1995) reported in her study, learning best practices and implementing them in the classroom are different stories. Kerry observed how Mrs. Olive posed questions to her students and attempted to emulate the practice, but she also found that it takes a great deal of practice to improvise while teaching and asking the right questions. Because Kerry's is a new teacher, it is natural that her lack of experience would play a role in her ability to pick up such advanced skills as CGI and poignant questioning skills.

Lastly, I described Kerry's teaching practice in relation to her identity and goals as a mathematics teacher. It has been frequently expressed that Kerry wanted to teach mathematics with real-world application. During her field experience, Kerry was engaged with Mrs. Olive's multiple methods of instruction, including various mathematics games. Kerry interpreted such practice as real-world application. During 50% of the classroom observations, Kerry

implemented different types of mathematical games. The following vignette is an example of how Kerry emulated Mrs. Olive's teaching practice. After the lesson described above, Mrs. Olive had Kerry lead the algebra activity.

Kerry's algebra lesson. During this activity, it was evident that Kerry was an active and central participant as a teacher because she was leading the game. During the game, Kerry passed out a piece of paper that contained the problems shown below.

1. Ten more than a number
2. A number decreased by 5
3. 6 less than a number
4. A number multiplied by 8
5. A number divided by 9
6. 4 more than a number

Figure 8. Sample problem posed by Kerry for algebra game on September 21, 2010

It was a group relay game. First, as soon as student 1 in the group solved the first problem and wrote down the equation on the white board, Kerry checked to see if the answer was correct or not. Then the student went back to their seat. If the answer was correct, the second person went to the board and wrote down the answer to the second problem. The game continued in the same format. The winner was the team who finished with the most correct expressions. Students

seemed to be enjoying this game a lot, and they were highly motivated. Most of the students successfully solved the problems, and they even helped each other to solve the problems.

After everybody was done, Kerry reviewed what they wrote down and discussed the important mathematical issues. During the review, Kerry highlighted the commutative property, which is $4+n$ is the same as $n+4$ (problem 6), and asked students multiple representations of $8 \times n$ (problem 4). It was reminiscent of what Mrs. Olive did in the previous lesson.

The other impressive aspect of Kerry's practice was how she engaged with students who came up with incorrect answers. When students came up with incorrect answers, Kerry encouraged students by saying that "when you make mistakes during the game that is totally okay. That is the purpose of doing this game." This statement possibly demonstrates two features. First, it can be interpreted that mathematical engagement and exploration of these problems are more important for Kerry than getting the correct answer. This also reflects Kerry's inclination to adopt one of Mrs. Olive's teaching practice, which was differentiating groups. The other feature is drawn from Kerry's identity as a constant learner. Kerry's stance that she always learns from her mistakes was clearly and repeatedly expressed throughout the interview. Thus, Kerry, as a teacher, wanted to help her students learn mathematics from their mistakes as well.

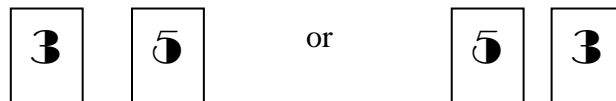
The next vignette also demonstrates how Kerry wanted to incorporate mathematics games into her teaching. What is special about this vignette is that

Kerry conducted this lesson while Mrs. Olive was not in the room. Kerry said she created this game by herself, and she had to lead the whole math lesson, because Mrs. Olive was out that day. The lesson's objective was to practice long division. The lesson started with pairing up the partners. Kerry used the name sticks to make partners and asked the class to record the problem-solving process on their white boards.

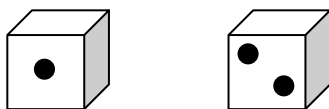
Kerry first announced to the class that they were going to play a division game. The class would practice two-digit problems for 15 minutes; then students could try for 3-digit problems if possible. While delivering direction, the students made a lot of noise. So Kerry directed the class to be quiet, but it didn't work.

Kerry had to direct the classroom two or three times to make students pay attention to her. Kerry explained:

- 1 **Kerry :** Listen. Here is what to do. One group is going to be given a deck of cards, number of 0 to 10. The rule is simple. Draw 2 cards and use those cards, make two digit numbers. For example, if you draw 3 and 5 you can make either 35 or 53, it doesn't matter. But it has to be only two digits. Does it make sense?



- 2 **Ss:** Yes
- 3 **Kerry:** Then roll two die and the sum of two die is going to be the divisor. For example, if you roll a die and get 1 and 2, what is my divisor?



- 4 **Ss:** 3
5 **Kerry:** Great. You have to find out the quotient. Any questions?
6 **S1:** What if the divisor is bigger than the dividend?
7 **Kerry:** That is a great question. I don't think that is going to happen
 because the dividend is a two digit number and the sum of dice
 only can go up to 12. But if that happens, draw one more card.

(Observed field notes–October 26, 2010)

Kerry demonstrated how to play this game with one boy. The drawn cards were 6 and 7 so the divisor was 13. Kerry made a division problem of $67 \div 13$, but the boy came up with $76 \div 13$. They both showed the class how they solved this problem with the traditional algorithm. Kerry's answer was 5, R 2 and the boy got 5, R 11. Until this moment Kerry didn't tell the class how the winner would be determined. She told the class she won, because whoever has the least remainder wins the game.

The lesson didn't seem to be fully prepared and her direction of this game was not clear enough to understand it. Students looked puzzled by her explanation, but Kerry proceeded with the game without further clarification. During the game, it was observed that the majority of students were struggling to figure out how to play and who won. For example, during the game, two students came up to her and asked for help to decide which remainder was smaller. To make it clearer, Kerry asked the class to pay attention to what she was going to do. She wrote down two answers from these students. One of the answers that two students came up with was 13, R 11, and the other was 13, R 13, so Kerry had to tell which remainder was smaller to decide the winner.

- 1 **Kerry :** Okay, please take a look of what we have here. We have 13 R 11 and 13 R 13. Which is bigger or which one is smaller?
- 2 **Ss:** (silent)
- 3 **Kerry:** This is a little confusing. Okay, let me re-write this into decimals.
13R11 is 13.11 and 13R13 is 13.13. Which one is bigger?
- 4 **Ss:** 13.13 is bigger
- 5 **Kerry:** Great. What about if we have 13R 2 so I changed into decimal, 13.2
So now we have 13.2 vs. 13.13. Which one is bigger?
- 6 **Ss:** 13.2 is bigger
- 7 **Kerry:** That is right. I will write it down the rule for you. The bigger single digit wins.
(the game continued)

This vignette shows the incorrect mathematics lesson, which was the result of Kerry's misconception of converting remainder into decimals. As seen in the excerpt (line 3) Kerry changed 13R11 into 13.11 and 13R13 into 13.13. This is mathematically incorrect. Kerry not only struggled with the conceptual explanation of comparing remainders but with converting fractions into decimals correctly. This lesson provided an example of Kerry's limited conceptual knowledge.

