THE DEVELOPMENT OF PROFESSIONAL IDENTITIES OF MATHEMATICS SPECIALISTS

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Abstract

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This study investigates how mathematics specialists perceive their professional identities and how those identities change over time, given the different contexts in which they work and the roles they play within those contexts. Specifically, the purpose of this interpretative phenomenological study was to explore the development of professional identities of experienced mathematics specialists who were working in jobs intended to support teachers in developing reform based mathematical practices. Five graduates of the University of Virginia's Mathematics Specialist program served as participants. Four of these participants are currently practicing mathematic specialists, while one of the participants has returned to teaching full time. Retrospective data was collected, including semi-structured interviews, and supporting artifacts from work as a mathematics specialist. Interviews were transcribed and analyzed with an interpretative, iterative process, using a framework grounded in communities of practice.

Analysis resulted in the emergence of four main themes related to the development of a strong professional identity. These themes include the presence of reform based beliefs about the nature of mathematics and mathematical instruction; the importance of building strong relationships built on trust in order to work with teachers in bringing about change; the role of the culture of the community of practice; and the development of a professional voice. While all of the participants held strong beliefs, it was vital that the culture of the community of practice, including the division policies and the support of school administrators, became aligned with the

beliefs of the specialist for a strong professional identity to occur. When this did not happen, the specialist found it difficult to make significant in teachers' practice and did not develop a strong identity as a mathematics specialist.

Implications include the importance of mathematics specialists as players in the development of teachers' social networks that are vital for bringing about educational change; the need for school divisions to develop policies and practice that are consistent with the goals of mathematics reform and to be consistent in working with mathematics specialists to implement these policies and practices; and the importance in considering the effect of time in bringing about educational change, and the need to allow time for specialists to develop a strong effective professional identity and practice.

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This dissertation, *The Development of Professional Identities of Mathematics Specialists,* has been approved by the Graduate Faculty of the Curry School of Education in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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DEDICATION

To Heidi and Nell: Please learn perseverance, not procrastination. I've certainly modeled both.

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Finally, Ron: The gold medal of thanks goes to you. What's it going to be like to be married to someone who isn't a student? I love you.

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CHAPTER 1

INTRODUCTION

This study investigates how mathematics specialists perceive their professional identities and how those identities change over time, given the different contexts in which they work and the roles they play within those contexts. It tells the story of four classroom teachers who made the transition to becoming mathematics specialists, and of one specialist who made the transition back to the classroom. All of these mathematics specialists and the teacher currently work in Virginia, one of the first states to officially endorse mathematics specialists through the adoption of licensure regulations. One of these specialists has only recently returned to Virginia after being previously employed in a mathematics leadership role in another state. All participants in this study are graduates of the same master level program designed specifically to prepare mathematics specialists. This study explores how each of these individuals moved beyond her or his preparation to become a mathematics specialist, looking closely at the experiences that have fostered or hindered the development of new professional identities. In so doing, it is hoped that new insights with the potential to influence professional development and support for mathematics specialists will emerge.

Background

In 1989, with the publication of the Curriculum and Evaluation Standards for School Mathematics, the National Council of Teachers of Mathematics (NCTM) launched a standards–based mathematics reform effort (Herrera & Owens, 2001, p.

85). Herrera and Owens note this document presented a vision of mathematics that differed significantly from what had been understood by teachers, and offered to students, in the past. In particular, this document advocated changes to content and pedagogy that are "suitable for all students, not only the college bound" (Herrera & Owens, p.89). In the years since the publication of this document, members of the mathematics teaching community have continued to promote the beliefs and associated practices that mathematics instruction "should be centered on engaging students in solving and discussing tasks that promote reasoning and problem solving" (NCTM, 2014, p. 10) rather than "delivered through lessons taught in the manner parents and teachers remember, focused on the memorization of facts, formula and procedures" (NCTM, 2014, p. 9).

For several decades, researchers have identified teachers as key to the success of mathematics reform (Battista, 1994), and continuing professional development (CPD) for teachers of mathematics as fundamental to fulfil the goals of the reform movement in K-12 mathematics education (Ball & Cohen, 1999; Cohen & Hill, 2000; Corcoran, Shields & Zucker, 1998; Darling- Hammond & McLaughlin, 1995; National Council of Teachers of Mathematics, 2014; National Commission on Teaching and America's Future, 1996; Simon, 2008). Doerr, Goldsmith and Lewis (2010) identify the main goal of CPD as "improving students' learning through the mechanism of improving instruction" (p.1), while DeMonte (2013) describes CPD as "the link between the design and implementation of education reforms and the ultimate success of reform efforts in schools" (p.2).

This demand for teacher CPD has been met with research that suggests professional development for mathematics teachers should focus on broad goals of developing

> teachers' mathematical knowledge and capacity to connect it to practice; teachers' capacity to notice, analyze, and respond to student thinking; the beliefs and dispositions that foster teachers' continued learning; and collegial relationships and learning structures that can support and sustain teachers' learning. (Doerr, Goldsmith & Lewis, 2010, p. 4)

Furthermore, essential characteristics of high quality CPD that address the aforementioned goals have been identified, including: a) coherence, where activities present a clear purpose and are tied to local, state, and national goals; b) active learning, focused on the work of teaching; c) adequate duration; d) collective and collaborative participation; e) systemic support; and f) a focus on content knowledge, including pedagogical content knowledge and mathematical knowledge for teaching (Ball, Lubienski &Mewborn, 2001; Birman et al., 2007; Boyle, While & Boyle, 2004; Doerr, Goldsmith & Lewis, 2010; Garet, Porter, Desimone, Birman &Yoon, 2001; Loucks-Horsley, Hewson, Love & Stiles, 1998; National Commission on Teaching and America's Future, 1996; Shulman,1986; US Department of Education, 2001). DeMonte (2013) inserts one more key feature to this list: high quality CPD includes follow up and continuous feedback.

