TEACHER MATHEMATICAL IDENTITY AND PARTICIPATION IN AN ONLINE TEACHER PROFESSIONAL DEVELOPMENT (oTPD) PROGRAM

By

SHERRI KAY PROSSER

A DISSERTATION PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA

2014

I thank my parents, Elmer and Mary.

ACKNOWLEDGMENTS

My acknowledgements necessarily begin with my doctoral committee. My chair, Dr. Stephen Pape, gave me opportunities to teach a variety of courses and participate in several research projects. The knowledge that I have gained through these experiences has been invaluable. Dr. Nancy Dana, my co-chair, has been a rock throughout this process. Her calming presence belies the passion that she feels for her work. I would also like to thank my committee members, Dr. Tim Jacobbe, and Dr. Holly Lane, for their time and advice. In addition, I wish to thank Dr. Marty League for her continuous support and guidance throughout my doctoral years. She held roles as my supervisor, colleague and mentor and I do not know how I would have made it through this process without her.

I would like to thank my colleagues from Volusia County Schools. I would not have pursued this opportunity without insistence and support of my mentors, Dr. Beattie and Dr. Potter and I would not have persevered in this program without the guidance of Dr. Stephen Bismarck. I am very thankful that I have kept in close contact with each of you over the years and look forward to many years of collaboration.

I thank my fellow graduate students that comprised my support network. Jonathan Bostic, Karina Hensberry, and Anu Sharma preceded me in the mathematics education program and Yasemin Sert was here with me through the end. Their willingness to listen and their suggestions on how to navigate this process is greatly appreciated. Karina was instrumental in helping me survive teaching my first college-level course and it was wonderful to have Yasemin's companionship when we would take a break from writing. From those who began this journey with me in the special education cohort, I would like to thank Susie Helvenston and Kate Zimmer in particular.

Our close friendship has endured—and been strengthened by—this program and I know will continue to grow throughout the years.

In addition to the love and patience I felt from my family, I wish to acknowledge the friendship of my close friends Bill Sherrier and Kevin Alligood. Bill is the dearest friend I have ever had and is a fount of wisdom. He helped me to keep things in perspective and encouraged me to find balance in my life through running. He told me that getting a doctorate was like a marathon and that my last year was like the final10k: painful, but quitting was not an option! Kevin's companionship was always a source of enjoyment. His time and his family made my years here substantially more enjoyable. I would, of course, like to offer my sincerest gratitude to my participants, Heide and Brynn, for agreeing to speak with me about their thoughts and experiences.

TABLE OF CONTENTS

page

LIST OF TABLES

LIST OF FIGURES

Figure page

Abstract of Dissertation Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Doctor of Philosophy

TEACHER MATHEMATICAL IDENTITY AND PARTICIPATION IN AN ONLINE TEACHER PROFESSIONAL DEVELOPMENT (oTPD) PROGRAM

By

Sherri Kay Prosser

May 2014

Chair: Stephen Pape
Cochair: Nancy Dana
Major: Curriculum and Instruction

The purpose of this study was to gain insight into the relationship between teacher mathematical identity and participation in an online teacher professional development (oTPD) program. Teachers' individual characteristics are factors in the notable variance in learning and implementation after professional development (Lieber et al., 2009). That professional development is increasingly offered online would likely exacerbate these variances. This study extends prior research by examining teacher mathematical identity in an online setting and the relationship between teacher mathematical identity and participation in an oTPD program.

Two general education elementary teachers were chosen from a cohort that completed an oTPD program. Data collection included extant data from the oTPD program (i.e., activities, forum posts, PI-conducted interviews, surveys, measures of mathematical content knowledge, and levels of participation) and interviews two years post-oTPD program. Data were analyzed using qualitative methods to identify similar and divergent themes within and between cases.

Each case study described the participant's mathematics history, self-efficacy, mathematical knowledge for teaching (MKT; Chang, 2009), views on mathematics teaching and learning, oTPD program participation, and identity shifts. Cross-case analysis revealed that both participants had similar negative histories as learners of mathematics, which were related to their views of mathematics teaching and learning. Participants' personal attributes, beliefs about the purpose of professional development, and willingness to changes were factors in oTPD program participation.

Although their participation levels in the oTPD program varied considerably, both participants underwent shifts in teacher mathematical identity. The participants' self-awareness and the extent to which their current teacher mathematical identity aligned with the oTPD program content and pedagogy were related to their shifts in teacher mathematical identity. Implications for research and practice as well as limitations will be discussed.

CHAPTER 1
INTRODUCTION

> What teachers bring to learning to teach—prior belief and experience—affects what they learn. Increasingly, teachers' own histories—personal and professional—are thought to play an important role in what they learn from professional development experiences. (Ball, 1994, p. 20)

Recent changes in the national policies of the United States have led to increased accountability for the teaching and learning of K-12 mathematics. Due in part to high-stakes assessments, stringent standards have been set for teachers to be highly qualified in content areas and in instructional practices (National Governors Association Center for Best Practices, Council of Chief State School Officers [CCSSO], 2010; No Child Left Behind Act [NCLB] of 2001; National Council of Teachers of Mathematics [NCTM], 2000). A rising emphasis on science, technology, engineering, and mathematics (STEM) education puts even greater pressure on inservice mathematics teachers to implement standards-based practices. In addition, teachers of mathematics are being asked to teach in ways that they themselves did not learn and "past experiences can act as obstacles" in shaping teachers' learning and teaching of mathematics (Ball, 1994, p.15), which creates a pressing need for quality professional development (PD).

Development of effective PD is an integral part of the effort to reform the teaching and learning of mathematics. Until recently, PD was limited to brief, face-to-face sessions consisting of whole-group lecture and printed materials. Even when face-to-face PD is extensive, individualized, and has an onsite support component, there is still a notable variance in each participant's learning and implementation (Lieber et al.,

2009). Complicating the problem of less-than-effective PD is that, as new and more readily available technology has become available, PD is increasingly being offered online. In fact, online teacher PD (oTPD) is developing so rapidly that best practices for design and implementation have yet to be established (Dede, Ketelhut, Whitehouse, Breit, & McCloskey, 2009). Given this lack of established best practices, the variance in outcomes present in face-to-face PD would likely be exacerbated in online formats.

Teacher characteristics play a major part in what is taken away from PD. There have been several early childhood education studies (Brady et al., 2009; Downer, Locasale-Crouch, Hamre, & Pianta, 2009; Lieber et al., 2009), reading or language arts studies (Brady et al., 2009; Downer et al., 2009), and special education studies (Dingle, Brownell, Leko, Boardman, & Haager, 2011) on teachers' characteristics and corresponding responses to PD, but few exist in mathematics education (Chang, 2009). Substantial research has been done that considers teachers' education, certification, experience, and prior PD, but inservice teachers' beliefs and attitudes about mathematics and their subsequent professional growth have been less frequently studied. Although there has been a call for additional research in this area, one can conclude from existing studies that for "some teachers, beliefs change before practice, whereas for others, changes in practice precede changes in belief" (Philipp, 2007, p. 309).

To increase the likelihood of teachers' professional growth, PD developers need a greater understanding of the relationship between teachers' personal characteristics and how teachers engage in PD. Even though different teachers have different reactions to PD, considering their histories as learners and teachers of mathematics

helps explain their approaches in adapting to reform-based practices (Drake & Sherin, 2006). Until there are understandings of how individual teachers participate in oTPD programs and why their participation differs, changes cannot be made to ensure that the PD content and pedagogy reaches practitioners. As Putnam and Borko (2000) so aptly state, “How a person learns a particular set of knowledge and skills, and the situation in which a person learns, becomes a fundamental part of what is learned” (p. 4).

Context of the Study

The context of this study was a follow-up to *Prime Online: Teacher Pedagogical Content Knowledge and Research-Based Practice in Inclusive Elementary Mathematics Classrooms* (Prime Online), a yearlong oTPD program. The *Prime Online* PD program was the result of an Institute of Educational Sciences (IES)-funded research project to develop an asynchronous oTPD program for third- through fifth-grade general and special education teachers. The Prime Online PD program consisted of 27 modules, within three segments over a period of one year, that focused on developing mathematical knowledge for teaching (MKT), the characteristics and learning needs of students with high-incidence disabilities, and practitioner inquiry.

Segment One examined the NCTM (2000) Principles and Standards for School Mathematics, mathematical proficiency, the characteristics of students with learning disabilities (LD) and research-based strategies to address their learning needs, and the inquiry cycle (i.e., develop a wondering, collect data, analyze data, take action, share with others; Dana & Yendol-Hoppey, 2009). Segment Two explored number sense, conceptual knowledge of multiplication and division, representation and operations of fractions and decimal numbers, evidence-based practices and Response to Intervention (RTI) for struggling learners, and further involvement in the inquiry cycle. In Segment

Three, participants engaged in the inquiry cycle by choosing a *Prime Online* PD program mathematics concept that had been challenging to teach in the past. The participants used progress monitoring to collect and analyze data on their struggling students and their culminating project was shared via synchronous web conferencing software.

Each module had four sections (i.e., *Introduction*, *Anticipatory Activity*, *Content and Discussion*, and *Reflection and Assessment)* to provide continuity across the weeks. In addition, at the end of each module, one of the facilitators posted a Course Announcement that summarized the week's experiences. Typical module activities included reflecting on beliefs and experiences, working with manipulative materials, reading practitioner journal articles and PowerPoint presentations, and analyzing videos of lessons. The outcomes of these activities were often forum posts and assignments (e.g., uploaded documents or images).

Statement of the Problem

In their recent oTPD research agenda, Dede et al. (2009) state that program effectiveness is over-studied, particularly those using pre- and post-intervention surveys to determine participant satisfaction. Not only do most studies ignore data unique to online environments (e.g., discourse analysis, interaction with the content), there is also a lack of studies addressing the need to know *how* and *why* oTPD works—without ignoring the *what* (Dede et al., 2009). A qualitative study would help fill a gap in the literature regarding how and why teachers grow professionally (Craig, 2011), especially considering the recent emergence of oTPD programs. Pre- and post-measures are not enough; professional growth needs to be analyzed across time to show different stages of teacher learning (Dede et al., 2009).

Understanding individual teacher's views of mathematics and their MKT can help determine if information presented in PD will be accepted or rejected, which has considerable implications for PD designers, implementers, and facilitators. PD is more likely to have an impact (i.e., enhanced knowledge and skills) if it is prolonged, intense, and content-specific; provides active engagement with the content; and is relevant to classroom contexts (Garet, Porter, Desimone, Birman, & Yoon, 2001). Data also support the commonly held belief that when teachers from the same grade level work together, greater improvements in knowledge and practice will result (Garet et al., 2001). The *Prime Online* PD program had all of these components, but an initial analysis of the participants showed noteworthy variance in teacher satisfaction and MKT acquisition. To better understand underlying factors involved in these, and other, variances, the purpose of this dissertation was to study the relationship between teacher mathematical identity and participation in an oTPD program.

Research Questions

Although the *Prime Online* PD program provided the context of this dissertation, the unit of analysis was the individual teacher. In order to gain insights about how teachers learned from and interacted with an oTPD program, this dissertation utilizes narrative inquiry. Archival data were analyzed to determine the stories of the participants and post-oTPD program interviews were analyzed to write a narrative of the participants' experiences (Connelly & Clandinin, 1990). To study the relationship between teacher mathematical identity and participation of third-, fourth-, and fifth-grade general education and special education teachers from *Prime Online*, the following research questions were posed:

1. What is the relationship between teacher mathematical identity and participation in an oTPD program?
2. What do narratives reveal about shifts in teacher mathematical identity two years post-oTPD program?

Methodology

Individuals interact with contexts in different ways based on their histories as learners and teachers of mathematics. Specifically, "within a context teachers learn professional characteristics that are adopted by individuals in unique ways" (Beijaard et al., 2004, p. 177). Comments or feelings that the participants had at any stage of the *Prime Online* PD program would likely have changed, particularly as the participants had over two years to integrate activities and implement instructional strategies learned in the oTPD program. It was also possible that some of what participants found important during the *Prime Online* PD program were not particularly useful in new contexts or with new constraints. This study used narrative inquiry to gain insights into the relationship between teacher mathematical identity and participation within an oTPD program.

Themes found in a review of the literature (e.g., teacher role, history as a learner of mathematics) provided the basis for the research questions and, ultimately, the questions for the first of the two post-*Prime Online* PD program interviews that were conducted as part of this study. To form an initial understanding of potential participants' teacher mathematical identity and participation levels, data collected as part of the *Prime Online* IES-funded research project were analyzed. Following the guidelines put forth by Braun and Clarke (2006), theoretical (i.e., deductive or top-down) thematic analysis was used on the Content Knowledge for Teaching Mathematics [CKT-M] measures, Segment One activities, PI-conducted interviews, Segment Two activities,

participation chart, module surveys, and segment satisfaction surveys. In theoretical thematic analysis, initial themes are established deductively, but as those themes "play out across the data" the final themes may "include, speak to, or expand on" themes in related literature (Braun & Clarke, 2006, p. 13).

The initial understandings of potential participants' teacher mathematical identity guided the purposive sampling of two participants with whom I would conduct two interviews. The questions in the first interview focused on constructs related to teacher mathematical identity and mirrored topics discussed during the *Prime Online* PD program (e.g., best recent mathematics lesson, perception of teacher role, definition of mathematical proficiency). A narrative of each participant's *Prime Online* PD program teacher mathematical identity and participation in the oTPD was written based on the analysis of the *Prime Online* PD program archival data. Then, based on analysis of the first interview, a separate narrative of each participant's present day teacher mathematical identity was written. A second set of interview questions was developed, specific to each participant, to clarify or expand upon interesting or conflicting statements that were uncovered during data analysis. The second interviews were conducted and analyzed, and then data were integrated into the existing narratives, as appropriate. Finally, each participant's present day teacher mathematical identity (i.e., two years post-oTPD) was compared to the *Prime Online* PD program teacher mathematical identity and a third narrative was written to describe shifts in their identity.

Overview of Constructs

Teacher Identity

Identity is an important construct when investigating the impact of PD because "a teacher's identity is shaped and reshaped in interaction with others in a professional

context" (Beauchamp & Thomas, 2009, p. 178). Teacher professional identity has been defined in very specific terms (e.g., encompasses knowledge and beliefs as well as sense-of-self, dispositions, interests, and ideas about work and change; Spillane, 2000) and in more of a broad sense (e.g., integrates personal and professional selves; Day, Kington, Stobart, & Sammons, 2006). After an analysis of recent research on teachers' professional identity, Beijaard, Meijer, and Verloop (2004) suggested that professional identity is an ongoing process, implies both a person and a context, consists of sub-identities, and connotes agency. As identity is not static, a teacher could have a different sub-identity in each subject area or course being taught. In truth, one's identity could be the answer to "Who am I at this moment?" (Beijaard et al., 2004, p. 108). Mathematics, therefore, provides a different context in which teachers can interpret, learn about, and implement reform (Spillane, 2000) and should be investigated as a distinct type of teacher identity.

Views of Mathematics

The overall purpose of PD is teacher learning that results in increased student achievement. Teachers' affect has been shown to impact their instruction and must be considered in mathematics PD programs. Negative views can extremely impede one's development as a quality teacher of mathematics (Hannula, Kaasila, Laine, & Pehkonen, 2005) and beginning elementary teachers without a background in mathematics have low teacher efficacy and decreased efficacy development, which can result in "lower quality of teaching" and "problems or difficulties in students' learning" (Chang, 2009, p. 293). The "feelings teachers experienced as learners carry forward to their adult lives, and these feelings are important factors in the ways teachers interpret

their mathematical worlds" (Philipp, 2007, p. 309). Teachers' beliefs and views of mathematics have been studied as:

- "belief of own talent, belief of difficulty of mathematics, and liking of mathematics" (Hannula et al., 2005, p. 3-95);
- "beliefs about the nature of mathematics, beliefs about mathematics teaching, and beliefs about student learning" (Cross, 2009, p. 328);
- nature of math, important elements in role as a teacher, confidence in teaching math (McDonough & Clarke, 2005); and
- view of themselves as learners and teachers of mathematics, view of mathematics and its teaching and learning, and view of the social context of learning and teaching mathematics (Kaasila, 2007; Kaasila et al., 2008)

The *views of mathematics* construct used in this dissertation comprises views of self-as-learner (e.g., mathematics history), views of self-as-teacher (e.g., efficacy), views of mathematics teaching (e.g., teacher role), and views of mathematics learning (e.g., how students learn).

Narrative Inquiry

This dissertation relied heavily on narrative inquiry and theories of identity development. Narrative inquiry studies human experience (Clandinin & Rosiek, 2006) and narratives can "provide a basis for studying teacher knowledge and teaching and a basis for teacher professional development and education" (Chapman, 2008, p. 16). Narratives have gained favor in mathematics education during the past two decades because of the link between teachers' storied histories and teacher knowledge (Chapman, 2008). Through these stories, narrative inquiry allows for a deeper understanding of the process by which teachers learn (Craig, 2011) and how they understand themselves, both personally and professionally (Drake, Spillane, & Hufferd-Ackles, 2001; Kaasila, Hannula, Laine, & Pehkonen, 2008).

Sfard and Prusak (2005) have established a narrative concept of identity that equates identity with stories told by or about a person and are, therefore, "reasonably accessible and investigable" (p. 17). Narratives-as-identity are further interpreted as either actual or designated identities. Actual identity is based on the current state of matters and designated identity is based on present or future expectations. "Designated identities are stories believed to have the potential to become a part of one's actual identity" (p. 18). Narratives that convey a bridging of the gap between actual and designated identity can then be perceived as changes in one's teacher mathematical identity.

Participation in Online Teacher Professional Development

Teacher identity is the way in which teachers come to know and understand themselves and is also a mechanism for guiding actions (Drake et al., 2001). Thus, teacher identity both affects and is affected by participation in PD. Measures of online participation can include the number of forum posts (Hrastinski, 2008; MacAleer & Bangert, 2011; Yang & Lui, 2004), the types of interactions (i.e., student–student, student–teacher; Wise, Chang, Duffy, & del Valle, 2004; Yang & Lui, 2004), quality of writing (Groth, 2007; Hrastinski, 2008), social presence (Picciano, 2002; Richardson & Swan, 2003; Wise et al., 2004), or perceptions of learning (Hrastinski, 2008; Picciano, 2002). In addition, it is argued that perceptions of learning be considered a performance outcome because these perceptions could incite one to seek out more learning opportunities (Picciano, 2002). For the purposes of this study, participation is comprised of completion of module surveys and CKT-M measures, engagement with Segment One and Two activities, and assignment completion and frequency of posts.

Structure of the Dissertation

This dissertation consists of six chapters. Chapter 1 is an introduction and contains an overview of the literature and the context of this study. Chapter 2 reviews three areas of literature: teacher identity and narratives as methodology, teacher mathematical identity, and participation in online teacher professional development. Chapter 3 includes a description of narrative inquiry, a thorough description of the context for this study, participant selection, data collection, and data analysis procedures. Chapters 4 and 5 present the findings for each participant separately as detailed narratives. Chapter 6 discusses the conclusions and implications of this research, as related to the purpose and research questions.

CHAPTER 2
REVIEW OF THE LITERATURE

The purpose of this dissertation was to examine the relationship between teacher mathematical identity and participation within an oTPD program. In this chapter, I present three relevant literature reviews that shaped how I approached this narrative inquiry. I begin by sharing literature that describes the constructs of identity and the study of identity using narrative inquiry. Once the importance of identity in teacher education has been established, the next review centers on components of teachers' mathematical identity construction and development. The final review pertains to the relationships between teacher identity and participation in oTPD program.

Teacher Identity

Interest in identity is not limited to the field of education; it has also been explored in psychology, anthropology, and philosophy. Within the field of education, much disparity exists in the definition of identity. The construct of teacher professional identity is interconnected with the concepts of emotions, agency, self-concept, and discourses, and one's personal identity cannot be extricated from one's professional identity (Beauchamp & Thomas, 2009). Although it is commonly accepted in educational research that identity is dynamic and changes due to both internal (van Veen & Sleegers, 2006; Zembylas, 2003) and external (Flores & Day, 2006; Rodgers & Scott, 2008) factors, defining identity is understandably problematic for researchers. Connelly and Clandinin (1990) explain:

> Identity is a term that tends to carry a burden of hard reality, something like a rock, a forest, an entity. Being true to this identity, being true to oneself, is often thought to be virtue. Yet, from the narrative point of view,

> identities have histories. They are narrative constructions that take shape as life unfolds and that may, as narrative constructions want to do, solidify into a fixed entity, and unchanging narrative construction, or they may continue to grow and change. They may even be, indeed, almost certainly are, multiple depending on the life situations in which we find ourselves. This is not less true for teachers in their professional knowledge landscape. (p. 95)

Historical Constructs

In his seminal piece, Gee (2000) proposed four types of identity: the *nature perspective* (i.e., N-Identities), the *institutional perspective* (i.e., I-identities), the *discursive perspective* (i.e., D-Identities), and the *affinity perspective* (i.e., A-Identities; Table 2-1). This approach is based on one's recognition as a "certain kind of person" instead of identity being solely an internal state (p. 100). The four types of identity are presented not as discrete terms but as a means of analyzing one's actions as an ascribed or an achieved identity. The N-Identity is a matter of genetics, whereas the I-identity is viewed as somewhat imposed by others. For example, I-Identity could refer to how teachers view their roles. In addition, one's I-Identity can be measured on a continuum; it could be welcomed by an individual or merely passively accepted. Gee (2000) refers to the two extremes of this continuum as being a *calling* or being an *imposition*. While it is unlikely that teachers would consider their roles as an imposition, it is reasonable to expect that there are differences in how individuals view their role as a teacher. The D-Identity is constructed and sustained when other people talk about or interact with an individual in a way that reinforces a trait. D-identity is also on a

continuum, with one extreme being labels that are pursued (e.g., charismatic) and the other being labels that are attributed (e.g., attention-deficit hyperactivity disorder).

Although these four perspectives are inextricably linked, the A-Identity view most relates to this dissertation. A-Identities formed at the behest of a school, for example, are "institutionally sanctioned" A-Identities (Gee, 2000, p. 107) and have been used as framework with which to analyze the identity formation of preservice teacher (PSTs) (Jewett, 2012). The affinity perspective—based on shared experiences and practices—implies social constructionism; however, the affinity perspective focuses primarily on group membership instead of interactions. To clarify, one's identity is affected by the bond formed around the common context, not the bond between group members. The common context of this dissertation is *Prime Online*, an oTPD program.

Table 2-1. Four Ways to View Identity (Gee, 2000)

Type of Identity	Process	Power	Source of Power
Nature-identity	a state developed from	forces	in nature
Institution-identity	a position authorized by	authorities	within institutions
Discursive-identity	an individual trait recognized in	the discourse/dialogue	of/with others
Affinity-identity	experiences shared in	the practice	of affinity groups

Contemporary Constructs

Gee's (2000) framework has been used to explore notions of teacher identity in recent research studies (Gresalfi & Cobb, 2011; Settlage, Southerland, Smith, & Ceglie, 2009) and dissertations (Jewett, 2012; Krzywacki, 2009). Settlage et al. (2009) used A-identity to explain the choices made by PSTs (e.g., when best practices conflicted with a student teaching placement). Gresalfi and Cobb (2011) expanded upon the notions of

institutional identity and affinity identity to account for normative identities (i.e., identity established within a context) and teachers' personal identities (i.e., identity developed by participation in that context) during PD discussions.

Personal identities were examined in terms of whether teachers resisted, complied, or identified with the normative identities, thereby illuminating the process by which teachers reconceptualized what it meant to teach and learn mathematics. The researchers found that motivation was the stimulus for teacher change. Teachers' feelings of closeness with the normative affinity identity (i.e., the PD program group) and the importance the teachers gave to the normative institutional identity (i.e., what it means to be competent) were the two integral factors in improving instructional practices.

A-identity can also be used to describe the impact of PD on teachers' professional identity development. Individuals' process of navigating a community of practice (e.g., PD) and their narrative about that process represents individuals' *core identity*, which is "never fully formed or always potentially changing" (Gee, 2000, p. 111). Some have equated Gee's (2000) concept of core identity as synonymous with professional identity (e.g., Sutherland, Howard, & Markauskaite, 2010), but many studies of teachers' professional identity tend to focus on teachers' personal practical knowledge (Beijaard et al., 2004). Based on a review of recent research, Beijaard and colleagues (2004) identified four essential features of teachers' professional identity: an ongoing process, interconnectedness between person and context, sub-identities, and a sense of agency.

Still others take a more global view on identity. According to Rodgers and Scott (2008):

> Contemporary conceptions of identity share four basic assumptions: (1) that identity is dependent upon and formed within multiple contexts, which bring social, cultural, political, and historical forces to bear upon that formation; (2) that identity is formed in relationship with others and involves emotions; (3) that identity is shifting, unstable, and multiple; and, (4) that identity involves the construction and reconstruction of meaning through stories over time. (p. 733)

Because identity integrates emotions and a sense of agency, there are widely recognized and well-studied affective constructs related to identity and identity development. In an effort to understand how PSTs understand their professional identity, Timostsuk and Ugaste (2010) chose participants based on maximum variation sampling (Creswell, 2002). PSTs from large and small programs and from various subject area concentrations were individually interviewed to elicit perceptions of their role as a teacher. Textual segments were then coded into four categories based on Wenger's (1998) theory of learning (i.e., experiencing, doing, belonging, learning). The 'experiencing' category occurred most frequently, by far, and was sub-categorized as environment (e.g., the passing on of content-specific knowledge), emotions (e.g., pride in motivating students, fear of own failure), and activities (e.g., successes and setback in classroom instruction). Given the inevitable contradictions between teaching contexts and individual values and beliefs, teacher educators need clarification on which components of professional identity to focus (Timostsuk & Ugaste, 2010).

Identity and narratives

Whereas some scholars (e.g., Connelly & Clandinin, 1999) see narratives as a means of expressing identity, Sfard and Prusak (2005) view identity as stories that can be used to explore one's learning. This more functional definition states that identities are not found *in* stories; they *are* stories and allow researchers to answer the question: "Why do different individuals act differently in the same situations?" (p. 14). By equating narratives with identities, stories can be used to study learning and allow the mechanisms of this learning (i.e., identity development) to be told.

Identity development is inexorably tied to communication, one's thinking, and stories that are "*reifying*, *endorsable*, and *significant"* (Sfard & Prusak, 2005, p. 14). To reify is to make something more concrete by using verbs that connote permanency (e.g., be) and adverbs that imply repetition (e.g., usually). Stories about a person are considered endorsable if that person would say the stories are accurate replications. Narratives are significant if they impact the storyteller's thoughts about the identified person; stories about one's degree of membership in certain communities are often the most significant stories of all. This is key, given that PD is typically social and context bound.

Sfard and Prusak (2005) argue that it is not experiences but the vision of our—or others'—experiences that form identities, and that stories that one tells oneself comprise what most people view as identity. Indeed, some view identity as the telling and retelling of stories over time (Rodgers & Scott, 2008). These *self-told* stories are "part of our ongoing conversation with ourselves" and, therefore, most likely affect change in one's actions (Sfard & Prusak, 2005, p. 17). Unfortunately, as researchers and teacher educators, we are not privy to these self-told stories and must rely on the

re-telling of these stories when studying changes in identity. Further complicating matters, teachers have multiple professional identities (Rodgers & Scott, 2008) and elementary school teachers likely have a sub-identity for each subject they teach. Therefore, when studying the identity of inservice teachers, it is prudent to focus on subject-specific identities.

Teacher Mathematical Identity

Building on Sfard and Prusak's (2005) definition of identity, Kaasila et al. (2008) explain how mathematical identity includes one's *view of mathematics* as a fundamental part of this sub-identity, which entails "knowledge, beliefs, conceptions, attitudes, and emotions" (p. 112). Teachers' views of themselves as teachers and learners of mathematics (Kaasila et al., 2008), views of mathematics teaching and learning (Kaasila et al., 2008), and their content knowledge (CK), pedagogical knowledge (PK), and pedagogical content knowledge (PCK; Hobbs, 2012) are fundamental parts of teacher mathematical identity. Shulman (1986) introduced the domains of CK, PK, and PCK as a way to understand the knowledge needed in order to teach mathematics effectively. These domains have been refined and are now recognized as MKT (Hill et al., 2008). Both Shulman's (1986) and Hill et al.'s (2008) frameworks are further explained in the upcoming section on MKT. Constructs related to knowledge and beliefs have framed studies of mathematics teachers' efficacy, identity development, and professional growth.

For example, teachers' content knowledge was a factor in the efficacy development of beginning elementary school teachers studied by Chang (2009). Based on performance on a mathematics teaching efficacy scale, 64 teachers were placed in low, medium, or high efficacy groups. Six teachers, two from each level, were

purposively selected for further study. Interviews, teachers' weekly reflections, and observations verified that teachers had progressed to the next gradation of an overlapping five-gradation model developed by Chang and Wu (2007). By year's end, the low efficacy teachers had only reached the second gradation and the medium efficacy teachers had reached the third gradation. Both high efficacy teachers went through the first two gradations within the first two months of the school year. One eventually reached the fourth gradation while the other—the only one with a mathematics and science background—reached the fifth gradation. Teachers in the same efficacy level progressed in a similar manner and differences were attributed to variations in internal and external factors. External factors were administrator and peer support and internal factors included teachers' beliefs, past experience teaching mathematics (e.g., tutoring), MCK, and educational history.

Mathematics history

Changes in teacher expectations due to the Principles and Standards for School Mathematics (NCTM, 2000) and the more recent Common Core State Standards for Mathematics (CCSS-M; CCSSO, 2010) have caused a gap between many teachers' current identity and other-designated identity (i.e., institutionally-sanctioned A-Identities). This is partly due to inconsistencies between teachers' histories as learners of mathematics and their experiences as teachers of mathematics. Furthermore, teachers' histories and MKT can affect interaction with a mathematics methods course in a variety of ways. For example, Ebby (2000) found that a PST with a strong mathematics background learned that there is a myriad of ways to work through a problem, a teacher with negative experiences in mathematics reconsidered her

assumptions, and a teacher with a traditional view of mathematics teaching came to recognize the importance of student-centered teaching.

In order to connect current professional identity to the narrator's past, a researcher might seek to determine what events or factors brought about change in the teacher's mathematical identity. Kaasila (2007), for example, interviewed PSTs at the beginning of a mathematics methods course. The questions centered on the PSTs' experiences as learners of mathematics and their views of themselves as teachers of mathematics. At the end of the course, the teachers were again asked about their views as teachers of mathematics. Kaasila (2007) focused on student teachers' comments during data analysis of interviews and teachers portfolios that "used evaluative language, negatives, repetition, contrastive connectives, or detailed description" (p. 211). One participant, Leila, clearly had a negative history as a learner of mathematics (e.g., "helpless", "barely scraped by"; p. 208) and did not feel competent to teach the subject at the beginning of the course. The positive change in Leila's mathematical identity was equally evident by the end of the course, as she felt more satisfied with her lessons and looked forward to teaching mathematics in her next placement. After a secondary analysis of the interviews, Kaasila (2007) posited that the *how*s and *why*s of the changes in Leila's mathematical identity were influenced by key events (e.g., success with a learner-centered approach to teaching mathematics) and significant others (e.g., support by peers and supervising teacher).

As seen in the previous study, a negative beginning as a learner of mathematics does not preclude one from acquiring a positive view of oneself as a teacher of mathematics. In another study, Kaasila et al. (2008) considered how PSTs viewed

themselves as learners and teachers of mathematics as well as how they viewed the learning and teaching of mathematics and examined facilitators of change in their beliefs. Data sources included pre- and post-questionnaires that assessed the PSTs' mathematical experiences and views of mathematics. Tasks to measure conceptual understanding, computation skills, and an understanding of pupils' errors were also included. Of the 269 participants, 21 were interviewed and four were selected for follow-up interviews. Two had a positive view of mathematics, high self-confidence, and mathematics achievement scores in the top 30%. The other two had a negative view of mathematics, low self-confidence, and pre-test performance in the lowest 30%. Each narrative case study sought to determine changes in motivations and dispositions by characterizing whether participants' comments implied task orientation (i.e., intrinsically motivated), social dependent orientation (i.e., help seeking), or ego-defensive orientation (i.e., low expectation).

The narratives indicated, either directly or indirectly, whether participants felt their views of themselves as learners and teachers of mathematics had changed. Students' memories of school mathematics, their views of mathematics, and their mathematical skills were used to determine initial socio-emotional orientations. Then the researchers compared pre- and post- performance on a mathematics test and analyzed interviews to establish an updated socio-emotional categorization of the participants. Of the four case studies presented, three participants had substantial changes in their view of mathematics teaching and one had a moderate change. Three course activities were suggested as the main facilitators of these changes: (a) reflecting on one's mathematical experiences, (b) exploring content with manipulative materials, and (c)

working with others. The authors concluded that, although participants' views as learners of mathematics were the least likely to change, the growth made in MCK and the other affective categories were encouraging. It follows, then, that past mathematics experiences and current identities would impact teachers' desires and abilities to fully participate in a mathematics-based oTPD program.