Based on my observations, it was apparent that she did not know how to determine which remainder was smaller, and thus, who won the game. For example, if the students made the problems such as $25 \div 4 = 6 \text{ R}1$ and $52 \div 4 = 13 \text{ R}0$, the winner would be the student who made $52 \div 4$ because 0 is smaller than 1. However, there was too much information students had to understand such as the rule of game, how to make dividend and divisor out of cards and die, procedural knowledge of long division, and comparing the reminder.

In addition to this, the meaning of remainder is complex notion. The given example above is simple because students had to compare 1 and 0. There are many possible counter examples; $25 \div 4 = 6 \text{ R}1$ and $37 \div 6 = 6 \text{ R}1$. In this case the remainders are the same as one. It is necessary to convert this remainder to fraction or decimal to compare precisely. Mathematically $25 \div 4 = 6\frac{1}{4}$ and $37 \div 6 = 6\frac{1}{6}$ and the remainder one is now changed into $\frac{1}{4}$ and $\frac{1}{6}$ depending on the divisor. Thus, the student who has $37 \div 6 = 6 \text{ R}1$ is supposed to win this game. Students in the classroom didn't seem to have solid understanding of the meaning of smaller remainder. As the notion of remainder is very complex, the exact meaning of remainder should have preceded before starting this game.

Looking across Kerry's teaching practice, it is obvious that Kerry wanted to do mathematics games to practice long division because that is what Mrs. Olive often did. Yet, Kerry's long division lesson seems to have been done in a much more limited manner. During the student teaching period, Kerry observed many times how Mrs. Olive used mathematics games to motivate students and practice skills. So Kerry wanted to adopt this strategy to practice long division. However, Kerry's explanation of her game was not clear, and it confused the students. It is possibly because Mrs. Olive proceduralized the long division lesson rather than focusing on the conceptual understanding and Kerry learns from it. Other possible explanation is that Kerry didn't anticipate how children would do this activity and failed to provide a clear rule for the winner when confusion started. Kerry attempted to teach mathematics with games to motivate students, but it

didn't come out successfully partly because of her own limited conceptual knowledge and also because of absence of her mentor. If Mrs. Olive was present in the classroom during the lesson, she would have been able to provide appropriate feedback or support.

Overall Summary

The concept of mathematical literacy continuously emerged as a critical notion for Kerry's identity development. In numerous interviews, Kerry explained how she obtained this view by describing her first experiences with math at home. Under the influence of her father, who was a high school mathematics teacher, Kerry recognized the importance of learning mathematics at home. Kerry had an opportunity to practice mathematical problems that related to everyday life with her father, and through that experience she learned how mathematics is used in everyday life. Because of this, she was highly motivated to learn mathematics. I also noticed that she frequently discussed her belief in mathematical literacy, mathematical goals, and the importance of carrying this notion into her future classroom.

Kerry saw herself as a constant learner. For example, when she failed algebra 1 in 8th grade, she didn't give up or escape but put in extra effort to overcome the hardships. A similar pattern was observed one more time during the student teaching period. When she was afraid and nervous about teaching mathematics, she continued to believe that she could always learn from her mistakes. According to Holland (1998), identifying themselves as who they are is

part of identity. Storytelling is also a part of identity (Drake 2009). Drawing on this literature, it can be said that identity is evidenced in practice and in stories. Her identity as a constant learner and her goal of mathematical literacy were reinforced while she was in the teacher education program.

When Kerry entered her university program, she already held the view that mathematical literacy is important. First, she took the classes MTE 180 and 181. She found these were valuable because she gained a lot of practical knowledge about teaching mathematics. In her senior year, Kerry took the mathematics methods class from Ms. P. Although she felt Ms. P's class was repetitive with MTE 180 and 181, there was one thing she liked. Kerry reflected that Ms. P's class influenced her to have a deeper understanding of mathematical literacy, and it provided an opportunity to think about gender issues in teaching mathematics, in particular.

Before taking this class, Kerry clearly connected with the idea of mathematics literacy, and her description about this class was consistent with her prior belief and goals that she held toward teaching mathematics. Wenger (1998) noted that identity is not just defined as who you are, but also where you have been and where you are going. It means one's prior beliefs and experiences influence who he or she is at present and one's goal and direction in life. Kerry's earlier experience from her parents influence contributed to her goal and image of what kind of mathematics teacher she wanted to be (like her father). Through

these early experiences, she gained knowledge and concrete examples of how to teach mathematics in alignment with her goals and desires from the methods class.

The importance of real world application in Kerry's mathematics teaching seems obvious in her interviews and the experiences she had. Kerry clearly exhibited that mathematics literacy is what she wanted to learn the most from her mentor. Kerry's participation during her field experience revealed a set of behaviors that allowed her to practice her identity in alignment with her goals. First, Kerry's teaching philosophy was similar to that of Mrs. Olive. Thus, Kerry highly valued her mentor's teaching practice and actively engaged her. She articulated in the interview that "Mrs. Olive teaches the mathematics the way I wanted to teach." This statement shows the evidence of Kerry's desire to take on the identity of her mentor.

Second, in Mrs. Olive's community of practice, Kerry was able to share her mathematical goals. She was also able to observe the teaching practice that aligned with her self-identity. Moreover, Kerry actively participated with planning the lessons with her mentor. More importantly, Kerry had the opportunity to teach lessons and obtain feedback to improve her lessons, which was close to her goal. Thus, throughout her participation, Kerry was able to practice her identity as a mathematics teacher and refine her identity based on the feedback from the mentor.

As Kerry expressed a desire to take on her mentor's identity, many similarities became evident in Kerry's teaching practice compared to her mentor.