There remains a strong belief that the "success of ambitious education reform initiatives hinges, in large part, on the qualification and effectiveness of teachers" (Garet, et al., 2001, p. 916). Therefore, it is not only important that mathematics CPD is offered, but that it is carefully designed and delivered to maximize its potential for improving instructional practices.

Researchers are careful to point out that increasing teachers' mathematical content knowledge and pedagogical knowledge is not enough to guarantee that mathematical education reform will occur, or that teachers will adopt new practices.

Fullan (2007) notes no matter how well leaders conceive any reform agenda, the chances of it failing are high if teachers' beliefs do not match the proposed innovations. More recently, Campbell et al. (2014) demonstrated that increased student achievement as a result of increases in teacher content knowledge and teacher pedagogical content knowledge is related to changes in teacher beliefs, or with teachers who had already established beliefs aligned with the reform movement.

Many teachers regard mathematics as a set of facts, rules and procedures, and see the goal of mathematics instruction as ensuring that children learn these same facts, rules and procedures. Ellis and Berry (2005) discuss the paradigm shift that must occur within teachers and schools if they are to engage fully in the practice of reform mathematics. A shift of this sort requires teachers to "see mathematics as a set of logically organized and interconnected concepts that come out of human experience, thought and interaction" (Ellis and Berry, 2005, p.12) rather than as an "objective set of logically organized facts, skills and procedures that have been organized over centuries… (that) exists apart from human experience" (Ellis and Berry, 2005, p.11). Such a shift in beliefs would precipitate a change in a teacher's instructional practice. Developing mathematical and pedagogical knowledge is not enough to ensure such a shift in beliefs about the nature of mathematics will occur; and if such a shift does not occur, it is unlikely teachers will see reform efforts and reform practices as useful in their classroom and instruction. It follows that if mathematics reform is to occur, CPD needs to address and alter the beliefs held by mathematics teachers, alongside improving knowledge of mathematics and mathematics teaching.

Job-embedded CPD. The traditional structure of CPD as courses or workshops can work against the professional development of teachers, as it is seen as

"something done to them, instead of doing something for them, involving them as active partners in their professional growth" (NCTM, 2014, p.101). One-day workshops, after school meetings, even semester long courses focused on content, fit the description of "short-term, episodic and disconnected professional learning" (DeMonte, 2015, p.1) if the purpose of the CPD does not match the beliefs or needs of the participants, if the CPD is not incorporated into the teacher's practice, and if the learning is not sustained. DeMonte (2013) reports that when "single-event" CPD is replaced with programs that occur over longer terms, there is a greater chance of improving overall instruction.

One way to provide CPD over a long period of time is through a job-embedded model. According to Croft, Coggshall, Dolan, Powers and Killion (2010), job-embedded professional development is teacher learning that occurs as part of the workday, focusing on content-specific instructional practices. It is primarily classroom or school based, and involves teachers identifying authentic problems within their practice and finding solutions to those problems. This type of CPD is collaborative and part of a cyclical process of on-going improvement that links teacher learning and practice with student achievement. Job-embedded CPD is based on the formal and informal interactions teachers have within schools, drawing upon each other's professional knowledge.

A mechanism for developing that professional knowledge and supporting job-embedded CPD within a school is through the use of content specialists or coaches. DeMonte (2013) reports research suggesting the use of coaches or specialists is an effective part of job embedded CPD programs. However, she makes the point that the success of the specialist or coaching model depends on the expertise of the coach or specialist. But if we assume the coach or mathematics specialist is adequately

prepared for and supported in the role, there are some tangible advantages to this model of professional development. Because they work in a school, mathematics specialists have proximity to teachers and the functioning of schools that few other types of CPD providers are privileged to have. Well-prepared mathematics specialists are positioned to work with teachers in a manner that is relevant to the teacher's daily work, that provides a consistent message aligned with school and system goals, and that provide regular, supportive, collaborative feedback on the work the teacher does. Therefore, mathematics specialists are uniquely situated amongst CPD providers to see that CPD is woven into the fabric of a teacher's daily practice.

For the purpose of clarity, when discussing coaches and specialists, only the term mathematics specialist will be used from this point on. In much of the literature the terms are interchangeable. This project is particularly focused on mathematics specialists in Virginia, and they refer to themselves with this nomenclature.

Function and role of mathematics specialists. In the latter part of the 20th century, calls for mathematics specialists began to emerge from leaders of the mathematics education reform movement (Dossey, 1984; National Council for Teachers of Mathematics, 1984; Bruni, 1991). The Association of Mathematics Teacher Educators, or AMTE, (2010/2013), recognizes that specialists are a particular type of mathematics CPD provider, often based in schools, tasked with the purpose of improving student achievement by increasing teachers' capacities to provide effective mathematics instruction. The Virginia Mathematics and Science Coalition (VMSC, 2005) states that mathematics specialists

> are teacher leaders with strong preparation and background in mathematics content, instructional strategies, and school leadership. Based in elementary and middle schools, mathematics specialists are excellent teachers who are

> released from full time classroom responsibilities so that they can support the professional growth of their colleagues, promoting enhanced mathematics instruction and student learning throughout their schools. They are responsible for strengthening classroom teachers' understanding of mathematics content, and helping teachers develop more effective mathematics teaching practices that allow all students to reach high standards as well as sharing research addressing how students learn mathematics (http://www.vamsc.org/index2.html).