MKT

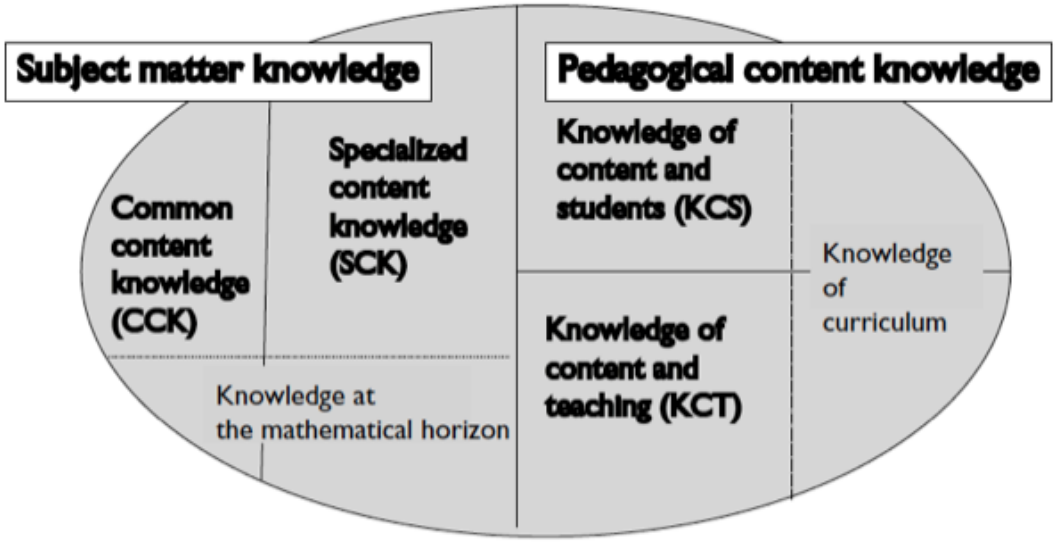

Figure 1-1. Domains of Mathematical Knowledge for Teaching. From *Knowing and using mathematics in teaching* (p. 19), by D. L. Ball, H. Bass, H. Hill, L. Sleep, G. Phelps, & M. Thames, 2006, Learning Network Conference: Teacher Quality, Quantity, and Diversity, Washington, DC.

The size of the gap between current and designated identities is also important because the designated identity needs to be seen as achievable (Sfard & Prusak, 2005). Thus, the mathematical content of a PD must be accessible to all teachers, given that it would likely contain both MCK and PCK components. MCK is conceptual knowledge about mathematics, whereas PCK is an understanding of mathematical content, how students learn that content, and how to teach students (Shulman, 1986). A more recent conceptualization, MKT, has four domains (i.e., common content

knowledge, specialized content knowledge, knowledge of content and students, knowledge of content and teaching) that build on Shulman's (1986) work and encompasses the knowledge required for teaching mathematics (Figure 1-1; Ball, Sleep, Boerst, & Bass, 2009).

Many elementary teachers lack the conceptual knowledge and deep understanding (Ball et al., 2009) that are required to teach mathematics effectively. Content knowledge alone is not enough; teachers with strong MCK may not be willing or able to explain concepts to students (Kahan et al., 2003). Indeed, the number of mathematics courses taken by a teacher is not highly correlated with student outcomes (Swars, Hart, Smith, Smith, & Tolar, 2007). Knowledge of how students learn (i.e., PCK) is also necessary. Although the majority of teacher identity research is on PSTs, it is important to reiterate that inservice teachers also undergo shifts in identity.

PD is a vehicle for teachers to increase knowledge, re-craft identifies, and question existing practices (Battey & Franke, 2008) and inservice teacher identity development occurs most often during times of educational reform (Day, Elliot, & Kington, 2005; van Veen & Sleegers, 2006) when teachers are asked to shift their instructional practices and the ensuing view of themselves as teachers of mathematics (Drake et al., 2001; Spillane, 2000). PD is inherently designed to support teachers' professional growth but ought to be differentiated to accommodate individual teachers' current levels of MKT. PD is a vehicle for teachers to increase knowledge, re-craft identities, and question existing practices (Battey & Franke, 2008). Therefore, recognizing and acknowledging teachers' current identities could support the

development of MKT and subsequent shifts in teacher mathematical identity. MKT can also influence how one sees oneself as a teacher of mathematics.

Self-as-Teacher of Mathematics

How one sees oneself as a teacher and learner of mathematics is influenced by MKT, perceptions of teacher role, beliefs about mathematical proficiency, and affective characteristics (e.g., confidence). To study perceptions of what it means to be a good teacher, Grion and Varisco (2007) designed an asynchronous discussion board to analyze the writing and assignments of 47 inservice and PSTs. The focus of the project, which occurred over a 4-month period, was the development of identity and collaborative practices. Each participant wrote two profiles of what constituted being a good teacher, one pre-intervention and one post-intervention. Individuals also shared a challenging situation from their own school years and constructed a case synthesis in groups. Discussion posts were coded as social, cognitive, or teaching speech segments using qualitative methods. The statements were then coded for varying levels of awareness and as teacher-focused, child-focused or inclusive. As might be expected, the word selection of the PSTs showed more growth than did the inservice teachers. The PSTs' pre-intervention writings about what it means to be a good teacher emphasized words related to feelings and attitudes and *love* and *sweetness* and *patience* and *sensitivity* were most commonly used. The PSTs' post-intervention writings provided more detailed descriptions and included more words related to professional skills and knowledge; words such as *reflection*, *assessment,* and *group* (i.e., the ability to work in a team) were most commonly used. In contrast, the inservice teachers had well-defined professional identities that did not alter much during the brief

research project. Grion and Varisco (2007) state that there is a “strong need to explore” the finding that inservice teachers were viewed as being rigid in both the forums and the case syntheses.

This image of a model teacher mirrors Sfard and Prusak’s (2005) designated identity and was the basis for a dissertation about PSTs in a masters-level mathematics education course (Krzywacki, 2009). Of eighteen possible candidates, two were purposively sampled for case study analysis based on background information and perceived evidence of growth during the course. The cases (i.e., John and Mary) differed in their motivation; John was unsure of his motives for wanting to be a teacher and Mary felt strongly about her decision to become a teacher. In addition, John had completed previous education coursework and Mary had not.

Data were collected over one academic year. The main data sources were three semi-structured individual interviews and portfolios, feedback surveys for the course, and essays written about school memories were supporting data. During the initial interviews, the PSTs were asked about their reasons for becoming a teacher, their educational history, their expectations of the course, their views on teaching and learning mathematics (e.g., mathematics history), what constitutes being a good teacher, and their perceptions of how to become that good teacher. The second interview asked students to reflect on the responses to the first interview, their updated strengths and concerns about being a good teacher, and their updated expectations for the course. The post-interview included reflections on a videotaped lesson, what constitutes a good teacher, how they felt about the course, and their strengths and concerns about being a good teacher.

Content analysis of the interview transcripts revealed three main categories: conceptions of teaching and learning mathematics, personal process of becoming a teacher, and teacher education programme supporting individual development. Noteworthy differences emerged. John viewed MCK as integral to being a good math teacher; Mary's views were more related to affective components (e.g., ability to motivate students). In regard to closing the gap between actual and designated identities, John included classroom management skills in his revised designated identity. Mary's revised designated identity went from vague references about PCK to a more precise definition by the end of the course. She still struggled, however, to relate to her designated identity.

The researcher posited that these differences in identity development occurred because John felt his current identity was closely related to his designated identity and he could, therefore, bridge the gap between the two; Mary's designated identity was consistent with her current identity so there was no need (i.e., *learning-fuelling tension*) for personal goals to develop. For John, the movement toward his designated identity appeared to be associated with awareness and clarification of what constitutes a good teacher (Sfard & Prusak, 2005, p. 20). For Mary, the movement toward her designated identity was associated with affective characteristics and the need for additional MCK. John and Mary both mentioned concepts related to CK, MCK, and PCK—Shulman's (1986) three domains of teacher knowledge and components embedded in MKT (Ball, Thames, & Phelps, 2008; Hill, 2010; Hill et al., 2008). This highlights how one's view of oneself as a teacher of mathematics can influence how one develops as a teacher of mathematics.

Mathematic Teacher Identity Development

Researchers have applied Sfard and Prusak's (2005) stories-as-identity to analyze teachers' identity during and after engagement in mathematics PD by illuminating facets of professional identity through stories that teachers tell others about themselves. Bjuland, Cestari, and Borgersen (2012) used reflective narratives (i.e., discourses and activities) to document an experienced elementary school teacher's professional identity during a university research project. The PD consisted of 16 workshops over the course of three years and focused on MKT and building communities of inquiry. Data sources were recorded and transcribed and included classroom observations in the first year, an individual interview and a focus group in the second year, and transcripts from workshops in the final year. This range of PD situations was selected to illustrate important instances of her identity development processes. Unlike many past researchers, Bjuland and colleagues did not assign identity based on a preconceived model. Instead they sought indicators of identity (i.e., positioning in relation to pupils, reflecting on developing a workshop model in teaching, integrating and expanding models of teaching, challenging positioning in relation to didactitions [i.e., instructors]) captured in multiple situations over time.

Classroom observations provided background information in the form of Agnes' positioning herself as the presenter, observer, and coordinator of the mathematics classroom (i.e., first identity indicator). A videotaped lesson was shown to Agnes almost a year after it was taken, and she was asked during the interview to reflect on the process of her students' learning. During the interview (i.e., first narrative), Agnes made comments that give insight into her current identity (e.g., "I am not [a person] that tells them everything"; p. 416). Agnes also discussed how important the workshops

have been, giving insight into her designated identity (i.e., wants to improve her teaching). The researchers explained that this data source should not be the sole determinant for Agnes's professional identity because questions posed in the interview may have caused Agnes to respond in such a way as to appease the interviewer.

The second indicator of identity is that of reflecting. Through comments made in three narratives, Agnes showed an inclination to transpose, implement, and integrate the content and strategies presented in the PD workshops. Comments found in the fourth narrative, post-intervention, were similar to comments in the first three narratives, lending support to this identity indicator. The integrating and expanding theme was most clearly exposed in Agnes's plenary workshop presentation (i.e., the fourth narrative) in which she shared a model of teaching (i.e., Phase Model) that she and her colleagues created. The model stressed the need for students to be challenged and to have agency, giving insight into Agnes's current identity. During the individual interview (i.e., second narrative), however, Agnes acknowledged that it was her participation in the PD that helped her to see the link between the PD content and the Phase Model. She also explicitly stated that the PD content helped her to further develop the model. The third narrative illustrates Agnes's positioning related to the PD facilitators. She initially viewed the facilitators as trying to tell her how to teach but came to view the facilitators more as co-participants in the PD. By the end of the second year, Agnes felt free to express her needs and perspectives on improvements for the PD and that the teachers' own contexts and experiences are as important to implementation as the facilitators' suggestions.

These identity indicators provide evidence into the process of teacher mathematical identity development. To combat possible misrepresentation by Agnes, a variety of data were collected over the course of three years. In addition, analysis was limited to reflective narratives that revealed the teacher's "critical thinking, reflection, and awareness" (p. 422), which were clustered to uncover the four identity indicators. The authors argue that this method could contribute to understanding the factors in teachers' professional development. Similar to Agnes's case, Settlage et al. (2009) argue that identity is constructed within a context and is less of an accrual of experience and more of a reshaping as one encounters novel communities, settings, and challenges. Mathematics-based oTPD could constitute that novel community with novel challenges.

Teacher Characteristics and oTPD

Online learner participation has been defined, in part, as a "complex process comprising doing, communicating, thinking, feeling and belonging, which occurs both online and offline" (Hrastinski, 2008, p. 1761) and is often deconstructed when being researched. In an attempt to discover individuals' approaches to learning in oTPD, del Valle & Duffy (2009) investigated learner characteristics and learning strategies. Participant characteristics (e.g., age, teaching experience) were compared to eight variables related to asynchronous course navigation (e.g., total time online, proportion of time in messenger mode, exploration) and four variables about course experience and evaluation (i.e., satisfaction, learning and transfer, previous experience, group learning preference).

Cluster analysis revealed three distinct approaches to learning: *mastery-oriented*, *task-focused*, and *minimalist-in-effort*. Teachers with a mastery-oriented approach

showed a high level of effort in course navigation and the effort was learning focused. This group showed their commitment to the course by having high levels of transitions between course activities, the number of course resources accessed, and time spent on learning resources. Teachers with a task-focused approach showed moderate effort in course navigation, but worked frequently and intensely in order to expeditiously fulfill course requirements. Teachers with a minimalist-in-effort approach used the most calendar days to complete the course but spent the least amount of time online. Experienced teachers were more focused on mastery and less experienced teachers were task oriented. The authors speculate that more experienced teachers have less classroom planning, allowing them more time with course materials, and have more background knowledge, allowing them greater comfort in exploring more deeply. A significant number of minimalist students stated a preference for working in groups; minimalists consistently reported less course satisfaction, lower learning, and ability to transfer.

Identity and oTPD participation

Teacher characteristics and approaches to learning are clearly associated with the quality and quantity of PD participation. Patterns of participation in an oTPD are positively correlated with professional learning (McAleer & Bangert, 2011), which necessitates a discussion of the how and why this correlation exists. Teacher identity (e.g., histories, MKT, teacher characteristics) plays a role in oTPD participation. Teachers' prior experiences in teaching and learning mathematics form a significant part of who they are as teachers (Drake & Sherin, 2006), which seems inexorably linked to identity. Unfortunately, a lack of content knowledge can inhibit teachers' professional growth and identity development. Surveys, classroom observations, online discussion

posts, reflective journals, and focus groups were used to assess the impact of a blended (i.e., online and face-to-face) mathematics and science/technology PD on teachers' "attitudes, knowledge, and classroom practice" (Sinclair & Owston, 2006, p. 59). The 48 mathematics teachers only felt significantly more prepared to teach only one of the 11 mathematics topics at the end of the two-year PD. Conversely, the 33 science/technology teachers felt significantly more prepared to teach three out of the four science/technology topics, even though the science/technology PD was eight weeks shorter than the mathematics PD. The authors speculated that the teachers' relatively weak mathematics background knowledge hindered more substantial gains in both content and pedagogical knowledge, as almost half of the teachers had no post-high school mathematics coursework. These studies suggest that teachers' current and designated identities need to be considered so that the mathematics content of a PD program is accessible.

Three case studies of paired secondary mathematics teachers offer other suppositions. Ponte and Santos (2005) designed an inquiry-based oTPD program around mathematics investigations, reflection, and collaboration. Data analyzed were several semi-structured interviews, a survey, message exchanges, and assignments. Although all six of the teachers had degrees in mathematics or mathematics teaching, the researchers concluded that a "specific readiness" was required to maximize the potential of the course activities (e.g., discussing readings, doing task-oriented activities, reflecting; p. 104). For example, the first pair did not understand the term *mathematical investigation*, had minimal participation and reflection in forums related to theory, and even considered quitting. The second pair had reflective comments and

frequent posts, which sometimes included references to outside materials. They were much more engaged than the other groups but their participation declined when they felt collaboration with, and forum posts by, their peers were not rich enough to be useful. The third group appreciated the potential usefulness of the mathematics investigations, used the course to deepen their knowledge, and collaborated the most. The third group also stated that the written assignments and postings had more value than face-to-face conversation with school-based peers, as it required greater reflection. Such varied experiences of seemingly similar teachers, working in self-chosen pairs, serves to highlight the need for further research on the role of mathematical identity.

Based on Gee's (2000) notion of affinity identity, Jewett (2012) analyzed wiki posts to determine perceptions of teacher identity and ideologies existing in the discourses about identity. In two consecutive fall semesters, a total of 21 secondary English PSTs participated in a blended methods course. Students were required to post at least twice a week as well as respond to others' posts. In addition to reading and writing activities, the participants had field placements from which to draw on for their wiki posts. The reflective and social nature of the tasks allowed students to simulate what it would be like to be an English teacher. The wiki assignments had not been designed to elicit comments about identity construction, so the author examined posts to reveal participants' notions of what it meant to become an English teacher.

Data sources were threaded discussions, journal entries, and student-initiated threads grouped by participant. Content analysis was used to determine codes (e.g., making a difference, building student success) and the resulting seven themes appeared at least three times and by roughly half of the participants. The researcher

found two patterns across the data: an emphasis on language related to “teacher as selfless giver” and a surprising lack of discussion regarding content-specific pedagogy and curriculum (p. 142). The researcher posited that the students fashioned their perceptions of an English teacher’s identity based on what they interpreted as important instead of what the facilitator interpreted as important. This has weighty implications for the development of future methods courses.

Another study of PSTs used discussion posts to search for possible changes in the quality of the postings. Sutherland et al. (2010) sought to gain deep “insights into students’ learning, the development of their professional knowledge, and their professional identity” (p. 457). Content analysis and a new construct, *teacher voice*, allowed researchers to compare asynchronous posts from the beginning and the end of a blended course. As an indicator of identity, students’ comments were categorized into one of three categories, depending on how closely they positioned themselves as future teachers: *theoretical* if the examples were from personal experience as a student, *linkage* if the examples given considered possible future practices) or *professional application* if the examples were discussed from the viewpoint of a decision maker. Engagement was determined by the level of knowledge used in the post (i.e., *explanation*, *elaboration*, or *reflection/application*) and the length of the post coded as each of the levels of knowledge. Development of teacher voice was evidenced by an 11% increase in the level of cognitive engagement and a 22% increase in paragraphs at the linkage and professional application levels over the 12-week course. The authors suggested that the participants’ prior professional experience and attitudes of online

learning might be substantial factors in their engagement with the content and resulting professional identity development.

Asynchronous discussions of reform-oriented pedagogy formed the basis of collective case study narratives on teachers' learning. The participants were enrolled in a graduate-level course for inservice middle school mathematics teachers. Groth (2007) selected the two participants with the most frequent number of posts, thereby yielding a substantial amount of data. Background knowledge regarding the teachers' beliefs about standards-based instruction was acquired prior to analysis of the forum transcripts, which were coded to model the teachers' movement away from traditional views of mathematics instruction.

First, posts were coded for levels of participation (i.e., *information exchange*, *knowledge construction*, *development*) based on a model by Salmon (2004). Information exchange was demonstrated when teachers highlighted points from readings, described their professional beliefs and practices, and affirmed the beliefs and practices of others. Knowledge contruction occurred through brainstorming and debating with others about possible resolutions to pedagogical problems. Development happened when teachers recognized the need for their own MKT growth. Second, the language in the posts was used to infer acquisition of knowledge (i.e., *resistance*, *enrichment*, *revision*). Resistance was when new information resulted in an argument or debate. Enrichment was demonstrated when new information was consistent with current beliefs, and revision happened when information was inconsistent with current beliefs.

Changes for both teachers were mainly enrichments and small-scale revisions. Although both initially showed resistance to alternative algorithms (i.e., invented strategies), one teacher relaxed her resistance after a debate with other course participants. The author noted that resistance is not an entirely negative construct. Even when some topics cause debate without subsequent revision, those topics still incited participation in the form of additional posts. Furthermore, as this oTPD program encouraged reflection, both teachers identified areas for their own future learning.

Reflection, collaboration, and communication with peers are important for growth during oTPD (McAleer & Bangert, 2011). Through the analysis of course artifacts (e.g., forum posts, assignments) we can begin to infer how participants interact with course content and with each other. Accordingly, Dede et al. (2009) argue for the analysis of data streams that leave a permanent record of teachers' exchanges with each other and with the course content. Such analysis might provide insight into why some oTPD programs have more impact on instructional practice and learner outcomes than others, which is an understudied topic (Dede et al., 2009). Instead of merely answering questions as to whether a particular oTPD program works, research should also ask why it works well and consider the "impact of professional development on teacher change", "diversify the number of outcome measures" to increase validity, and "analyze outcome measures across time" to elucidate different stages of teacher change (p. 16).

Conclusion

Although the majority of the research on identity development focuses on PSTs, teachers' identities continue to develop throughout their careers (Beauchamp & Thomas, 2009). While there is a call to study the professional identity development of PSTs in varying contexts, there is a paucity of literature related to inservice teachers'

identity development in any context. How identities are constructed has implications not only for the supports essential to participation in oTPD programs but also to quell possible hindrances (Coldron & Smith, 1999).

Identity is personal, as is one's MKT. It follows, then, that the association between one's identity and participation in an oTPD program be studied at the individual level. An individual's distant history as a learner and recent history as teacher are both relevant aspects of biographical studies (Knowles, 1992). Most studies on teacher professional identity utilize interviews as the primary data sources and are small-scale and in-depth (Beijaard et al., 2004), which aligns with narrative inquiry as a methodology. Narratives can be used to hear the teachers' voices in order to describe, in a cohesive manner, how their identities impacted—and have been impacted by—participation in an oTPD program.

CHAPTER 3
METHOD

This dissertation was designed to examine the relationship between teacher mathematical identity and participation within an oTPD program. The goal of this chapter is to describe the context of the study, narrative inquiry, participant selection, data collection, data analysis, trustworthiness and credibility, and researcher subjectivity as they relate to questions that guided my research:

1. What is the relationship between teacher mathematical identity and participation in an oTPD program?
2. What do narratives reveal about shifts in teacher mathematical identity two years post-oTPD program?

Context of the Study

Prime Online PD Project

The context of this study was the *Prime Online* PD program, which was created as a result of the *Prime Online* design-based IES Goal 2–Development and Research project. The purpose of the IES-funded research project was to determine the feasibility and impact of the *Prime Online* PD program through an iterative design process. The *Prime Online* PD program was a yearlong asynchronous oTPD program for third- through fifth-grade general and special education teachers. During Phase 1, August 2010-December 2010, the content and measures for the *Prime Online* PD program were generated. Participants were selected from a nearby school district. The goals of the project were to impact (a) teachers' pedagogical content knowledge in mathematics, (b) their ability to meet the learning needs of students with learning disabilities (LD) in general education classrooms (grades 3-5), and (c) their knowledge and skill in using curriculum-based measurement within a model of classroom-based research. Phase 2

of the IES-funded research project, January 2011-December 2011, was the implementation of the *Prime Online* program with ten third- through fifth-grade general education and special education teachers. PI-conducted interviews, module surveys, segment satisfaction surveys, weekly activities and forum posts, participation data, and measures of MCK and PCK were collected to aid in PD program revision.

Prime Online PD Program

The *Prime Online* PD program took place from January 2011-December 2011 and, therefore, spanned two school years. Participants were given a $1000 stipend and either nine graduate credit hours or 180 inservice credit hours for completing the PD program. Each participant was provided with necessary materials and supplies including textbooks, audiovisual equipment, and an NCTM membership to access *Teaching Children Mathematics* (TCM) articles that were part of the oTPD program content. The oTPD program was presented asynchronously on a virtual learning environment called Moodle (Dougiamas, 1999), with the exception of one activity that required a synchronous group chat and the culminating activity that required web conferencing.

The *Prime Online* PD program consisted of 27 modules within three segments (Appendix A). Segment One, *Building the Foundation for Inclusive Elementary Mathematics Classrooms*, had eight weeks. Weeks 1 and 2 presented the NCTM *Principles and Standards for School Mathematics* (NCTM, 2000) and the *Strands of Mathematical Proficiency*, (Kilpatrick, Swafford, & Findell, 2001). In these weeks, participants reflected on themselves as learners and teachers of mathematics, their meaning of mathematical proficiency, and instructional practices that support mathematical proficiency. The remaining modules in Segment One focused on

supporting struggling learners. Topics included characteristics of students with LD; research-based practices (i.e., explicit strategy instruction, self-regulated learning, self-regulated strategy development); RTI; and progress monitoring. Teacher inquiry was also introduced in Segment One.

Segment Two, *Deepening Mathematics Content and Pedagogy*, consisted of 13 weeks and was heavily focused on mathematics content. Weeks 9-12 concentrated on number sense and conceptual understanding of multiplication and division. Participants completed virtual mathematics activities and used virtual manipulative materials, analyzed *invented strategies* and common *error patterns* in multiplication and division, represented the area model and partial products model with manipulative materials and then compared those models to the traditional algorithm for multiplication, and solved partitive and quotative division problems with manipulative materials. Weeks 14-18 concentrated on representation of fractions and operations of rational numbers. During these weeks, participants

- wrote about their understanding of a fraction, reviewed NCTM (2000) and CCSS-M standards (CCSSO, 2010) and related them to the Strands of Mathematical Proficiency (Kilpatrick et al., 2001), read about fraction representation, discussed and worked with partition and iteration models, and wrote a new statement about their understanding of a fraction;
- explored models “of” and “for” thinking about partition and iteration; worked through modeling fraction addition and subtraction with virtual manipulative materials; read a TCM article and discussed need for common denominators; implemented a multi-day lesson about the relationship between fractions, decimal numbers, and percentages; and explored an NCTM webpage for lessons appropriate for their students;
- estimated solutions and explained strategies for multiplication of rational numbers, completed and discussed an online NCTM article, and explained why traditional algorithms for multiplication of fractions and multiplication of decimal numbers work;

- created a word problem when given a fraction division problem, reasoned about conceptual meaning of multiplication and division of fractions, and reflected on how their new understandings could impact their future instructional practices;
- completed online lessons, read TCM articles, related operations with decimal numbers to operations with fractions, and further discussed models "of" and "for" thinking.

Three weeks in Segment Two (i.e., 13, 19-20) related these same topics to teaching students with LD by reviewing evidence-based practices, concrete-semiconcrete-abstract instruction, RTI, and co-teaching models. Week 21 had the students reflect on mathematics topics that had been challenging to teach in the past; develop a *wondering*, defined as a burning question they had about their mathematics teaching practice (Dana & Yendol-Hoppey, 2009); and list goals for the coming school year.

Segment Three, *Studying the Application of Newly Learned Mathematics Content and Pedagogy to Student Learning*, contained six weeks of content. As some of the weeks (e.g., Week 24: The Road Map: Developing the Data Collection Plan and Formative Data Analysis) actually covered multiple calendar weeks, Segment Three took place during September through December 2011. After learning more about data collection and progress monitoring, participants began an inquiry cycle related to the *Prime Online* PD program mathematics content and designing and implementing a research plan to study their instructional practices (Dana & Yendol-Hoppey, 2009). The final weeks were devoted to writing up and presenting their findings from the inquiry process to the *Prime Online* PD program cohort and facilitators via web conferencing.

Each module (i.e., *Week*) included four sections: Introduction, Anticipatory Activity, Content and Discussion, and Reflection and Assessment. At the end of each week, a facilitator posted a Course Announcement that summarized the learning for the

week. Course Announcements were automatically emailed to all participants and were used for any important announcements. The Introduction familiarized the participants with the content for the week by outlining the objectives and materials needed (e.g., articles, websites) as well as a list of assignments and activities contained in the Anticipatory Activity, Content and Discussion, and Reflection and Assessment. The Anticipatory Activity was intended to activate participants' prior knowledge, revealing current knowledge of mathematics concepts, or reflecting on their thinking. In Week 16, *Multiplication of Fractions*, for example, participants estimated operations with rational numbers using mental mathematics and explaining their strategies in a forum post.

The Content and Discussion required participants to explore a mathematics concept with understanding, read articles or website lessons, engage with developer-created materials (e.g., PowerPoint, video), or work through a virtual mathematics activity. For example, Week 16 contained three Content and Discussion activities. In the first activity, participants were asked to read an article and watch embedded videos and then post a reflection on what was interesting, why it was interesting, how it could be used in their classroom, and any questions or concerns on the topic. In the second forum, participants were asked to discuss why the traditional algorithm for multiplying fractions works. In the third forum, participants were asked to represent fractions in a word problem and then hypothesize why they are able to 'cancel' when multiplying fractions. The Reflection and Assessment typically asked participants to examine their classroom in relation to the content for the week implement an activity from the week, or model and discuss mathematics concepts. In Week 16, participants were asked to provide a conceptual explanation for multiplication of decimal numbers.

The oTPD program archival data were used to create narratives of the participants' teacher mathematical identity, as it existed throughout their participation in the *Prime Online* PD program. Segment One and Two activities, PI-conducted interviews, module surveys, segment satisfaction surveys, participation chart, and CKT-M scores were analyzed, but five weeks of the PD program were of particular importance. In Segment One, activities from Weeks 1 and 2 were selected because of their focus on teachers' recollections of their histories as learners of mathematics and their best lessons, their perceptions of their role as teachers of mathematics, and when they felt most and least effective as teachers of mathematics. In Segment Two, activities from weeks 9, 11, and 15 were selected because they offered a range of topics (i.e., number sense, multiplication, and rational numbers), a variety of interactive assignments and reflective forums (i.e., a virtual activity, an activity with manipulative materials, and implementation of a multi-topic hands-on lesson), and overall high levels of participation (e. g., quality and quantity of posts).

Narrative Inquiry

Narrative inquiry refers to creating data in the form of stories, the ways of interpreting that data, and the methods of representing data in narrative form (Schwandt, 1997). Narrative inquiry is, more precisely, the study of human experience, and narrative researchers collect and tell stories of those experiences (Connelly & Clandinin, 1990). Teachers' lived stories (i.e., descriptions of their work and explanations of their actions) are powerful sources for narrative inquiry (Connelly & Clandinin, 1990) and typical data sources for narrative inquiries include interviews, journals, autobiographies, and documents.

The goal of narrative inquiry is to attain narrative truth when composing the research story (Spence, 1984). Narrative truth occurs when the occurrences have been represented satisfactorily (Kaasila, 2007) and when the explanation conveys conviction (Spence, 1984) and plausibility (Connelly & Clandinin, 1990). Collecting and retelling lived stories is a challenging process. Connelly and Clandinin (1990) impart the complexity and multiple levels of narrative inquiry by stating "…it is the personal narratives and the jointly shared and constructed narratives that are told in the research writing, but narrative researchers are compelled to move beyond the telling of the lived story to tell the research story" (Connelly & Clandinin, 1990, p. 10).

A narrative (e.g., an interview) is a sequenced series of events that holds meaning for both the narrator and the narrator's audience (Kaasila, 2007). One limitation of any narrative is that some people find it difficult to tell a story. This limitation is minimized with episodic interviews, however, because there are many short narratives instead of a single complete narrative (Flick, 2009). Episodic interviews are specific types of narratives that provide in-depth focus on situations (i.e., episodes) that are pertinent to the research study. Advantages of episodic interviews are that the interviewer has more flexibility in defining specific events for the interviewee to recount. The interviewee can then choose a specific description or story to respond to the interview question. This link between question-answer sequences and narratives is a triangulation of different data collection approaches (Flick, 2009).

The stories obtained in an interview can be considered a way to express identity (Connelly & Clandinin, 1999) or as identity itself (Sfard & Prusak, 2005). When taking the narrative-as-identity approach, narratives are seen as "stories with authors and

recipients" and contain "words that are taken seriously and shape one's actions" (Sfard & Prusak, 2005, p. 45). Teachers' words, then, can be viewed as their teacher mathematical identity. This dissertation sought to interpret inservice teachers' mathematical identity and experiences in an oTPD program. This study, therefore, emphasized qualitative data over quantitative data and participants' lived stories, in the form of archival data and interviews, were the primary data sources. Furthermore, the interviews conducted for this dissertation were structured so participants could recount events relevant to their teacher mathematical identity.

Participants

Participant Selection

The participants were purposively sampled from the eight inservice teachers who completed the *Prime Online* PD program. Purposive sampling is expected in narrative inquiries and increases rigor, trustworthiness, and credibility (Patton, 1999; Patton, 2001). Cases may be purposively sampled as *typical*, *deviant*, or *critical* (Patton, 2001), but purposive sampling for *maximum variation* is most common in narrative inquiries on teacher identity (e.g., Forbes & Davis, 2008) and teacher change (e.g., Smith, 2011). Such studies select a small number of participants with diverse backgrounds in order to create rich, detailed narratives and still gain varying perspectives. Due to the breadth of data sources and the expected depth of data analysis in this study, two teachers were selected for this study.

Based on my review of the literature, views of self as a learner of mathematics (e.g., mathematics history, PD experiences) and views of self as a teacher of mathematics (e.g., self-efficacy) are important aspects of teacher mathematical identity. Quantity and quality of participation within the oTPD program (e.g., assignment

completion, frequency of posts) were also of interest. Therefore, to obtain thorough and pertinent data to answer the research questions, participants with maximum variation in levels of participation and views of mathematics were invited to participate in this study (Miles & Huberman, 1994).

The participant selection process began with an examination of archival data. During this process, I knew participants only by their *Prime Online* PD program participant numbers to limit potential biases. Data sources were chosen that would provide information about participants' history as learners and teachers of mathematics and their views of mathematics teaching and learning. Segment One activities and PI-conducted interviews were examined collectively to minimize bias (Newton et al., 2012) and general statements of teacher mathematical identity were noted (e.g., example of best lesson, perception of teacher role). Quantitative data were overall levels of participation, satisfaction across the three segments, and measures of MKT. Summary sheets were created to document an initial understanding of each participant's *Prime Online* PD program teacher mathematical identity and participation in the oTPD.