For instance, she appropriated the practices of using multiple methods of teaching, real world applications, and differentiated group work, and her behaviors in these practices mimicked those of Ms. Olive. Mrs. Olive was a beginning CGI teacher and was developing her teaching practice based on CGI, such as, questioning skills focused on students' reasoning and conceptual understanding. Thus, Mrs. Olive herself was constructing her identity and her questioning skills and conceptual explanation were not strongly demonstrated during student teaching. Similar to her mentor, it was consistently observed that Kerry's lack of questioning skills and conceptual explanation of the content of the lesson. This relationship highlights the role of the mentor in shaping student teacher's teaching practice and her identity construction.

What we see in all of these cases in this study is that identity is developed to a great extent, prior to Kerry ever entering preparation programs. Across the multiple contexts, math methods class, and field experiences, Kerry engaged with communities of practice that were consistent with her earlier identity. These experiences played a critical role in solidifying the early identity and developing consistent teaching practices.

Summary

The stories of Jackie, Meg, and Kerry reveal that the process of identity development is complex because it shows a variety of experiences across multiple contexts. Thus, it is necessary to reconcile all three cases to have better understanding of identity development as a whole. In the section above, I

summarized the overall experience of each community of practice in relation to the student teachers' emerging identities. Drawing on Wenger (1998), "identity is socially constructed (p.145)" I briefly categorized the students' experiences based on whether the experience was consistent or inconsistent with their emerging identities. When it was consistent, I considered that identity was reinforced by the consistent social environment, and it is marked as "O." Inconsistent social structure was considered to suppress their emerging identities, and is marked as "X" (See table 6 in the next page).

Table 6

Summary of Multiple Contexts

	Jackie	Meg	Kerry
Early	X	X	O
Consis Methods	O	O	O
-tence Student teaching	O	X	O
Confidence	X	O	O
Opportunity to teach	X	O	O
Mentor feedback	X	X	O
Goal/where they are moving towards	Teacher who teaches mathematics with fun	Teacher who teaches mathematics with conceptual understanding	Teacher who teaches mathematics with mathematics literacy

Jackie and Meg reflected that their engagement with K–12 school experiences was not consistent with their emerging identity as a mathematics teacher. Both Jackie and Meg said that the identity they wanted to take on as a mathematics teacher was very different than that of their K–12 schoolteachers. Only Kerry

reflected that her prior experience was similar to her later experience in the teacher education program.

What is commonly shared among the three teachers was that their K–12 school experiences seemed to influence their confidence level of teaching mathematics. Regardless of consistency or inconsistency with their earlier experiences, all three student teachers' confidence level in teaching mathematics seemed to be primarily related to their K–12 school experiences. Meg and Kerry, who were confident in doing mathematics during this period of time, were able to continue holding confidence when they had to teach mathematics later on. Jackie's insecurity with mathematics while she was young was continuously observed as she moved toward becoming a mathematics teacher.

With respect to their experiences in mathematics methods class, all three participants reflected that it was helpful for them to build their teaching practice and align it to their identity. They all agreed that Ms. P's methods class provided teaching practices and knowledge that were consistent with their goals as mathematics teachers. This is the only characteristic that all of the student teachers shared in common. Jackie and Meg exhibited a strong desire to take on Ms. P's identity as a teacher. Kerry expressed that she too wanted to take on aspects of Ms. P's practice, especially real world applications. It suggests that the mathematics methods course reinforced the participating teachers' identity development. However, it has to be noted that these suppositions were still hypothetical at the time of writing this dissertation because at that point, the

novice teachers hadn't practiced their identity in their own classrooms yet.

Regarding the notion of Wenger's community of practice (1998), it is necessary to consider the relationships between opportunity to practice, their identity, and their identity development.¹

Experiences during student teaching varied across three teachers. During this period of time, two themes emerged as critical. One is the opportunity to teach mathematics, and the other is the apprenticeship structure, especially where it pertains to sharing goals with a community of practice represented by the mentor and obtaining feedback from the mentor. The overall result indicates that Kerry's case seems to be the ideal situation in which she was able to construct her identity aligned with her goals, because she had extensive practice, and active feedback from an experienced other in the field that actively shaped her knowledge, skills, and identity. All of her prior experiences were consistent with her identity. For instance, from early experiences she started to think about becoming a mathematics teacher who focuses on mathematics literacy. While going through the teacher education program, she was provided knowledge and practice that were consistent with her goals. During the student teaching period, Kerry was able to put her skills and knowledge into practice, and her mentor provided valuable feedback that helped her build her identity. In addition to this,

¹ I have followed up on these teachers in their first year of teaching. Anecdotal findings are consistent with the students' struggles to reconcile the methods course's pedagogy with their understanding of the requirements and norms of the school setting, coupled with their (lack of) confidence in their mathematical abilities.

Kerry was confident in learning and teaching mathematics and was not afraid to make mistakes. She believed in learning from mistakes constantly. Taken together, it is considered that Kerry was the one who probably held the most secure and positive identity as a mathematics teacher.

CHAPTER 6

DISCUSSION

Drawing on Lave and Wenger (1991), this study explored how preservice teachers develop themselves as teachers of mathematics, in particular, from the time of their teacher education courses to their field experiences. The study documented the critical experiences that contributed to the construction of identity and their roles as student teachers in their identity development. Lave and Wenger (1991) argue that a novice becomes an expert by increasing participation from that of legitimate peripheral participation to more central forms of participation as they develop the required skills and competence to become a master. Based on this notion, I defined the concept of professional identity as how teacher candidates view their role as mathematics teachers. I also consider it to include how they take actions based on their own personal history and how this specific perspective is continuously developed through the acquisition of new teaching skills and experiences.

All of the participant teachers in this study brought their incoming identities to the teacher education program, and how these identities were constructed was different for each. The answers for the following research questions explain the details.

Research Questions and Answers

1. How do aspiring elementary teachers construct their professional identity? Specifically in what ways do they develop an identity related to mathematics teaching during the critical period when they engage in the mathematics methods course and through student teaching?

With respect to the construction of one's identity, Wenger (1998) highlighted the role of both human agency and social structure. As he stated, the findings of this study reveal that the emerging identity of preservice teachers varied depending on the individual students' beliefs and knowledge, and the social structure of where they were situated. All three novice teachers' participation in multiple contexts—K–12 schooling, mathematics methods classes, and student teaching experiences—show the complexity of their existing identities and how they developed over time. As each student had a unique personal history and social context, it is not enough to fully understand identity development without comparing all three participant teachers.