In addition to working with teachers in a coaching capacity, mathematics specialists "serve as resources in professional development, instructing children with learning difficulties, curriculum development, mentoring of new teachers and community education" (VMSC, 2005, http://www.vamsc.org/index2.html). They are recognized as school leaders, but hold no supervisory powers. They are teachers in the school, but do not have their own classroom of students.

Stein, Smith and Silver (1999) discuss ways in which mathematics specialists embed professional development into the daily functioning of schools. They act as reflective partners as a teacher discusses a teaching episode. They lead groups of teachers as they explore artifacts of teaching, such as lesson plans, student work, or case studies about teaching and teachers. They help teachers to grapple with mathematics concepts themselves before they try to teach the content to children, as well as help teachers design tasks that encourage children to develop deep mathematical understanding. They work with teachers to develop the pedagogical moves that encourage students to communicate and represent their thinking. They respond to the needs of the teachers, and this often means responding to the needs of a school or district. Furthermore, the mathematics specialist must be able to consider

the multiplicity of factors that affect the work of teachers, and work to establish a coherent CPD program. Thus, mathematics specialists need to be skilled in working within and developing communities of practice.

It is notable that Stein, Smith and Silver (1999) and the VMSC (2005) describe the roles in schools that mathematics specialists might take, as well as the types of activities with which mathematics specialists engage. However, neither specifically mentions the philosophical change that mathematics specialists must work to bring about in most teachers, as well as within most schools and communities, if mathematics teaching is to change fundamentally in ways recommended by reform agenda (e.g., NCTM 1989; 2000;).

In addition to the roles attributed previously, mathematics specialists are agents of change. Fullan (2007) points out that ideally, but perhaps idealistically, educational change is introduced to help schools improve by becoming more effective and efficient. This often requires making changes to, or replacing structures, policies, programs, and practice. Exploring what is meant by "change in practice" Fullan notes there are at least three aspects of any current practice at stake through innovation. These include: "1) the possible use of new or revised *materials*…2) the possible use of new *teaching approaches*; …and 3) the possible alteration of *beliefs"* (p. 37). The mathematics reform movement is attempting to change decades old classroom practice including beliefs about how children learn and the role of teachers in bringing about that learning. Mathematics education reform also challenges parental understanding of the purpose of school mathematics, and challenges societal understanding of what it means to know and do mathematics. Mathematics specialists are responsible for bringing about these changes (AMTE, 2010/2013). As many

mathematics specialists begin as teachers, this change often originates at a personal level.

The development of mathematics specialists and their professional identities. Several important points are made here regarding the above discussion. First, mathematics specialists are often selected to prepare for the role because they are excellent classroom teachers. As noted earlier, excellence as classroom teachers does not ensure they will be effective teacher leaders. Second, the description VMSC puts forward includes a claim that mathematics specialists are well versed in mathematics, pedagogy, and leadership. Mathematics specialists, at least in Virginia, as defined though the licensure requirements (Virginia Department of Education, 2013), are mathematics teacher educators who have completed specific coursework and practicums intended to prepare them for the role they undertake. How this preparation has changed their beliefs and practices will depend on the interpreted experiences of the individual specialists. Third, despite extensive preparation, mathematics specialists will inherently find themselves novices, rather than experts, in their job. Thus, while mathematics specialists may have completed a program that prepares them to undertake this new position, and may in fact have deepened or altered their beliefs about mathematics teaching and learning, this knowledge and belief system will likely be challenged by the situations they encounter working with teachers, administrators, parents, and the community. While they may have had a strong professional identity as excellent teachers, their identity as mathematics specialists will be fragile and will need to develop.

Therefore, in considering the professional identity of mathematics specialist-attention must be paid to the preparation mathematics specialists receive before they assume the new role. However, academic preparation alone may not be sufficient to

ensure new mathematics specialists have the necessary skills to meet the challenges they will encounter in their jobs, and to develop the competence and confidence they will need to successfully bring about change. For example, academic preparation will not fully prepare a mathematics specialist to handle tactfully the teacher who consistently cancels coaching sessions, nor will it guarantee that the mathematics specialist has an immediate answer when a teacher asks for guidance about a particular topic. Academic preparation cannot fully prepare a mathematics specialist to handle clashes when different belief systems about teaching and learning mathematics collide. Learning to become a mathematics specialist is a continual process; a mathematics specialist's professional identity continually evolves. This professional identity is derived from beliefs and experiences, and from reflections on how challenges are met, handled, and resolved. The investigation of factors contributing to the development of mathematics specialists' professional identities, and how these identities change over time, if at all, over time is the subject of this study.