Although several teachers volunteered to take part in this study, Heide and Brynn were selected as participants, as they were expected to provide the maximum variation in participation and views of mathematics sought in this study (all names are pseudonyms). In addition, Heide and Brynn had an age gap of over 20 years, dissimilar teaching contexts, and a difference of eight years of teaching experience, but they had the same certification and degrees, and both had prior experiences teaching special education. As part of the *Prime Online* development project, all eight participants gave

consent for analysis of their archival data. Heide and Brynn signed an informed consent form that provided information about this dissertation study (Appendix G).

Description of Participants

Heide and Brynn taught in the same school district in the Southeastern United States. All teachers in the county were required to follow the curriculum-pacing guide and to use the Gradual Release of Responsibility (GRR) model of instruction (Pearson & Gallagher, 1983). The GRR model integrates four lesson components: focused lesson, guided instruction, collaborative learning, and independent tasks. GRR is sometimes referred to a *scaffolded instruction* or an *I Do* (i.e., direct instruction)*, We Do* (i.e., guided instruction)*,* and *You Do* (i.e., independent practice) method of instruction. Neither participant had attended a mathematics PD program since the conclusion of the *Prime Online* PD program.

Heide

Heide had the highest scores on the satisfaction surveys, the highest levels of participation throughout the oTPD program, and completed all surveys and CKT-M assessments. The participant selection process revealed that Heide had a negative history as a learner of mathematics but was motivated to learn. She also had a very low efficacy as a teacher of mathematics when compared to the others in her cohort.

Heide grew up in an outdoor education camp setting and always knew she wanted to teach. She worked in outdoor education for eight years prior to her current teaching position in the public school system. Heide earned a bachelor's degree in elementary education, a master's degree in special education, and had certification in elementary education (K-6) and special education (K-12). She also recently acquired certification in Earth space science (6-12). Heide was familiar with online learning, as

many of her master's courses were in an asynchronous format. Her prior mathematics PD experiences were limited to those related to the newly adopted textbook series and one in which an expert was brought in to lecture on how to make mathematics relevant. Heide stated the following reason for joining the *Prime Online* PD program:

> [I] was going crazy in the classroom because I integrated all of my subjects except math . . . I just never was confident. . . . I was looking at the kids who were so unmotivated and unengaged so when I saw it [the *Prime Online* PD program], I was, like, "Yes! Please give me something"! I mean, seriously, I wanted it so bad. [I-2p2]

At the time of this study, Heide was in her thirteenth year of teaching, eleven of which were at her current school, a rural K-4 elementary school that served approximately 520 students. She was in her fifth year as a general education teacher, but she taught third- through fifth-grade students with high-incidence disabilities in a self-contained classroom for the majority of her teaching career. During both school years that spanned the *Prime Online* PD program, she taught fourth-grade general education. She indicated, however, that a majority of her students either had disabilities or were in Tier 3 RTI groups (i.e., needing intense instruction). During that time, a part-time paraprofessional five days a week and a special education co-teacher assisted her two days a week. Heide taught third-grade general education one year post-PD and at the time of this study, two years post-PD, taught first- through fourth-grade gifted science.

Brynn

Brynn's scores on each satisfaction surveys were near the mean and her participation across modules was intermittent. She did not give feedback on any

module surveys and did not participate in the final CKT-M. The participant selection process revealed that Brynn had a negative history as a learner of mathematics and traditional views of mathematics instruction. She considered herself to be an average teacher who was concerned about grasping the content in the *Prime Online* PD program.

Brynn earned a bachelor's degree in elementary education and a master's degree in special education. She had certification in elementary education (K-6) and special education (K-12). The *Prime Online* PD program was her first mathematics-specific PD and her only prior experience with online learning was one synchronous special education course. Brynn conveyed that she joined the *Prime Online* PD program because her experiences as a special education co-teacher and her current role as a teacher of Grades 4-5 mathematics seemed to align well with the PD program's focus on teaching upper elementary mathematics in an inclusive setting.

At the time of this study, Brynn was in her fifth year of teaching at a low socioeconomic status (SES) K-5 elementary school that serves approximately 570 students. The first year of the *Prime Online* PD program was also Brynn's first year as a general education classroom teacher. She had not taught the year prior to the *Prime Online* PD program because she stayed home after the birth of her son. For the two years prior to that, however, she had been a special education co-teacher and shared the classroom responsibilities with two fifth-grade general education teachers. Brynn had a different teaching assignment for both school years that coincided with the *Prime Online* PD program. During the first year, she taught a general education fourth/fifth grade combination inclusion class. The class was composed of higher achieving fourth

graders and lower achieving fifth graders. She recalled that between seven and 10 students had high-incidence disabilities (e.g., specific learning disability, emotional/behavioral disability). Due to an increase in enrollment, Brynn's classroom became a fifth-grade inclusive classroom early in the second year. She has taught a combination fourth/fifth-grade class since that time.

Data Collection

Data included quantitative and qualitative archival *Prime Online* PD program artifacts and two post-oTPD interviews conducted as part of this study. Archival qualitative data sources were Segment One activities, PI-conducted interviews, Segment Two activities, and module surveys. Archival quantitative data were the participation chart, CKT-M measures, module surveys, and segment satisfaction surveys. The archival data were collected in 2010-2011 as part of the larger study and two post-oTPD interviews were collected in July and October of 2013 (Table 3-1).

Table 3-1. Data Collection Summary

	Instrument	Month(s) collected
Archival Data	CKT-M pre-assessment	December 2010
	Segment One activities	January–February 2011
	PI-conducted interviews	February–March 2011
	Segment Two activities	April–May 2011
	CKT-M proximal assessment	August 2011
	Participation chart	January 2011–December 2011
	Module surveys	January 2011–December 2011
	Segment satisfaction surveys	March 2011–December 2011
	CKT-M post-assessment	January 2011
Current Study	First Interviews	July 2013
	Second Interviews	October 2013

[a] Module 13 survey includes questions about hindrances to participation

Archival Data

CKT-M measures

The CKT-M assessments were designed to measure teachers' MKT across a variety of tasks such as error analysis, multiple representations, estimation, and invented strategies (Hill, Schilling, & Ball, 2004). Three forms of two scales were used: Elementary Number Concepts and Operations - Content Knowledge (EL.NCOP-KC; Learning Mathematics for Teaching, 2001a) and Elementary Number Concepts and Operations-Knowledge of Content and Students (EL.NCOP-KCS; Learning Mathematics for Teaching, 2001b). Hill et al. (2004) report that Forms A, B, and C of both scales have adequate reliability (i.e., EL.NCOP-KC α = .719, .766, and .784, respectively; and EL.NCOP-KCS α = .622, .657, .698, respectively).

The CKT-M measures were administered prior to the oTPD program (December 1-16, 2010), after completion of the Segment Two (July 29-Aug 5, 2011), and after the conclusion of the oTPD program (Jan 16-22, 2011). Each participant was given a percent correct for each of the six CKT-M measure administrations.

Segment One activities

Two modules in Segment One were analyzed for this study: Weeks 1 and 2 (Appendix B). Three activities from Week 1 were examined. The Anticipatory Activity (i.e., Classroom Practices that Promote Mathematical Proficiency) asked participants to upload a statement reflecting himself or herself as a teacher of mathematics by describing their best mathematics lesson, their role as a mathematics teacher, and when they feel most effective and least effective as a teacher of mathematics. For the Content and Discussion, participants read *A Vision of School Mathematics* (NCTM, 2000). Then the participants were asked to relate their Anticipatory Activity response to

the reading and write two posts. The first post was regarding the ways in which their classroom reflected the *Vision of School Mathematics* (NCTM, 2000) and any perceived barriers in working toward the goals presented in the reading. The second post asked the participants to discuss commonalities across the first posts such as common barriers to implementation. Finally, the Reflection and Assessment activity asked participants to consider the content for the week and their statement from the Anticipatory Activity (i.e., who they are as a teacher of mathematics) and upload a reflection on how their views have or have not changed over the course of the week.

Three activities in Week 2 (i.e., NCTM *Principles and Standards for School Mathematics*) were also analyzed. In the Anticipatory Activity, participants were asked to reflect on their history as a learner of mathematics in Grades 3–5 and comment on how that has affected their view of what it means to be mathematically proficient. For the Content and Discussion, participants read *The Strands of Mathematical Proficiency* (Kilpatrick, Swafford, & Findell, 2001) and *Tying It All Together* (Suh, 2007). Then the participants were asked to find commonalities across their peers' Anticipatory Activity posts, describe their current instructional practices that support mathematical proficiency, and express their goals related to developing their students' mathematics proficiency. In the Reflection and Assessment, participants were asked to consider the content for the week and their response to the Anticipatory Activity (i.e., history as a learner of mathematics and what it means to be mathematically proficient). The participants then wrote and uploaded a brief statement about how their views had or had not changed about how they view their role in supporting the development of mathematical proficiency. Due to the wording of the six assignments (e.g*., I see my role*

as a mathematics teacher to be . . . , *reflect on your history of learning mathematics*), these data provided many sources for indicators of teachers' *Prime Online* PD program teacher mathematical identity.

PI-conducted interviews

The PIs of the IES-funded research project conducted interviews during Segment One (i.e., between February 21st and March 16th of 2011) at a place and time convenient for the participants. The PI-conducted interviews, which had no time limit and were audiotaped and transcribed, sought to understand participants' perceptions of the *Prime Online* PD program content and pedagogy (Appendix C). The PI-conducted interviews were semi-structured with open-ended questions about the following:

- why they enrolled in the *Prime Online* PD program,
- their past experiences with mathematics PD and online learning,
- what has gone well or has been challenging in the *Prime Online* PD program,
- how the *Prime Online* PD program content has been integrated into their current practice,
- time management with the *Prime Online* PD program,
- one forum discussion that has been particularly meaningful or helpful,
- discussions (i.e., forum posts and responses) with their cohort,
- the most valuable and least valuable activities,
- how their thinking about mathematics has changed, and
- factors affecting their participation in the *Prime Online* PD program.

Similar to the Segment One activities, the PI-conducted interviews contained narratives of teachers' experiences and actions in the first two months of the *Prime Online* PD program, which provided a variety of insights into participants' teacher mathematical

identity (e.g., efficacy, views of mathematics) and participation (e.g., successes, hindrances).

Segment Two activities

Participants' threaded discussions (i.e., original post followed by its responses) during three activities from Segment Two, *Deepening Mathematics Content and Pedagogy*, were chosen to highlight the quality of participants' engagement with the oTPD program mathematics content (Appendix D).

In Week 9, *Number Sense, Procedural Knowledge, and Conceptual Knowledge*, participants used mental mathematics to solve a multiplication problem as many ways as possible for the Anticipatory Activity; read about number sense, procedural knowledge, and conceptual knowledge, and used virtual calculator software for the Content and Discussion; and, for the Reflection and Assessment, discussed their students' strategies and number sense after using the virtual calculator software in class. For one forum, entitled *Broken Calculator*, participants were to access an NCTM webpage, read the content, watch the embedded videos, and then work with the virtual software. The virtual calculator required users to compute addition and multiplication problems with some of the calculator's keys disabled. After completing the *Broken Calculator* (NCTM, 2006) activity, participants were asked to discuss the strategies they used, how the applet might be used with their students, and their reflections regarding the online materials.

Week 11, *Building Conceptual Knowledge of Multiplication and Division,* participants reviewed an RTI video on problem-solving as the Anticipatory Activity, completed three Content and Discussion activities, and discussed their students' strategies for multiplication for the Reflection and Assessment. The Content and

Discussion activities included discussing examples of students' multiplication error patterns in a synchronous group chat room; using pictures and virtual manipulative materials to examine set, length, and area models for multiplication; and working with base-ten blocks to model multiplication problems. The third Content and Discussion activity, *Working with Base-Ten Blocks*, required participants to model several double-digit multiplication problems with base-ten blocks and upload the images of their work. Finally, the participants responded to questions related to using manipulative materials support understanding of the partial products algorithm and the comparison between the partial products algorithm and the traditional algorithm for multiplication.

In Week 15, *Fractions and Decimal Numbers: Addition and Subtraction*, participants uploaded images of fraction representation as the Anticipatory Activity; used virtual manipulative materials to add or subtract fractions; read about and discussed conceptual understanding of finding common denominators, and working through an activity called *A Meter of Candy* (NCTM, n.d.) for the Content and Discussion; and search a website for examples of rational numbers activities and resources for the Reflection and Assessment. The third Content and Discussion activity, *A Meter of Candy*, asked participants to work through a multi-lesson activity—with their students, if possible—on the connection between fractions, decimal numbers, and percentages. The forum asked participants to discuss the features of the activity that would support students' conceptual understanding, the three models presented in the activity, how they would typically assess these concepts, which of the suggested assessments were most appealing, and what they liked or did not like about the lesson.

The three Segment Two activities selected for this study—*Broken Calculator*, *Working with Base-Ten Blocks*, and *A Meter of Candy*—covered a range of mathematical concepts (e.g., number sense, manipulative materials use, the relationship between fractions and decimals) and had particularly high levels of overall participant engagement as measured by the length of initial posts and the number of follow-up responses. The content of the posts and responses gave insights into participants' MKT and teacher mathematical identity (e.g., self-as-learner of mathematics). Additionally, because of the high level of overall engagement, these activities were an indicator of the breadth and depth of participant's involvement in mathematics activities and the ensuing discussions.

Participation chart

The participation chart was a record of the number of times participants posted or submitted an assignment within each module over the course of the oTPD program. The *Prime Online* PD program project manager updated the participation chart twice a week. For each task (i.e., post or assignment), the number of submissions made and whether the submissions were completed by the due date were used to calculate each participant's *participation* and *requirements met*. For assignment *participation*, the number of each participant's tasks was compared to the number of required tasks. A ratio was then determined to indicate whether the participant met, exceeded, or did not meet oTPD program expectations. The percentage of late or missing tasks was also calculated. The requirements met ratio for a task represented the number of each participant's submissions compared to the minimum requirements for that module. The percentage of late or missing submissions was also calculated. Therefore, participants' participation percentage may exceed 100% while the requirements met could not

exceed 100%. The participation chart provided information regarding consistency of meeting or exceeding oTPD program requirements. These two variables were quantitative indicators of each teacher's participation within the PD.

Module surveys

The participants were emailed a link to the untimed module surveys and were asked to completed the anonymous surveys at a time convenient for them. Each module survey had five to seven Before–After Likert-type items specific to the module content with a 1 indicating *not at all true of me* and a 4 *indicating very true of me* (Appendix E). In addition to the Likert-type items, each module survey contained several free-response items related to the module content. For example, participants were asked to explain significant things they had learned, what they would have liked to learn more about, and suggestions for module improvement.

Module surveys from Weeks 1 and 2 were chosen because they aligned with the Segment One activities and Weeks 9-12 and 14-16 were used because they aligned with the Segment Two activities being analyzed in this study. For example, the Week 1 module survey asked participants whether they felt that they had the knowledge and skills to integrate the NCTM Principles for School Mathematics into their instructional practices. The Week 2 module survey included an item that asked participants how much they understood about how their history of learning mathematics had influenced their thinking about what it means to be competent in mathematics. An item in the Weeks 9-12 module survey asked participants if they understood how to use manipulative materials to support their students' conceptual understanding of arithmetic operations such as multiplication and division. The Weeks 14-16 module survey

contained an item that asked participants if they understood how to use estimation to support students' thinking when they computed fractions operations.

A mean and standard deviation (SD) were calculated for each Before–After item in the module surveys as a quantitative measure of participants' perceived growth during each week of the oTPD program. Participants' perceived growth and open-ended responses were considered as possible indicators of teacher mathematical identity (e.g., views of teaching and learning mathematics). The Week 13 module survey also included questions about hindrances to participating in a timely manner such as the 10 Likert-type items offering *too much work in an individual week* and *content has become too challenging* as possible hindrances. Participants were also asked to provide additional feedback that was not already included in the 10 Likert-type items, which added qualitative information regarding levels of participation.

Segment satisfaction surveys

The participants were emailed a link to the untimed segment satisfaction surveys and asked to complete the anonymous surveys at a time convenient for them. The segment satisfaction surveys were administered at the end of Segment One (i.e., Weeks 1–7), Segment Two (Weeks 9–21), and Segment Three (Weeks 25–27) and were constructed using a 4-point Likert scale of *strongly agree, agree*, *disagree*, and *strongly disagree* (Appendix F). Each segment satisfaction survey consisted of between 46 and 51 questions regarding overall participant satisfaction with module content, pedagogy, and technology and support. Survey prompts included *the instructional methods presented in the modules are practical in the amount of time they will require in my classroom*, *the assessment and reflection activities helped me understand what I learned through the modules*, and *interacting and sharing ideas with*

other participants contributed to the overall effectiveness of the modules. The response were tallied and a mean and SD were calculated. A mean was also established for each participant's overall segment satisfaction. The segment satisfaction surveys provided a quantitative measure of participants' satisfaction with each segment as well as any trends in satisfaction across the segments.

Current Study

Two interviews were conducted as the main sources of data in this study. Over two years had lapsed since the conclusion of the oTPD to give teachers time to incorporate the activities from the *Prime Online* PD program and to allow shifts in teacher mathematical identity to occur. The interviews were scheduled at a time and place convenient for the participant and were audio recorded with a digital recording device and transcribed verbatim. Throughout both interviews, participants were prompted to tell stories about their experiences by providing detailed recollections about the feelings, thoughts, actions, and contexts of those experiences. A relationship was established with each participant so that both of our voices were heard (Connelly & Clandinin, 1990). I minimized my own comments—particularly those that could have been interpreted as judgmental—so that the participant's voice was acknowledged.

> In narrative inquiry, it is important that the researcher listen first to the practitioner's story, and that it is the practitioner who first tells his or her story. This does not mean that the researcher is silenced in the process of narrative inquiry. It does mean that the practitioner, who has long been silenced in the research relationship, is given the time and space to tell her or his story so that it too gains the authority and validity that the research story has long had. (Connelly & Clandinin, 1990, p. 4)

The first interviews took place in July of 2013, two years post-*Prime Online* PD program. Both were conducted at the participants' schools while they prepared for the upcoming year. Heide's first interview lasted approximately 50 minutes and Brynn's first interview lasted approximately 40 minutes. The first set of interview questions and prompts focused on teachers' current views of mathematics (Appendix H). Most of the topics mirrored those in the archival data that were relevant to this study to encourage responses that would elicit indicators of teacher mathematical identity. For instance, the participants were asked the following:

- Tell me a story about one of the best recent mathematics lessons you taught.
- Looking back, when are you least effective as a teacher of mathematics? Please tell me a story that would be an example of when you feel least effective.
- How do you see your role as a teacher of mathematics? Describe how that might look from a student's perspective.
- How do you view your role in supporting the development of mathematical proficiency? How might this look in a typical mathematics lesson? How would you feel, think or do?

After the first interviews were transcribed and analyzed, follow-up questions were determined and the second interviews were held in October of 2013. Both follow-up interviews were conducted in the teachers' classrooms after school hours. Heide's second interview lasted approximately 40 minutes and Brynn's second interview lasted approximately 30 minutes. The second interviews had similar topics for each participant, (e.g., instructional practices, participation, general clarification of statements) but the specific questions were based on the congruence or dissimilarities found between teacher mathematical identity from the archival data and the teacher mathematical identity from the first interview (Appendices H & I).

For example, Heide was asked if she would have considered her pre-*Prime Online* self to be one of the teachers who "felt constrained" and were unable to integrate mathematics into other subjects [I-1p14]. Brynn was asked to compare statements made regarding the use of manipulative materials. While a participant in the *Prime Online* PD program, Brynn's comments in the Week 2 Content and Discussion seemed to have a negative connotation toward manipulative materials. This was contrasted with the second indication, during our first interview, when Brynn called manipulative materials her "best friend" [I-1p7]. Other questions were asked for clarification so that I could more accurately interpret their words and meanings. For example, Heide was asked to compare her definition of mathematical proficiency during the Week 2 Anticipatory Activity with the one from our first interview and reflect on whether she perceived those as having different meanings. Similarly, Brynn was asked to differentiate the terms *quick strategies* used in the Week 1 Anticipatory Activity and *tricks* used in the Week 2 Anticipatory Activity.

Data Analysis

A researcher's journal was kept to record my actions such as contact made with participants and reflections including field notes from each interview session. Notes and journaling created an audit trail to document my interactions with participants, subsequent revisions, and decision-making processes. The journal was a place to document "experiences, ideas, fears, mistakes, confusions, breakthroughs, and problems that arise during fieldwork" (Spradley, 1980, p. 71). I also used the journal to record the steps taken during this study and keep a log of codes, both of which helped track emerging themes during data analysis.

Qualitative data analysis is a “systematic search for meaning” in order to communicate what has been learned to others (Hatch, 2002, p. 148). This dissertation expanded upon the notions of teacher identity and professional growth by examining the relationship between teacher mathematical identity and participation within an oTPD program. Theoretical thematic analysis was chosen to examine these data because

> studies that rely on interviewing as the sole or primary data collection tool are often undertaken with a fairly focused purpose, a fairly narrow set of research questions, and a fairly well-structured data set in terms of its organization around a set of fairly consistent guiding questions. When the study was designed, the researcher had as his or her goal to capture the perspectives of a group of individuals around particular topics. If the study was well designed and implemented, data from the interviews ought to provide lots of evidence related to participants’ perspectives on the topics of interest. So the topics that the researcher had in mind when the study was designed will often be logical places to start looking for typologies [i.e., categories, themes] on which to anchor further analysis. (Braun & Clarke, 2006, pp. 152-153)

Therefore, a coding scheme based on a review of the literature was developed. Constructs often studied in relation to teacher mathematical identity are history as a learner of mathematics (i.e., views of self-as-learner), efficacy (i.e., views of self-as-teacher), teacher role (i.e., views of mathematics teaching), and how students learn (i.e., views of mathematics learning), which were encompassed in my views of

mathematics construct. I also searched for statements related to participation and MKT. Each case was analyzed following the guidelines put forth by Braun and Clarke (2006):

1. Becoming familiar with the data.
2. Generating initial codes.
3. Searching for themes.
4. Reviewing themes.
5. Defining and naming themes.
6. Producing the report.

First, I became familiar with the data by reading through its entirety multiple times to search for patterns while keeping my mind open to possible new meanings. During this phase, I started "taking notes or marking ideas for coding" so that I could return to them later (Braun & Clarke, 2006, p. 17). Next, I began the more formal coding process. During the second phase, generating initial codes, codes were created to identify parts of the data that seemed interesting and instances of each code were highlighted. Some passages were highlighted for more than one code. After reading each set of highlighted data, the main ideas from each source were recorded on a summary sheet for each participant. The results of the quantitative analysis were then added to the summary sheets and I began to look for meaning or searching for themes.

At this point, I sorted the codes into potential themes, assessed whether the themes were supported by the data, and searched for non-examples of my themes (i.e., reviewing themes). This required rereading all of the data, including the parts that were not highlighted. As stated by Braun and Clarke (2006), "Simply because an analysis starts with a deductive step does not preclude the researchers being aware that other important categories are likely to be in the data or prevent the researcher from searching for them" (p. 161). I refined the themes by collapsing or separating them. I read the extracts within each theme to check for coherence and assessed how

accurately the themes reflected the overall data set. During the fourth phase, defining and naming themes, I "conducted and wrote a detailed analysis" to determine how each theme fit into the broader narrative in relation to the research questions and again sought to identity any sub-themes. The final step was to return to the data, look for connections across themes and find compelling excerpts to let the audience into the contexts and "hear the voices of the participants" (i.e., producing the report; Hatch, 2002, p. 159).

Limitations and Delimitations

There were limitations and delimitations of this study that need to be acknowledged. A limitation was that the population was restricted to the eight teachers who completed the yearlong oTPD program and was further limited by those willing to participate in this dissertation study. However, a small number of possible participants available for final analysis was expected and most studies on teachers' professional identity are small-scale and in-depth (Beijaard et al., 2004) and participants were sampled for maximum variation as in other studies of teacher identity (e.g., Kaasila et al., 2008; Ponte & Santos, 2005). In addition, participants' perceptions of their instructional practices were not triangulated with classroom observations. This study was delimited in that statements regarding teachers' efficacy were based on interview data and not on the results of available efficacy scales. Additionally, course usage data (i.e., how often each page and link was accessed and over what period of time) were available through the Moodle (Dougiamas, 1999) software but was not analyzed. Passive engagement in an online course—sometimes referred to as *lurking*—can still lead to learning due to the resultant thoughts and reflection after reading others' posts (Mazzolini & Maddison, 2003). However, accessing the course without submitting a post

or assignment (e.g., reading Course Announcements, reading peers' posts and responses) was not considered participation for the purposes of this study.

Trustworthiness and Credibility

There has been a recent movement to return the construct of qualitative validity to a matter of ethics. Koro-Ljungberg (2010) states that "researchers are ultimately responsible for their decisions and doing "good", meaningful, trustworthy, and valid research—they cannot escape their responsibilities or leave the rigor or trustworthiness of their research for others to create, inspect, or evaluate" (p. 604). Validity is a measure of trustworthiness and trustworthiness of data is inexorably linked to the trustworthiness of the researcher (Patton, 1999).

That which constitutes validity in qualitative research continues to evolve and is influenced by the theoretical perspective taken by the researcher as well as what has become the norm in that particular field of study (Flick, 2009). For example, McMillan and Schumacher (2005) propose 10 strategies to enhance validity and trustworthiness in qualitative educational studies. Multi-method strategies, prolonged field work, participant verbatim language, low-interference description (e.g., thorough field notes), and negative case searches are considered *essential strategies*, while mechanically recorded data, participant review, multiple researchers, and member checking should be used as often as is feasible. The findings in qualitative studies are "highly context and case dependent" (Patton, 1999, p. 1197), thus researchers should strive to make their work transparent (Koro-Ljungberg, Yendol-Hoppey, Smith, & Hayes, 2009). Transparency and trustworthiness are important components in establishing the credibility of qualitative research (Patton, 1999). I will now describe Lincoln and Guba's

(1989) four constructs of trustworthiness—credibility, transferability, dependability, and confirmability—and how each related to my dissertation.

Credibility

Credibility is how well the research describes the phenomena from the participant's point of view or the "degree to which the interpretations have *mutual meanings* between the participants and the researchers" (McMillan & Schumacher, 2005, p. 324). Triangulation of sources and methods were used to strengthen credibility (Denzin, 1989; Lincoln & Guba, 1985). Data were obtained from multiple sources to study the same phenomenon. Interviews were augmented with qualitative and quantitative archival data. Such triangulation can "focus the single case" by allowing comparisons among data sources during data analysis (Flick, 2009, p. 27). Studying the same issues over time supports credibility and trustworthiness, and archival data sources were triangulated with each other as well as with the interviews.

Dependability

Dependability refers to prolonged engagement, the use of multiple researchers, and the degree to which the researcher has disclosed changes that occurred during the study and how these changes affected the study (Rossman & Rallis, 2003). I worked for three years on the *Prime Online* PD program development project as a graduate research assistant. This dissertation had two researchers, as the *Prime Online* PD program methodologist analyzed the quantitative archival data as part of the larger study. Dependability can also indicate the assurance that the inquiry process has been "logical, traceable, and documented" (Schwandt, 1997, p. 164). An audit trail documenting the specifics of observations is helpful for establishing dependability (Brantlinger, Jimenez, Klingner, Pugach, & Richardson, 2005), which was done through

the use of a researcher's journal. All data were systematically managed and securely maintained throughout this dissertation and are available for auditing.

Transferability

Transferability requires the researcher to provide rich details about the study context and assumptions so that others might decide whether similar findings would likely transfer to their own situations (Lincoln & Guba, 1985). Even one teacher can provide information for researchers due to common experiences and concerns with other teachers (Muchmore, 2002). Initial descriptions of the participants and the *Prime Online* PD program and content have been provided in previous sections of this chapter in an effort to make the methods transparent.

Confirmability

Confirmability is the level at which the results can be corroborated by others and can be made transparent by linking assertions to data or through peer reviews, the search for negative cases, and continual data checks. My chair, a researcher with educational psychology and mathematics education backgrounds, provided feedback throughout this study. My co-chair, a qualitative researcher with professional development and practitioner inquiry backgrounds, also provided feedback during data collection and analysis. Direct quotations from oTPD program artifacts and interviews justified my resulting claims but confirmability is inevitably impacted by the subjectivities and role of the researcher (Miles & Huberman, 1994).

Researcher Subjectivity

Because the researcher is the instrument of measure in qualitative analysis, a statement of potential biases is warranted (Hatch, 2002). My professional experiences, education, and perspectives were all factors in both the collection and the analysis of

the data. By making my subjectivities transparent in this section of the dissertation, I think that this awareness would assist me in applying these subjectivities in order to better understand the participants' life stories and experiences (Hatch, 2002).

Much of my professional life guided my interest in this study. I had quite a bit in common with the teachers in the *Prime Online* PD program. I was an elementary school teacher for five years, three of which were working as a resource teacher for students with high-incidence disabilities (e.g., specific learning disabilities). This gave me an understanding of what it is like to teach third- through fifth-grade students who struggle academically. I then spent seven years as a sixth-grade mathematics teacher. This gave me a familiarity with the pressures of teaching mathematics such as county pacing guides, standardized tests, and students' negative perceptions of mathematics. In addition, the fact that I received alternative certification to teach middle grades mathematics gave me commonality and empathy for teachers who did not have a background in mathematics.

My experiences over the past three years increased my perspective on and understanding of inservice PD. While working toward my doctoral degree in curriculum and instruction, I took seminars on designing PD and on the research and practice of teacher inquiry. I also wrote research proposals on inservice teachers' PD in other doctoral seminars. More significant, however, was my work as a graduate research assistant on the *Prime Online* development project. I attended most of the PIs' meetings, which provided me knowledge of the inner workings of the development, implementation, and revisions of to the oTPD program. I assisted in developing the mathematics content and in monitoring participants' progress. I also mentored a *Prime*

Online PD program participant through her inquiry cycle as my independent project in a doctoral-level course on practitioner research. I had occasional online contact with the oTPD program participants as a facilitator during the mathematics content modules, but for the majority of the year my role was that of an *eavesdropper*. Consequently, oTPD program participants might have recalled my role in the *Prime Online* PD program and had been more willing to engage in this study.

Unbeknownst to me at the time, one of my tasks for the *Prime Online* development project was the antecedent of this dissertation. At the request of the PIs, I completed case studies of the two participants identified as most and least satisfied (i.e., highest and lowest score on the Segment Two satisfaction survey). Quantitative data were the participation chart, CKT-M scales, and module and segment satisfaction surveys. Qualitative data were PI-conducted interviews, weekly activities, and module surveys. Data were then reduced to illuminate the individual factors (e.g., teaching experience, familiarity with online learning, personal and professional constraints), oTPD program activities, and patterns of participation that may have contributed to their level of overall satisfaction with the *Prime Online* PD program. This task piqued my interest because it made me reflect on my own PD experiences in mathematics education. I have often wondered why some PD did not have much of an impact and why one particular PD became such a pivotal experience for the development of my own MKT. This pivotal PD experience was school-wide, multi-year, and interdisciplinary. The mathematics component integrated the Principles for School Mathematics (i.e., equity, curriculum, teaching, learning, assessment, technology; NCTM, 2000) and the five strands of mathematical proficiency (i.e., conceptual

understanding, procedural fluency, strategic competence, adaptive reasoning, productive disposition put forth by Kilpatrick et al. (2001). These same components were explicitly and implicitly embedded in the *Prime Online* PD program. I was curious if it was the content and pedagogy presented or one of the many other facets (e.g., teacher agency, inter-departmental collaboration) that made such an impact on me and hoped this dissertation would provide me with further insights. In addition, I had a personal stake in understanding how and why PD relates to teachers' identity formation, as my post-graduation goal was to work with inservice teachers of mathematics.

Structure of the Narratives

A narrative in four sections is used to frame the findings for each participant in this dissertation (Chapters 4 and 5). The first section describes the participant's *Prime Online* teacher mathematical identity as reconstructed from archival data and the participant's history as a learner of mathematics, self-efficacy, MKT, and views of mathematics teaching and learning. Next the Participation in the *Prime Online* PD program is presented. This section of the narrative was also generated based on archival data and includes general feelings expressed about participating in the *Prime Online* PD program, quantitative and qualitative levels of participation, satisfaction with the oTPD program, and supports and hindrances to participation. The third section represents the participant's present day teacher mathematical identity (i.e., two years post-*Prime Online* PD program) and used the two interviews conducted as part of this study as data sources. The presentation of this section is similar to that of the *Prime Online* PD program teacher mathematical identity (i.e., includes views of mathematics teaching and learning) but the themes are different for each participant. Finally, each case concludes with the participant's shifts in teacher mathematical identity, as revealed

by comparing archival data with the interviews from the current study and a brief of the participant's narrative.