The identity of each student teacher before entering university program was characterized differently. Jackie's mathematical identity was the least confident and secure, and she saw mathematics as irrelevant to everyday life. Further, she was not active in overcoming the struggles she had in middle school. Jackie's identity contrasts with Kerry's who was confident in mathematics and who loved mathematics and its real world application. She put in a lot of effort when she encountered hardships, which allowed her to overcome her struggles in

math. Of the three students, Meg was the most confident learner of mathematics. She saw herself as a successful mathematics student who rarely experienced struggles. All the participants brought their unique identities into the teacher education program. Each of them evolved differently over the course of their senior years.

The major goal of the methods class was to provide a conceptual understanding of math content, to propose new ways to think about math instruction, and to learn how to use a variety of teaching methods including hands on materials and math games. During the methods class, the student teachers in this study had various experiences that may have supported their identity development. For instance, they were exposed to a variety of teaching demonstrations from the instructor, knowledge and skills around mathematics teaching practice, opportunity to think about what it means to become a mathematics teacher, discussion about the role of mathematics teachers among peers, engagement with the class assignments and readings, and the ability to share their ideas about teaching mathematics with the instructor. Moreover, each had a practical internship during their methods semester that immersed them in observation of important aspects of teaching practice, some of which were mathematically oriented. This study reveals that, despite a sharing of common goals in this community of practice, what each participant took from the methods class was different. Also, each student's identity evolved differently, especially with respect to how they envisioned what kind of mathematics teacher they want

to be. Some aspects of this methods class provided experiences that were consistent with the participants' beliefs about teaching mathematics and their existing identities; but for others, it raised tension due to the conflicting views of teaching mathematics. Ronfeldt and Grossman (2008) stated that "during the transitional time represented by professional education, students negotiate their self-images as professionals with the images reflected by their programs" (p.41). Thus preservice teachers brought their incoming identities from their prior experiences and tried to reconcile them with existing identities and ultimately to "construct identities that fit into that world" (p.41).

Jackie and Meg's experiences from the methods class were very different from their earlier experiences, but in a positive way. Such inconsistency forced Jackie and Meg to re-conceptualize what it meant to teach mathematics and produce desirable teaching practices and knowledge. Jackie and Meg expressed that they wanted to teach mathematics differently than the way they were taught. When they started the teacher program, Jackie and Meg were challenged in methods class, which compelled them to act upon that knowledge. In sum, Jackie and Meg brought incoming identities that were not consistent with what was provided in the methods class, so they wanted to reconstruct their prior identity to become a different mathematics teacher that fit within the community of practice in which they belonged. As typical preservice teachers, Meg and Jackie brought their traditional beliefs and knowledge of teaching mathematics into the university mathematics methods class. In this class they were provided with knowledge that

focused on students' mathematical thinking, problem solving, multiple strategies, and reasoning. This knowledge was very different from the way they were taught. Such innovative ways of teaching mathematics challenged their prior image of what it means to teach mathematics. The cases of Jackie and Meg support the general argument that many research studies pointed out as the role of methods class. An extensive amount of teacher education literature has argued that university mathematics, methods classes provide reform oriented teaching approaches (Schram et al., 1988) that change the majority of student teachers' traditional beliefs toward more a reform-based perspective (Borko & Eisenhart, 1992; Cady et al, 2006; Ensor, 2001; McDiarmid, 1990).

Thus, the mathematics methods class influenced Meg and Jackie to take a different direction and become mathematics teachers that are different from those they experienced in the K–12 experiences. As they implemented their desires to become different mathematics teachers, it was necessary for Jackie and Meg to enact this identity and practice it. For Kerry, there was consistency between her incoming identity and what was provided in the methods class. Thus, Kerry was able to conceptualize the mathematics teaching practice more readily and carry out that practice in alignment with her identity, such as real world problems and differentiated group work. Consequently, the methods class provided Kerry with reinforcement and further refinement to be able to strengthen her existing identity; but for Jackie and Meg, it was an experience that required negotiation to practice the newly obtained knowledge and skills.

The student teachers' participation and negotiation of their identities continued during their student teaching experiences in more complex ways. Jackie, Meg, and Kerry developed their initial identities as mathematics teachers throughout the mathematics methods class. However, at the time, their participation was limited and hypothetical because they hadn't had much opportunity to practice their identities as teachers. During student teaching, Jackie, Meg, and Kerry were placed in a community of practice run by a master teacher and were provided an opportunity to practice their identity as mathematics teachers. Once again, depending on their personal agency and the social structure, the identity development of all three students varied over the semester.

Throughout her participation in the methods class, Jackie constructed her goal as a mathematics teacher who teaches math with fun and wanted to practice her identity during her field experience. However, during this period of time, Jackie's incoming identity as a fun mathematics teacher was reinforced the least. Jackie was situated in a classroom that was consistent with her image and goal of a mathematics teacher, but she did not have much opportunity to teach to reach her goal. Lave and Wenger (1998) argue that identity development is a negotiated process and novice teachers become experts through increasing participation. Jackie's participation remained peripheral during the student teaching period, and her opportunity to practice was not enough to fully participate as a mathematics teacher. Thus, Jackie's goal as a mathematics teacher was not supported by new

knowledge and skills leaving her to maintain her prior identity before the teacher education program.

Meg's case contrasts with Jackie's. Throughout the methods class, Meg developed her identity as a reform mathematics teacher who focuses on conceptual understanding and a desire to build the knowledge and skills that would reinforce her identity. However, the community of practice that she was situated in during her field experience did not provide the environment that was consistent with Meg's incoming identity. Nevertheless, unlike Jackie, Meg was able to increase her participation from peripheral to central participation; and she is considered the student teacher whose participation was the most central to the teaching practice. However, Meg was not a full participant in a reform community of practice because the goal of the situated community and the teaching demonstration from her master teacher contrasted with her emerging identity. Cole and Knowles (1993) mentioned, the process of negotiation is difficult, especially when there are conflicting ideas in learning to teach. Thus, Meg's developing identity was suppressed in this community of practice and she possibly had to have more time to practice and negotiate her developing identity.