Purpose of the Study

The purpose of this interpretative phenomenological study was to explore the development of professional identities of experienced mathematics specialists. No studies have been located that discuss the development of mathematics specialists' identities over time. This dissertation addresses this omission in the literature. Professional identity development occurs when personal knowledge and beliefs merge with expectations and demands raised by preparation and the job context (Beijaard, Meijer, & Verloop, 2004). Developing a professional identity occurs over time, in a process that eventually integrates personal and professional aspects of becoming a mathematic specialist (Olsen, 2010). Understanding the development of professional

identity is important as identity defines not only how we see ourselves, but also how we interact with others (Wenger, 2000). Thus, the general intent is to begin to learn about and describe those experiences and contexts seen as significant by mathematics specialists towards developing professional identities, and likewise, those experiences and contexts mathematics specialists view as a challenge or hindrance to the development of their professional identities. Through an examination of key incidences, a picture of how professional identities change over time as a result of context and role will be developed. Therefore this study considers the following questions: Given the different roles and contexts of mathematics specialist, how do mathematics specialists perceive their professional identities? and In what ways, if any, do professional identities of mathematics specialists change over time, experiences, and contexts?

Significance

The potential significance of this study lies in what it might suggest for the preparation of mathematics specialists in particular and providers of mathematics CPD in general. Even (2008) alludes to the irony of the current situation, claiming "the recent focus on mathematics teacher education with lack of attention to the teacher educators mirrors, to some degree, the early research in mathematics education, which centered on student learning but lacked attention to teachers, teaching, and teacher learning" (p.59). This study will fill part of the knowledge gap describing the preparation of mathematics specialists, how mathematics specialists transform preparation into practice, how practice itself provides continued development for the mathematics specialist, and finally, how mathematics specialists develop a professional identity.

This study has the potential to address two problems identified by Even (2008). The first of these issues is the lack of research on the preparation of those who provide CPD for teachers, while the second problem is the lack of research on the practice of CPD providers who specifically work with teachers of mathematics. The cases in this study will shed light on both of these areas. In fact, these cases will conceivably illuminate the close connections between the preparation, practice, and continuing development necessary to become an effective mathematics specialist.

This study will also add to the literature that explores the development of professional identity. There is a growing body of literature that examines how beginning teachers develop their professional identity (Beauchamp & Thomas, 2009; Flores & Day, 2006; Hodgen &Askew, 2007; Pillen, Beijaard, & Den Brok, 2013; Živković, 2013) as well as how teachers negotiate the change in professional identity as they move from the classroom to leadership or teacher educator roles (Beijaard, Meijer, & Verloop, 2004; Clarke, Hyde & Drennan, 2013; Sutherland & Markauskaite, 2012; Murray & Male, 2005). However, such studies tend to focus on professional identity in the early stages of a career change. This study has the potential to provide important insights into the growth of professional identity over time, and perhaps to highlight key experiences that aid in the refinement of professional identity at critical junctures.

There are some staff development and policy concerns this study might identify. Through examining the stories of these individuals, key points about how to improve preparation for the role of mathematics specialist may emerge, as might recommendations about how to improve support for mathematics specialists as they begin their work outside of the classroom. While this study may be specific to

mathematics specialists, findings are likely to highlight issues that arise for anyone who moves from teaching to providing CPD for teachers.

Finally, this research adds to the growing body of work focused on mathematics specialists. Some research is emerging focused on the preparation of mathematics specialists. Campbell and Malkus (2010) have reported on the positive effects resulting from mathematics specialists in schools for students in grades three, four and five. Whitenack and Ellington (2009, 2013) describe how teachers, in the process of preparing to be mathematics specialists, come to reconsider what is entailed in teaching and learning mathematics. Some researchers (Chval, Arbaugh, Lannin, van Garderen, Cummings, Estapa, & Huey, 2010; Nickerson & Moriarty, 2005) have examined the development of professional identities of mathematics specialists immediately after they begin working as a mathematics specialist. NCTM recently published a handbook on mathematics specialists that provides insight into the many challenges mathematic specialists might face, as well as guidance on how to meet these challenges. However, an internet search reveals many more articles that call for mathematics specialists and make claims as to why they are essential (e.g. Fennell, 2006) than report on the initial preparation, continuing development, or identities of mathematics specialists.

Definition of Terms

Community of Practice. A group of people who share a craft or profession. working together to facilitate learning and knowledge sharing, and that act as the backdrop for the development of professional identity; also theoretical lens with which one can examine the situated learning and identity development that takes place in these groups

***Continuing Professional Development*:** Any activity that serves to develop and maintain skills and knowledge for professional growth.

Mathematics Specialist: This term specifically refers to someone whose job is to provide school-based, job embedded support for teachers of mathematics. For this project, mathematics specialists do not have their own classrooms, but rather work with teachers in their school(s) to develop mathematical understanding and mathematics pedagogical understanding. Specialists might also assume the role of mathematics leader in the school or district, and offer curricular support, organizational support (for instance, reviewing textbooks for adoptions, maintaining school mathematics supplies and manipulatives), lead school wide mathematics professional development, and liaise with the wider school district on issues regarding mathematics.

***Professional Identity/Identity*:** How one sees one's self in the performance of one's professional role based on attributes, beliefs, motives, successes and failures, professional trajectories, and experiences. Professional identity reflects how well an individual has been able to align his or her personal and professional values with the values of others in the community; how the individual has been able to successfully engage with the practices of the community; and how the individual has been able to imagine his or her self as part of the community. Identities are in flux, so this definition implies a constant interpretation and reinterpretation of one's identity.

Organization of the Study

Chapter 1 introduces the problem under investigation, outlines the purpose and significance of the study, and defines key terms. Chapter 2 contains a review of current literature, including a description of the Virginia Mathematics Specialists program, a discussion of the literature that explores communities of practice, and

professional identity development. The literature review provides a framework for this study. Research questions are presented at the end of Chapter 2. Chapter 3 describes methods used to collect and analyze data. Chapter 4 presents findings through case studies of individual participant and through case comparisons based on themes that emerged from the cases. Chapter 5 provides a summary of the study, and discusses implications, suggestions for further research, and limitations of the study, as well as a final conclusion.