My interpretations of the data are supported by pertinent quotations from the archival data and interviews. All quotations were coded with a system to identify the source of the data. For example, Week 1 has an Anticipatory Activity [i.e., Wk1AA], multiple forums in the Content and Discussion [e.g., Wk1F1], and a Reflection and Assessment [Wk1RA]. Week 2 data are denoted in an identical manner. Feedback obtained from the module surveys are signified by the corresponding weeks. The module survey for Weeks 9-12 is denoted [MS9-12], Week 13 is denoted [MS13], and Weeks 14-16 is denoted [MS14-16]. Segment Two activity notations are as follows: [Wk9BC] refers to the *Broken Calculator* activity in Week 9, [Wk11BT] refers to *Working with Base-Ten Blocks* activity in Week 11, and [Wk15MC] refers to Week 15's *A Meter of Candy* activity. For the three interviews that were considered for this study, representation of the fourth page of a participant's first interview is [I-1p4], second interview is [I-2p4], and PI-conducted interview is [PIp4].

CHAPTER 4
HEIDE: STUDENT-CENTERED TEACHER, ENTHUSIASTIC LEARNER

Prime Online PD Program Teacher Mathematical Identity

> *My reflection on my own personal math* experiences in school, exposure to the thinking and memories of cohorts, plus the reading, have made me question everything I do when teaching math, from planning, classroom discussions, testing, to the focus of my reflections. [Wk2RA]

Mathematics History: A Lack of Understanding

Although Heide could not recall specific instances from her elementary school mathematics education, she did report two vivid memories from her adolescent years. The first incident occurred when she was kept after school for extra help to learn the metric system. Her teacher told her father, in her presence, that she was "hopeless" and "would never learn it" [Wk2AA]. Her experience in ninth-grade Algebra was not any more positive. Even though she "desperately tried and wanted to do the math correctly," she had "NO [emphasis in original] doubt" that she would never understand it [Wk2AA]. She explained that she was afraid to ask for help because of the favoritism her teacher—the football coach—showed the boys, leaving her with a constant feeling of failure. Heide recalled her history of mathematics as having a "lack of understanding of number relationships" [Wk1F1] and she still considered herself "mathematically challenged" [W9BC]. Heide questioned this label at times, though. When commenting that mathematics was never her strength, she wrote "or is that just what teachers long ago led me to believe?" [F1Wk1].

Self-Efficacy

Heide's uncertainty about her effectiveness as a teacher of mathematics was a common theme in multiple forums, assignments, and interviews during the program. She explicitly stated how her negative mathematics history had hindered her teaching. For instance, she wrote that "many of us are caught in a dichotomy where our desire to teach for greater success is hampered by our own personal lack of overall understanding" [Wk2F1]. In Week 2, participants were asked to write about the goals they had for their classroom practice related to improving classroom proficiency. Heide agreed with one of her peers that she no longer wanted to learn the mathematical topics along with the students each day. She explained her challenges in adapting to and comprehending the new mathematics curriculum:

> I find myself reading the math lessons every night . . . looking ahead to see where this is all going, reflecting on where we've been, and struggling to help kids make the connections. Then I have to analyze the various strategies for modeling the skill, which takes another 1/2 hour. It's the one time out of the whole day when I have to have complete silence because I have to REALLY concentrate in order to understand it. [Wk2F1]

Heide realized the impact that a single teacher can have on a students' learning; she indicated that her negative history drives her to be a better teacher. She credited her past educational experiences as the reason she felt the need to "truly celebrate their [her students'] 'ah ha' moments" [Wk1F1]. She would "often discard the textbook in an attempt to provide students with something more meaningful and motivating" [Wk1F1]. Heide considered this action to be a personal "risk" but acknowledged the confidence and understanding she gained when her students showed academic growth [Wk1F1].

Heide wrote about her best lesson for the Week 1 Anticipatory Activity, which provided details that seemed to contradict her insecurities as a teacher of mathematics. During the lesson, each student had his or her own set of fraction bars (i.e., manipulative materials) and their desks were arranged in pairs. After providing explicit directions for the use of the manipulative materials, Heide gave her students the opportunity to discover relationships among the pieces (e.g., two ¼ fraction bars are equivalent to one ½ fraction bar). She stated that she had students respond to each other's questions and had them explain their observations during the lesson. As Heide had not yet read the *Principles and Standards for School Mathematics* (NCTM, 2000), she did not realize that her instruction was, in fact, aligned with the Teaching Principle: "Teachers establish and nurture an environment conducive to learning mathematics through the decisions they make, the conversations they orchestrate, and the physical setting they create". In addition, she was developing her students' ability to "construct viable arguments and critique the reasoning of others" and "look for and make use of structure", which are two of the CCSS-M Standards of Mathematical Practice (CCSSO, 2010).

MKT During *Prime Online* PD Program Activities

According to Heide, much of the *Prime Online* PD program mathematics content was new to her. However, she scored above the mean on the Content Knowledge portion of CKT-M Tests 1 and 2; the Test 3 CK score was below the mean (Table 4-1). Early in the oTPD program, she stated, "I'm smart enough to know that there's much for me to learn" [Wk1F1]. She considered several Segment Two activities (e.g., examining students' strategies, examining students' error patterns) to be a "challenge, but meaningful" [MS9-12]. She said that she was put in the same position as her current

students: “no matter how hard I was trying, some of those things were really difficult to understand” [I-2p9]. Some of the difficulties faced by Heide were based on her lack of familiarity with mathematical models (e.g., set, area, and length) and manipulative materials.

Table 4-1. Heide’s CKT-M scores

	Test 1 Percent Correct		Test 2 Percent Correct		Test 3 Percent Correct	
	CK	KS	CK	KS	CK	KS
	79.2	65.0	76.9	84.2	56.5	71.4
Mean	*71.4*	*75.0*	*72.1*	*72.9*	*65.8*	*73.5*

Instead of being overwhelmed with all of the new information, Heide was open to the topics and activities being presented. She was the only *Prime Online* PD program participant who indicated that she tried the mathematics activities in Weeks 9-16 with her students. An activity requiring the use of mental mathematics to solve a multiplication problem and then explain her strategies made Heide “crazy” because it seemed “so difficult to put into words” [MS9-12]. Nevertheless, she recognized the necessity of explanations because students were now expected to defend their mathematical thinking. She took the Week 9 number sense content (i.e., mental mathematics and multiple strategies) and “put it to use right away” [MS9-12]. She also implemented the *Broken Calculator* (NCTM, 2006) activity from Week 11 and *A Meter of Candy* activity (NCTM, n.d.) from Week 15 in her classroom (Appendix D).

Even when she struggled with understanding the mathematics content, Heide persevered. During a week on fraction division, Heide reported thinking to herself: “Oh my God, I am how old and I have to sit here and think?” [I-2p8]. When she noticed that others became frustrated, Heide said that she “actually thought, ‘Oh my gosh, I cannot wait’ . . . because it was a challenge to me” [I-2p9]. In addition, she reported that the

Broken Calculator (NCTM, 2006) activity was a "test of my understanding of the relationships among numbers and my ability to manipulate them accordingly" [Wk9BC].

In her forum post, she concisely stated the strategy that she used to work through the applet. She then elaborated on that strategy (i.e., gave specific steps, numbers, and an explanation of her thinking) when others posted to request help with the assignment. As one of the few participants to try the *Broken Calculator* (NCTM, 2006) activity with her students, Heide emphasized that they "REALLY loved" it and that she was excited about the potential for students' thinking and engagement [Wk9BC]. When another participant mentioned that the *Broken Calculator* (NCTM, 2006) activity would impede progress on the curriculum-pacing guide, Heide responded that the activity would support students' progress on state standardized test, not hinder it.

Heide was likewise focused on her students' thinking during the *Working with Base-Ten Blocks* forum in Week 11. When the participants were discussing the activity (i.e., using base-ten blocks to model multi-digit multiplication problems), one of her peers stated that base-ten blocks would be helpful for struggling students. Heide countered that the manipulative materials might also help students who already knew their multiplication tables because they might "not really know what their work represents," meaning those students could have basic fact fluency without having number sense (i.e., conceptual understanding) [Wk11BT]. In her own post, Heide reported:

> Using the base-ten blocks made me think COMPLETELY differently about what I was doing. I had to actually think about place values, grouping accordingly, quantities . . . it is so different than any kind of rote

> memorization approach. My mind was on expanding quantities by adding "more" blocks and larger quantities - just what multiplication is all about! [Wk11BT]

In contrast, when Heide computed those same products using the traditional algorithm, she observed that she was "not thinking of them as 'quantities' - only 'numbers'" [Wk11BT].

Heide's post for the *A Meter of Candy* forum was effusive. First, she answered all of the questions in the prompt by identifying features that support the interconnectedness of types of rational numbers, the three models presented for rational numbers, and a typical assessment for this topic (Appendix D). The remainder of her lengthy post was a description of the lesson that she implemented over the course of four days. She indicated that her small groups of students were "100% engaged" and had "almost full ownership of the learning experience" [Wk15MC]. She explained:

> They continually went back to the materials to prove their thinking - and often recognized errors in reasoning and shifted gears with the help of their partners . . . MUCH higher level of thinking than traditionally found within a math lesson on paper! [Wk15MC]

Mathematics Teaching and Learning

During the first two weeks of the oTPD program, Heide had multiple opportunities to share her views on mathematics teaching and learning. Heide not only integrated *Prime Online* PD program activities with her instruction, she also recognized the impact of the oTPD program content on her teaching practices and her views on how students learn. When presenting the *Broken Calculator* (NCTM, 2006) activity, Heide had to use

the *I Do, We Do, You Do* lesson format. During the *You Do* part of the lesson, she "turned them loose with their partners and a sheet that had problems similar to the ones I had demonstrated and became progressively more difficult. They loved it!" [Wk9BC]. Earlier in the oTPD program, Heide reported that although she used to ask her students how they got their answers, the *Prime Online* PD program made her see the need to explicitly tell her students that "we can all use a variety of strategies" [PIp8].

Heide expressed appreciation that her students' newfound independence and cooperative learning allowed her time to reinforce skills with students who needed additional support. Activities learned in the *Prime Online* PD program also proved to save time. She reported that the concepts covered in *A Meter of Candy* (e.g., connections between fractions, decimals, and percentages; (NCTM, n.d.) would take "several days to teach traditionally - and then with little true understanding" [MS14-16]. Heide stated a preference for having a "facilitator role" in her classroom and *A Meter of Candy* (NCTM, n.d.) provided her with the opportunity to step back and allow students to take more ownership of their learning [Wk15MC].

She also conveyed her wish to increase her students' independence by incorporating the use of the strategy notebooks and mathematics journals that were presented in the *Prime Online* PD program. Her students, particularly those with intensive learning needs, were overwhelmed when a new strategy was presented every day, which was the case with the curriculum-pacing guide. Heide wrote that strategy notebooks, complete with a table of contents, would be particularly beneficial for struggling learners and that mathematics journals could become a "working tool for our students" [Wk15MC]. In addition, Heide declared that, because of what was presented

in the *Prime Online* PD program, her goal was to include more "real-life and integrated" problem-solving opportunities to pique students' interest and expose them to higher order thinking [Wk2F1].

Heide's comments during the *Prime Online* PD program provide insight into her beliefs about what supports students'—and her own—mathematical proficiency. She spoke of feeling proficient in elementary school because she memorized facts and could "get the right answer, quickly, without much effort" [Wk2AA]. Although this definition remained static in middle school, Heide recalled equating proficiency with students who had "brains working differently in comparison to mine" [Wk2AA]. Her current definition of mathematical proficiency was "knowing the subject inside and out, whether it's to know the answer, know where to look for the answer, or know how to solve for the answer" [Wk2AA].

Heide repeatedly stated the importance of her students' overall feeling about mathematics and their willingness to persevere (i.e., productive disposition; Kilpatrick et al., 2001). In a Week 1 forum post, Heide lamented her students' lack of confidence in their problem-solving ability. She was frustrated that her students "acted like they couldn't think" and she wanted to "figure out how to get around that" [PIp3]. She referred to the *Broken Calculator* (NCTM, 2006) as an activity that "makes them really think—something that is the goal of our instruction!" [Wk9BC].

By attempting to follow the county-mandated curriculum-pacing guide, Heide bolstered her own confidence about mathematics teaching and learning. When students performed poorly on summative assessments, she hypothesized students' lack of retention was due, in part, to following the curriculum-pacing guide, which left little

time for reteaching. Therefore, she decided to "sort of throw that book away" and use more hands-on activities to help students understand the concepts instead of having them rotely follow procedures [PIp16]. In fact, part of her excitement with *A Meter of Candy* (NCTM, n.d.) was her students' perseverance in using the manipulative materials to justify their thinking. Heide shared that she gains an immense amount of personal satisfaction by "empowering and motivating others to be enthusiastic about the world around them" [Wk1RA].

Heide recognized some other benefits of the new district-mandated curriculum. She reported that it was "automatically prompting these discussions that didn't happen in that way before" [PIp15] and helping her, as well. She attributed her "greater understanding of mathematical relationships" to how the lessons presented in the new mathematics series appealed to her visual-kinesthetic learning style [Wk1F1]. Heide mentioned several times (e.g., Wk1F1, PIp17) that her own lack of mathematical understanding restricted both her confidence and her ability to integrate mathematics to the extent that she would like. For example, she professed a willingness to use mathematical models now that she was able to "more fully understand their usefulness for student understanding" [MS14-16]. Similarly, she wrote that she now understood how to use manipulative materials in a manner relevant to a particular concept that was being taught. After noting her perceived limitations, Heide stated that "I'm finally 'getting it'" and "as a result, I'm a better math teacher" [Wk1F1].

Participation in the *Prime Online* PD Program

> It's been very interesting to see what I say in the Anticipatory [Activity] and then reflect on where I was coming from because, I think from what we've

done so far, this requires a complete paradigm shift in thinking towards teaching mathematics. [PIp4]

Teamwork and Optimism

Throughout the *Prime Online* PD program, Heide made comments about being part of a learning community and her hopefulness about actualizing her goals for professional growth. For example, Heide made explicit mention of the importance of sharing her newfound knowledge with others. When describing how she routinely shared her oTPD program readings, she wrote: “I’ve been excited; you can ask my intern” [PIp15]. It was only the second week of the *Prime Online* PD program when she remarked, “I've already had trouble containing my enthusiasm as I've interacted with my principal, CRT, intern, ESE [special education] support staff, and my own children this week” [Wk2RA]. When there was technical difficulty with the *Broken Calculator* (NCTM, 2006) applet, Heide took it upon herself to search the Internet for other versions and posted the information to help her peers that were also having difficulty.

She found it challenging to change her teaching methods, but to do so with “little background experience” or “true understanding” was even more vexing [MS14-16]. Heide continued to voice apprehension that her mathematics ability would hinder her quest to gain knowledge, stating a need for “initial hand-holding to develop my professional knowledge. As with any paradigm shift, there was the risk of ‘failure.’ I will need a support system” [Wk2RA]. In Week 9, she expressed concerns about balancing the time needed to implement her newfound teaching strategies with the individual support required by all of her students. Two weeks later she seemed even more apprehensive and stated a need for “lots of modeling and practice” to be able to use the strategies effectively [Wk11BT]. As with her initial difficulty in explaining her problem-

solving strategies, Heide surmised that her comfort level would increase once these experiences became a routine part of her teaching practices.

Although Heide made frequent remarks about the negative impact her mathematics history had on her teaching competency, she also expressed high hopes that the *Prime Online* PD program would facilitate her professional growth. She wrote:

> I am intrigued, inspired, and challenged with my new knowledge of the five strands necessary for math proficiency. I am highly motivated to explore and implement activities and opportunities that will expand student thinking and ability, and deviate from traditional methods. I am hopeful. [Wk1RA]

She maintained a desire to "actively seek out resources that will build my understanding of how to promote the 5 strands," spend time listening to her students, and reflect on her teaching in order to drive her planning and instruction [Wk2F1]. She was also optimistic that the *Prime Online* PD program would help her "stand up to any peer pressure" and teach the way she knew was best for her students [PIp4].

Participation and Satisfaction

Heide's participation in the *Prime Online* PD program was exemplary. Her overall *participation* (i.e., the number of submissions divided by the number of required submissions) percentage indicated that she submitted 73% more than what was required and only one percent of the submissions were late or not completed. During the mathematics-specific weeks, her participation was even higher. She participated 82% more than what was required and no tasks were late or not completed. Heide's overall *requirements met* (i.e., if she met the minimum requirements) percentage was

99%, which was the same as the requirements met percentage for the mathematics-specific weeks.

Analysis of the segment satisfaction surveys showed that Heide was more satisfied than the average participant for Segment One (3.62, M=3.24) and Segment Two (3.91, M=3.29). She gave the highest rating possible for the content, pedagogy, technology and support, and the overall satisfaction for Segment Three (4.00, M=3.40).

During Segment One, Heide was presented with a chart showing that she frequently exceeded the number of required posts. She replied that she did not pay attention to how many responses were required but then followed up that statement with "I feel bad if I post too often" [PIp17]. Heide continued this pattern of numerous and lengthy forum responses throughout Segment Two, including a 471-word post for *A Meter of Candy*; the next most lengthy post by other participants was 183 words long.

Heide participated in all but three of the module surveys and each included responses to the open-ended feedback prompts. Heide wrote: "online 'discussions' [emphasis in original] not meaningful and/or possible when so few people participate. I'd rather just get feedback from facilitators, rather than try to post just to fulfill the requirement of the module" [MS13]. The facilitator feedback "always meant something" to her, whether it was directed to her or directed to one of her peers [I-2p13]. Heide seemed to view her level of participation as disproportionate. She said that she was "just weird, because I read it [all of the responses and facilitator feedback]. I was like a sponge, sucking it up" [I-2p13].

Supports and Hindrances to Participation

Unlike the online courses she took as part of her graduate program, Heide found the forum posts to be valuable. In previous courses, Heide just posted to fulfill course

requirements. During the *Prime Online* PD program, however, the posts "meant something" [I-2p14]. She reported continually seeking out anything written by one of her peers, because she inferred that he held himself to the same high standard as she did. Heide also mentioned that the positive feedback or encouragement from oTPD program facilitators was "really appreciated" and that she "took it to heart and thought about it" when she was prompted to reflect on her post [I-2p13].

Heide had the highest satisfaction levels and the highest levels of participation of the cohort but noted impediments to her complete engagement. In response to a survey question regarding possible hindrances to participation, Heide indicated that *the end of the school year is a difficult time of the year to get everything done* was a "significant problem" [MS13]. Both *the content has become more challenging* and *I do not like participating in the online discussions* were designated as "somewhat a problem" [MS13]. For example, during her PI-conducted interview, Heide stated that she did not have much discussion with her colleagues and that she questioned the quality of her answers because "people don't respond to me" [PIp10]. When asked to review the entirety of her posts thus far (i.e., January to June), however, she noticed that others' had, in fact, responded to her posts. She told the interviewer that if others were posting in a previous week, she did not always go back and read those posts.

Other issues specific to online learning also hindered Heide's opportunity to interact with the oTPD program content. Even though the Course Announcements, a summary posted by one of the oTPD program facilitators at the conclusion of each week, were sent directly to her email, Heide did not read them. She said that she automatically deleted them because she thought they were merely duplicates of her

peers' posts, which also arrived via email. When asked about missing a group assignment, Heide explained that it was more difficult to work together online and gave her age and her isolation as possible factors. She remarked, "For me personally that's hard. If I was maybe younger . . . and more in tune" and that if "somebody else was working with this it might be different but because I'm here alone" [PIp12]. Unlike others in the *Prime Online* PD program, Heide was not part of a school dyad.

She said that she missed having a school-level PD, where the entire school or a core group of teachers would do the "leg work to make it happen at your school" [PIp14]. Heide remarked that she missed interacting in a classroom setting or having the "opportunity to really discuss for real" [PIp14]. Even two years post-*Prime Online* PD program, Heide mentioned that there were times when she had wanted a face-to-face experience so that they could have done mathematics activities as a group. She thought it would have been "fun to be, all be, dumb together" and that the camaraderie would have broken down barriers because "many teachers feel like they can't say that they don't know how to do something" [I-2p15].

Heide expressed feeling a lack of connection with her peers and dismayed at the quality of online discussions. She said that she did not always read others' posts because "it's just mush-mush. It's the same old mush-mush that I hear at school; it's just talk, you know? I'm very much an action person so it's hard for me . . . it would be like discussing the weather" [PIp11]. She wanted the *Prime Online* PD program cohort to have the "common goal to support each other," which was problematic when some of her peers completed their forum posts late or did not seem to be as invested in the PD [MS14-16]. Heide found it "discouraging to witness the somewhat unreceptive and

sometimes outright negative attitudes" of others [MS14-16]. She also had a difficult time relating to her peers' "boo-hoo's" when they did not understand an assignment or activity. She wondered, "Why did they ever sign up? Were they forced to?" [I-2p12]. This tempered the content of her postings because she "didn't want to be that person that people are like, 'what is her problem? She *loves* [emphasis in original] this?'" [I-2p12].

This is not to say that Heide did not also struggle with the mathematics activities. She logged on in either late evening or early morning because it was the only time that she could "actually think" [PIp6]. Heide found learning mathematics in an online environment to be daunting. She explained that "discussing math in an online setting is difficult", made requests for more hands-on activities, and noted several times during the first four mathematics-specific weeks that jargon was impeding her learning [MS9-12]. She reported needing "some time to reflect" on not only the mathematics, but the pedagogy as well. She wondered, "How do I implement that in the classroom?" but was able to use the "more low-key" times in the course to "internalize it" [I-2p9]. She spoke of her appreciation of these downtimes and of the oTPD program structure when contrasting the *Prime Online* PD program with attending a conference. She would come home from conferences with "wonderful notes" and "great ideas," which would "go in a folder" and never get implemented [I-2p10].

Present Day Teacher Mathematical Identity

Recent Teaching Experiences

One year post-*Prime Online* PD program, Heide was moved to third grade, where how she taught was "definitely dictated" in a way that it had not been in the past [I1-p2]. She explained that she was required to use certain worksheet-based

mathematics booklets and that the "Xerox copies were made for me and delivered to my room" [I-1p3]. She expressed a feeling that she and her fellow teachers were being watched, which she found "unnerving" [I-1p4]. The whole year was "disheartening in the sense of—I just feel like that's not teaching" [I-1p3-4]. She was frustrated with the change in her teaching assignment:

> I couldn't understand how I was one of the ones chosen because my gains in fourth were fine and I felt like people who know me know how I teach and so it was just, I don't know, I didn't understand how I got put where I was and told to teach with worksheets. [I-1p4]

Heide was so affected by this experience that, by year's end, as a means to "get out" and get away from the "whole worksheet mentality" she pursued her science teaching certification [I-1p4]. However, she was given the opportunity to teach gifted science the following year and decided to remain at her current school.

Mathematics Teaching and Learning

During our interviews, Heide was asked to reflect on her teaching efficacy. When questioned about what makes her feel least effective as a teacher, she did not respond with a recent example. Instead, Heide's mind went back to her pre-*Prime Online* PD program teaching practices. She said that during the first semester of the *Prime Online* PD program "I was very . . . I felt ineffective" because she realized that she taught mathematics the same way that she was taught mathematics [I-1p8]. For example, after presenting a lesson, she would ask students if they had any questions before they started their independent practice. "Every hand went up" and she would lecture her students about how she had just taught the material and they had not even bothered to read the problem before asking her a question [I-1p8]. She would remark to other

teachers that she was appalled that the students were being “taught not to think,” but now realized that she was “actually promoting that same thing by doing the talking” [I-1p8].

In contrast to her pre-*Prime Online* PD program self, Heide often reminded her students that they do not need to have “everything memorized” and that it was more important that they know “how to use the tools that are around them” [I-1p12]. For instance, she tutored three low-achieving students over the summer and helped them create strategy notebooks. The students’ current teachers told Heide that the students knew “right where to go,” even though there was no table of contents in the notebooks [I-2p2]. She found this to be “really exciting” because it meant that the students had taken ownership of their learning [I-2p2].

Another example of students’ taking more responsibility for their learning was the breadth and depth of classroom discussions. She reported that there was

> . . . a lot more talking in math, where before I had this mentality that they had to listen carefully. I would get so frustrated and I would be, like, ‘Just listen.’ ‘Just follow this.’ Where, now, it’s not like that at all; it [the change] is huge. [I-1p7]

She explained that she was most effective now “because I introduce the skill or the concept and, much more quickly, the kids have manipulatives . . . and discuss, discuss, discuss” [I-1p7]. Then the whole class would share how they solved the problem and considered the reasonableness of their solutions.

Teacher Role and Student Confidence

Post-*Prime Online* PD program, Heide stated that, as a teacher of mathematics, she needed to have content knowledge, know how to implement activities “in ways that

supports the kids", know her students' current levels of understanding, build the students' confidence, and fill in any gaps in their knowledge [I-1p11]. She thought her students saw her as someone who helped them "make the connection to something that they already know" [I-1p8]. Heide asserted that she asked students to justify their statements "so they're more confident in what they know, " which made them "not so timid about offering what they're thinking" [I-1p8]. "Different kids offered different ideas" and any one student's statement then became the spark for small group or whole class discussions [I-1p12]. She reported asking probing questions such as "What are you thinking when you're looking at this?" and "How do you think that would be related?" [I-1p8]. She introduced the main concept or skill but then she would "quickly step back and become the facilitator" [I-1p8].

As a facilitator of her students' learning, Heide gave her students freedom to use a variety of manipulative materials and explore various strategies instead of saying "use *this* [emphasis in original] manipulative" [PIp3]. By letting them have "discoveries on their own," students "get more ownership and more confidence in their ability" [I-2p4]. She said it was "great" that her students went from "very insecure, timid kids . . . being afraid to offer anything . . . and not really truly understanding" to "where they had enough work with it that they could discuss it and then kids were learning from kids. Kids were showing kids" [I-1p5]. Heide admitted that there were still students who became frustrated but those students were now quicker to ask their peers than rely on her. In comparison to her earlier statement regarding her pre-*Prime Online* PD program teaching, where "every hand went up," now

there are no hands that go up. None. Because . . . if they read it and don't know, they're asking a neighbor, which is awesome. It's awesome because then I can just go work with the kids that I know don't have a clue. It's unbelievable. It should have been filmed. It should have been videotaped. Had I only known. [I-1p8-9]

Professional Growth and Confidence

Heide's own confidence was apparent when she described classroom discussions that impacted her as a teacher of mathematics. She said that when listening to a student's explanation, she was "trying to learn from him" and understand how he got his answer [I-1p10]. She elaborated that "some little thing that he tells me . . . makes a difference to me, where I understand" his thinking. Heide asserted that having classroom discussions improved her proficiency because she could "include that thinking in my base [of knowledge]" [I-1p10]. Her learning of mathematics "never ends" because, by listening to her students, she said that she learned how other people think about mathematics [I-1p13]. As an example, she described a student's explanation of a geometrical term that, although seemingly "minor", was something that "will be used for the rest of my teaching [career]" [I-1p13]. This discovery "would not have ever happened if kids were not allowed to talk or were encouraged to be thinking about ways that they could retain the information" [I-1p13].

Heide expected the changes brought about by her *Prime Online* PD program experience (e.g., increased MCK, awareness of how students think and learn) to play an important part in her forthcoming science-only teaching position. She plans to integrate mathematics into science lessons, stating, "you can't separate them" [I-1p16]. She will have two classrooms, one of which is a lab, and her mathematics manipulative

materials will be stored in the main building. She intends to bring over what she needs because if a concept (e.g., differences in temperature or weights) comes up that the students do not understand, she was "going to stop" and work through it before moving on [I-1p16]. She said, "I certainly don't know everything, but I feel so much more confident in talking and teaching and discussing and setting up mathematical related things, whatever they are" [I-2p7]. In fact, when considering that her current teaching assignment was a math-only gifted teaching position in prior years, she did not think that she would have been "confident enough to take gifted math" without having participated in the oTPD program [I-2p7].

Heide's post-*Prime Online* PD program self was better able to understand her colleagues. She questioned why other teachers were not implementing the modeling strategies put forth in the new mathematics curriculum. She "absolutely" would have considered herself among this group of frustrated teachers who thought teaching mathematics was "just awful" [I-2p10]. She conceded that, "after doing *Prime Online*, I think a lot of it is teacher knowledge of what to do" [I-1p7]. Heide expressed empathy:

> I feel really bad now when I look around at teachers who—and I see it every year—who feel so constrained. And math, because I actually love teaching math now, math is an area where traditionally teachers . . . might look at the overview for the week, but it's just bang, bang, bang. It's just cut and dry, you don't integrate it. . . . you open the book and you do what it says. So I don't know what it would take, and yet we all know that our kids are not proficient in math. [I-1p14]

Shifts in Teacher Mathematical Identity

> Before, it was more teacher-talk . . . so the understanding was superficial. Where now I feel like I'm more effective because the kids are actually discussing it and they're writing in their journals, in their own words, and drawing pictures. I became much more confident in utilizing the thinking of the kids in the classroom and having them supporting each other appropriately. [I-1p8-9]

MCK and MKT

Heide said that her "paradigm shift was enormous, enormous," and spoke about being "dedicated" to doing whatever she could to make sure her students learn [I-1p7]. First, she had to get past her own lack of content knowledge in mathematics. Heide admitted on the module surveys that mathematical jargon stunted her progress in Weeks 9-12 (i.e., the mathematics-specific weeks). However, her increase in MCK was evident when she compared multiplying multi-digit numbers with base-ten blocks versus the steps in the traditional algorithm. She said that, because of the knowledge she gained, "I love teaching math" [I-1p8].

That was not true of her pre-*Prime Online* PD program self. Mathematics was the one subject that she "always felt so stilted" by and that left her "so frustrated" because she didn't know what else she could say or do to help her students understand the concepts [I-1p7]. Heide frequently mentioned how she was able to integrate all other subjects beside mathematics. Although "known to 'buck the system' when the kids aren't learning," she was never sufficiently confident to do this when she taught mathematics [I-2p3]. Early in the oTPD program Heide stated that the integration of mathematics was one of her goals. Once Heide had a clearer understanding of how to

teach mathematics, she incorporated the concepts throughout the day and also intended to extend that integration into next year's science-specific curriculum.

Role of Assessments

Heide expressed more confidence about teaching mathematics before the *Prime Online* PD program even concluded. During the PI-conducted interview, two months into the oTPD program, Heide described her best lesson as being inspired by the *Teaching Children Mathematics* journal articles from the second week of the program. She said that she had walked into her class on an assessment day and told the students that they were going to do something different. She told them to "use manipulatives, number lines, graph paper, etc. as necessary and if you're stumped, discuss your thinking with a classmate. Adults will only provide a definition for a word/phrase and/or read the problem to you. Otherwise, you're on your own" [PIp3].

In addition to shifting the mathematical thinking away from her and onto the students and creating a more collaborative learning environment, this teaching practice also provided Heide with the opportunity to learn about her students' individual needs. She "felt a certain sense of liberation, as I circulated to listen to their discussions and watch their problem-solving strategies in order to learn more about how they think" [Wk2F1]. She then used this information to help decide how to organize students for future small groups and paired mathematical activities. In Week 9, Heide was concerned about the time needed to keep track of students' progress, but by Week 15, she found that she was able to "become an observer and could circulate, taking notes on each student's level of understanding" [Wk15MC].

Teaching with Manipulative Materials

Another shift in Heide's teacher mathematical identity was that she learned how to more effectively teach mathematics using manipulative materials. During Week 1 she wrote about a lesson in which fraction bars were used to teach fraction equivalency. She summed the lesson up as being "positive, concrete, interactive, fun, and meaningful" [Wk1AA] and later described it as more of an "experience" than a lesson [Wk1RA]. Heide said, "If they can experience it first and then take what they know and apply it, I just, I've always had great success teaching that way and I was doing it in every subject except math" [I-2p5]. Until the *Prime Online* PD program, she had been unable to teach mathematics with the engaging, hands-on approach to learning that she favored.

Heide explained that she had always liked, and incorporated, manipulative materials, but she lacked the "ability to use them as effectively (and often) as necessary" [MS14-16]. Midway through the oTPD program, Heide learned about teaching addition and subtraction of fractions conceptually prior to procedurally. She wrote that it was "yet another week that is making it impossible for me to teach like I used to!" which reinforced her "desire to allow for student exploration BEFORE [emphasis in original] trying to teach procedure" [MS14-16]. She now introduces mathematical topics using manipulative materials to support students' conceptual understanding.

Summary

I had a paradigm shift of the highest magnitude [I-1p14].

Heide seemed to truly enjoy talking about her teaching and her experiences with the *Prime Online* PD program. She was relaxed and laughing during both of our

interviews. Her comments throughout the oTPD program and interviews, as well as the physical layout of her classroom, support her assertion that she had an integrated, hands-on teaching style. She had experience in outdoor education, special education, general education and, now, gifted education. She had considered leaving her school of 11 years, however, because of constraints placed on her by school-based administration.