Kerry can be considered the student teacher who was able to refine her identity the most in alignment with her goals. Kerry's teaching goal and her incoming identity emerged around teaching mathematics with real world applications. She considered her prior experience as similar to what she learned in methods class, and it continued over her semester of field experience. Both of

the math method class and student teaching provided consistent examples and strategies to build knowledge and skills around her identity, so Kerry was able to have many opportunities to hone her identity. Consistent with Lave and Wenger (1991), the stories of Jackie, Meg, and Kerry show that identity development involves more than just personal histories. It relates to the environment they are in, and it is an on-going process. Depending on where they were situated, the student teachers' participation level was different, and their identities were suppressed or reinforced across multiple contexts. Thus, it is necessary to investigate what kinds of experiences were important in their identity development.

2. What are the critical experiences, people, knowledge, and skills that contributed to the construction of identities?

Kennedy (1999) argued that preservice teachers' experiences from K–12 schools were influential to their teaching, because when they began to teach, they adopted the style of their former teachers in K–12 schools. Kennedy explains that it is because student teachers learn from their schooling as children what school subject matter and the role of students and a teacher in a classroom looks like. In other words, their teaching style is likely to emulate that of their own teachers and the way they were taught. With respect to the importance of K–12 school experiences, many researchers (Ball, 1990; Ebby, 2000; McDiarmid, 1990) state that student teachers' K–12 school experiences in learning mathematics are mostly traditional. The data from my study supports these ideas. Findings from

my study indicate that two out of three preservice teachers described their K–12 schooling as very traditional. It also shows evidence that student teachers’ prior experiences are critical in learning how to teach mathematics. In particular, they influence their attitudes towards mathematics as a teacher. Jackie’s case strongly demonstrates her negative experiences in learning mathematics, such as lack of confidence and lack of effort, and how they influenced her identity as a teacher. Similarly, the positive and successful experiences with mathematics during K–12 gave rise to confidence in teaching mathematics for Meg and Kerry. In this study, preservice teachers’ K–12 school experiences contributed to their identities, especially their confidence level in teaching mathematics.

This study also indicates that the mathematics methods class is also a critical experience. As noted earlier, Jackie and Meg came to the university program with traditional experiences in learning mathematics and held similar views of mathematics teachers. While taking the methods class, Jackie and Meg’s incoming beliefs and identities were reconstructed and they developed a desire to take on the identity that new models and the mathematics teacher provided in the method class. However, Jackie and Meg didn’t understand the depth of what it means to teach this way so they took on more superficial goals. Kennedy (1999) argued that the most important role of teacher education is to change the initial perspectives of early teachers as the “teacher education program is located in between their past experiences as a student and future experiences as a teacher. She also said, from this experience, teachers develop the ideas that will guide

their future practice” (p.57). In this study, the methods class served to challenge the student teachers and transform their image of what it means to be a mathematics teacher. For Jackie and Meg, Ms. P’s methods class impacted their incoming identities and provided examples of new practices that both of them wanted to adopt. This methods class was also critical for Kerry because she was able to reinforce her incoming identity by engaging with models of teaching that were consistent with her incoming identity. However, the participant teachers’ reconstructed and reinforced identities were, nevertheless, challenged by their mentor’s during their student teaching experiences as discussed above.

In sum, it is hard to provide a simple answer regarding what the critical experiences might be because all the experiences are interwoven, and they all impacted their identities to some degree. However, this study does raise two critical points. First, a preservice teacher’s prior experience is integral to their identity construction, especially their confidence in mathematics and their initial image of a mathematics teacher. Second, the knowledge and practice Ms. P provided during the mathematics methods class also impacted their identity construction. In particular, it challenged their incoming identities and provided new models of a mathematics teacher. As the preservice teachers started student teaching, mentor structures became the most important experience in shaping their identities. This is particularly true of the opportunity to teach mathematics and receive the mentor’s support and feedback. How it impacted student teachers’ identity construction is investigated as the last research question.

3. How does the context of student teaching impact pre-service teachers' identities and teaching practices?

Findings from this study indicate that the structure of student teaching practice, including apprenticeship under a mentor teacher, emerged as the most critical experience in shaping preservice teacher's identities in three ways. The first is the role of demonstrating expert teaching practices that are desirable to adopt. There is a prevalent belief that mentor teachers are supposed to serve as role models for student teachers, and that student teachers should emulate mentor teachers' teaching practices (Wang and Odell, 2007). This structure is similar to the apprenticeship model of midwives discussed by Lave and Wenger (1991). In this type of relationship, it is important for the apprentice to have goals that are similar to those of the community to maximize learning. As Ronfeld and Grossman (2008) noted, it is very difficult to reconcile their existing identity with their emerging identity as a mathematics teacher when the novice and the mentor do not share the same idea about what it means to become a mathematics teacher. Meg's case is a good example of this. As Meg's goal as a mathematics teacher was very different from her mentor's, the teaching model she observed did not align with her incoming identity. Yet, Meg was confident in teaching mathematics and held a clear view of a teacher of mathematics and had extensive amount of opportunity to teach mathematics. All these aspects helped Meg develop her identity as a more reform minded teacher in the beginning but due to

the absence of feedback, her professional identity as a mathematics teacher was reinforced in a limited way during her student teaching.

Secondly, student teaching was critical due to the opportunity to practice their knowledge and skills to practice their identities. Research studies argue that opportunity to practice is important for student teachers to learn because learning to teach can only be accomplished by engaging the novice teacher in authentic teaching tasks (Ball and Cohen, 1999) as opposed to pseudo teaching situations (Feiman-Nemser and Buchmann 1987).

As Lave and Wenger (1991) described in the learning of midwives, novices can easily learn meanings from those practices. The cooperating teachers provided student teachers with the opportunity to practice their knowledge and skills as they needed to build them to be a mathematics teacher. My study found that depending on their relationship with mentors, preservice teachers' participation varied from a more peripheral manner to a central manner. The stories of Jackie, Meg, and Kerry show evidence for how the different models of student-teacher relationships impacted their identity construction. As described so far, depending on how much freedom or opportunity to teach is given by the mentor, my student teachers were able or not able to practice their new knowledge and skills, which to a great extent determined how well they were able to develop their identities as teachers during their field experiences. In addition, the comfortable relationship between the mentor and the student teachers influenced participant teacher's opportunity to teach. The cases of Meg and Kerry clearly

show the evidence for this. Both Kerry and Meg had confidence in teaching mathematics, but they also felt very comfortable with their mentors. Meg had an internship with Mrs. Green in the previous semester, so she had already built a relationship with her mentor and was familiar with Mrs. Green's teaching practice. Meg felt comfortable enough to ask to try what she wanted to try, and her confidence in math supported her to take the opportunity. Similarly, Kerry had very comfortable relationship with her mentor as Ms. Olive's major goal was to make Kerry feel as comfortable as possible during student teaching. Kerry's confidence in mathematics and her willingness-to learn attitude also helped her not only to take the opportunity to practice her identity but to actively seek the feedback from the mentor. Jackie also had a good relationship with her mentor, but due to her lack of confidence, Jackie was not comfortable enough to take the opportunity.