CHAPTER 2

REVIEW OF THE LITERATURE

This chapter presents a review of literature relevant to the development of professional identities among mathematics specialists, providing an outline and rationale for this study. To facilitate an understanding of the nature of mathematics specialists, an historical context is outlined. This begins with a discussion of the changes in prevalent learning theories that occurred in the latter half of the 20th century, and concomitant changes in beliefs about the nature of what it means to learn and teach mathematics that are the driving force behind the mathematics reform movement. An argument is made that mathematics specialists are a logical outcome to meet the needs that arose from these changes; the challenges mathematics specialists face are directly related to the extent others in their communities have adopted reform beliefs and associated practices. More locally, the historical events that resulted in Virginia identifying the need for mathematics specialists are outlined, followed by a description of the mathematics specialist program in Virginia.

Next, the construct of communities of practice is examined, including a discussion about gaining access to, and acceptance within, a community, and how identities develop in relation to communities of practice. Identities are then examined in more detail by exploring research focused on the development of professional identities, especially of the professional identities of people working in education. Finally, a conceptual framework based in the literature review is outlined.

Historical Background

While mathematics specialists are a relatively new phenomenon in schools, the recognition of the need for mathematics specialists has existed for several decades (for example, see Dossey, 1984; National Council for Teachers of Mathematics, 1984; Bruni, 1991).The early call for mathematics specialists coincided with, and was precipitated by, the mathematics reform movement. To clearly locate mathematics specialists as an essential part of the reform movement, it is helpful to place the reform movement in an historical context, and to view it as a logical outcome of changes in understanding of how learning occurs, and the concurrent changes in beliefs about instructional practices necessary for learning to occur.

Changing definitions of learning. Psychological learning theories are concerned with such issues as how learning occurs, what factors influence learning, and how transfer occurs (Ertmer & Newby, 1993/ 2013). Gaining prominence in the 1980s, constructivism is the theory of learning and development that anchors the reform movement (Fosnot & Perry, 2005); beliefs and practices associated with constructivism have led to a radically different view of mathematics education than what had been held previously (Ellis & Berry, 2005) when theories such as behaviorism and cognitivism held sway.

Behaviorism. In the mid-20th century behaviorism was the prevailing psychological stance regarding learning mathematics (Battista, 1994). Ertmer and Newby (1993/2013) note behaviorism focuses on stimulus and response interactions, with a goal of changing external behaviors, stating that "Learning equates with changes in either the form or frequency of observable performance…. Learning is accomplished when a proper response is demonstrated following the presentation of specific environmental stimulus" (p. 50.) The evidence that learning has occurred is important, but not the mental process or internal understandings that occur to bring

about the desired result, because the underlying assumption is that the stimulus led to the response, and the learner has little control over its own development (Wadsworth, 1996). Handal and Herrington (2003) note that a behaviorist teaching style in mathematics instruction stresses "rote learning and memorization of formulas, single solutions, and adherence to procedures and drill" (p. 277). Such an approach to mathematics instruction is understandable if we consider that, in the middle of the last century, school mathematics was often associated with the rote learning of computational skills. Learning those skills occurred in lessons that allowed for presentation, practice, and reward (Battista, 1994).

Cognitivism. By the 1960s and 1970s, cognitivism was gaining prominence as another learning theory applied to mathematics education (Schuh & Barab, 2008). Instead of viewing learning as changes in observable behaviors, cognitive scientists were interested in describing learning processes. Cognitive scientists describe how learners could respond to stimulus in the environment, and how learners make gradual changes to their own understanding.

Cognitive theories recognize that all learning cannot be accounted for by only considering external stimulus, thus cognitivism differs from behaviorism. Cognitive theories consider how learners receive, organize, store, and retrieve information, and how learners form mental structures that allow for the ordering and recall of information (Ertmer & Newby, 1993). While behaviorism is concerned with changes in response, cognitivism is concerned with how information is processed. However, both approaches exhibit an objectivist ontology in that they assume "the world is real and exists outside the individual" (Schuh & Barab, 2008, p. 72) and "instruction intends to map the structure of the world onto the learner" (Ertmer& Newby, p. 54.)

Constructivism. The works of Piaget and Vygotsky gave rise to constructivist theories of learning (Schuh & Barab, 2008). Constructivist theories are not all in agreement. However they all differ from behaviorism and cognitivism in that constructivists believe learning occurs as individuals experience the world and determine reality through personal interpretations of these experiences. Schuh and Barab discuss two branches of constructivism. *Cognitive constructivists,* whom Schuh and Barab claim are more closely aligned with Piaget, assume there is one reality that exists, and what we know of that reality is derived from individual experiences with that reality. As one gains experience, knowledge grows by incorporating new understandings, and modifying existing understandings. *Social constructivists,* whom Schuh and Barab associate with Vygotsky, also believe that reality exists and is understood through interpretations. But unlike cognitive constructivists, social constructivists theorize that knowledge is not created by individual interpretations, but through social interaction and negotiation.