At the beginning of the *Prime Online* PD program, Heide wrote that she hoped to learn enough to be able to teach how she knew was best for her students and stand up to any peer pressure regarding the curriculum-pacing guide. During the interviews two years post-oTPD program, Heide said that she could tell that some of her *Prime Online* PD program peers followed the curriculum-pacing guide. Heide, however, said that she was not worried about keeping her job if she did not follow suit. She volunteered, "If I don't keep my job I'll go do something else, but I'm not worried about necessarily pleasing the principal" [I-1p14]. Heide went from being concerned about being pressured into following the curriculum-pacing guide to not caring if she lost her job if she did not follow the curriculum-pacing guide.

Heide professed that it was only due to the *Prime Online* PD program that she was able to teach mathematics the way she had always taught the other content areas. Heide attributes her "atypical" *Prime Online* PD program experience to a combination of her age and her experiences with students with exceptionalities [I-1p15]. She said that she never had the "attitude . . . that . . . children weren't smart if they didn't learn something. I knew that there was more to it, that there were other ways that you could show them or teach them" [I-2p6]. She explained that, as a special education teacher,

she had to “figure out a different way to do things” [I-1p15]. When asked about personal factors that may have contributed to what she took away from the PD, Heide credited her motivation and her perfectionism. She said she did not want to “do it [the oTPD program] badly” and she had a “responsibility” to her students to do well [I-2p6]. She was open to learning new content and pedagogy because, as she stated frankly, “I never have a problem admitting if I don’t know something” [I-2p10].

CHAPTER 5
BRYNN: TRADITIONAL INSTUCTION, SPORADIC PARTICIPATION

Prime Online PD Program Teacher Mathematical Identity

> I was not a strong math student, though, as a kid. And something I've always been afraid of is that [not being a strong math student] would kind of hold me back as a math teacher. I'm happy, though, to get an opportunity to do anything that improves my math teaching skills and even my math skills. [PIp1]

Mathematics History: An "Average Student"

Brynn recalled being an overall "average math student", but there was a marked difference between her experiences in elementary school and her experiences in subsequent years [Wk2F1]. In third through fifth grade, she was a "math genius" [Wk2AA]. Brynn credited her parents for her early success in mathematics. They had her practice counting money at the grocery store and required her to make flash cards to help her memorize basic facts. Brynn recalled only being taught traditional algorithms. She was not taught that there were multiple ways to solve multi-digit multiplication or long division problem and surmised that this was because she showed proficiency with the traditional algorithms. Brynn reached her "math skills peak" in seventh-grade pre-algebra [Wk1F1]. After that, mathematics became her most difficult subject and she was also concerned about any science classes that involved mathematics. Her negative experiences in secondary and post-secondary education quelled her desire to extend her "math thinking beyond that level" [Wk2F1].

Self-Efficacy

Brynn said that, regardless of their abilities as learners of mathematics, teachers have an obligation to overcome any challenges for the sake of their students. She reported that she was confident in her ability to teach mathematics during her first year. She became "very uneasy", however, when her students gave her "the same look that I gave my math teachers in high school" [Wk1F1]. Brynn did not want her students to have the same negative experiences as learners of mathematics that she had. She wanted to become a better teacher of mathematics and to positively affect her students' mathematical dispositions. Soon after beginning the *Prime Online* PD program, she wrote, "I'm excited about helping my students move from being put off by math toward being mathematically proficient" [Wk2RA]. To this end, Brynn expected her oTPD program participation to help her "achieve higher levels of competency in my own understanding of math." [Wk2F1].

Even with her concerns as a learner and teacher of mathematics, Brynn considered herself to be an "average math teacher" [Wk1RA]. After reading about the Principles for School Mathematics (i.e., equity, curriculum, teaching, learning, assessment, and technology) (NCTM, 2000), Brynn remarked on the amount of PD that would be needed to develop her instructional practices to meet those levels. She wrote about the effort that she was going to have to put forth to glean what she wanted from the oTPD program content, especially considering its asynchronous format. In the Week 2 Reflection and Assessment, Brynn expressed concern that the lack of true discussions and enough visual aids might prevent her from "grasping future content and applying it in my classroom" [Wk2RA].

As part of a Week 1 assignment, Brynn gave an example of a recent 'best lesson' in mathematics in which she was the special education co-teacher during whole-group instruction on fraction equivalence. The lesson was organized in the following manner: vocabulary review, teacher demonstration, independent practice, remediation or enrichment as needed, and a one-question assessment. She purported that this teaching method (i.e., gradual release) created an environment that supported her students' willingness to learn mathematics. She remembered, however, that she and the general education teacher had doubts even while teaching the lesson. They recognized a potential for "awesomeness" (i.e., an even better lesson) but needed to get the students to a point where they could "figure out something that's quick and easy and they can do it and it's a no-fail situation" [I-2p7].

During the PI-conducted interview, two months into the *Prime Online* PD program, Brynn was asked if there had been any changes in her thinking about teaching mathematics. She responded by describing a district-mandated calendar lesson that she had done that day. Instead of following the lesson plan she was given, she used this time as "another teaching opportunity" [I-2p2]. She adapted the calendar lessons to incorporate skills that her students had not yet mastered. She recalled details of the lesson:

> So I said, "Has anyone noticed that the bigger this number gets the smaller our quotient gets? As the divisor gets bigger the quotient gets smaller. Did anyone notice?" And they're like, "Yeah." And I said, "Why do you think that is?" And they're just quiet. And I said, "Well somebody has to think something," so I just wrote the question up on the board and

had them pair up with each other and I said, “How about you guys discuss why you think the quotient is getting smaller as the divisor gets bigger?” And I said, “If you need to draw a picture using base-ten blocks to kind of give you an idea of what I’m talking about, do that. If you want to do some example problems do it.” So they’re doing it and as they’re talking to each other and having these math conversations. A couple [of] kids [said], “I think it’s because you have to break it up into more groups when the number gets bigger.” And I’m like, “Oh, you’re getting it.” I’m getting chills and I’m walking around the class and I’m like, “Oh God, this is great.” But I don’t think I would have done that before because Calendar Math is such a small part of our day but that was very much a teachable moment and before. . . . *Prime Online* I can’t say I would have done it. [PIp11]

MKT During *Prime Online* PD Program Activities

Brynn scored above the mean in CKT-M Test 1 and 2 (Table 4-2). She could not recall why she did not complete Test 3 (i.e., posttest). Contrary to her initial concerns about grasping the content, Brynn persevered even when it was “a lot to kind of take in at once.” [PIp8]**.** When she needed clarification, she asked for it. For example, **s**he had a revelation during the Week 2 Content and Discussion. Brynn did not know if she understood the article on mathematical proficiency because her response was probed by one of the oTPD program facilitators. Even though she thought his question might have been rhetorical, she responded to his query. Brynn later reflected, “it was probably the first time I ever said, ‘Well, let me ask the question back so I can really get it this time’” [PIp8]. That question (i.e., *What do you think?*) was “big” and “opened up a little more discussion on my end as far as mathematical proficiency goes” [PIp8].

Table 4-2. Brynn's CKT-M scores

	Test 1 Percent Correct		Test 2 Percent Correct		Test 3 Percent Correct	
	CK	KS	CK	KS	CK	KS
	83.3	80.0	73.1	73.7	no response	no response
Mean	*71.4*	*75.0*	*72.1*	*72.9*	*65.8*	*73.5*

Brynn also persevered while working through the *Broken Calculator* (NCTM, 2006) activity in Week 9 (Appendix D). She called it "TOUGH!" and reported that her friends thought it was a "mean joke" likely because it was a calculator without fully functioning keys [WK9BC]. She struggled to find a strategy for solving the problems and likened the *Broken Calculator* (NCTM, 2006) activity to a Rubik's cube. Brynn did not let that discourage her and she even asked others to find out if the method or pattern—if there even was one—should be taught to the students or if the students should figure it out themselves. She wanted to know which method would be better for developing students' number sense. Supplementing her statements that this was a difficult activity, Brynn agreed with a peer who suggested that the *Broken Calculator* (NCTM, 2006) activity would be appropriate for the "math whiz kids in class" [Wk1F1].

Brynn had less difficulty using base-ten blocks for multiplication of larger numbers in Week 11. She called the activity "very interesting" and was able to relate the manipulative materials to her understanding of place value [Wk11BT]. After completing the activity, Brynn stated that she still preferred the traditional algorithm. She then admitted that she probably favored the traditional algorithm because of her own history as a learner of mathematics. She cautioned that relying on strategies (i.e., the use of manipulative materials) other than the traditional algorithm would not be practical in most situations such as when multiplying two very large numbers. Unfortunately, further examination of Brynn's MKT during the *Prime Online* PD program

activities was limited because she did not respond to anyone's posts in the Week 11 Broken *Calculator* (NCTM, 2006) activity, participate in the Week 15 *A Meter of Candy* (NCTM, n.d.) activity, or provide feedback in Segment Two module surveys (e.g., MS9-12, MS14-16).

Mathematics Teaching and Learning

During the first two weeks of the oTPD program, Brynn had multiple opportunities to share her views on mathematics teaching and learning. Helping students become independent, functioning adults was an important part of how Brynn saw her role as a teacher of mathematics. Brynn wanted her students to be "mathematically literate in their personal and professional lives" and said that she was happiest when she could make a challenging concept accessible to all of her students [Wk1RA]. Sometimes this meant teaching students tricks or quick strategies. In our second interview, Brynn was asked to clarify the difference between the terms tricks and quick strategies and to give an example of each. She was unable to recollect exactly what she meant by those terms and determined that they were likely synonymous. She was also unable to give an example of a quick strategy with certainty. Brynn supposed that, given a problem such as 1/2 multiplied by 2/6, a quick strategy would be to simplify 2/6 to 1/3 prior to calculating the product instead of simplifying the product after multiplying 1/2 and 2/6. During Week 2 Brynn joked that, without being able to reason and come up with a strategy, everyone might have to resort to carrying "bags of those red and yellow counters when we grocery shop" [Wk2F1]. She stated that if students reached the intermediate grades without conceptual understanding and procedural fluency they would need to rely heavily on quick strategies in order to be successful in mathematics.

Brynn had very clear ideas about what was important for students to learn to become mathematically proficient. Not only did she emphasize strategies that she thought would ensure success, she was also a self-described 'stickler' for basic facts mastery. She saw quick strategies as a way for non-proficient students to have some measure of success in mathematics. When questioned about her stance on using tricks, Brynn wrote:

> I see the benefit of knowing ways to make math bearable and enjoyable for a child who isn't confident in his computation ability. I find that my students who are stronger students that prefer the traditional methods of computation aren't as interested in the tricks [quick strategies]. They think it holds them up when they could be moving on. The kids who struggle look for an alternative method. [Wk2AA]

Additional comments made by Brynn during the Week 2 Anticipatory Activity showed how her thoughts on mathematical proficiency aligned with her thoughts about the relationship between students' learning and the need for real-world application. For example, in response to her peers' descriptions of proficiency, Brynn suggested that mathematical proficiency was equivalent to strategic competence (i.e., the "ability to formulate, represent, and solve mathematical problems"; NRC, 2001, p. 116). Furthermore, she believed:

> being proficient in math means being able to naturally apply learned operations to various unrelated situations. Instead of only thinking about division when seeing a division symbol, one should recognize situations

that require division and apply knowledge from another area of math to answer a real-life question. [Wk2AA]

Part of mathematical literacy is application of concepts to real-world contexts, which was a recurring theme for Brynn throughout the oTPD program. She explained that she was most effective as a teacher of mathematics when she taught a student to apply a newly developed skill to a real-world context. Brynn saw how excited her students became when they came to the realization that "something that has been taught in class has become useful in life" [Wk1AA]. She supported this learning by seeking out new ideas and activities from the other teachers at her school to try out in her classroom. She also "loved" to create lessons that allowed students to have "meaningful and fun interactions with math" [Wk1F1].

Because Brynn valued student interactions, she was not averse to relinquishing her role as teacher when the opportunity arose. Because of the state-specific standards in place at the time, Brynn's fourth graders were taught how to classify two-dimensional figures when they were in third grade. According to the newly adopted CCSS-M (CCSSO, 2010), classifying two-dimensional figures is now a fifth-grade standard. Therefore, her fourth graders were, at times, able to teach mathematical concepts to her fifth graders. Brynn reported feeling that student-student learning would reinforce the fourth graders' skills while teaching the fifth graders additional strategies. Brynn wrote that, most importantly, she enjoyed "watching the conversations that students are having with each other when they take on the role of the teacher" [Wk1F1].

Brynn explained that her desire for fun and interactive lessons sometimes conflicted with county curriculum mandates. She wanted to "implement these lessons

without fear of falling too far behind according to the pacing guide and being reprimanded for it" [Wk1F1]. She said that this caused her to "race" through lessons "for the sake of exposing the class to the content in a timely manner" [Wk1F1]. Two weeks into the oTPD program, however, Brynn began to integrate her learning into her teaching and proclaimed, "I'm excited, I'm excited; I like it [*Prime Online*]" [PIp11].

Participation in the *Prime Online* PD Program

> I also like reading a lot of what people are talking about within the forums, like the Content and Discussion, especially when it . . . makes people kind of riled up and be like, "You know, I have a lot to say about this topic." [PIp3]

Applicability and Openness to Change

Brynn conveyed her aspiration to make mathematics relevant to her students' lives and that she expected PD to be relevant to her teaching. While she enjoyed the readings from practitioner journals, she sometimes found the research articles difficult to understand. She preferred articles that provided concrete, practical ways to teach mathematics. She summarized, "I think that's what professional development's about, giving [you] something you can use" [PIp9].

Brynn was receptive to trying new ideas and expanding her views about mathematics teaching. As part of the Week 2 activities, participants were asked to read an article in *Teaching Children Mathematics*, a practitioner journal, about "mathematical practices that promote mathematical proficiency" (Suh, 2000, p. 163). Brynn was pleased that the article gave "detailed, explicit ways to encourage problem solving and math application as a life skill" [Wk2F1]. In her forum post, she mentioned several strategies from the article that she planned to implement in her classroom: *Math Curse*

had students “see math everywhere” and bring real-life mathematics problems to class, *Math Happenings* involved the teacher posing her own real-life mathematics problems to the class (e.g., painting a nursery), and *Convince Me* guided students through the writing process of justifying their answers. Brynn’s openness to new activities and teaching practices seemed to be a natural consequence of her goal to make learning mathematics a positive experience for her students. She was particularly interested in strategies that would help her struggling learners such as strategy notebooks. These could support the learning of those students who, “from lesson to lesson or chapter to chapter are just like, ‘I don’t even understand and I tried to do repeated subtraction, but I’m on my third page of subtracting and why can’t I do that?’” [PIp12].

Brynn was similarly open to modifying how students are assessed. She applauded the collaborative assessment implemented by a *Prime Online* PD program colleague and related it to her experiences as an adult learner:

> It reminds me so much of MANY of my college courses in which teachers allowed us to collaborate with a classmate during assessment using whatever resources we had collected over the semester to enhance our understanding of a concept. It's interesting that in elementary school we're encouraged to have students collaborate ALL THE TIME through things like Kagan Structures but when testing day comes, they're on their own. I know that as an adult in college and as a professional, there are very few times when I can't say "I'll check a source and get back to you with an answer.” [Wk2F1]

Participation and Satisfaction

Brynn's participation in the *Prime Online* PD program could be characterized as inconsistent. Her overall *participation* (i.e., the number of submissions divided by the number of required submissions) percentage indicated that she submitted 41% more than what was required and 26% of the submissions were late or not completed. She fared a bit better when the mathematics-specific weeks were considered separately (i.e., 146% and 21%). Brynn's overall *requirements met* (i.e., if she met the minimum requirements) percentage was 93%, although 24% were late or not submitted. In this instance, the requirements met for the mathematics-specific weeks were lower than the overall requirements met (i.e., 87% and 26%).

Analysis of the segment satisfaction surveys showed that Brynn was less satisfied than the average participant for Segments One (3.15, *M*=3.24) and Two (3.20, *M*=3.29). After Segment Three of the *Prime Online* PD program, Brynn was still less satisfied than the average participant (3.35, *M*=3.40).

During Segment Two, Brynn's participation waned. At least one post and one response were required for each of the three forums considered for this study. Brynn completed the requirements for the Week 9 *Broken Calculator* (NCTM, 2006) activity, supplied a post but no response for the Week 11 *Working with Base-Ten Blocks* activity, and did not participate at all in the Week 15 *A Meter of Candy* (NCTM, n.d.) activity (Appendix D). She did participate, however, in the Anticipatory Activity and Forum 1 for Week 15. When asked about this lack of participation, she concurred that it was almost certainly due to Week 15 coinciding with the last week of the school year. Brynn had many opportunities to give feedback to the oTPD program facilitators. When given a survey after Week 13 to help determine participants' hindrances in completing posts

and assignments in a timely manner, Brynn did not respond. Brynn provided open-ended feedback on Weeks 1 and 2 module surveys, but did not provide any feedback for the remaining 11 module surveys. She indicated that she struggled to "balance it all" during her first year as a general education classroom teacher (PIp4).

Supports and Hindrances to Participation

It is easy to assume that one's lack of participation is a sign of disinterest. Brynn's comments, however, refute this supposition. During the PI-conducted interviews, teachers were asked to reflect on their participation levels. When Brynn was shown her statistics (i.e., the number of times posts and assignment requirements were met and completed on time) from the first six modules, she was quick to point out, "I'm a late person, I'm just a late person" [PIp13]. She would try to find time at school to "jump online", but said that most of her assignments were completed at home and were treated like any other obligation outside of the school day [PIp4].

Submitting discussion posts was the most challenging part of the oTPD program for Brynn, particularly if she had missed a due date. At the beginning of the oTPD program, each week's assignments had different due dates spread throughout the week (e.g., Sunday, Wednesday, Friday, and Monday). By Week 4, all assignments were due at the end of each week to give participants more flexibility. Before this change, Brynn would become frustrated, saying, "I didn't do my Anticipatory Activity on Sunday now it's Friday and it looks like I'm just now anticipating something I should have been thinking about all week" [PIp4]. She explained that submitting discussion posts on time was more difficult in the first few weeks because the due dates kept changing and she was "that person who needs to know in advance" [PIp12].

The timeliness of Brynn's posts was a factor in the ease in which she could interact with others. She explained that if she posted late in the week, that person might not go back and check the discussion forum. For example, if Brynn was the last person to post and she posed a question to a peer or tried to add to the discussion, that person might not log back on until the beginning of the next week and, even then, might not go back and check the previous weeks' posts. Conversely, if she posted early in the week, then *she* might be the one who does not go back and check the discussion forum. For example, if Brynn was able to complete her Anticipatory Activity, Content and Discussion, and Reflection and Assessment by Thursday, she might not log on until Sunday when the next week started and might not look at the previous week's posts when she did log on.

A lack of interaction with her *Prime Online* PD program cohort was mentioned more frequently than any issues regarding scheduling or the timing of discussion posts. Brynn lamented that some of the forums posed questions that were "so specific" that it made discussion and interaction "hard to pull off" [PIp5]. Brynn indicated a need to feel connected to the other participants and to have an idea of what went on in their classrooms. During Week 5, participants were asked to provide one example of how the components of self-regulated learning could be enacted in their classrooms. Brynn remarked, "This was one of my favorites to read, by far, because again this is letting me look in Abby's classroom, Amy's classroom, Heidi's classroom, Madelyn's classroom, Brad's, Carly's . . . " [PIp9]. She repeatedly stated how much she enjoyed articles and forum discussions that gave her ideas and resources that could be used in her classroom right away.

Some of Brynn's hindrances were specific to the online format. During Week 4 (i.e., Theories of Learning and Teaching Practices: Explicit Strategy Instruction) the participants were assigned to one of two groups. Each group of four was to work together and respond to three questions after reading a research-based article on instructional strategies for students with LD. When faced with this group assignment, Brynn said that she was unsure of how to approach it without being able to meet or call her peers. She said that she did not mind working in groups when in face-to-face environments and that it was the online format that made the group assignment "tough to figure out" [I-2p13]. She had hoped for a "real, collaborative" effort instead of each person doing part of the assignment and then putting it together at the end [I-2p13]. Brynn explained that group projects should be "full-out discussion" and "putting our heads together" [I-1p13]. She wanted the "type of dialogue that we would be exchanging in a classroom setting" [PIp3]. She had a "gripe" that she said applied to any type of online learning:

> you don't have the benefit of that flowing dialogue where someone says something and then that immediately makes you go, "oh." And you can ask for clarification and it's just constantly moving, like it would be if we were just talking. [I-2p9]

Her concerns about interaction with the facilitators were also specific to the online format of the PD. Brynn said that it was the "nature of online" that students were unaware if their posts were being read by the facilitators [I-2p12]. Although she said that she was uncertain if her comments were being read, she clarified that this uncertainty applied to any online course, not just the *Prime Online* PD program. As with

any asynchronous oTPD, it is unlikely that a participant would receive an immediate response to a posted comment or question. Brynn remembered thinking, as she responded to one of the mathematics prompts, “I hope I’m really answering the question in the correct way because, again, I can’t raise my hand and say, ‘Well, I’m thinking of saying something like this, does that make sense?’” [I-2p11]. She said that she would also never know if a question that she posed in her post was going to be answered, whether by the facilitators or her peers.

Even though the facilitators’ posts were part of the general forum thread, Brynn reported that when a facilitator commented directly to her it was “almost like you feel like they were talking to you, then, and not the class” [I-2p12]. She referred to one instance of facilitator feedback that prompted her to think more deeply about her initial response. She said that this interaction was “more ‘conversation’ as opposed to ‘assignment’” [I-2p12]. Although Brynn appreciated individualized attention from the facilitators, she acknowledged that she did not think there was a direct relationship between her own participation and the frequency or quality of facilitators’ forum posts.

Present Day Teacher Mathematical Identity

Mathematics History: Closing Doors

Brynn expanded on her history as a learner of mathematics to include regrets and the long-reaching consequences of her negative experiences. Once again she pinpointed her downfall as being in her eighth-grade year; until then, she was “really good at math” [I-1p13]. Because of her academic difficulties, Brynn chose to take Algebra I in high school instead of skipping to Algebra II. She recalled that her “math confidence went way down” because it was the first time that she struggled in a class [I-1p13]. Brynn said that, looking back, she “hates” that she “didn’t really put 10,000% of

my energy into being a better math student" [I-1p13]. Once she got to college she saw many interesting career options, but realized that she did not have the mathematical background required for those fields. Brynn stated that she "hates" that she limited her options by not taking more mathematics courses [I-1p13]. The resulting doors closed on potential career choices fueled her to

> take my own experiences, and keep in mind my own shortcomings in math, and try to be better at teaching math to students so that they don't have to feel like I felt when I wasn't good at it anymore. [I-1p13]

Mathematics Teaching and Learning

During our first interview, Brynn harkened back to her own mathematics history to explain her feeling of obligation to help her students understand the value of mathematics for the rest of their lives. She called mathematics an "empowering life skill" because being good at mathematics could "open doors" to future careers, help you "do a budget", and help you avoid getting "cheated" [I-1p9]. Brynn suggested that mathematical proficiency "really varies from person to person based on their walks in life and where they are" [I-1p10]. She gave examples of people who unwittingly made bogus investments and professional athletes whose money was squandered because of mismanagement. Brynn stated a sincere hope that all mathematics teachers can impart on all of their students the importance of knowing enough mathematics to reach their future goals, especially as they are not yet sure of where life may take them.

She said that she tried to provide a deeper connection and support proficiency by integrating mathematics into other subject areas. Like many other teachers, Brynn realized the value of using real-world contexts for mathematics problems. She looked for teachable moments throughout the day because it "gives them a better idea of math"

[I-1p11]. While she admitted that it was easiest to discuss the relevance of mathematics when teaching science, Brynn also indicted a desire to incorporate mathematics-related literature and set up a class store. Her ultimate goal was to "find more ways to just make them do math all the time" [I-1p11]. Brynn recalled reading about the *Math Happenings* (Suh, 2007) strategy:

> students actually have to search in their own day-to-day lives, even at home, and say, "Okay, well, when am I really using math?" Because I think the more aware they are of it the more likely they are to kind of just focus in on it and say, "Okay, I can do this because I remember doing this in school" or "I can do this in school because I remember doing this at home." [I-1p11]

During our second interview, Brynn brought up her continued struggle to balance the integration of mathematics, her students' instructional needs, and keeping pace with the mandated county curriculum. She credited the *Prime Online* PD program discussions, however, for making her "totally look at my teaching practices differently" [I-2p2]. There was still pressure to "stay on pace" and make sure she was "hitting the standard at this date, during this time of your day for this long" [I-2p2]. She explained that the reality was that students were not progressing simply because the curriculum-pacing guide said that they should.

Unlike her pre-*Prime Online* PD program self, Brynn responded to this dilemma by teaching for mathematical understanding and moving students from the "concrete to pictorial to abstract" and not merely teaching concepts abstractly [I-2p2]. When asked to describe her best recent mathematics lesson, she replied, "teaching division of whole

numbers; introducing it and being able to use base-ten blocks" [I-1p3]. Brynn reported that it was difficult to use manipulative materials with the instructional materials (i.e., county adopted textbooks) they were given because each day was a new lesson and a new strategy. On this particular day, however, Brynn didn't "really care what the book says. Right now I just want to know that they understand how division actually works" [I-1p4]. She took out base-ten blocks and dry erase boards and had the students put their books on the floor. Brynn launched into a discussion with her students about a topic she knew they would understand—doing laundry. They talked about dividing the clothes by color and then moved on to the number of loads that can be done if you have *x* pieces of clothing and the washer holds *y* pieces of clothing at one time. She modeled problems with base-ten blocks on the SMART Board™ and had a whole group discussion about the various ways to solve each problem. Brynn asserted that the lesson provided a "jumping off point" for a deeper understanding of division and "it was fun, they got it, they liked it" [I-1p4].

She struggled with knowing the value of having a deeper understanding of grade-level concepts and the need for time to remediate her students. Brynn remarked that she was most ineffective as a teacher of mathematics when many of her students come in each year not knowing their multiplication tables. The first four chapters of the textbook were multiplication and division, but she had to spend weeks practicing basic facts. Brynn indicated that this left her frustrated because she knew where she was supposed to be in the county pacing guide. In addition, as a student who learned her multiplication tables at home, she had difficulty empathizing with these students. She said she tried to "kind of pull myself back" and realized that she could not compare her

mathematics history to that of her students [I-1p8]. Being a gifted student, Brynn did not "struggle with much at all" in elementary school and had to remind herself that it "takes some patience and . . . just trying to understand" the various learning needs in her classroom [I-1p8].

One way she supported her students' remediation was by using small-group instruction. Although she would have liked small groups to occur more frequently, it was during this time that Brynn considered herself to be most effective as a teacher of mathematics. She reported enjoying being able to "sit down with them and work with them on a concept all, kind of, within close quarters" [I-1p7]. She used small-group instruction to make sure the students not only knew the algorithm, but also had a real understanding of "how that [algorithm] actually works in reality" [I-1p7]. This was typically achieved by using manipulative materials. When working in whole group activities, her students knew how to work with the student sitting next to them and share the set of manipulative materials they were given. There were not enough manipulative materials for each student, but Brynn said that putting students in pairs provided more opportunities to interact and participate than their typical groups of four.

When describing a particularly effective small-group activity, Brynn remarked that base-ten blocks were her "best friend now" [I-1p7]. The mini-lesson was modeled after an assignment she did in the *Prime Online* PD program. She wanted to support her students' understanding of zeros in a subtraction with regrouping problem. She told her students, "I know it's a zero, but it's not really nothing. It's really a ten, even though it's a zero and there's a zero in the ten's place and we think zero means nothing" [I-1p7]. Because actual base-ten blocks were not on hand, Brynn used drawings of base-ten

blocks to show a student how to regroup. The student crossed out a ten (i.e., a rod or long), drew out the units and then crossed out the units that were being subtracted. Brynn attested that the student was able to “cross out and break up” the picture because base-ten blocks were used often in class [I-1p7]. In summarizing this story, Brynn revealed that she ”loves” being able to “devote that attention to a kid that needs it” and that she “felt good about it because she [the student] felt good about it” [I-1p7].

Professional Growth and Opportunities

Participation in the *Prime Online* PD program spurred Brynn’s professional growth in several ways. She was more open to oTPD, mathematics PD, and PD in general. She was still “not a big fan of online formats”, but realized they are ubiquitous and that “anything is going to be as good as you make it. And if it’s online I can benefit from it as much as I choose to pour into it” [I-1p14]. When Brynn sees an oTPD program now, she said she would “jump on it” [I-1p14]. She made similar comments about mathematics PD:

> When I see a professional development opportunity for math, I’m jumping on it. And now I’m starting to feel like I want to do the same thing with reading because I am just constantly trying to figure out how can I be better at this so it can better benefit them. [I-1p14]

Brynn continued by stating that her students’ academic struggles are what steers her toward a subject specific PD. Brynn regarded her students’ struggles as a reflection on her and, therefore, sought “better ways to reach them” [I-1p14]. It was this type of thinking that made her take notice of the *Prime Online* PD program. Brynn stated that the most important factors in choosing a particular PD program are if it had good, quality

literature and if the PD program provided activities that she could “take back to my room and use” [I-1p15].

Since the conclusion of the *Prime Online* PD program, Brynn became more familiar with the mathematics content specific to her grade level. She was asked by her principal to represent their school and help map out the county pacing guide for the newly adopted mathematics instructional materials. This involved merging the previous mathematics series with the current mathematics series because the new textbook series only covers CCSS-M (CCSSO, 2010) and the students would still be tested on the state’s standardized test, which was not aligned with the CCSS-M (CCSSO, 2010).

Brynn reported having a “new respect” for the pacing guide, but spoke of a student who was “not going to be where he or she was expected to be when the pacing guide says they should be there” [I-1p16]. Brynn expressed that she often left her room feeling like she had done a disservice to her students because her “hands are tied” by county mandates. She said that it saddens her but she had to persevere because “What else can you do?” [I-1p15]. She indicated that she believed she could reach all students if she could just keep them a bit longer each day. She wanted to be able to say, “Forget the books. Let’s just get on the floor and let’s just pick things up and let’s just draw things out and let’s take out a measuring stick. And just let them be in math. [I-1p15]

Shifts in Teacher Mathematical Identity

> The thing about professional development—and I know I would probably get more out of it if I was posting earlier in the week more consistently—is that . . . you have an opportunity to kind of go back and forth and you’re going to get out of it whatever you put into it, just like everything. [PIp14]

Self-Efficacy

A notable shift in Brynn's teacher mathematical identity was that, due to her confidence in her teaching abilities, she ignored the textbook and taught the content using manipulative materials and discourse. For example, Brynn mentioned that it took two weeks for her students to get comfortable with the area model. She did not move on to the next lesson to keep up with the curriculum-pacing guide because she wanted her students understand the concept. She explained the challenges she faced and how the *Prime Online* PD program impacted her instructional practices.

> As a novice teacher . . . you're holding onto your pacing guide and you're teaching your teacher's editions. . . . [trying to] make sure I don't lose my job and that I teach everything that I'm supposed to teach and just get through the year. You feel like that for a lot of years, but I feel like *Prime* [*Online*] really just kind of brought in my education about what it means to truly teach math and truly help a kid understand math. And I loved *Prime* [*Online*]; I cannot say that about every PD that I've done. I really enjoyed it. . . . It helped me understand. [I-2p3]

Brynn's view of what constituted good teaching had also shifted. Each of her *best lessons*, reported during Week 1 and then two years post-OTPD program, included remediation and enrichment, the use of manipulative materials, and followed the same gradual release approach (i.e., *I do, We do, You do*). The more recent lesson, however, included deviation from the prescribed lesson to support her students' conceptual understanding. Instead of following the textbook lesson on division of whole numbers, she introduced the concept by having the students discuss how their mothers sorted loads of laundry. Brynn had the students model the various examples using base-ten

unit cubes for each piece of clothing. Next, she helped students understand how the words they were using could be translated into an equation and then solved using the manipulative materials. She explained that her perception of herself as a teacher of mathematics had changed because, in addition to wanting her students to see the importance of mathematics, she now wanted them to recognize the value of *understanding* mathematics. Making mathematics relevant to her students was a recurring theme with Brynn. During the *Prime Online* PD program, she stated that she was most effective when she was able to teach students to apply a skill to a real-world context. However, she now felt most effective when using manipulative materials (e.g., base-ten blocks) during small-group instruction.

Manipulative Materials

Brynn's post-*Prime Online* PD program attitude toward manipulative materials had changed since her negative statement in Week 2. During our second interview she acknowledged that she sounded like she "turned my nose at those manipulatives", but that now she "loves" manipulative materials [I-2p4]. Her notion of what constitutes manipulative materials had expanded. She used to think of manipulative materials as the "tons of boxes" that she had but now recognized money as a manipulative material. She explained, "it's [money's] concrete. . . . cents are the same thing as single unit cubes" and talked to her students about how a unit cube is one out of 100 hundred, as is a penny. She assigned credit for this shift: "*Prime Online* really opened my eyes to how we can represent math. . . . as a teacher I want to . . . put it, like I said before, in a concrete, meaningful way for my kids" [I-2p4].