Lastly and the most importantly, my study argues that the opportunity to teach is not greatly influential in the development of identities as mathematics teachers (at least in a positive manner) in and of itself, but that feedback must be provided to the preservice teachers to help them hone their practices and, thus, challenge or shape their growing identity to be consistent with the community of practice as represented by the mentor teacher. Another role of the mentor is supposed to be to help student teachers learn to teach mathematics by modeling it, by asking important questions about how to think about it, and by providing appropriate and immediate feedback so novices are able to improve their teaching

practices. By appropriate feedback, I mean feedback that improves their teaching strategies and knowledge that is consistent with their developing identity.

The student teachers in my study stated that they revised or followed the lesson plan depending on the mentor's feedback; so they considered their mentor's feedback as an important part of teaching evaluations. It calls attention to the need for appropriate feedback; for instance, the purpose of feedback, the focus of feedback, and the best time for giving feedback. Kerry's case is a good example. Kerry's mentor teacher, Mrs. Olive, attempted to provide immediate feedback by stepping in during Kerry's math instruction. However, sometimes it focused on procedural knowledge and missed questioning at a deep level of students' mathematical thinking as Mrs. Olive was developing her practice around this knowledge. While student teaching, Kerry held a goal of teaching mathematics with real world application and had opportunity to practice her identity towards her goal. Yet, Kerry did not obtain detailed feedback on how to elicit students' mathematical thinking and how to explain content conceptually. Thus, Kerry' teaching practice using games was conducted superficially without focusing on students' conceptual understanding. Kerry's case tells us that it is important to obtain feedback that contains critical aspects of learning to teach mathematics.

However, regardless of the level of autonomy, all of the student teachers stated that they wanted to respect their mentor's teaching style because it was her/his class. This implies that student teachers had to negotiate between what

they wanted to try and what was already given to them, how much they want to push/suggest in terms of their desire, or how much they accepted the given culture. As negotiation is also part of identity (Wenger, 1998), this power relationship seems to be important.

Of the three student teachers, Jackie's case strongly suggests the importance of having the opportunity to teach mathematics to build more confidence and acquire more content knowledge, which are needed to build around identity. Jackie did not have a positive relationship with mathematics during her early school years, and her incoming identity evolved into that of a fun mathematics teacher. Yet, her lack of knowledge and confidence limited her participation and ability to take on more central practices and identities of fun mathematics teaching. Meg's case also proves that student teaching is critical in two ways. First, it is important to share goals with a community of practice to have the opportunity to observe teaching practices that one values and wants to adopt. Second, it is important to receive feedback from the mentor to refine the identity towards one's goal of mathematics teacher. Kerry's case is better. She had positive experiences with mathematics both from home and school since she was young. And, Kerry was placed with a mentor that reinforced the ideas she learned in the methods class. Further, she was able to have extensive teaching practice, and Kerry's incoming identity as a constant learner allowed her take a more central role as a mathematics teacher. Kerry was supported by the mentor's prompt feedback compared to other student teachers. Yet, it is important to note

the complexity of identity construction. Even though Kerry's case was better than other preservice teachers, the feedback Kerry received lacked in depth because as mentioned above, it misses critical ideas in teaching mathematics. Kerry believed real world application—in her terms, mathematics literacy—was so important that she seemed to over simplify her goals as a mathematics teacher. Thus, at the time of writing this dissertation, Kerry possibly needed to have more practice to move her identity as a mathematics teacher toward her goal. This includes gaining content knowledge, conceptual understanding, pedagogical content knowledge, and questioning skills.

As I have argued thus far, my study shows that identities were not developed by the individual alone but by the engagement with the given community of practice. Shifter (1996) argued that the community of practice is important in identity because professional identity draws on experiences in different communities. Ma and Singer-Gabella (2011) pointed out that there is little research in teacher education that has focused on prospective teachers' identity construction in relation to the communities of practice they are in. This is especially true of studies that recognize different incoming identities in the first place. This study adds to the literature of teacher education by illustrating how prospective teachers' incoming identities impact their identities as mathematics teachers and how they negotiate the construction of their identities through the different forms of participation in different communities. As a future study, adding more cases of student teachers who engage in different mentoring

structures will be helpful to understanding student teacher's identity construction process, in both more depth and breadth. As a future study, various cases of prospective teachers can be added. In this way, it might be productive to follow a prospective teacher who sees herself/himself as a traditional mathematics teacher and wants to keep her/his incoming identity during mathematics methods class and investigate how student teaching impacts development of her/his identity.

Previous research has emphasized the importance of field experiences in terms of the acquisition of content knowledge and the development of beliefs about teaching mathematics; but the role of mentor and preservice teachers' identity development has not been widely discussed. Therefore, this study broadens teacher education literature by raising some compelling issues about the importance of the structure of the student teaching experience. We often think that one of the mentor's roles is to provide best teaching models, and novices are supposed to adopt or learn from the mentor. However, Meg's case showed that there are some cases in which the teaching philosophies are not aligned with each other, so learning will be reduced. Meg had a productive relationship with her mentor, and she was able to grow despite their differences. Yet, her learning was limited in that feedback was not consistent with her goals. Teacher education programs often regulate placement based on location or convenience. My study suggests that it is necessary to consider several issues when student teachers are placed. They should be placed into the mentor's classroom to maximize the student teachers' learning in alignment with their desired identity.

Implications of Mentor Practice in Teacher Education

My study highlighted the role of mentor relationships during the traditional student teaching period. Based on the analysis of mentoring relationships in the corresponding cases, this study suggests that successful mentoring requires the following three issues: Sharing common goals, opportunity to practice, and provision of feedback.