Confrey and Kazak (2006) claim "constructivism developed in mathematics education to counter the effects of behaviorism" (p. 306). Simply stated, the emphasis amongst many mathematics educators has moved from a direct instruction, teacher-centered, behaviorist approach in which students learn through a process of presentation by the teacher and practice focused on the material presented, to a student-centered, constructivist approach, in which students explore mathematics in a way that allows them to interact with mathematical ideas with the goal of building personal understanding of the concepts. Discussing constructivist theory applied to mathematics teaching, Van de Walle (1999) told delegates to the 77th Annual Meeting of NCTM

> The basic tenet of constructivism is simply this: *Children construct their own knowledge.* Construction requires tools. The tools children use to construct knowledge are the ideas they already have. To use ideas to construct new ideas means that children must be mentally engaged in the act of learning. They must call up those ideas that are relevant and use them to give meaning to the new or emerging or changing ideas that they are developing (Children and Learning section, para, 3).

Social constructivism applied to mathematical learning emphasizes classroom learning as a process of both individual and social construction. Cobb, Yackel and Wood (1992) delineated many of the important features of a learning environment based on tenets of social constructivism. These features include the individual's developing understanding or construction of mathematical meaning, which builds upon the individual's previous knowledge. Because students experience the world as individuals, understandings will differ. Therefore, social interaction is necessary for a taken-as-shared understanding to emerge. In other words, individual meanings and understandings become aligned with those understandings of others in the classroom. Learning occurs as students attempt to reconcile problems that arise when new concepts are encountered, meanings are questioned, or old understandings are applied in new situations. Eventually, taken-as-shared understandings in the classroom are elaborated to align with taken-as-shared understandings of the broader mathematical community.

A paradigm shift. Critical to the establishment of such a learning environment is the ability of mathematics teachers to construct a reformed framework for practice that fits with their students' ways of learning mathematics (Wood, Cobb, & Yackel, 1995). Ellis and Berry (2005) suggest such a framework incorporates a

(re)consideration of the mathematical content, ideas from cognitive psychology that indicate students should take an active role in learning, and the belief that all students should have access to learning important, culturally relevant mathematics. The adoption of such a framework amounts to what Ellis and Berry refer to as a paradigm shift from a procedural based approach to teaching and learning mathematics, to a

> radically different view of mathematics education [in which] many of the core beliefs of the traditional paradigm are challenged. Emphasis is shifted from seeing mathematics as *apart from* human experience to mathematics as *a part* of human experience and interaction. This is not to imply that students must reinvent mathematics in order to learn it. Rather, for students to really understand mathematics they need opportunities to both a) share common experiences with and around mathematics that allow them to meaningfully communicate about and form connections between important mathematical concepts, and b) engage in critical thinking about the ways in which mathematical may be used to understand relevant aspects of their everyday lives. (p.12)

This paradigm shift requires mathematics teachers to ascertain what their students know, and design instructional activities that challenge and further this knowledge (Steffe & Wiegel, 1994). Cobb, Wood, and Yackel (1993) elaborate on teachers' responsibility in the mathematics classroom as playing the dual role of fostering the development of conceptual knowledge among students and facilitating the process of arriving at taken-as-shared knowledge in the classroom community.

In a traditional classroom where the approach to mathematics instruction takes a behaviorist, procedural stance, emphasis is on *what* the content or procedure is and *how* to carry out the procedure, and finally *how* to apply the procedure, but not *why*.

In a reform classroom built on social constructivist theory, the teacher becomes responsible for helping students understand *why*. This requires teachers to develop a different set of pedagogical skills, as well as an increased understanding of the mathematics, beyond procedures and rules. Battista (1994) notes that most teachers were taught in a system that "promoted the conception of mathematics as procedures rather than as sense-making" (p. 464), and this is the belief they carry into their own teaching. Thus, success in a reform based classroom requires that teachers alter their beliefs about what mathematics is, what it means to learn mathematics, and what is required to ensure all students are engaged with a challenging and relevant mathematics curriculum.

Furthermore, Battista (1994) notes these teachers work in schools where textbooks and testing programs support a rule-based view, and where this approach to mathematics instruction is understood best, and expected by parents, school administrators and politicians. Moreover, the school environments in which teachers now teach demand this rule-based view of mathematics. Their mathematics textbooks support it. State and district testing programs assess adherence to it. Most parents, school officials, and politicians - all of whom dictate curricula to teachers - also see mathematics as sets of rules to follow. To bring about changes in pedagogy and growth in mathematical knowledge, and to help teachers in adopting a new set of beliefs about mathematic instruction, professional development and support are necessary. Enter the mathematics specialist!

The early call for mathematics specialists: National climate. By the 1980s mathematics educators were beginning to give voice to the need for improved professional development to help teachers meet the demands of a constructivist- based classroom, and to improve mathematics instruction in general. In 1981 NCTM called

for state teacher certification boards to provide for endorsements of elementary mathematics specialists (Dossey, 1984). While this suggestion was not met with a much enthusiasm, NCTM persevered in this direction and a few years later released a *Position Statement on Mathematics Leaders in Elementary/Middle Schools* (NCTM, 1984). In this paper, NCTM described school leaders who would raise the level of mathematical knowledge and pedagogical skills of staff, would coordinate instruction within schools and across schools in a district, and would support all parties in developing practice that improved mathematical practice. In particular, school mathematics leaders would assist with tasks involving curriculum design, curricular content, methodology and materials, assessment, and various support functions.