Instead of an impractical means of computing numbers in real life, Brynn now saw that manipulative materials build "concrete understanding" [I-2p5]. Her more recent

best lesson involved using base-ten blocks to do subtraction with regrouping. Since the *Prime Online* PD program, she has expanded her instructional repertoire to include ten frames, a manipulative material that she was introduced to while helping a second grader. She called ten frames "such a good thing" and said that using ten frames to count up had "really helped" her students [I-1p7]. In fact, she said, "every single type of manipulative, if I can figure out a way to use it and it helps the kid, I am using it" [I-1p7]. Prior to the *Prime Online* PD program Brynn taught with some manipulative materials, but the traditional algorithm was the focus of her teaching. Her post-*Prime Online* PD program self saw manipulative materials as a precursor to, instead in competition with, the traditional algorithm.

Teaching for Conceptual Understanding

In addition to using manipulative materials, Brynn supported her students conceptual understanding by using multiple strategies and requiring multiple representations. Her knowledge about and implementation of multiple strategy use began in Segment One. When speaking of her pre-*Prime Online* PD program self, Brynn said she was not sure "when to use what strategies" to help her struggling learners [PIp12]. Two months into the oTPD program, however, Brynn told a PI that she was able to "use what I'm learning to talk to them**"** [PIp12]. Post-*Prime Online* PD program, she and her students have classroom discussions about different strategies they used and which one might be the most practical. Brynn described an example in which her students were learning the area model for multiplication of large numbers. Some students said they would still rather use base-ten blocks, so she had the students work through several more problems. The class unanimously determined that when it comes to multiplying 42 and 28 with base-ten blocks, "nobody wants to do that" [I-2p6].

She had also learned strategies for teaching multiplication basic fact fluency. In addition to fluency, Brynn said that she expected her students to understand fact families and be able to represent problems with arrays and area models. This was in contrast to her pre-*Prime Online* PD program reliance on teaching with the traditional algorithm. Brynn was asked to reflect on her Week 1 stance on struggling students using tricks in order to have some success in mathematics. She recalled that during the *Prime Online* PD program, there were many discussions about being able to work through a traditional algorithm without understanding why the traditional algorithm works. She said that now she "hates" just going to the traditional algorithm or quick strategies when teaching a new concept and preferred "walking the kids through *why* this is like this" [I-2p9]. She had also noticed that the "more concrete" (i.e., using manipulative materials) she started, the more likely her students were to "understand reasonableness when it comes to the answers" [I-2p9].

Summary

I value my growth as an educator because I know that, as I grow, my students grow. [I-2p3]

Brynn was open to sharing how the *Prime Online* PD program had changed her views on mathematics teaching and learning. She took time to ponder her responses during our second interview, sometimes reading her forum posts multiple times so she could accurately reflect on the meaning of her words. Brynn's animated face and gestures mirrored the passion in her words when speaking about how important it was for her students to have understanding and appreciation of mathematics.

Brynn enrolled in the *Prime Online* PD program to increase her own MCK. Although confident during her first year of teaching, she soon realized that her students

had difficulty comprehending mathematics concepts. At the beginning of the oTPD program, Brynn wrote that she doubted her ability to grasp the content to the degree that would be needed for classroom implementation. By mid-oTPD program these concerns had abated and, during the interviews two years post-*Prime Online* PD program, there were no indications that she still doubted her ability to successfully teach mathematics. She conveyed that she appreciated how the oTPD program helped her understand how to use manipulative materials and, as corroborated by comments in the follow-up interviews, gave her a deeper understanding of the role of manipulative materials. Brynn's post-*Prime Online* PD program self continued to actively seek additional strategies to support her students' number sense. For example, after telling me about discovering ten frames, she inquired whether I had additional resources that might be applicable.

Brynn's oTPD program participation was inconsistent and when she did participate, her responses were not as lengthy or in-depth as most of her peers. She explained that the format of online discussions did not lend itself to "flowing dialogue" [I-2p9], which was exacerbated if she posted very early or very late in the week. Even with her less-than-optimal participation levels, the oTPD program influenced her instructional practices from the beginning. One early indication was the adaptations she made to the county-mandated Calendar Math activities to better suit the needs of her students. More recently, the infusion of conceptually-based activities showed her knowledge about how to support the development of her students' number sense. One of her goals was for her students to understand and appreciate the power of mathematics instead of being "put off by math", so she sought resources that provided

detailed, practical ways to teach mathematics for understanding [Wk2RA]. At the end of the second interview, Brynn was asked if there was anything else she wanted to share. She interrupted me to say, “*Prime* [*Online*] was amazing” [I-2p14].

CHAPTER 6
CONCLUSION

The purpose of this dissertation was to examine the relationship between teacher mathematical identity and participation within an oTPD program. In Chapters 4 and 5, I presented narratives of Heide and Brynn to describe their teacher mathematical identity and participation in an oTPD program. In Chapter 6, I analyze these stories, individually and across the cases, as they related to the two research questions that framed this study. This chapter also summarizes the findings and concludes with implications for practice and suggestions for future research.

Research Question 1

What is the relationship between teacher mathematical identity and participation in an oTPD program?

The first research question focused on how teacher mathematical identity was related to participation in an oTPD program. Each participant's teacher mathematical identity during the *Prime Online* PD program was determined by analysis of archival data for indicators of views of mathematics (e.g., history as a learner of mathematics, perception of teacher role). Participation was determined by the participation and requirements met ratios from the participation chart, completion of the surveys and CKT-M, and the content of Segment One and Segment Two activities.

Heide

Since the very beginning of the *Prime Online* PD program, Heide was open about her negative history as a learner of mathematics. During Week 1, she recalled a pivotal incident in which she was called "hopeless" and told she "would never learn it [the metric system]" by her seventh-grade mathematics teacher [Wk2AA]. Heide seemed to

have internalized this message because, in ninth grade, she had “NO [emphasis in original] doubt” that she would never understand algebra—even though she “desperately tried” and wanted to do well [Wk2AA]. These struggles as a learner of mathematics hindered her future MKT. In fact, Heide wrote that she “could speak volumes on what it means NOT [emphasis in original] to be proficient in math” [Wk2AA]. Heide’s teacher mathematical identity, combined with her personal attributes, created a complex relationship regarding her high levels of participation in the *Prime Online* PD program.

Heide was likewise unguarded when reflecting on how her lack of background knowledge affected her mathematics instruction. During a Week 1 forum post about possible barriers to becoming an ideal teacher of mathematics, Heide stated the she had much to learn and that mathematics was never her strength. She made many other statements that indicated her low self-efficacy as a teacher of mathematics. However, Heide felt a strong sense of duty toward her students, which brought her to the *Prime Online* PD program. Heide taught with student-centered, integrated lessons in all subjects other than mathematics. She said that she was never confident in mathematics, but also hated teaching out of the textbook because her students were “so unmotivated and unengaged” [I-2p2]. She reported that she very much wanted to make her mathematics instruction as integrated and hands-on as the rest of her teaching.

Once enrolled in the *Prime Online* PD program, Heide had difficulty with some of the mathematics activities in Segment Two, which was indicative of her lack of foundational knowledge. She rated the activities as “meaningful” but “challenge[ing]”

[MF9-12]. This led her to reflect on how her students must have felt. Heide reported that she tried as hard as she could and still had a really difficult time understanding the concepts. She also remarked that the mathematical jargon was hindering her learning and that she appreciated being given extra time to be able to truly reflect on the concepts.

Considering her difficulty with the oTPD program mathematics content, it would be reasonable to assume that Heide's *Prime Online* PD program teacher mathematical identity would have had a negative influence on her participation in the oTPD program. However, Heide's personality traits (e.g., perfectionism) and values (e.g., sense of responsibility) seemed to fuel her to overcome these challenges. When asked, two years post-*Prime Online* PD program, what may have contributed to her "enormous" paradigm shift [I-1p7], she quickly replied, "my motivation, my perfectionism. I mean, I give 110 percent. I don't want to do it badly. . . . and I have a responsibility to them [her students]. Period." [I-2p6].

Heide spoke freely about her lack of mathematics ability and feelings of inadequacy as a teacher of mathematics. Unexpectedly, these facets of her teacher mathematical identity became the impetus for, instead of barriers to, her participation. Heide had the highest participation rate (i.e., 82% more than required in the mathematics-specific weeks) and had the lengthiest posts. She likened herself to a "sponge" when discussing her engagement with the forum discussions [I-2p13]. Additionally, Heide showed initiative and perseverance when she sought out an alternative resource when the *Broken Calculator* applet did not work properly. Her

perfectionism and sense of duty to her students combined to create an eagerness to learn and subsequent high levels of participation.

Brynn

Brynn's teacher mathematical identity (e.g., views of mathematics teaching and learning) conflicted with the *Prime Online* PD program content, which was likely related to her sporadic levels of participation. Brynn's history as a learner of mathematics influenced her beliefs about mathematics learning. Brynn reported that she felt like a genius in elementary school and was successful learning and using the traditional algorithms and mastering her multiplication basic facts. Because mathematics came easily to her in elementary school, Brynn reported having difficulty empathizing with her students when they struggled to achieve mastery. Not surprisingly, given her history as a learner of mathematics, Brynn's instruction emphasized the traditional algorithm and fact fluency.

During Week 9, she wrote that using manipulative materials to represent multi-digit multiplication was "interesting", but that she still preferred the traditional algorithm because that is how she learned multi-digit multiplication. She shared that the more-proficient students preferred the traditional algorithm and found alternative strategies a waste of time and the less-proficient students favored the alternative strategies. Brynn grappled with *Prime Online* PD program assignments that presented strategies other than the traditional algorithm. For example, in response to a peer in the Week 9 about using mental mathematics to solve 36 multiplied by 8, she wrote, "I cannot explain the subtracting strategy to save my life!" [Wk9AA]. In the Week 15 Anticipatory Activity Brynn stated, "fractions are an area where I feel as though I NEED paper and pencil to

work it out" [Wk15AA]. After having difficulty with the Broken Calculator activity in Week 9, she agreed with a peer that the Broken Calculator activity would be an appropriate activity for the brightest students in class.

Brynn's preference for the traditional algorithm, however, conflicted with the needs of her students. In the Week 11 Reflection and Assessment, she shared that when multiplying two-digit numbers by four-digit numbers, her students were successful with using repeated addition and boxes for partial products, but there were only "a handful of kids" who could use the traditional algorithm effectively. In the Week 15 Anticipatory Activity, she wrote that she saw a "much better level of concentration when the kids could put their hands on fraction bars and play around with them to answer questions" than when she presented virtual fraction bars using the interactive whiteboard [Wk15AA].

Brynn's beliefs about mathematics teaching and professional growth were also related to how she valued the content of the *Prime Online* PD program. She believed the purpose of professional development was to give you "something you can use" [IIp9], instead of as a means of increasing her MKT or encouraging her to think about her instruction differently. She explained that she preferred the readings from the practitioner journals because they provided her with lessons and strategies that could be put to use immediately.

Brynn favored teacher-centered instruction, felt that her role as a teacher was to provide activities, and the *Prime Online* PD program presented content and pedagogy that was not aligned with Brynn's teacher mathematical identity. It follows, then, that she would have been more engaged when the *Prime Online* PD program content

provided such activities and less engaged when the activities were focused on her own mathematical thinking or not relevant to her current context (e.g., not appropriate for implementation in a fourth/fifth-grade combination class).

Brynn noted that she felt overwhelmed because this was her first year as a general education classroom teacher and that she struggled to "balance it all" [PIp4]. Although she provided open-ended feedback on the first two module surveys, she did not complete any for the duration of the oTPD program. She also did not participate in the final CKT-M assessment or meet the requirements in a timely manner for many of the assignments and discussion forums. It is unclear if the lack of participation was because Brynn was a *late person*, if she was overwhelmed with her first year as a classroom teacher while also being a student, or if certain activities were not completed merely because they coincided with especially busy times of the school year (e.g., *A Meter of Candy* during the last week of school), or if the assignments were given low priority because the PD program content did not align with her teacher mathematical identity. The *Prime Online* PD program also did not match her definition of what a PD program should be. Instead of being provided with activities for immediate use, she was asked to engage in an intensive and lengthy PD program that included a variety of mathematical tasks.

Looking Across the Cases

Heide and Brynn had similar histories as learners of mathematics. Both participants recalled learning elementary level mathematics by traditional (i.e. teacher-centered) instruction. More noteworthy, however, was that both participants pinpointed an incident in seventh grade as a turning point in their mathematics histories, after

which mathematics was arduous and a source of stress and poor achievement. That they struggled in, and disliked, mathematics from seventh grade through their college years certainly impacted their understanding of mathematics and how much they were able to participate in the *Prime Online* PD program mathematics activities. Both participants had concerns about learning in an online PD program and were particularly concerned about learning mathematics in an online format. They stated having difficulty discussing mathematics problems and solutions without the face-to-face discussions and found group work to be especially problematic.

The participants thought that their learning would have been enhanced by more, and more in-depth, discussions. Heide missed classroom interactions and wanted to be able to discuss "for real" [PIp14]. Brynn wanted to be able to have dialogue like they "would be exchanging in a classroom setting" [PIp5]. The participants also sought more communication from the PD program facilitators. Brynn wanted more individual feedback from the facilitators; she thought this would let her know that someone was reading her posts. Heide preferred the feedback she received from the facilitators to the responses she received from her peers. Heide valued the facilitators' feedback so much that it was "always" meaningful, even when it was directed to one of her classmates [I-2p13]. Although both stated a desire for more communication, each of them also admitted that they did not always go back into the module to check others' posts and responses. This dislike of online discussions would likely have hindered the quality and quantity of both participants' responses, but Heide's personality traits outweighed her negative feelings about online learning.

Heide and Brynn also had similarities regarding their views of mathematics teaching and learning. Both participants considered empowering their students to be part of their teacher role. Brynn wanted her students to understand how mathematical knowledge could impact their adult lives, such as providing them with more career choices or preventing them from making poor business decisions. Heide wrote that what she "absolutely adore[s] about teaching" is being given the opportunity to motivate others to be "enthusiastic about the world around them" [Wk1RA]. In addition, both participants mentioned the importance of relating mathematics instruction to real-world contexts. Brynn specifically mentioned the value of the Math Curse, which encourages students to recognize mathematics in their own lives. The desire to inspire their students would have likely increased participants' engagement in the *Prime Online* PD program activities that have real-world application (e.g., mental mathematics, estimation of solutions for multiplication of rational numbers). Many of the *Prime Online* PD program activities asked Brynn to present and justify her own mathematical thinking, which conflicted with her perception of the purpose of PD and likely affected her engagement.

Heide and Brynn presented a few differences regarding the relationship between teacher mathematical identity and participation in an oTPD program. One difference was the teachers' self-awareness or openness about their need to change how they taught mathematics. Heide was much more critical of herself. For example, in the Week 1 Reflection and Assessment participants were asked to consider their response to "Who Am I as a Teacher of Mathematics?" in light of reading the *Principles and Standards for School Mathematics* (NCTM, 2000). As part of her post, Brynn noted that

she had thought that she was an average teacher of mathematics and “since finishing the reading, I feel the same about my teaching” [Wk1RA]. Heide reflected on her teaching practices in the context of one particular lesson. She wrote that she had “failed in my [her] role as teacher because the very children who reap the greatest benefits from the type of instruction that the NCTM promotes were lost to old practices” [Wk1RA]. One possible reason for Heide’s over-participation is the awareness of her inadequate preparation to teach mathematics. She believed that she could be an effective teacher of mathematics whereas Brynn saw herself as an average teacher of mathematics and was somewhat satisfied with her level of MKT.

The disparity in the quality and quantity of posts was also related to subsequent shifts in teacher mathematical identity. Heide’s exemplary participation and shift in teacher mathematical identity was fueled by her self-proclaimed perfectionism where as Brynn’s lack of sufficient engagement with the *Prime Online* PD program content limited her shift in teacher mathematical identity. Heide had the most frequent and lengthy posts in the *Prime Online* PD program, and even explained that she felt bad about posting so much more than her peers. During Segment Two, Brynn posted and responded once during the *Broken Calculator* activity; Heide posted and responded to others’ posts six times. For the *Working with Base-Ten Blocks* activity, Brynn posted but did not respond to others; Heide posted and responded twice. Brynn did not participate at all during *A Meter of Candy* activity; Heide posted—471 words, responded once, and sent a 399-word email to the oTPD program facilitators about how much she and her class enjoyed the activity. Even though Heide had considerably more experience with online courses than Brynn, it is unlikely that this familiarity with online

learning was the reason for Brynn's lack of participation. The difference in participation was more likely due to a combination of her being a late person, it being a busy time of hear, her feeling overwhelmed, and the discrepancy between her priorities at the time and the purpose of the *Prime Online* PD program.

Summary

Both participants lacked foundational knowledge because they began struggling with mathematics in seventh grade. A negative history as a learner of mathematics had a relationship with participation levels but was mediated by other factors. In Heide's case, a factor of teacher mathematical identity (i.e., efficacy) combined with personal attributes (i.e., perfectionism and sense of responsibility) and a willingness to change seemed to have led to her levels of participation. Brynn had a strong preference for traditional teaching methods and felt that the purpose of PD was to provide lessons and activities that could be applied to her current context. This may have caused Brynn's sporadic levels of participation, as the *Prime Online* PD program presented reform-based (i.e., student-centered) instructional strategies as a mechanism for increasing teachers' MKT.

Research Question 2

What do narratives reveal about shifts in teacher mathematical identity two years post-oTPD program?

The second research question focused on shifts in teacher mathematical identity that occurred since the conclusion of the *Prime Online* PD program. Interviews were conducted to determine the participants' present day teacher mathematical identity and

shifts were revealed by comparing participants' *Prime Online* PD program teacher mathematical identity with their present day teacher mathematical identity.

Heide

During our first interview, Heide made a profound statement about the shift in perception of herself as a mathematics teacher. She explained that, post-*Prime Online* PD program, she was able to see that her mathematics instruction had been teacher-centered and "straight from the book" [I-1p8]. She stated that, pre-*Prime Online* PD program, she would be frustrated that the students did not understand the lesson and would lecture them about paying attention. Heide said "it just was appalling to me how the kids were taught not to think, but *I was actually promoting that same thing by doing the talking* [emphasis added]. I just didn't realize it" [I-1p8].

The *Prime Online* PD program gave Heide the knowledge and confidence in mathematics to extend her MKT beyond the specific content that was presented in the weekly modules. Heide reported that she now used manipulative materials before teaching any lesson formally, even those concepts that were not explicitly taught during the *Prime Online* PD program. Her classroom was also arranged so her students were able to access a variety of manipulative materials to represent the concepts on which they were working. Her mathematics instruction went from being teacher-centered to being student-centered. She no longer told them which manipulative materials to use to solve a particular type of problem. Heide had been using student-centered activities in all other subjects, but, pre-*Prime Online* PD program, she did not have the knowledge or confidence to use them during mathematics instruction.

Brynn

Brynn's most apparent shifts in teacher mathematical identity (i.e., self-efficacy, manipulative materials, and teaching for conceptual understanding) were presented in Chapter 5, but a more in-depth analysis is warranted. The most telling shift was in her perceptions of the importance of conceptual knowledge away from quick strategies, which reflected a fundamental misunderstanding about the use of manipulative materials. At the beginning of the *Prime Online* PD program, Brynn mentioned it would be impractical to rely on manipulative materials as an adult (e.g., shopping with yellow and red counters). Statements such as this exemplify her misunderstanding of the purpose of manipulative materials. She did not see manipulative materials as a resource to support students' initial understanding of a concept. Instead, Brynn saw them as the "tons of boxes [of unused manipulative materials] I have" [I-2p4]. Post-*Prime Online* PD program, her feelings toward manipulative materials had shifted—she "loves" them and her conception of manipulative materials had shifted [I-2p4]. During the second interview, she explained that she now recognizes money as a manipulative material because "it's concrete" and it is a "way to represents numbers" and stated that dollars and cents could be used interchangeably with base-ten blocks (i.e., flats and unit cubes). She said that the *Prime Online* PD program, "really opened my eyes to how we can represent math" [I-2p4].

Working in concert with greater use of manipulative materials is the acceptance Brynn now has for using multiple strategies to solve a problem. In her post about working through the Broken Calculator activity, Brynn's wrote about wanting "a strategy or pattern or formula to figure it out," which connoted that there was but one way to

solve each problem [Wk9BC]. Her present day teacher mathematical identity presents quite a shift. She now teaches her students different strategies and explained how she helps them understand how to "pick the most practical one" [I-2p6]. Brynn still wanted her students to be fluent with the traditional algorithm, but they were free to use alternative methods, particularly when learning a concept for the first time. In fact, Brynn found that her students had a greater understanding of the reasonableness of their answers when she began by teaching at the concrete level versus only teaching what "works automatically . . . and just get it done" as with the traditional algorithm or quick strategies [I-1p9].

Looking Across the Cases

Both participants shifted in their views of mathematics teaching and learning to include teaching for conceptual understanding and the importance of manipulative materials. During the *Broken Calculator* activity, Heide wrote that being taught methods with manipulative materials would have helped her have a conceptual understanding of mathematics as a child. Those methods "would have been enormously beneficial to me as a kid (only if I had teachers who understood how to use the manipulatives effectively!)" [Wk9BC]. Brynn, on the other hand, still favored the traditional algorithm due to her familiarity with it and its practicality. Two years post-oTPD program, both participants stated that they enjoyed using manipulative materials on a regular basis.

The two cases had a similar omission, as well. One of Heide's most noteworthy shifts was related to a deepening of MCK and MKT and she wrote about a teacher's need to understand how to use manipulative materials effectively. However, neither participant mentioned the need for any facet of MKT to facilitate her professional

growth. For example, Heide said that teachers' lack of reform-based instructional practices, including her pre-*Prime Online* PD program self, was due to teachers' lack of knowledge of "what to do" instead of teachers' lack of MCK. The participants did not seem aware of the connection between MKT and changes in instructional strategies.

Both Heide and Brynn's narratives indicated professional growth, but Heide reported that her growth reached the level of a "paradigm shift of the highest magnitude" [I-1p14]. Brynn did not use any similar term to describe her growth nor did her retellings support any such intensity in her teacher mathematical identity shift. The difference between the two participants mirrors the identity shifts of John, a PST described by Krzywacki (2009). John reflected on the gap between his current and designated identity related to his PCK. He was able to visualize himself in this future image and his ideals seemed attainable, so he set specific goals to work toward this ideal. Heide's pre-*Prime Online* PD program self was already using student-centered instruction, but she lacked the CK and MKT to integrate these reform-based practices into her mathematics instruction. Conversely, John considered his current and designated identities regarding mathematical competence to be fairly consistent with his designated identity. Thus, there was no learning-fuelling tension to motivate him to set goals for professional development. At the beginning of the *Prime Online* PD program Brynn considered herself to be an average teacher of mathematics and seemed content with this level of performance, even after comparing herself to the ideals presented in the *Principles and Standards for School Mathematics* (NCTM, 200).

Krzywacki (2009) explains, "it seems that the ideal image paves the way for reflection on one's present state as well as for setting personal aims" (p. 166-167). Both

participants had beliefs about what was needed to become a better teacher of mathematics. When a participant's beliefs are more closely aligned with the content and pedagogy embedded in an oTPD program, more substantial shifts in teacher mathematical identity are likely to occur. In additional, there is a need for learning-fuelling tension to act as the impetus for these shifts. An openness to change is integral to support shifts teacher mathematical identity, but less obvious factors (e.g., self-awareness) also play an important part in supporting these shifts.

Implications for Practice and Suggestions for Future Research

By investigating teacher mathematical identity shifts, this dissertation sought to extend the literature and help those interested in the development and implementation of oTPD programs—particularly those with a mathematics content focus. In order to facilitate teacher PD programs, we must first understand how teachers grow professionally and the conditions that encourage that growth (Clarke & Hollingsworth, 2002). The results of this study provide evidence for a description of the complex interactional patterns that result in identity formation and shifts in teacher mathematical identity.

How a teacher views mathematics teaching and learning is related to development of a learning-fueling tension, which in turn affects participation and identity shifts. For example, Heide stated that she knew mathematics should be taught in the same integrated, student-centered way that she taught other subject areas. She signed up for the *Prime Online* PD program to bridge this gap between her instruction in other areas and those she implemented when teaching mathematics, which constituted a gap between her current and designated identities. She was eager to learn the PD program

content and implement the suggested activities and strategies. Her perseverance and high levels of participation contributed to the paradigm shift that she experienced. Brynn joined the PD program without a learning-fuelling tension. She signed up for the *Prime Online* PD program because "why not?" [PIp1]. Brynn was satisfied with her teaching style, which was dissimilar to the type of instruction presented in the *Prime Online* PD program. Without a learning-fuelling tension, her participation was sporadic. She had limited interaction with the PD program content and her peers and did not experience identity shifts of magnitude. Brynn also did not have a clear vision of a designated identity or who she wanted to become as a teacher of mathematics and, thus, was left without the motivation needed to bridge any gaps between her present instructional strategies and those presented in the PD program.

Both participants made statements about wanting to be a better teacher for their students. The difference was the degree of their learning-fuelling tension. Using Gee's (2000) construct of identity, Gresalfi and Cobb (2011) found that the keys to teacher change included how close teachers' normative affinity identity is to the normative institutional identity and the importance teachers place on that normative institutional identity. In other words, how closely one relates to the PD group and how much value one places on the ideals put forth by the PD group is a factor that may impact teachers' views of mathematics teaching and learning. Heide had a great need to attain her designated identity, whereas Brynn saw her current and designated identities as similar. She saw herself as an average teacher and did not see an urgency to change her own level of MCK.

Heide came into the PD program with an openness to learning and a *novice state of mind*, which is characterized by a belief that there is "always room for what I can learn from others and with others" (Turniansky & Friling, 2006, p. 783). Those with a novice state of mind "view questions as a necessity, see everything as requiring explanation, regard nothing as sacred and know that the possibility of making a mistake is always lurking in the background" (p. 783). Heide stated multiple times that she knew that she had much to learn and that, although trying new ideas was a "risk", she was driven by a sense of "responsibility" to her students and a desire to increase her own CK [Wk2RA]. In addition, Heide felt that her weakness in mathematics was inhibiting her students' learning. During the post-*Prime Online* PD program interview, she stated that reflecting on self-as-teacher at the end of Week 1 made her realize that her teaching style was actually *causing* her students lack of critical thinking. Heide needed an increase in MKT for her current identity—a proponent of reform-based teaching practices—to become her designated identity—one who could implement reform-based teaching practices in mathematics lessons. Because she already used reform-based practices in other subject areas, the gap between her current *overall* teacher identity and her designated teacher *mathematical* identity seemed attainable (Sfard & Prusak, 2005). Heide did not see an openness to learning in her peers, however. She mentioned being frustrated at her peers' lack of participation and "unreceptive" and "negative attitudes" and wondered if they had been "forced" to sign up [MS14-16].

Brynn joined the *Prime Online* PD program voluntarily but felt overwhelmed by the pressures of being a novice classroom teacher. Her participation was also likely hampered because her traditional teaching style did not align with student-centered

instruction emphasized by the *Prime Online* PD program. As Brynn did not value alternative strategies, her interest in the PD program content did not seem to be a priority. Instead, she was concerned with "exposing" students to the content "in a timely manner" [Wk1F1]. During the *Prime Online* PD program, Brynn wrote that activities such as the *Broken Calculator* activity were more appropriate for "whiz kids" and that her struggling learners needed rote learning and tricks in order to master the traditional algorithm and have some measure of success in mathematics [Wk1F1]. Because she felt that she was teaching mathematics the way that her students learned best, there was no opportunity for a learning-fuelling tension to develop. Additionally, as it was her first year as a general education classroom teacher, Brynn seemed to prioritize balancing her responsibilities over attaining a designated identity. Her lack of participation, whether due to her busy schedule, prioritization, or being a "late person", provided limited opportunities for shifts in Brynn's teacher mathematical identity [PIp13]. Indeed, del Valle and Duffy (2009) found experienced teachers to have the time and comfort level to explore and engage with PD experiences more so than their novice counterparts, whose time was taken up with classroom planning.

In addition, Brynn's perception of the purpose of PD did not align with the *Prime Online* PD program goal of increasing participants' MKT. She wanted activities that she could implement immediately. She did not expect to, nor see the meaningfulness of, engaging in her own mathematical thinking. She found some of the assignments challenging and she did not persevere in those activities. Other assignments were not completed at all. She wanted her students to understand the application of mathematics to real-world contexts, but did not view mental mathematics and estimation

of solutions as a valuable part of a PD program. In her interview with me, Brynn stated that she now "jump[s]" on PD programs to better herself as a teacher [I-1p14]. She made no mention about the content of the PD program or if it aligns with her desires and needs. Instead, she said that she looks for PD programs that have practitioner-based articles and activities that are applicable to her classroom context and can be implemented immediately.

One factor associated with a learning-fuelling tension is teacher characteristics. Teachers with negative histories of mathematics can change their beliefs (e.g., Ebby, 2000; Kaasila, 2007), but low-efficacy teachers have been found to be the slowest to develop their efficacy (Chang, 2009). Heide's perfectionism and sense of duty to her students mitigated her negative history as a learner of mathematics and her low self-efficacy as a teacher of mathematics. Without her perfectionism, her lack of foundational knowledge would likely have substantially hindered her participation in the Segment Two mathematics-specific activities. Instead, she persevered by asking for help from others (e.g., family members, peers) and by seeking other resources (e.g., another version of the Broken Calculator applet). Heide also mentioned her sense of responsibility to her students as a reason for her perseverance with challenging tasks. Brynn did not speak of any such motivating factors and had lower levels of participation, yet she also underwent shifts in her teacher mathematical identity.

The differences in these cases could be explained by how the participants viewed their designated identities. Heide seemed to have a clear image of her designated identity. She said that she was frustrated with her current teaching practices because her students were "unmotivated and unengaged, and, although she integrated

all “subjects except math,” she “never was confident” enough to integrate mathematics [I-2p2]. Heide wrote that she had failed in her role as a teacher of mathematics and “wanted it so bad” when she learned about the *Prime Online* PD program [PIp1]. Brynn saw herself as an average teacher of mathematics and said that when she learned about the *Prime Online* PD program, she said “why not?” but was “happy, though, to get an opportunity to do anything that improves my math teaching skills and even my math skills” [PIp1]. Brynn’s words did not have the same sense of urgency and were not as indicative of a learning-fuelling tension as Heide’s words.

Finally, there were factors associated with the development of a learning-fuelling tension that were specific to the online context of the *Prime Online* PD program. For example, both participants mentioned a preference for facilitator, rather than peer, feedback. Heide stated that listening to her peers was just “mush-mush” [PIp11] but that she “took it to heart” [I-2p13] when a facilitator asked her to reflect. Brynn explained that facilitator feedback prompted her to think more deeply so that she was able to ‘”really get it this time” [PIp8]. She said that individualized facilitator feedback made the discussion posts seem more conversational and less like an “assignment” [I-2p12]. This finding is similar to studies measuring the importance of consultants (Downer, 2009), mentors (Dede, 2006), and coaching (Yang, 2004) in online contexts. Additionally, both participants shared that true discussions were not possible in an online format but admitted to not going back into the modules to read others’ posts. Sfard and Prusak (2005) posit that identity development *is* communication. Without creating narratives or telling stories, one cannot impact one’s thoughts because “our vision of our experiences forms our identity” (p. 30). Therefore, without experiences

(e.g., participating in discussion forums, reflecting on facilitator feedback), there can be no identity shift.

Implications for Practice

The implications for practice highlighted by this research are applicable to both oTPD program developers and oTPD program facilitators. More so than the content taught during a PD program, the totality of a teacher's "formal and informal educational experience" is integral to understanding teacher actions and, subsequently, the design of PD programs (Xu & Connelly, 2009, p. 221). An important, and obvious, aspect of teacher mathematical identity is one's current level of MCK, but a participant's self-efficacy and history as a learner of mathematics and teacher of mathematics may also influence participation in PD programs.