The case of Meg and Mrs. Green showed that developing shared goals is crucial to support the novice's teaching practice. Mrs. Green built a close relationship with Meg and greatly supported her in establishing classroom management skills while providing an extensive amount of teaching practice. However, Mrs. Green's class, the mentor's mathematics teaching practice was not parallel with the teaching pedagogy that Meg was prepared for from her teacher education program. Meg had to negotiate which practices to take on from among those provided by her mentor and by the teacher education program. An important implication of this relationship is that we need to provide ongoing professional development to mentors, not just as a one-time event, if we wish practices to be reasonably consistent across preservice teachers' experiences. The mentor workshops should include pedagogical content knowledge and classroom management that is parallel to the content that the protégés received from teacher education program. In this study, drawing on reform pedagogy, student teachers focused on students' mathematical thinking, problem solving with multiple

strategies, teaching mathematics with conceptual understanding, and questioning skills to elicit students' mathematical thinking.

Student teachers need the opportunity to learn how reform-minded teaching practices can be implemented in real classroom settings by the master teacher. In Meg's example, reformed mathematics teaching practice was not embedded in Mrs. Green's belief and teaching experiences. To prepare mentors to give specific support, teacher educators should build partnerships with mentors to help them understand and support the direction of the program and give them credit for it. By doing this we will be able to help potential master teachers to become potential mentor teachers.

More importantly, this study stressed that sharing a common vision of teaching mathematics is not enough to develop a consistent identity as a mathematics teacher, because student teachers need space to practice their knowledge and skills. Jackie's work with her mentor, Mr. Brown, confirms the importance of practice. Mr. Brown was a veteran teacher and mathematics was his strongest subject to teach. His mathematics teaching reflected reform pedagogy and consistently supported Jackie to be able to teach mathematics comfortably. However, it didn't seem that Mr. Brown pushed her to move out of her comfort zone until she gained independence and confidence. As Jackie was not confident in mathematics content and teaching practice, she needed an extensive amount of opportunity to practice her knowledge and skills, more so than the other cases.

Jackie's case also points out the importance of fading out control of masters and increasing student teacher's responsibility. Further study needs to be done to better understand how to balance the relationship between the mentor and the student teacher. In this case, it appeared that Mr. Brown didn't clearly realize where Jackie was in her development of learning to teach mathematics. Like children's development in learning mathematics, when we teach mathematics, we believe students' mathematical thinking and what they bring to the classroom is important to teach for conceptual understanding. During the apprenticeship, student teachers come to the field experience with their own teaching perspectives, identity, and experiences with mathematics. To help them to be more successful in their first year of teaching mathematics, it is important to educate mentors to better support their student teachers. Schwille (2008) emphasized tailored mentoring and stated that it is important to educate mentors to be able to understand where the novice was in his or her learning process and also in terms of their identity as mathematics teachers. We also need to provide mentors with opportunities to think about their role as mentors and about effective mentoring. It is a question on how best to support mentors to fill in necessary knowledge and skills around student teachers' emerging identities and enable mentors to modify their mentoring practices in response to their protégés.

Lastly, findings in this study highlight that the level of feedback from the mentor is also crucial. The most effective mentor in this study was Mrs. Olive. The factors that led to successful mentoring were that, like Mr. Brown, Mrs. Olive

shared similar teaching philosophy with her student teacher, Kerry, and like Mrs. Green, she provided Kerry with an appropriate amount of opportunity to practice.

As Mrs. Olive's teaching practice contained reform pedagogy that was consistent with the teacher education program, she consistently provided support and feedback for Kerry's teaching practice to help her improve her teaching. More importantly, what stood out the most from the relationship with Kerry and Mrs. Olive was that Mrs. Olive often provided *prompt and immediate* feedback compared to the other two mentors. Mrs. Green and Mr. Brown tended to provide feedback mostly after or before the class, and it was rarely observed that these two mentors jumped in while student teachers were teaching. Schwille (2008) called this type of instant/prompt feedback as "reflection-in-action" and emphasized that this type of mentoring is important for two reasons: 1) it helps novices learn the tasks of teaching as they occurred during teaching, and 2) it is helpful especially when facilitating student discussions that leads to conceptual understanding. The case of Mrs. Olive suggests that prompt feedback is critical in novices' learning to teach because discussion and conceptual understanding is central in reform minded teaching mathematics. It brings up the issue of training for mentors. Further study is needed to be able to state how to educate mentors to better provide feedback; when is the best time to step in or out; what are the major foci of the feedback such as pedagogical content knowledge, knowledge including questioning, student's mathematical thinking and classroom management; and how teachers should be provide feedback.

Wang and Paine (2001) stated “being a good teacher does not necessarily make one an effective mentor” (p.179). This statement emphasizes the importance of mentor education. My findings confirm this suggestion because it shows the mentors’ roles are huge in preservice teachers’ learning to teach and their identity development as well. However, we don’t know the long-term effect of mentoring practice (Evertson & Smithey, 2000) on teachers’ identity formation. One suggestion is to research various types of student-mentor relationships, such as Jackie with a mentor who really pushes her to teach, or Meg with a mentor who fits her needs. This will give us what we need to think about in placing student teachers in their mentor’s class in order to maximize the learning experience.

This study focused on the identity development of three preservice teachers from their teacher education program to field experiences, so it raises the issue of temporality, as identity is an ongoing process. Drawing on Lave and Wenger’s (1998) notion of identity as well as from what I found in this study, the results indicate that student teachers’ social structure is critical in shaping one’s identity as a mathematics teacher. However, the school structure as they are full time teacher was not considered in this study. It would have been more informative to follow the same preservice teachers into their K–12 classrooms and investigate their situated school culture. As an extension of this study, there is a need to do longitudinal research that investigates identity development not only within the university setting but also within school culture. As many research studies (Eisenhart and Borko, 1993; Kagan, 1992; Grossman 2000) point out, the

existing gap between student teachers' university classrooms and their social environment is crucial to address to help student teachers transition as smoothly as possible. In addition to the longitudinal study, it is worth researching the patterns of successful teachers to help first-year teachers. The more knowledge teacher educators have for this particular period of time, the better we can help pre-service teachers prepare.

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APPENDIX A

EXAMPLE OF INTERVIEW PROTOCOL FOR STUDENT TEACHER

► Prior experience

1. Tell me about your mathematical background as a student. (always successful on math, enjoying math?) Describe yourself as a mathematics learner (Auto biography).
2. Are there any experiences in math that you remember as being important?
3. Describe good/ideal math teacher from your experiences (role model of math teacher) ?
4. How the math method course has influenced you? What's been the most valuable aspect, or surprising? Describe an event from this course that stands out in your mind as important to you.
5. Compared to your own learning math experiences, how would you say her approach (method course instructor) to teaching mathematics? Similar or different? (or compared with your own experiences)
6. How much do you think you're using what've learned from this course? Why or why not? How much do you want to implement or what do you want to implement the most or the least, from method course and why?