At the same time, Dossey (1984) argued that the mathematics community needed to be vociferous in their claim that mathematics specialists were not only important, but necessary if curriculum reform were to take place. Dossey envisioned such specialists working in classrooms with teachers, assisting in diagnosing and remediating lower ability students, providing programs for talented mathematics students, and serving as coordinators of mathematical needs for a school or district. While it is not clear if either NCTM or Dossey intended for specialists to be released from full time teaching or to serve as a resource while still maintaining the role of a classroom teacher, both sources reflect early thinking about the role a specialist could take and the benefits a specialist would bring to a school and school district engaged in the process of adopting a constructivist approach with the aim of altering mathematics curriculum and instruction.

By 1991, following the publication of *Curriculum and Evaluation Standards for School Mathematics* (NCTM 1989) and the *Professional Standards for Teaching Mathematics* (NCTM,1991), Bruni (1991) noted “never before has the need been

greater for ‘designated math leaders’ in every elementary school” (p. 7). Reflecting on the vision of constructivist-based classrooms and instruction created by these documents, Bruni averred that the need for leadership at all levels was clear, and that of special importance was the identification and professional development of mathematics leaders in elementary schools. Bruni referred to these school-based mathematics leaders as change agents, but recognized that change would only occur if there was significant professional support to help elementary *teachers* become elementary *mathematics leaders*. In retrospect, Bruni’s suggestions for the possible support for teachers seem minor, and are focused on participation in and with activities and materials developed by NCTM. However, his commentary is a clear statement that reflects the growing attitude in the mathematics education community in the United States at the time that support for mathematical change should be available within schools.

The history of mathematics specialists in Virginia. Virginia also recognized the need for mathematics specialists. In 1992, the Virginia Council of Teachers of Mathematics (VCTM) published a position statement that supported the placement of mathematics lead teachers in each elementary school (VCTM, 1992). VCTM would soon join with other organizations in Virginia in a National Science Foundation funded project called V-Quest. The aim of V-Quest was to provide support for elementary and middle school teachers that prepared them for the role of Math or Science leader in their school.

While V-Quest achieved measurable success, and evidence emerged that Lead Teachers were having a positive impact on schools (Critchfield and Pitt, 1997), it became apparent that a state wide, coordinated program for preparing mathematics specialists was necessary for schools to maintain progress. In particular, there was a

growing recognition that state licensure was needed to provide stability and structure to a blossoming effort. Furthermore, it was becoming apparent that mathematics lead teachers who remained responsible for their own classroom were inadequate support to address a school's mathematical needs.

In 2002, a task force was formed by VMSC to prepare a case and write a report in support of a cohesive program for preparing mathematic specialists (VMSC Task Force, 2005). This report included a job description, competencies, necessities of preparation, and recommended licensure. The contents of this report served as a basis of what was to become a concentrated effort among state-wide universities and school districts to prepare and place mathematics specialists in elementary and middle schools, and of what has become a nation leading model for mathematics specialists. As evidence of this, a joint position paper of the Association of Mathematics Teacher Educators (AMTE), the Association of State Supervisors of Mathematics (ASSM), the National Council of Supervisors of Mathematics (NCSM), and NCTM describes elementary mathematics specialists with language reminiscent of that employed by VMSC five years previously. Furthermore, the professional needs described in the joint paper coincided with those recommended in the VMSC Task Force report, including deep mathematical content knowledge as well as an understanding of elementary context and pedagogy, skills in helping others develop instructional and assessment expertise, and strong leadership skills and capacity (VMSC Task force, 2005; AMTE, ASSM, NCSM, NCTM, 2010). These recommendations formed the basis of the licensure endorsement that went into effect in Virginia in 2007.

The Virginia Mathematics Specialist Program

With the support of grants received from the Virginia Department of Education Mathematics and Science Partnership (MSP) Program as well as the

National Science Foundation (NSF), mathematics specialist master's degree programs were instituted at three universities in Virginia (Pitt, 2005). Funding supported development of a core set of five subject knowledge courses that would be common to all three universities. Over the grant's 5 year term funding also supported research on the impact of mathematics specialists on student learning, as well as much of the cost of courses for mathematics specialists. The general program that was developed is the result of collaboration between university mathematicians and mathematics educators, district mathematics leaders, elementary mathematics teachers, state professional organizations, and the State Department of Education. While the universities have some minor differences in the requirements for earning a degree, core courses remain consistent (Murray and Pitt, 2013) and the degree programs are completed with similar courses focused on leadership, student diversity and inclusive practices, research, and a final practitioner based research project. Licensure as a mathematics specialist can be obtained without completing the master's program by meeting requirements through other means. However the program has proven the most direct route to licensure for interested teachers.

Description of courses. As just presented, mathematics specialists in the MSP programs undertake five courses focused on content. At the University of Virginia, where participants in this study were enrolled, the program is completed with three courses that develop leadership skills courses, electives that include coursework on diversity and inclusion, and research. The research project explores an aspect of pedagogy or leadership (or both) of interest to the student. The content of the courses prepares specialists to support teachers in developing the knowledge and pedagogical skills necessary for teaching the Virginia Standards of Learning (SOL). Brief descriptions of the courses follow, as discussed in Murray and Pitt (2013).

Mathematics content courses. There are five content courses. Three of these courses, titled, *Number and Operations*; *Rational Numbers and Proportional Reasoning*; and *Patterns, Functions and Algebra,* develop content and skills in the areas of number and algebra. Through these three courses, specialists develop a deep understanding of whole numbers, integers and rational numbers. The end goal of these courses is for specialists to develop a coherent vision of the number system and a conceptual understanding of operations that can be applied fluently from whole numbers to rational numbers and integers, and then to operations with unknown quantities. Content includes: counting; the construction of number systems, including base 10 and extensive work towards developing an understanding of place value; and representing and generalizing about the relationships between quantities and operations. The latter includes notions such as the relationship between division and fractions; conceptual understandings of properties of operations; and functions, with a particular emphasis on multiple representations.