Heide suggested that implementation of reform-based mathematics instructional practices is about teachers knowing "what to do" [I-1p7] as well as what teachers are "comfortable doing" [I-1p14]. Teachers with negative views of self-as-learner of mathematics have much more to overcome than merely a lack of foundational knowledge; there are also the years of low self-efficacy as teachers of mathematics. Ball (1994) clarifies the basis and impact of this issue:

> Elementary teachers are themselves the products of the very system they are now trying to reform. An overwhelming proportion are women, and the majority did not pursue mathematics beyond what was minimally required. Many report their own feelings of inadequacy and incompetence, and can even recall experiences that became turning points when they decided to stop taking mathematics. Rather than becoming critical of the way we

> ‘school’ mathematics, they often assume that their experiences are due to their own mathematical lacks and to the inherently useless content of mathematics. Those same experiences have equipped them with ideas about the teacher’s role, and about who can learn mathematics, and about what it takes to learn and know mathematics. (p.16)

Both participants’ narratives provided many similarities to the teachers in Ball’s (1994) description. Activities that challenge participants’ thinking and prompt reflection on self-as-teacher and views of mathematics teaching and learning need to be embedded throughout PD programs. Although reading about the Principles for School Mathematics (NCTM, 2000) or CCSS-M Standards for Mathematical Practice (NGA & CCSSO, 2010) was beneficial, participants stated multiple times that watching videos enhanced their learning more so than articles or PowerPoint presentations. Seeing what these principles look like in action might help teachers increase their awareness that a gap between their current and designated identity does, indeed, exist and that the gap can be bridged. A more explicit self-assessment of Brynn’s current and designated identities may have incited her to challenge her beliefs about manipulative materials, alternative strategies, and multiple representations thereby forming a learning-fuelling tension. Participants should be asked to explicitly acknowledge areas of concern, how they might see their improved self (i.e., designated identity) and the steps that could be taken to achieve that improved self. Specific goals could be set and revisited throughout the PD program. Philipp (2007) agrees with the importance of reflection in teacher change:

> How do mathematics educators change teachers' beliefs by providing practice-based evidence if teachers cannot see what they do not already believe? The essential ingredient for solving this conundrum is reflection upon practice. When practicing teachers have opportunities to reflect upon innovative reform-oriented curricula they are using, upon their own students' mathematical thinking, or upon other aspects of their practices, their beliefs and practices change. (p. 309)

In other words, opportunities for reflection and self-assessment can support the cultivation of learning-fuelling tensions.

As facilitators constitute the affective aspect of oTPD programs, they need to support the development of participants' willingness to change (i.e., motivation) and learning-fuelling tensions. In addition to opportunities for reflection, participants must have a novice state of mind in order for a PD program to impact teacher change (Turniansky & Friling, 2006). Particularly given that elementary school teachers have varying levels of MKT, participants need to "feel individual confidence in the group and trust in others to open himself, his views, values, understandings, knowledge to examination and re-evaluation" (Grion & Varisco, 2007, p. 282). A PD program cannot control if a participant is a late person or a perfectionist. However, a PD program does have influence over cultivating a novice state of mind by providing a trusting environment in which one's designated identity seems attainable. Without participants' openness to changing their beliefs and practices, engagement with PD program content would necessarily be limited.

Regarding the implications for practice specific to online contexts**,** it is clear that norms must be established for communication and support. Participants want and appreciate individualized feedback from oTPD program facilitators. In instances where the role of a facilitator is minimized, participants need to be guided as to how to take control of their own and their peers' learning. Both participants mentioned missing the face-to-face interactions and discussions of traditional PD programs. While those exchanges cannot be replicated in an online environment, care should be taken to make this a priority of oTPD program design (e.g., structure group assignments for true collaboration). In addition to being aware of the above-mentioned implications, facilitators have an integral role in sustaining engagement (i.e., participation) in oTPD programs.

Suggestions for Future Research

More effective PD programs can be designed based on an increased understanding of teacher learning (Kazemi & Hubbard, 2008). Research is needed to determine the most effective ways to support teachers' reflection and self-assessment. Teacher reflection is an indicator of identity development (Bjuland et al., 2012; Sfard & Prusak, 2005) and is essential to changing beliefs and practices (Kaasila, 2008; Philipp, 2007).

The relationship between participants' openness to change and subsequent shifts in teacher mathematical identity warrants further study. Heide came into the PD program with a novice state of mind. She was aware that her negative history as a learner of mathematics was affecting her ability to teach her students, which motivated her to engage with the PD program content. She reported that her non-mathematics instruction was student-centered, which was corroborated by the physical presence of

on-going activities and the classroom layout visible during the two interview sessions. Because Heide was already a proponent of reform-based instructional practices, she could bridge the gap between her current *overall* teacher identity and her designated teacher *mathematical* identity. The PD program deepened her MKT, which allowed her to attain her designated identity of implementing reform-based instructional practices in her mathematics lessons. It would be helpful to understand if this is a trend amongst teachers who are implementing student-centered instructional practices or if Heide was an extreme (i.e., atypical) case.

Additionally, it would be helpful to determine if Brynn's lack of perseverance and participation was due to a lack of trust in the group, perhaps because one member of the cohort was a teacher at her school. Further analysis could provide insight into Brynn's lack of participation. Given her notions of the purpose of PD, Brynn might have participated more during the weeks with activities related to her grade level that she could implement right away. She also stated that she was struggling to balance her responsibilities, as the first year of the *Prime Online* PD program was her first year as a general education classroom teacher. It is not uncommon for novice teachers to participate in PD programs. Further research needs to be undertaken to understand the mechanisms by which otherwise overwhelmed teachers remain engaged in PD programs.

A few suggestions for research are specific to PD programs in online contexts. The remaining *Prime Online* PD program participants could be interviewed about the relationship between their participation and the quality and quantity of facilitator feedback. Follow-up studies could analyze course usage data to investigate the role of

lurking in PD program engagement. In addition, research is still needed about how to best create collaborative group or communities of practice in asynchronous online settings.

Conclusion

In order for a PD program to support shifts in teacher mathematical identity, participants need a learning-fuelling tension and a novice state of mind working in concert with one another. Without a novice state of mind, participants may not feel secure enough to be open to learning the PD program content and their learning-fuelling tension may go unresolved. Conversely, participants may voluntarily join a PD program and feel open to learning, but without a learning-fuelling tension there is no gap between a current and designated identity that needs to be bridged. This was the case with Brynn. In other instances, there is no motivation, or learning-fuelling tension, *and* no openness to learning, or novice state of mind. Heide suggested such a condition when she suggested that the lack of participation and negative attitudes of her *Prime Online* PD program peers was due to them being forced to enroll.

APPENDIX A
PRIME ONLINE PD PROGRAM WEEKLY ACTIVITIES

Segment 1	***Building the Foundation for Inclusive Elementary Mathematics Classrooms***
Week 1	NCTM Principles and Standards for School Mathematics
Week 2	Classroom Practices that Promote Mathematical Proficiency
Week 3	Characteristics of Students with Learning Disabilities
Week 4	Tools for Understanding Struggling Learners: Explicit Strategy Instruction
Week 5	Theories of Learning and Teaching: Self-Regulated Learning
Week 6	Research-Based Practices: Self-Regulated Strategy Development (SRSD)
Week 7	Teacher Inquiry, Response-To-Intervention (RTI), and Progress Monitoring
Week 8	Reflecting on Segment One of *Prime Online* PD program
Segment 2	***Deepening Mathematics Content and Pedagogy***
Week 9	Number Sense, Procedural Knowledge, and Conceptual Knowledge
Week 10	Building Conceptual Knowledge of Multiplication
Week 11	Building Conceptual Knowledge of Multiplication and Division
Week 12	Building Conceptual Knowledge of Multiplication and Division
Week 13	Examining Multiplication and Division and Students with LD
Week 14	Fractions and Decimal Numbers: Representation
Week 15	Fractions and Decimal Numbers: Addition and Subtraction
Week 16	Multiplication with Fractions
Week 17	Division with Fractions
Week 18	Connections to Operations with Decimal Numbers
Week 19	Examining Fractions and Decimal Numbers and Students with LD
Week 20	Revisiting and Expanding Concepts to Support the Learning of Students with LD
Week 21	Reflecting on Segment Two of *Prime Online* PD program
Segment 3	*Studying the Application of Newly Learned Mathematics Content and Pedagogy to Student Learning*
Week 22	Teacher Inquiry as a Vehicle to Better Understand the Teaching of Mathematics and Struggling Learners
Week 23	The Start of Your Journey: Developing Questions or "Wonderings"
Week 24	The Road Map: Developing the Data Collection Plan and Formative Data Analysis
Week 25	Time to Analyze: Summative Data Analysis for the Teacher Inquirer
Week 26	Writing Up Your Work
Week 27	Assessing the Quality of Teacher Research and Sharing Your Work With Others

APPENDIX B
SEGMENT ONE ACTIVITIES

Week 1 Anticipatory Activity: Who Am I as a Mathematics Teacher?

In a Word document, reflect upon yourself as a teacher. Through your discussion provide an illustration of who you are as a teacher of mathematics. Please use the following stems as the beginning sentences of your statement:

One of the best mathematics lessons I taught was . . . (in your statement, you may include the objectives and the sequence of events; the physical layout of your classroom and how that played into your lesson structure; and the interactions between you and your students that reflect the mathematical conversations typical in your classroom)

- I see my role as a mathematics teacher to be . . . (provide concrete ways in which this role was instantiated within the lesson described above)

- I am the most effective as a teacher of mathematics when . . .

- I am the least effective as a teacher of mathematics when . . .

Upload the Word document (it will not be shared with other participants) and keep a copy for yourself.

Week 1 Content and Discussion: A Vision of School Mathematics

Read NCTM (2000) Chapter 1: A Vision of School Mathematics. After reading, reflect upon your "Who Am I as a Mathematics Teacher" statements in relation to the vision of mathematics teaching and learning depicted in the Standards. Create a post by clicking on "Add a discussion topic" below in which you answer these questions: In what ways does your classroom reflect NCTM's vision of school mathematics? What barriers do you perceive in terms of realizing this goal?

After reading through your colleagues' initial posts, discuss the commonalities you see in their statements such as common successes and barriers. You may either create a new discussion thread or respond to a thread one of your colleagues has begun for Part Two. Do not respond to an individual's initial Part One post.

Week 1 Assessment and Reflection: Reflecting on What You've Learned

Reread the Word document about who you are as a teacher of mathematics from the Anticipatory Activity. Reflect on what you've learned this week about the vision and principles for school mathematics. Write and submit a brief reflection statement indicating how the readings and discussion have changed (or not) how you view your mathematics teaching and your role in the classroom.
Upload your reflection.

Week 2 Anticipatory Activity: Mathematical Proficiency

Reflect on your history of learning mathematics. Think about how you learned mathematics in grades 3-5. Create a post by clicking on "Add a discussion topic" below. In your post, discuss how you remember learning mathematics in the elementary classroom. Based on this history of learning, comment in your post on what it means to

you to be proficient in mathematics. You will return to these posts in the "Content and Discussion" section later this week.

Week 2 Content and Discussion: Strands of Mathematical Proficiency

Read through your colleagues' initial posts from the Anticipatory Activity discussion forum. Identify common themes among your colleagues' experiences as a 3rd through 5th grade learner of mathematics and their conceptions of mathematical proficiency.

Create a post in which you consider the commonalities among your colleagues' history as learners of mathematics and views of mathematical proficiency in relation to the "Strands" readings. In your post, consider the following questions:

- How is mathematical proficiency as described in the "Strands" readings similar to and/or different from the common themes you identified among your colleagues' histories as learners of mathematics and statements of what it means to be proficient in mathematics?

- In what ways do your classroom practices promote the five proficiency strands as discussed in the readings?

- What goals would you set for your classroom practice for improving mathematics proficiency?

Respond to at least two colleagues by Sunday.

Week 2 Assessment and Reflection: Reflecting on What You've Learned

Reread the Word document about who you are as a teacher of mathematics from the Anticipatory Activity. Reflect on what you've learned this week about the vision and principles for school mathematics. Write and submit a brief reflection statement indicating how the readings and discussion have changed (or not) how you view your mathematics teaching and your role in the classroom.
Upload your reflection.

APPENDIX C
PI-CONDUCTED INTERVIEWS

General Questions (Asked of Every Participant)

1. What brought you to the Prime Online?

- What types of experiences have you had in the past with professional development focused on mathematics?

- What types of experiences have you had in the past with professional development focused on special education?

- What types of experiences have you had in the past with on-line learning?

2. Tell me a little about your experiences so far with Prime Online.

- Overall, in your opinion, what aspects of Prime Online are going well so far?
- What aspects of Prime Online are challenging or frustrating?
- How have you integrated Prime Online into your life? Routines?

3. There are a number of components each week to the Prime Online experience, including the following (provide a brief rationale for why we chose to include each component; have the participants talk about each component below in terms of whether or not each is meaningful and/or important):

- an introduction to the week's content
- an anticipatory activity
- content and discussion questions for the week
- assessment and reflection activity

4. Posting plays a big role in on-line learning. Take me to a post you created during the first 4 weeks of Prime-Online (or however many weeks completed at the time of the interview) that you believe exemplifies an important moment in your own learning. (Read the post together).

- What are some reasons you selected this post?

- What does it exemplify about your learning?

- What are your thoughts/feelings about the value of individual posting as a part of your professional learning in Prime Online?

- Have the teacher identify a post that was not as supportive of his/her learning. Use the first two probes above.

5. On-line discussion with colleagues also plays a big role in Prime Online. Take me to a post created by one of your Prime-Online colleagues during the first 4 weeks of Prime-Online (or however many weeks completed at the time of the interview). (Read the post together).

- What are some reasons you selected this post?
- What does it exemplify about your learning?
- What are your thoughts/feelings about the value of on-line discussion with peers as a component of Prime Online?
- What were your thoughts when you responded to the post?

6. Cyndy, Steve, and Nancy contribute to the discussions as facilitators of Prime Online both in discussion forums and through "Course Announcements." Take me to a post created by one of the Prime Online facilitators during the first 4 weeks of Prime-Online (or however many weeks completed at the time of the interview) that you believe contributed significantly to your learning. (Read the post together).

- What are some reasons you selected this post?
- What does it exemplify about your learning?
- What are your thoughts/feelings about the facilitators' role in Prime Online?

7. In what ways, if any, has your thinking about teaching mathematics changed as a result of your participation in Prime On-line to date?

8. In what ways, if any, has your thinking about teaching struggling learners changed as a result of your participation in Prime On-line to date?

9. Have you made any changes to your classroom practice so far based on your experiences in Prime Online? (If Yes – Describe any changes in practice)

Specific Questions (Tailored to the Individual Participation Data on Each Participant)

Craft 2 – 3 specific questions here for the individual based on the data Marty has provided for us, such as –

- "I noticed that during week 3, you got all of your posting and assignment completed on time. Tell me a little bit about week three and what contributed to you being able to complete everything on time."
- "I noticed that during weeks 2, 4, and 5, your posts were late. Tell me a little bit about your experiences during these weeks. What might have been structured differently to help you stay on pace?"
- Do the due dates facilitate your movement through the modules?

- “I noticed that you have/ have not completed the brief evaluation surveys at the end of each module? What contributed to your ability to complete (what prevented you from completing) the survey(s)?”

Final Questions

- So far, what has been the most valuable learning that has occurred for you in Prime Online?

- So far, what do you believe to be the least valuable component of Prime-Online?

- What suggestions do you have for the future development of Prime Online?

APPENDIX D
SEGMENT TWO ACTIVITIES

Week 9 Content and Discussion: Broken Calculator

Click on the link below and read through pages 4 and 5. Work through Challenges 1-3 and watch the 2 videos on page 4 and the 1 video on page 5.

www.nctm.org/eresources/view_article.asp?article_id=7457

Post your thoughts related to the following questions:

What strategies did you use to solve the addition problems? How did you have to change your approach to work the multiplication problems?

How might this activity support students' developing number sense?

Write a brief reflection on the classroom videos. What stood out to you? What questions or concerns do you have about Dr. Epson's video?

Come back to this forum and have a discussion with your colleagues regarding their responses.

Week 11 Content and Discussion: Working with Base ten Blocks

For this activity, you will use base ten blocks to model several multiplication problems. Use base ten blocks placed on a piece of white paper to illustrate each problem.

22 x 13

43 x 21

37 x 14

Outline the partial products on the paper by using a marker to separate them similar to the model above and take a digital picture of your representation of the product similar to the illustration above. Upload your pictures in the "Image of Multiplication with Base Ten Blocks" assignment. Then, go to the discussion forum where you will engage with your colleagues in a discussion of two questions.

In the discussion forum, respond to the following questions. As always, go back to the forum and engage your colleagues in a discussion regarding the following two questions:

1. Think about each step you took while modeling each multiplication problem using the base ten blocks. How does the motion with the manipulative materials support an understanding of the partial products algorithm for multiplication?
2. Compute these products using the traditional algorithm. How is the partial product algorithm for multiplication similar to or different from the traditional algorithm for multiplication?

Week 15 Content and Discussion: Building Connections Between Fractions and Decimals: A Meter of Candy

In week 14 we discussed the importance of helping students make connections between the different conceptions of rational numbers (i.e., part-whole comparisons, decimal numbers, percents, ratios, etc.). In the lesson "A Meter of Candy", students are challenged to construct interrelated understandings of fractions, decimals, and percents.

Print the lesson (it will come up as a PDF) and associated student materials from the link to the NCTM website below. Links to student documents are embedded within the webpage.

A Meter of Candy

You can do this activity in two ways--with or without your students. If you are able to use this lesson with your students, then please do so. The Illuminations website indicates that this lesson will take 3 class periods, and it will be a richer experience if you are able to use this lesson with your children. If you are not able to use this lesson with your students, then work through each section of the lesson on the website.

Engage your colleagues in a discussion over one or more of the following:

Discuss one or more features of the lesson or the ancillary materials that you felt would support student understanding of the interconnections between constructs of rational numbers.

Three models of rational numbers are represented in this activity. Identify each of these models. How are these models of rational numbers related to one another?

How might you have typically assessed your students' knowledge of this concept? Which of the suggested Assessment Options appeal to you most and why?

Pose a question about something that you did not understand OR that you did not agree with in the lesson.

APPENDIX E
MODULE SURVEYS

Week 1

Before–After Items

1. I understand the vision for school mathematics set forth by NCTM.

2. I have reflected on my teaching in terms of the NCTM vision of school mathematics.

3. I understand the principles for school mathematics set forth by NCTM.

4. I have reflected on my teaching in terms of the NCTM principles for school mathematics.

5. I understand the interrelationships between the NCTM vision and principles and my students' understanding of the mathematics I am teaching.

6. I have the knowledge and skills to incorporate the NCTM vision and principles in my teaching.

Free Response Items

7. Please describe 1-3 significant things you learned in this module.

8. Please list 1-3 issues, ideas or topics from this module you would have liked to learn more about.

9. If you were the module designer, how would you improve this module in the aspects of content delivery, organization, instructional strategies, etc.

Week 2

Before–After Items

1. I think of mathematical competence as a broad and multifaceted construct.

2. I understand how I can support my students' development of mathematical competence.

3. I understand how my history of learning mathematics has influenced my thinking about what it means to be competent in mathematics.

4. I understand classroom practices I can incorporate within my instruction to support students' developing conception of mathematical proficiency.

5. I know how to incorporate classroom practice that will support my students' developing conception of mathematical proficiency.

Free Response Items

6. Please describe 1-3 significant things you learned in this module.

7. Please list 1-3 issues, ideas or topics from this module you would have liked to learn more about.

8. If you were the module designer, how would you improve this module in the aspects of content delivery, organization, instructional strategies, etc.

Weeks 9-12

Before–After Items

1. I understand the definition of number sense.

2. I understand the importance of number sense for students' invented strategies.

3. I understand the relationship between procedural and conceptual knowledge.

4. I understand the importance of invented strategies for students' developing procedural knowledge.

5. I understand how to use manipulative materials to support my students' developing conceptual understanding of arithmetic operations such as multiplication and division.

6. I can identify word problems that represent each type of division problem.

7. I can justify to a parent why it is important for students to learn basic operations using manipulative materials.

Free Response Items

During weeks 9-12, we incorporated several new online components. Please provide feedback on each of the following online components in terms of your learning mathematics content for teaching. Please provide a specific rationale for your statements. This rationale might be of the form … "My reasons for providing this feedback include…"

8. Working with web-based applets such as the Broken Calculator (week 9)

9. Viewing videos of classroom episodes (weeks 10-11)

10. Working in a chat room where you discuss an assignment with your colleagues (week 11)

11. Working with manipulative materials to model arithmetic operations (weeks 11 & 12)

12. Viewing a video of one of the instructors explaining a concept (i.e., relationship between motion of materials and the division algorithm) (week 12)

During weeks 9-12, we focused on a number of topics related to teaching and learning multiplication and division. Discuss each of these topics in terms of its usefulness for your practice. Please provide a specific rationale for your statement.

13. Number sense (week 9)

14. Relationship between procedural and conceptual knowledge (week 9)

15. Explaining your strategies for a mathematical procedure (week 9)

16. Examining students' invented strategies (week 10)

17. Examining students' error patterns (weeks 11 & 12)

18. Using manipulative materials (i.e., base ten materials) to supports students' understanding of arithmetic operations (e.g., multiplication and division) (weeks 11&12)

19. Examining your students' strategies (weeks 10-11)

20. How would you improve the modules for weeks 9-12 in terms of content delivery?

21. How would you improve the modules for weeks 9-12 in terms of instructional strategies?

22. Is there anything else you might change to improve the learning of mathematics for teaching for subsequent cohorts of participants?

Week 13

Before–After Items

1. I know that the IDEA ensures that students with disabilities receive research-based practice instruction by requiring that all school staff have the skills and knowledge to use scientifically-based instructional practices.

2. I know the instructional recommendations in mathematics put forth by the authors of the IES Practice Guide.

3. I have enough information to try Woodward's integrated instructional approach with students in my classroom.

4. I can use the Stages of SRSD to evaluate instructional practices.

5. I can use the learning characteristics of students with LD to evaluate instructional practices.

Likert-Type Items

Reasons for having difficulties participating in the online modules in a timely manner.

6. Too much work within an individual week.

7. Too many consecutive weeks of *Prime Online*.

8. The content has become more challenging.

9. The end of the school year is a difficult time of the year to get everything done.

10. The content doesn't seem relevant to my class context.

11. I am not learning from the module content.

12. Things have happened in my personal life that are interfering with my ability to complete the assignments.

13. I do not have convenient access to the technology.

14. I do not have facility with the technology.

15. I do not like participating in the online discussions.

Free Response Items
17. Provide other feedback that is not included above.

Weeks 14-16
Before–After Items
1. I understand three models for representing fractions (i.e., set, area, and length).

2. I understand two fraction processes referred to as *iterating* and *partitioning.*

3. I understand the connections between language used and the underlying images students may have of fractions.

4. I understand the controversies related to teaching algorithms for addition and subtraction of fractions procedurally and conceptually.

5. I understand how to use estimation to support students' thinking when they compute fractions operations.

6. I understand how to represent the multiplication of fractions in multiple ways.

Free Response Items
During Weeks 14-16, we focused on a number of topics related to teaching and learning fractions and decimal numbers. Discuss each of these topics in terms of its usefulness for your practice. Please provide a specific rationale for your statement.
7. Three models for representing fractions (i.e., set, area, and length) (Week 14)

8. Modeling two different fraction processes, referred to as iterating and partitioning (Week 14)

9. Connections between language used and the underlying images students may have of fractions (e.g., out of, cut evenly, make copies) (Week 14)

10. Using manipulative materials to supports students' understanding of addition and subtraction of fractions (Week 15)

11. Teaching algorithms for addition and subtraction of fractions both procedurally and conceptually (Week 15)

12. Working through as activity that supports connections between fractions and decimals (i.e., A Meter of Candy)

13. Using estimation to compute fractions operations (Week 16)

14. Representing the multiplication of fractions in multiple ways (Week 16)

15. How would you improve the modules for Weeks 14-16 in terms of content delivery?

16. How would you improve the modules for Weeks 14-16 in terms of instructional strategies?

17. Is there anything else you might change to improve the learning of mathematics for teaching for subsequent cohorts of participants?

APPENDIX F
SEGMENT SATISFACTION SURVEYS

Segment One Satisfaction Survey

Content of the Modules

1. The content was clear to me.
2. The content was clearly aligned with the modules' objectives.
3. The content helped me achieve the modules' objectives.
4. The content was appropriate for teachers in grade levels 3, 4 and 5.
5. The assignments in the modules helped me to achieve the modules' objectives.
6. The instructional methods presented in the modules were appropriate for teaching students in grade levels 3, 4 and 5.
7. The material about supporting students with learning disabilities (LD) will help me improve their learning.
8. The instructional methods presented in the modules are practical in the amount of time they will require in my classroom.
9. The out-of-school planning time required by the instructional methods presented in the modules is reasonable.
10. I will be able to use the instructional methods presented in the modules for helping students with LD and still meet the needs of other students in the classroom.
11. By implementing the instructional methods presented in the modules for helping students with LD, I have gained new insights for teaching all students.
12. I will use the instructional methods presented in the modules to meet the needs of students with LD.
13. By completing the modules I have learned how to analyze students' responses in class and their work to alter my instruction.
14. The modules stimulated my thinking about the content of the modules.
15. The questions I had about the topics in modules were answered in the modules.
16. My expectations for participating in this professional development were met by the modules.
17. The screening and progress monitoring methods taught in the modules will help me to modify my instruction to improve students' learning.

18. Overall, the mathematics content, instructional strategies and teacher research strategies in the modules would be beneficial for all students as well as students with LD.

Pedagogy of the Modules

19. The learning objectives in the modules were clear to me.

20. The activities in the modules helped me to achieve the objectives of the modules.

21. The introduction to the modules provided a clear overview of the modules.

22. The anticipatory activities in the modules connected to my prior knowledge about the material in the modules.

23. The content and discussion in the modules were clear to me.

24. The content and discussion in the modules were at an appropriate level of difficulty for me.

25. The assessment and reflection activities in the modules helped me deepen my understanding about the material in the modules.

26. The assessment and reflection activities in the modules helped me understand what I learned through the modules.

27. The videos in the modules were engaging

28. The assessment and reflection activities in the modules helped me understand what I still need to learn about the materials in the modules.

29. The modules engaged me in an active manner.

30. The modules provided opportunities to reflect on how the information I was learning applied to my own classroom.

31. Interacting and sharing ideas with other participants contributed to the overall effectiveness of the modules.

32. The discussion forums stimulated my thoughts about the material in the modules.

33. The readings fostered my understanding of the modules' content.

34. The videos in the modules enhanced my learning.

35. The activities in the modules helped me to understand the content of the modules.

Technology and Support

36. The modules were designed in a manner that is appropriate for my computer skills.
37. The modules were easy to navigate.
38. The modules' aesthetic design presents and communicates information clearly.
39. The modules are well-organized.
40. The modules are visually consistent.
41. The modules are functionally consistent.
42. I was able to access the videos in the modules.
43. The modules provide a user-friendly environment for online discussion.
44. Adequate technical support was provided to enable me to work independently.

Segment Two Satisfaction Survey

Content of the Modules

1. The content was clear to me.
2. The content was clearly aligned with the modules' objectives.
3. The content helped me achieve the modules' objectives.
4. The content was appropriate for teachers in grade levels 3, 4 and 5.
5. The assignments in the modules helped me to achieve the modules' objectives.
6. The instructional methods presented in the modules were appropriate for teaching students in grade levels 3, 4 and 5.
7. The material about supporting students with learning disabilities (LD) will help me improve their learning.
8. The instructional methods presented in the modules are practical in the amount of time they will require in my classroom.
9. The out-of-school planning time required by the instructional methods presented in the modules is reasonable.
10. I will be able to use the instructional methods presented in the modules for helping students with LD and still meet the needs of other students in the classroom.
11. By learning about the instructional methods presented in the modules for helping students with LD, I have gained new insights for teaching all students.

12. I will use the instructional methods presented in the modules to meet the needs of students with LD.

13. By completing the modules I have learned how to analyze students' responses in class and their work to alter my instruction.

14. The modules stimulated my thinking about the content of the modules.

15. The questions I had about the topics in modules were answered in the modules.

16. My expectations for participating in this professional development were met by the modules.

17. The screening and progress monitoring methods taught in the modules will help me to modify my instruction to improve students' learning.

18. The mathematics content in the modules is relevant to the topics I teach.

19. As a result of the modules, I have a better understanding of NCTM and common core standards.

20. Overall, the mathematics content, instructional strategies and teacher research strategies in the modules would be beneficial for all students as well as students with LD.

Pedagogy of the Modules

21. The learning objectives were clear to me.

22. The activities helped me to achieve the objectives of the modules.

23. The introduction to the modules provided a clear overview of the modules.

24. The anticipatory activities in the modules connected to my prior knowledge about the material.

25. The content and discussion were clear to me.

26. The content and discussion were at an appropriate level of difficulty for me.

27. The assessment and reflection activities in the modules helped me deepen my understanding about the material.

28. The assessment and reflection activities helped me understand what I learned through the modules.

29. The videos were engaging

30. The assessment and reflection activities helped me understand what I still need to learn about the materials in the modules.
31. The modules engaged me in an active manner.
32. The modules provided opportunities to reflect on how the information I was learning applied to my own classroom.
33. Interacting and sharing ideas with other participants contributed to the overall effectiveness of the modules.
34. The discussion forums stimulated my thoughts about the material in the modules.
35. The readings fostered my understanding of the modules' content.
36. The videos in the modules enhanced my learning.
37. The activities in the modules helped me to understand the content of the modules.

Technology and Support

38. The modules were designed in a manner that is appropriate for my computer skills.
39. The modules were easy to navigate.
40. The modules' aesthetic design presents and communicates information clearly.
41. The modules are well-organized.
42. The modules are visually consistent.
43. The modules are functionally consistent.
44. I was able to access the videos in the modules.
45. The modules provide a user-friendly environment for online discussion.
46. Adequate technical support was provided to enable me to work independently.

Segment Three Satisfaction Survey

Content of the Modules

1. The content was clear to me.
2. The content was clearly aligned with the modules' objectives.
3. The content helped me achieve the modules' objectives.

4. The content was appropriate for teachers in grade levels 3, 4 and 5.

5. The assignments in the modules helped me to achieve the modules' objectives.

6. Engaging in the process of practitioner research presented in the modules helped to enhance my understanding of one or more instructional methods presented in segments one and two.

7. Inquiry into my own teaching practices with students with learning disabilities (LD) will help me improve their learning.

8. The process of practitioner research presented in the modules is practical in the amount of time it required in my classroom.

9. The out-of-school work time required by the teacher researcher is reasonable.

10. I will be able to use the process of practitioner research presented in the modules for helping students with LD and meeting the needs of other students in the classroom.

11. By engaging in practitioner research, I have gained new insights into teaching mathematics.

12. By engaging in practitioner research, I have gained new insights into helping students with LD or other students with special learning needs.

13. I will utilize the process of practitioner inquiry presented in the modules to meet the needs of students with LD.

14. By completing the modules I have learned how to systematically and intentionally study my own mathematics teaching practice.

15. The modules stimulated my thinking about raising questions I have about children's mathematic learning.

16. The modules stimulated my thinking about ways to utilize data to inform my instruction.

17. Engaging in the teacher inquiry process gave me confidence to make instructional decisions in the best interest of my students.

18. The questions I had about the topics in modules were answered in the modules.

19. My expectations for participating in this professional development were met by the modules.

20. The progress monitoring methods taught in the data collection module will help me to modify my instruction to improve students' learning.

21. The teacher research strategies taught in the modules will help me to modify my instruction to improve students' learning.

22. The teacher research strategies taught in the modules will help me to modify my instruction to improve students' learning.

Pedagogy of the Modules

23. The learning objectives were clear to me.

24. The activities helped me to achieve the objectives of the modules.

25. The introduction to the modules provided a clear overview of the modules.

26. The anticipatory activities connected to my prior knowledge about the material.

27. The content and discussion were clear to me.

28. The content and discussion were at an appropriate level of difficulty for me.

29. The assessment and reflection activities helped me deepen my understanding about the material.

30. The assessment and reflection activities helped me understand what I learned through the modules.

31. The video of the interview with a teacher researcher was engaging

32. The assessment and reflection activities helped me complete my own practitioner inquiry.

33. The modules engaged me in an active manner.

34. The modules provided opportunities to reflect on how the information I was learning applied to my own classroom.

35. Interacting and sharing ideas with other participants contributed to the overall effectiveness of the modules.

36. The discussion forums stimulated my thoughts about the material.

37. The readings fostered my understanding of the modules' content.

38. The interview with a teacher researcher video enhanced my learning.

39. The activities helped me to understand the content of the modules.

Technology and Support

40. The modules were designed in a manner that is appropriate for my computer skills.
41. The modules were easy to navigate.
42. The modules' aesthetic design presents and communicates information clearly.
43. The modules are well-organized.
44. The modules are visually consistent.
45. The modules are functionally consistent.
46. I was able to access the video in the modules.
47. The modules provide a user-friendly environment for online discussion.
48. Adequate technical support was provided to enable me to work independently.

Overall

49. I felt my time was well-spent in this professional development program.
50. I will recommend this professional development program to other teachers.
51. I was satisfied with the professional development program.

APPENDIX G
INFORMED CONSENT FORM

Dear Educator,

I am a doctoral candidate in the School of Teaching and Learning at the University of Florida conducting research for a dissertation on mathematics-based online teacher professional development. I am conducting this research under the supervision of Dr. Stephen J. Pape and Dr. Nancy F. Dana. The purpose of this study is to understand the relationship between participation in an online teacher professional development and how a teacher views mathematics teaching and learning. I am asking you to participate because of your successful completion of the *Prime Online* professional development project.

With your permission, I would like to interview you on two occasions over the course of three weeks. Each of the two interviews will last no more than one hour and will be audiotaped. The interviews will be scheduled at your convenience. You will not have to answer any questions you do not wish to answer. Only I will have access to the audiotapes, which will be transcribed by a transcription service and any identifiers will be removed by replacing your name and any other names mentioned with pseudonyms. The tapes will be kept locked in a cabinet in my home. Your identity will be kept confidential to the extent provided by law and will not be revealed in the final manuscript.