► Relationship to mentor teacher and mentor's teaching practice

1. How does she or he provide feedback about your teaching mathematics in specific? When you teaching math, do you have full responsibility/autonomy including preparation of material?
(I want to see if student teacher has a chance to practice what she wanted to do, what she learned from Teacher education program)
2. How would you describe your mentor's teaching mathematics? What seems the most important thing (her main focus) in her/his teaching mathematics?
(If someone who never seen her teaching math and ask you, how does she teach mathematics, how would you answer for that question?)
3. How does your mentor's teaching practice influence you? How is your mentor teacher teaching math in relation to how you'd like to teach it?
(what do you like the most, you want to adopt, and revise a little, would do it differently)

4. What has been the biggest change in terms of teaching mathematics before and after student teaching? (e.g. expect A would be difficult but turned out to be easier, student thinking is more important than I thought etc.)
5. What did you learn the most from this experience and what would you still like to learn about teaching mathematics?

► **Identity as a mathematics teacher**
(adapted from Drake, Spillance, & Hufferd-Ackles, 2001)

1. Describe yourself as a teacher in general & a teacher of mathematics.
 - Why do you think that?
 - Is there any differences? If so, why?
 - Any experiences that leads you to describe yourself as what you said)
2. Describe your mentor as a teacher in general and a teacher of mathematics (same prompt question)
3. Describe your ideal image of mathematics teacher. What kind of a mathematics teacher do you want to become?
4. What are your goals for teaching mathematics?
 - Why is that a goal for you?
 - What knowledge or skills do you think you need to build to reach your goal?
5. Tell me 5 characteristics you think it is important to become a (good) mathematics teacher?
(content knowledge, responsibility, caring, patience, organization etc.)

Least most

_____ |-----|-----|-----|-----|-----|-----|-----|-----|-----|

1 2 3 4 5 6 7 8 9 10

Least most

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Least most

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1 2 3 4 5 6 7 8 9 10

Least most

_____ |-----|-----|-----|-----|-----|-----|-----|-----|-----|

1 2 3 4 5 6 7 8 9 10

6. As a student teacher, how would you position your role?

Leamer Teacher

|-----|-----|-----|-----|-----|-----|-----|-----|-----|

1 2 3 4 5 6 7 8 9 10

7. What do you expect to face the most challenging work when you go into your first year of classroom?

► **Relationship to the students**

1. How do you think children learn math the best?
2. What are the biggest challenges in teaching mathematics to students?
3. How observing/experiencing student's learning math in the classroom influence you as a mathematics teacher?
 - Tell me one example that explains the influence

APPENDIX B

EXAMPLE OF INTERVIEW PROTOCOL FOR MENTOR TEACHER

► **Prior experiences – background & teacher education program**

1. How many years have you been teaching?
 - What types of school environment, grade levels, K-8 certificate
2. I'd like to hear about your math autobiography. Tell me about your experiences with learning mathematics
 - Are there any experience that stands out to you as important in your math autobiography?
3. How have you learned about mathematics teaching? What was an experience that was important to you in learning about teaching mathematics?

► **Relationship to student teacher**

1. How do you provide feedback about student teacher's teaching mathematics in specific? When he or she needs to teach math how would you help her design the lesson? Do they have full responsibility/autonomy including preparation of material?
(want to know see if student teacher has a chance to practice what she wanted to do, what she learned from Teacher education program)
2. What is your goal of mentoring student teacher?
(to understand in what direction does the mentor lead the student teacher)

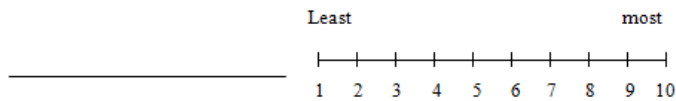
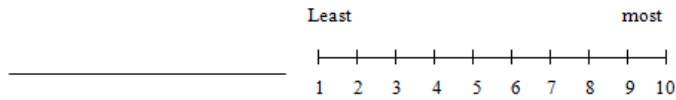
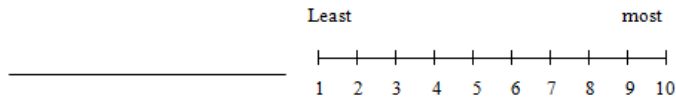
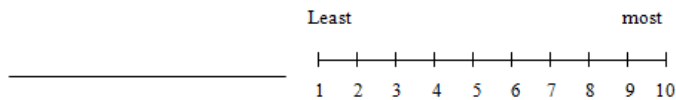
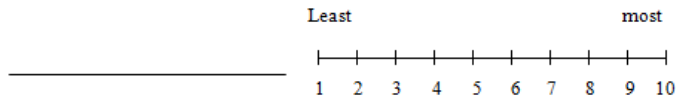
► **Identity as a mathematics teacher
(adapted from Drake, Spillance, & Hufferd-Ackles, 2001)**

1. Describe yourself as a teacher in general & a teacher of mathematics.
 - Why do you think that?
 - Is there any differences? If so, why?
 - Any experiences that leads you to describe yourself as what you said)
2. Describe your mentor as a teacher in general and a teacher of mathematics (same prompt question as # 1)
3. How might your colleagues describe you as a math teacher and why?
 - Can you tell me about an event that happened that leads you to believe students would describe you as what you described?
4. How would your students describe you as a math teacher and why? (same prompt question as # 3)

5. What are your goals for teaching mathematics?
 - Why is that a goal for you?
 - What knowledge or skills do you think you need to build to reach your goal ?

6. Tell me 5 characteristics you think it is important to become a (good) mathematics teacher?

(i.e. Content knowledge, responsibility, caring, patience, organization etc. Will help me understand mentor's teaching focus)




► **Relationship to the students**

1. How do you think children learn math the best?
2. What are the biggest challenges in teaching mathematics to students?
3. How observing/experiencing student's learning math in the classroom influence you as a mathematics teacher?
 - Tell me one example that explains the influence

APPENDIX C

INSTITUTIONAL REVIEW BOARD (IRB) CERTIFICATION LETTER



Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that **Hyun Jung Kang** successfully completed the NIH Web-based training course “Protecting Human Research Participants”.

Date of completion: 09/03/2008

Certification Number: 81252