There are no anticipated risks, compensation, or other direct benefits to you as a participant in this study. Your participation, however, will support our understanding of how a teacher's views mathematics teaching and learning may change after participation in an online teacher professional development. Your participation is voluntary and you may withdraw your consent at any time without penalty.

If you have any questions about this research protocol, please contact me or my faculty supervisors, Dr. Stephen J. Pape or Dr. Nancy F. Dana. Questions about your rights as a research participant may be directed to the IRB02 office at the University of Florida.

If you agree to participate in this study, please sign and return this copy of the letter to me in the enclosed envelope. A second copy is provided for your records. By signing this letter, you give me permission to report the data I collect in interviews with you. This report will be submitted to my faculty supervisors as part of my dissertation requirements. Also, by signing, you give me permission to use these data in academic presentations and publications.

Thank you,
Sherri K. Prosser

I have read the procedure described above. I voluntarily agree to participate in the study on teacher's views of mathematics and participation in online teacher professional development. I voluntarily agree to participate in the interview and I have received a copy of this description.

_____ _____

Signature of Participant Date

APPENDIX H
INTERVIEW ONE

During this interview I will ask you general questions about your learning and teaching of mathematics, some of which are similar to discussion prompts or writing assignments during the first few weeks of *Prime Online*. In most cases, I will ask you to provide a description or tell a story to explain your response. I hope that you will provide rich details in these descriptions or stories. Before we get started, I would like to confirm your background information (i.e., teaching assignments from January 2011–December 2011 [e.g., grade level(s), subject(s), public or lab school], teaching history, degree(s) earned, area(s) of certification, teaching history). Do you have any questions before we begin?

1. It's been 18 months since I've interacted with you as a participant in *Prime Online*. How have you been? What have you been up to over the last 18 months? Have you engaged in any professional development activities since *Prime Online?*

2. Tell me a story about one of the best recent mathematics lessons you taught (you may include the objectives and the sequence of events; the physical layout of your classroom and how that played into your lesson structure; and the interactions between you and your students that reflect the mathematical conversations typical in your classroom).

3. If you look back, when are you most effective as a teacher of mathematics? Please tell me a story that would be an example of when you are most effective.

4. If you look back, when are you least effective as a teacher of mathematics? Please tell me a story that would be an example of when you are least effective.

5. How do you see your role as a teacher of mathematics? Describe how that might look from a student's perspective.

6. You may recall reading an article called *Tying It All Together* by Suh (2007) that discusses *mathematical proficiency*. The author explains that students that are mathematically proficient: understand the concept, learn the procedures with meaning, solve problems using efficient strategies, defend and justify their reasoning, and find mathematical investigations challenging and engaging.

7. What does *mathematical proficiency* mean to you?

8. Describe a situation in which you would know if a student is mathematically proficient.

9. How do you view your role in supporting the development of mathematical proficiency?

10. How might this look in a typical mathematics lesson? How would you feel, think or do?

11. How do you see yourself as a learner of mathematics? Give me an example that explains your answer.

12. Is there anything you would like to add that might be relevant to this study?

APPENDIX I
INTERVIEW TWO – HEIDE

I would like to begin by asking you a few questions to help me understand your professional background and then continue with some questions about your teaching practices. Finally, I would like you to reflect on some of the statements you made during our first interview as well as your participation in *Prime Online*.

1. Which science certification do you have: Grades 5-9 General Science or Grades 6-12 in Biology, Chemistry, Earth-Space Science, or Physics?

2. Have you been at Newberry Elementary since 2003? Where did you teach prior to that? Prior to *Prime Online* had you only taught 3rd-5th grade self-contained special education? Is this your fifth year as a general education teacher?

3. Tell me what led you to the teaching profession.

4. What brought you to the *Prime Online* project?

INSTRUCTIONAL PRACTICES

5. You mentioned in your Spring 2011 interview: "*One thing that just struck me was the strategy notebook that a child could have with a table of contents. I'm still thinking about that after… and I read that however long ago*" [PIp8]. Have you incorporated strategy notebooks in your classroom?

6. In your Spring 2011 interview, you said that you decided to "sort of throw that book away" because the pacing guide left little time for re-teaching [PIp16]. During our first interview, you told me about a two-week period when you chose to "ditch the curriculum" and do "nothing out of the book" [I1-p5]. Has this always been a part of who you are as a teacher? (i.e., Did you do this before you enrolled in *Prime Online?* Was this a true shift in identity?)?

7. When speaking about how your students might perceive your role as a teacher of mathematics, you said:

   I'm asking them questions about what they know so they're more confident in what they know. They're not so timid about offering what they're thinking because often I'm saying yea, you're right on track, that's exactly right. And then, you know, I draw other kids into it. So it's definitely facilitation, more the learning in the kids. [I-1p8]

   What factors brought about this change in your teaching practices?

8. During the *Prime Online* course, you defined mathematical proficiency as: *"…knowing the subject inside and out, whether it's to know the answer, know where to look for the answer, or know how to solve for the answer" [Wk2AA].*

During our interview, you compared mathematical proficiency to being able to model a multiplication problem using base ten blocks, similar to one of the *Prime Online* activities. By being able to work through that task, students would show that they have a "*deeper understanding of the whole place value importance in what they're doing, as opposed to 'when you get to the tens place, you put the zero down there'*" [I-1p10].

- Do you see these as different interpretations of the term 'mathematical proficiency?

- Did these definitions of mathematical proficiency impact on your views about the teaching and learning of mathematics during each of those time periods?

<u>IDENTITY SHIFT</u>

You made many explicit comments about the impact *Prime Online* had on your teaching of mathematics. I would like to further probe your thoughts on that by asking you several, more specific, questions.

9. In our first interview you talked to me about how "disheartened" you were with "the whole worksheet mentality" and how it was "dictated" to you when you taught third grade. [I-1p4]. You said, "I just feel like that's not teaching". Would you please elaborate on that?

- Why were you disheartened at this particular time?
- What were your concerns with worksheet-based instruction?
- Would this have always been a concern?

10. You attributed your "paradigm shift of the highest magnitude" to your special education background and to your age [I-1p14]. Would you expand on that?

- Was one of these more important of a factor than the other?

- Were there other personal factors or attributes that you brought to *Prime Online* that may have increased what you took away from the PD?

11. Do you anticipate that the "paradigm shift" you experienced with *Prime Online* will have an impact on your teacher identity as a K-4 <u>science</u> teacher next year? Why or why not? Paint me a picture of how that might look.

12. Toward the end of our interview you seemed to empathize with the general education teachers at your school who struggle when teaching math:

"I feel really bad now when I look around at teachers who—and I see it every year—who feel so constrained. And math, because I actually love teaching math now, math is an area where traditionally teachers … might look at the overview for the week, but it's just bang, bang, bang. It's just cut and dry, you don't integrate it…..you open the book and you do what it says. So I don't know what it would take, and yet we all know that our kids are not proficient in math. [I-1p14]

- Would you have considered yourself as one of these teachers, prior to your *Prime Online* experience?

PARTICIPATION

At least two times you mentioned the lack of participation by your *Prime Online* peers.

- In Week 13 module survey, regarding possible reasons for participants' lack of timely participation, you wrote: *Online "discussions" not meaningful and/or possible when so few people participate.* In Week 14-16 module survey, regarding how to improve the learning of subsequent cohorts, you wrote: *Having kept up with assignments, unlike some others, it's been discouraging to witness the somewhat unreceptive and sometimes outright negative attitudes.*

- Did your feelings of discouragement or about the lack of meaning of the discussions affect your own participation? If so, to what degree?

- Do you think it affected how much you were able to take away (i.e., learn) from the *Prime Online* experience?

13. In week 14-16 module survey, you wrote: *I'd rather just get feedback from instructors, rather than try to post just to fulfill the requirement of the module.* Was there a relationship between instructor input and your participation in the forum posts? (Does the quantity/quality of your posts depend on if the instructor has responded to you – or others)

APPENDIX J
INTERVIEW TWO – BRYNN

I would like to begin by asking you a few questions to help me understand your professional background and then continue with some general questions about your teaching practices. Finally, I would like you to reflect on some of the statements you made during our first interview as well as your participation in *Prime Online*.

1. Tell me what led you to the teaching profession.

2. You said that you had worked as a co-teacher for two years. What were your responsibilities when you were co-teacher?

- What did a typical day look like for you?

3. During your first individual interview, in March of 2011, you were asked if you thought your teaching of mathematics had changed since starting *Prime Online*. During your response, you mentioned that you no longer use the Daily Depositor the way it was intended.

> So it starts off where the students have to recognize the pattern of the calendar and I usually make them make a prediction about something that will happen later on in the month. Then we do Daily Depositor, which I really don't use it the way it's supposed to be used, but I have them… this month I just wanted them to practice division some more because we did it in a previous chapter. So I had them take the year 2011 and divide it by the date, so it was 2011 divided by 11 and then we deposit that much money into the Daily Depositor. [PIp11])

- What is the nature of the changes you made?
- To what do you attribute these changes?

4. You spoke about being involved with the development of the new mathematics pacing guide for the county. Talk to me about how you became involved in this activity. What factors led to your involvement?

5. How has your perception of yourself as a teacher of mathematics changed over the last two years?

6. How did the *Prime Online* PD experience influence your teaching practices?

STRATEGIES AND MANIPULATIVE MATERIALS:

7. During our interview in July, you told me about many activities in which you used manipulative materials. You even told me that base ten blocks are your "best friend now" [I-1p7]. Reflect on your response to a forum prompt you wrote about mathematical proficiency during the second week of the *Prime Online* program:

> Regardless, if you can analyze a problem, whether in a book or in real life, and perform a series of mathematical operations to reach the needed answer, regardless of what operations those are (e.g., using multiplication instead of repeated addition or vice versa), you are able to reason and come up with a strategy to problem solve. (I assume that as adults, most if not all of the participants in this class act mathematically in this way, but I don't really know. Some of us might be carrying five bags of those red and yellow counters when we grocery shop.) [Wk2F1].

The end of this statement seems to indicate a negative perspective on the use of manipulative materials.

- Has your thinking about using these materials changed?
- To you, what is the role of manipulative materials in the learning process? In the teaching process?

8. After using base ten blocks to model multiplication with the partial products algorithm you wrote, "I like the traditional algorithm the best, mainly because that's the way I learned to multiply as a child. I also don't like relying on strategies that aren't practical in a majority of situations where I need to carry out a mathematical task" [Wk11F3]. Reflect on this statement. What do you think you meant by this statement? What is the role of manipulative materials in learning?

9. You also mentioned strategy use while describing your *best lesson*: "We showed students how to use a strategy involving multiplication to compare and order fractions. The strategy involved multiplying each fraction's numerator by the other fraction's denominator." You stated that "students preferred the aforementioned strategy to finding common denominators to compare and order fractions. <u>When students reach upper elementary grades without number sense or basic facts knowledge, quick strategies are what they rely on heavily to be successful in math</u> [Wk1AA].

- What do you mean by "quick strategies"?

- How do you decide when to teach with manipulative materials and when to teach quick strategies? How do you balance the two?

10. You posted this during a discussion about week about mathematical proficiency:

    I think tricks are so cool. I don't think I missed out as a student by not knowing the tricks, but as a teacher I see the benefit of knowing ways to make math bearable and enjoyable for a child who isn't confident in his computation ability. I find that my students who are stronger students that prefer the traditional methods of computation aren't as interested in the tricks. They think it holds them up when they could be moving on. The kids who struggle look for an alternative method. [Wk2-AA]

- How do quick strategies compare to "tricks"?
- What is your current stance on using "tricks"?

11. You spoke about your mathematics history during our last conversation. You said, "I was never taught any "tricks" for solving multi-digit multiplication problems or long division, and I imagine this is because I showed proficiency after being taught the traditional methods of regrouping and DMSB." [Wk2AA]

- Is your stance on tricks related to your history as a learner of math?

<u>PARTICIPATION:</u>

12. As part of my study, I focused on three activities in Segment Two, one of which was *A Meter of Candy* in Week 15. You responded to the Anticipatory Activity and Forum 1 for that week (Fraction and Decimal Numbers: Addition and Subtraction), but not Forum 3, A Meter of Candy. Do you recall what hindered your participation during that module?

13. What caused your levels of participation to vary?

- The prompts (the questions asked in the forums)? You mentioned that "*conversations…hard to pull off sometimes online because it's so specific, each posting*" [PIp5]. Can you elaborate?

- The group assignment? You said "*Also the week that we had to do a group assignment, that was a little tough just trying to figure it out. We don't meet, we don't call…"* Do you have any further recollections about how you felt during that

assignment? What parts of it were “tough to figure out”? [PIp3-5] Were all of those specific to the online format?

- The instructor involvement? Regarding your response to the post on mathematical proficiency, you stated that it was “*big*” and “*kind of opened up a little more discussion on my end as far as mathematical proficiency goes*” when Dr. Pape asked you, “What do you think” [PIp8]. Can you elaborate?

- Was there a relationship between instructor input and your participation in the forum posts? (Does the quantity/quality of your posts depend on if the instructor has responded to you – or others?)

LIST OF REFERENCES

Ball, D. L. (1994, November). *Developing mathematics reform: What don't we know about teacher learning—but would make good working hypotheses?* Paper presented at Conference for Teacher Enhancement in Mathematics K–6, Arlington, Virginia.

Ball, D. L., Bass, H., Hill, H., Sleep, L., Phelps, G., & Thames, M. (2006, January). *Knowing and using mathematics in teaching* [PowerPoint slides]. Paper presented at the Learning Network Conference: Teacher Quality, Quantity, and Diversity, Washington, DC. Retrieved from http://www-personal.umich.edu/~dball/presentations/

Ball, D. L., Sleep, L., Boerst, T. A., & Bass, H. (2009). Combining the development of practice and the practice of development in teacher education. *The Elementary School Journal, 109*, 458-474. doi:10.1086/596996

Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education, 59,* 389-407.

Beauchamp, C., & Thomas, L. (2009). Understanding teacher identity: An overview of issues in the literature and implications for teacher education. *Cambridge Journal of Education, 39*, 175-189. doi:10.1080/0305 7640902902252

Beijaard, D., Meijer, P., & Verloop, N. (2004). Reconsidering research on teachers' professional identity. *Teaching and Teacher Education, 20*, 107-128. doi:10.1016/j.tate.2003.07.001

Bjuland, R., Cestari, M. L., & Borgersen, H. E. (2012). Professional mathematics teacher identity: Analysis of reflective narratives from discourse and activities. *Journal of Mathematics Teacher Education, 15*, 405-424. doi:10.1007/s10857-012-9216-1

Brady, S., Gillis, M., Smith, T., Lavalette, M., Liss-Bronstein, L., Lowe, E., . . . Wilder, T. D. (2009). First grade teachers' knowledge of phonological awareness and code concepts: Examining gains from an intensive form of professional development and corresponding teacher attitudes. *Reading and Writing, 22*, 425-455. doi:10.1007/s11145-009-9166-x

Brantlinger, E., Jimenez, R., Klingner, J., Pugach, M., & Richardson, V. (2005). Qualitative studies in special education. *Council for Exceptional Children, 71*, 195-207. doi:10.1352/0047-6765(2005)43<92:IOEAWA>2.0.CO;2

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3,* 77-101. doi:10.1191/1478088706qp063oa

Chapman, O. (2008). Narratives in mathematics teacher education. In D. Tirosh & T. Wood (Eds.), *Tools and processes in mathematics teacher education* (pp. 15-38). Rotterdam, Netherlands: Sense Publishers.

Chang, Y. (2009). A case study of elementary beginning mathematics teachers' efficacy development. *International Journal of Science and Mathematics Education, 8*, 271-297. doi:10.1007/s10763-009-9173-z

Chang, Y. L., & Wu, S. C. (2007). An exploratory study of elementary beginning mathematics teacher efficacy. In J. Woo, H. Lew, K. Park, & D. Seo (Eds.), *Proceedings of the 31st Conference of the International Group for the Psychology of Mathematics Education*, *Vol. 2* (pp. 2-89–2-96). Seoul, Korea: PME 31.

Clandinin, D. J., & Rosiek, J. (2006). Mapping a landscape of narrative inquiry: Borderland spaces and tensions. In D. J. Clandinin (Ed.), *Handbook of narrative inquiry: Mapping a methodology* (pp. 35–75). Thousand Oaks, CA: Sage.

Coldron, J., & Smith, R. (1999). Active location in teachers' construction of their professional identities. *Journal of Curriculum Studies, 31*, 711-726. doi:10.1080/002202799182954

Connelly, F. M., & Clandinin, D. J. (1990). Stories of experience and narrative inquiry. *Educational Researcher, 19,* 2-14. doi:10.2307/1176100

Connelly, M., & Clandinin, J. (1999). *Shaping a professional identity: Stories of educational practice*. London, Ontario: The Althouse Press.

Craig, C. (2001). The relationship between and among teachers' narrative knowledge, communities of knowing, and school reform: A case of the "Monkey's Paw". *Curriculum Inquiry, 31,* 303-331. doi:10.1111/0362-6784.00199

Craig, C. (2011). Narrative inquiry in teaching and teacher education. In J. Kitchen, D. Ciuffetelli Parker & D. Pushor (Eds.), *Narrative inquiries into curriculum-making in teacher education* (pp. 19-42). Bingley, United Kingdom: Emerald Publishing.

Creswell, J. W. (2002). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (3rd ed.). Upper Saddle River, NJ: Prentice Hall.

Cross, D. I. (2009). Alignment, cohesion, and change: Examining mathematics teachers' belief structures and their influence on instructional practices. *Journal of Mathematics Teacher Education, 12*, 325-346. doi:10.1007/s10857-009-9120-5

Dana, N. F., & Yendol-Hoppey, D. (2009). *The reflective educator's guide to classroom research: Learning to teach and teaching to learn through practitioner inquiry, 2nd Edition.* Thousand Oaks, CA: Corwin Press.

Day, C., Elliot, B., & Kington, A. (2005). Reforms standards and teacher identity: Challenges of sustaining commitment. *Teaching and Teacher Education, 21*, 563-577. doi:10.1016/j.tate.2005.03.001

Day, C., Kington, A., Stobart, G. & Sammons, P. (2006). The personal and professional selves of teachers: stable and unstable identities. *British Educational Research Journal, 32*, 601-616. doi:10.1080/01411920600775316

Dede, C. Ketelhut, D. J., Whitehouse, P., Breit, L., & McCloskey, E. M. (2009). A research agenda for online teacher professional development. *Journal of Teacher Education, 60*, 8-19. doi:10.1177/0022487108327554

del Valle, R., & Duffy, T. M. (2009). Online learning: learner characteristics and their approaches to managing learning. *Instructional Science, 37*, 129-149. doi:10.1007/s11251-007-9039-0

Denzin, N. K. (1989). *The Research Act* (3rd ed.) Englewood Cliffs, NJ: Prentice Hall.

Dingle, M. P., Brownell, M. T., Leko, M. M., Boardman, A. G., & Haager, D. (2011). Developing effective special education reading teachers: The influence of professional development, context, and individual qualities. *Learning Disabilities Quarterly, 34,* 87-103.

Downer, J. T., Locasale-Crouch, J., Hamre, B., & Pianta, R. (2009). Teacher characteristics associated with responsiveness and exposure to consultation and online professional development resources. *Early Education & Development, 20*, 431-455. doi:10.1080/10409280802688626

Dougiamas, M. (1999). Moodle (Version 3) [Software]. Retrieved from http://moodle.com/

Drake, C., & Sherin, M. G. (2006). Practicing change: Curriculum adaptation and teacher narrative in the context of mathematics education reform. *Curriculum Inquiry, 36*, 153-187. doi:10.1111/j.1467-873X.2006.00351.x

Drake, C., Spillane, J. P., & Hufferd-Ackles, K. (2001). Storied identities: Teacher learning and subject-matter context. *Journal of Curriculum Studies, 33*, 1-23. doi:10.1080/00220270119765

Ebby, C. B. (2000). Learning to teach mathematics differently: The interaction between coursework and fieldwork for preservice teachers. *Journal of Mathematics Teacher Education, 3*, 69–97.

Flick, U. (2009). *An introduction to qualitative research* (4th ed.). London: Sage Publications.

Flores, M. A., & Day, C. (2006). Contexts which shape and reshape new teachers' identities: A multi-perspective study. *Teaching and Teacher Education, 22*, 219–232. doi:10.1016/j.tate.2005.09.002

Forbes, C., & Davis, E. A. (2008). The development of preservice elementary teachers' curricular role identity for science teaching. *Science Teacher Education, 92*, 909-940. doi:10.1002/sce.20265

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Education Research Journal, 38,* 915-945. doi:10.3102/00028312038004915

Gee, J. P. (2000). Identity as an analytic lens for research in education. *Review of Research in Education, 25*, 99–125. doi:10.3102/0091732X025001099

Gresalfi, M. S., & Cobb, P. (2011). Negotiating identities for mathematics teaching in the context of professional development. *Journal for Research in Mathematics Education*, *42*, 270-304.

Grion, V., & Varisco, B. M. (2007). On line collaboration for building a teacher professional identity. *PsychNology Journal, 5*, 271-284.

Groth, R. E. (2007). Case studies of mathematics teachers' learning in an online study group. *Contemporary Issues in Technology and Teacher Education, 7*, 490-520.

Hannula, M. S., Kaasila, R., Laine, A., & Pehkonen, E. (2005). Structure and typical profiles of elementary teacher students' view of mathematics. In H. L. Chick & J. L. Vincent (Eds.), *Proceedings of the 29th Conference of the International Group for the Psychology of Mathematics Education: Vol. 3. Research Reports* (pp. 89–96). Melbourne, Australia: University of Melbourne.

Hatch, J. A. (2002). *Doing qualitative research in education settings*. Albany, NY: State University of New York Press.

Hill, H. C. (2010). The nature and predictors of elementary teachers' mathematical knowledge for teaching. *Journal for Research in Mathematics Education, 41*, 513-545.

Hill, H. C., Ball, D. L., & Schilling, S. G. (2008). Unpacking pedagogical content knowledge: Conceptualizing and measuring teachers' topic-specific knowledge of students. *Journal for Research in Mathematics Education, 39*, 372-400.

Hill, H. C., Schilling, S. G., & Ball, D. L. (2004). Developing measures of teachers' mathematics knowledge for teaching. *Elementary School Journal, 105*, 11-30. doi:10.1086/428763

Hobbs, L. (2012). Examining the aesthetic dimension of teaching: Relationships between teacher knowledge, identity and passion. *Teaching and Teacher Education, 28*, 718-727. doi:10.1016/j.tate.2012.01.010

Hrastinski, S. (2008). What is online learner participation? A literature review. *Computers & Education, 51*, 1755-1765. doi:10.1016/j.compedu.2008.05.005

Jewett, M. A. (2012). *"I felt like the enemy and the savior all at once": English teacher identity in a methods course wiki* (Unpublished doctoral dissertation). University of New Mexico, Albuquerque, NM.

Kaasila, R. (2007). Using narrative inquiry for investigating the becoming of a mathematics teacher. *ZDM Mathematics Education, 3*9, 205-213. doi:10.1007/s11858-007-0023-6

Kaasila, R., Hannula, M. S., Laine, A., & Pehkonen. (2008). Socio-emotional orientations and teacher change*. Educational Studies in Mathematics,* 67, 111-123. doi:10.1007/s10649-007-9094-0

Kahan, J. A., Cooper, D. A., & Bethea, K. A. (2003). The role of mathematics teachers' content knowledge in their teaching: A framework for research applied to a study of student teachers. *Journal of Mathematics Teacher Education, 6,* 223-252.

Kazemi, E., & Hubbard, A. (2008). New directions for the design and study of professional development: Attending to the coevolution of teachers' participation across contexts. *Journal of Teacher Education, 59*, 428-441. doi:10.1177/0022487108324330

Kilpatrick, J., Swafford, J., & Findell, B. (Eds.). (2001). *Adding it up: Helping children learn mathematics*. Washington, DC: National Academy Press.

Koro-Ljungberg, M. (2010). Validity, responsibility, and aporia. *Qualitative Inquiry, 16,* 603-610. doi:10.1177/1077800410374034

Koro-Ljungberg, M., Yendol-Hoppey, D., Smith, J. J., & Hayes, S. B. (2009). (E)pistemological awareness, instantiation of methods, and uninformed methodological ambiguity in qualitative research projects. *Educational Researcher, 38*, 687-699. doi:10.3102/0013189X09351980

Krzywacki, H. (2009). *Becoming a teacher: Emerging teacher identity in mathematics teacher education* (Unpublished doctoral dissertation). University of Helsinki, Helsinki, Finland.

Lieber, J., Butera, G., Hanson, M., Palmer, S., Horn, E., Czaja, C., . . . Odom, S. (2009). Factors that influence the implementation of a new preschool curriculum: Implications for professional development. *Early Education & Development, 20*, 456-481. doi:10.1080/10409280802506166

Lincoln, Y., & Guba, E. (1985). *Naturalistic inquiry*. Beverly Hills, CA: Sage.

Mazzolini, M., & Maddison, S. (2003). Sage, guide or ghost? The effect of instructor intervention on student participation in online discussion forums. *Computers & Education, 40*, 237–253. doi:10.1016/S0360-1315(02)00129-X

McAleer, D., & Bangert, A. (2011). Professional growth through online mentoring: A study of mathematics mentor teachers. *Journal of Educational Computing Research, 44,* 83-115. doi:10.2190/EC.44.1.e

McDonough, A., & Clarke, B. A. (2005). Professional development as a catalyst for changes in beliefs and practice: Perspectives from the Early Numeracy Research Project. In P. Clarkson, A. Downton, D. Gronn, M. Horne, A. McDonough, R. Pierce, & A. Roche (Eds.), *Building connections: Research, theory and practice. Proceedings of the 28th annual conference of the Mathematics Education Research Group of Australasia*, Melbourne (pp. 521-528), Melbourne, Australia: MERGA.

McMillan, J., & Schumacher, S. (2005). *Research in education: Evidence-based inquiry* (6th ed.). Boston, MA: Allyn & Bacon.

Miles, M. B., & Huberman, A. M. (1994). Qualitative data analysis (2nd ed.). Thousand Oaks: Sage Publications.

Muchmore, J. A. (2002, December). Methods and ethics in a life history study of teacher thinking. *The Qualitative Report, 7*. Retrieved from http://www.nova.edu/ssss/QR/QR7-4/muchmore.html

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics. (2006). *Learning number sense from a broken calculator*. Retrieved from www.nctm.org/eresources/view_article.asp?article_id=7457

National Council of Teachers of Mathematics. (n.d.). *A meter of candy*. Retrieved from http://illuminations.nctm.org/Lesson.aspx?id=3229

National Governors Association Center for Best Practices, Council of Chief State School Officers. (2010). *Common Core State Standards for mathematics*. Washington, DC: Author.

No Child Left Behind (NCLB) Act of 2001, Pub. L. No. 107-110, § 115, Stat. 1425 (2002).

Patton, M. Q. (1999). Enhancing the quality and credibility of qualitative analysis. *Health Services Research, 34*, 1189-1209.

Patton, M. Q. (2001). Qualitative research and evaluation methods. Thousand Oaks, CA: Sage.

Pearson, P. D., & Gallagher, M. C. (1983). The instruction of reading comprehension. *Contemporary Educational Psychology, 8*, 317-344. doi:10.1016/0361-476X(83)90019-X

Philipp, R. A. (2007). Mathematics teachers' beliefs and affect. In F. Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (257-315). Reston, VA: National Council of Teachers of Mathematics.

Picciano, A. (2002). Beyond student perceptions: Issues of interaction, presence, and performance in an online class. *Journal of Asynchronous Learning Networks, 6*, 21-40.

Ponte, J. P., & Santos, L. (2005). A distance in-service teacher education setting focused on mathematics investigations: The role of reflection and collaboration. *Interactive Educational Multimedia, 11*, 104-126.

Putnam, R. T., & Borko, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning? *Educational Researcher, 29*, 4-15. doi:10.2307/1176586

Rodgers, C., & Scott, K. (2008). The development of the personal self and professional identity in learning to teach. In M. Cochran-Smith, S. Feiman-Nemser, D.J. McIntyre & K.E. Demers (Eds.), *Handbook of research on teacher education: Enduring questions and changing contexts* (pp. 732–755). New York, NY: Routledge.

Rossman, G., & Rallis, S. (2003). Learning in the field: An introduction to qualitative research (2nd ed.). Thousand Oaks, CA: Sage.

Salmon, G. (2004). *E-moderating: The key to teaching and learning online*. London: Routledge Falmer.

Settlage, J. Southerland, S. A., Smith, L. K., & Ceglie, R. (2009). Constructing a doubt-free teaching self: Self-efficacy, teacher identity, and science instruction within diverse settings. *Journal of Research in Science Teaching, 46*, 102-125. doi:10.1002/tea.20268

Schwandt, T. A. (1997). *Qualitative inquiry: A dictionary of terms.* Thousand Oaks, CA: Sage Publications.

Sfard, A., & Prusak, A. (2005). Telling identities: In search of an analytic tool for investigating learning as a culturally shaped activity. *Educational Researcher, 34*, 14-22. doi:10.3102/0013189X034004014

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, *15*, 4-14. doi:10.3102/0013189X015002004

Sinclair, M., & Owston, R. (2006). Teacher professional development in mathematics and science: A blended approach. *Canadian Journal of University Continuing Education, 32*, 43-66.

Smith, J. (2011). *The meanings of teaching from the perspective of exemplary and experienced teachers* (Unpublished doctoral dissertation). The Pennsylvania State University, University Park, PA.

Spillane, J. P. (2000). Constructing ambitious pedagogy in the fifth grade: The mathematics and literacy divide. *Elementary School Journal*, *100*, 307–330.

Suh, J. M. (2007). Tying it all up. *Teaching Children Mathematics, 14,* 163-169

Sutherland, L., Howard, S., & Markauskaite, L. (2010). Professional identity creation: Examining the development of beginning preservice teachers' understanding of their work as teachers. *Teaching and Teacher Education, 26,* 455-465. doi:10.1016/j.tate.2009.06.006

Swars, S. L. (2005). Examining perceptions of mathematics teaching effectiveness among elementary preservice teachers with differing levels of mathematics teacher efficacy. *Journal of Instructional Psychology, 32*, 139–147.

Swars, S., Hart, L. C., Smith, S. Z., Smith, M. E., & Tolar, T. (2007). A longitudinal study of elementary pre-service teachers' mathematical beliefs and content knowledge. *School Science and Mathematics, 107*, 325-335. doi:10.1111/j.1949-8594.2007.tb17797.x

Timostsuk, I., & Ugaste, A. (2010). Student teachers' professional identity. *Teaching and Teacher Education, 26*, 1563-1570. doi:10.1016/j.tate.2010.06.008

Turniansky, B., & Friling, D. (2006). The Expert Novice. In S. A. Barab, K. E. Hay, & D. T. Hickey (Eds.), *Proceedings of the 7th International Conference on Learning Sciences ICLS*, (pp. 778-784). International Society of the Learning Sciences, Bloomington, IN: ISLS.

van Veen, K., & Sleegers, P. (2006). How does it feel? Teachers' emotions in a context of change. *Journal of Curriculum Studies, 38*, 85–111. doi:10.1080/00220270500109304

Vosniadou, S. (1994). Capturing and modeling the process of conceptual change. *Learning and Instruction, 4*, 45-69. doi:10.1016/0959-4752(94)90018-3

Wenger, E. (1998). *Communities of practice: Leaning, meaning, and identity*. New York: Cambridge University Press.

Wise, A., Chang, J., Duffy, T., & del Valle, R. (2004). The effects of teacher social presence on student satisfaction, engagement, and learning. *Journal of Educational Computing Research, 31*, 274-271. doi:10.2190/V0LB-1M37-RNR8-Y2U1

Xu, S., & Connelly, F. M. (2009). Narrative inquiry for teacher education and development: Focus on English as a foreign language in China. *Teaching and Teacher Education, 25*, 219-227. doi:10.1016/j.tate.2008.10.006

Yang, S. C., & Liu, S. F. (2004). Case study of online workshop for the professional development of teachers. *Computers in Human Behavior, 20,* 733-761. doi:10.1016/j.chb.2004.02.005

Zembylas, M. (2003). Caring for teacher emotion: Reflections on teacher self development. *Studies in Philosophy and Education, 22*, 103–125.

BIOGRAPHICAL SKETCH

Sherri Kay Prosser graduated from the University of Florida with a Bachelor of Arts in Education in special education in 1996 and a Master of Education in special education in 1997. After graduation she moved to Volusia County and taught elementary school special education for five years and middle school mathematics for seven years. In 2009, she enrolled at the University of Florida and began work on a Doctor of Philosophy in curriculum and instruction with an emphasis on mathematics education. Sherri graduated in May 2014 and works as a consultant for Volusia County Schools in the Office of Professional Development and Support. She creates online teacher professional development relating to best practices in mathematics and English language arts.