Geometry and Measurement addresses the content a specialist will encounter in teaching grades kkindergarten-8. This content includes exploration of two and three dimensional shapes, including definitions and properties of shapes and the connections between three dimensional shapes and two–dimensional representations; similarity and congruence; measurement in one, two and three dimensions (i.e. linear measurement, area and volume), and includes angular measurement. Much of the work is explored with the Van Hiele model (Crowley, 1987) of how children make advances in geometric understanding.

Like *Geometry and Measurement*, through *Probability and Statistics* specialists deepen their understanding of the content taught in these strands in grades K-8. Statistical understanding is built through the collection, representation,

description and interpretation of data. Elementary probability concepts are learned through analysis of experiments and events. Content includes measure of central tendency; types of graphs and choosing appropriate representation; identifying the chance of an event and how to represent that chance; independent and dependent events; and theoretical and experimental probability.

In each of these courses, alongside developing an understanding of the content, specialists explore how children construct mathematical ideas. In this regard there is an emphasis on the mathematical process standards of problem solving, representations, reasoning and proof, communication, and making connections (NCTM, 2000). Through extensive use of written and video case studies, specialists learn to analyze student thinking, and consider how to create activities and organize discussions that move all students forward in their mathematical understanding. The specialists' own mathematical knowledge is often enhanced when they explore a student misconception and consider what might be the root of such thinking. For example, one case (Schefter, Bastable & Russell, 2010) that often intrigues specialists involves a child working on a problem like the following: *Mary saw 32 birds in the tree. 18 flew away. How many birds remained in the tree?* In the case study, the child takes 20 away from 32, but is unsure how to think about the additional 2 that was added to the 18 to make subtraction easier. From previous work using a compensation strategy with addition, the child's original instinct is to subtract 2 more. (To add 35 + 19, I add 35 + 20; because I have added one too many, I need to take one away from the sum of 55. Therefore, my answer is 54.) The teacher in the case study prompts the child to think about how many birds actually flew away, and the child adjusts her answer correctly. Through this case, the specialist is forced to consider mathematical ideas (how to interpret subtraction, how addition and subtraction differ, how

representation can develop a more conceptual understanding of the process of compensation), as well as how to help students think about these ideas.

Leadership courses. Mathematics specialists complete three leadership courses. Through these courses specialists continue to deepen their understanding of elementary mathematics. They also begin to understand the role of the mathematics specialist and what it will mean to work as a leader with other teachers, principals, system administrators, and stakeholders such as parents. The first of these courses examines what it means to be an effective mathematics teacher, predicated on the assumption that, to be an effective mathematics leader, one must be skilled at designing, delivering and evaluating mathematics instruction. In this initial leadership course, specialists also delve into what it means for teachers to be learners, first reflecting on their own practice, and then on their work in a coaching capacity with individual teachers.

The second leadership course shifts the focus from developing practices needed for individual growth to a focus on developing skills, knowledge and characteristics helpful to assume a mathematics education leadership role in elementary and middle schools. Specialists polish their abilities to work effectively with adult learners, building their knowledge of teachers as learners by expanding their coaching skills, and by planning and facilitating professional development activities for small groups and entire schools. In the final course in this series, specialists continue to develop their leadership skills as they work with a growing body of constituents. Specialists create assessment tasks that identify student understandings and misconceptions, and help teachers use these assessments to inform instruction. Specialists make instructional observations and coach teachers. They identify mathematics teaching problems and find resources to address raised

issues. They also advocate for changes and support of improved mathematics education practices with teachers, schools, school administrators, parents and interested parties. Specialists consider how they will negotiate their new roles with principals and reluctant teachers. Thus, as a result of these leadership courses, specialists begin to contemplate their new professional identity and what it means to be a mathematics specialist.

Inclusive practice, research, and practicums. Electives and a practicum round out the specialists program. *Mathematics for Diverse Populations* asks specialists to consider best practices for all students, examining needs that arise from issues of equity, including gender, ethnicity, cultural differences and socioeconomic status. Specialists build their awareness of public laws that require equitable treatment for all students. To assure equity, specialists learn to support all students with a variety of teaching strategies, assessment tools, and instructional materials. Through a supervised research course, specialists gain skills necessary to identify, locate and apply current research to instructional planning, assessment, professional development and curriculum or policy questions. Specialists are prepared to carry out an action research project. This action research project is the focus of the practicum, the capstone experience for the program. Through this project, specialists demonstrate mathematical, pedagogical, and leadership skills they have learned throughout the program and that will be necessary as they adopt the role of school mathematics leader.

Final words about the mathematics specialist program. The program at the University of Virginia reflects the best thinking of mathematics educators, mathematicians, teachers, and other interested parties. Its design suggests careful consideration of the mathematical and pedagogical knowledge necessary for teaching

in an elementary or middle school, as well as for teaching adults how to improve their instructional practice. Equally important, the program prepares specialists to work as part of social learning environments, consistently emphasizing the role of social interaction and the development of shared meanings. Specialists learn to respect students as constructors of mathematical knowledge, but they also learn to respect teachers as constructors of knowledge: knowledge of mathematics and knowledge of mathematics instruction.

While their success as a specialist depends on their deep knowledge of mathematics, it rests equally on their knowledge of how people learn, and how they, as specialists, can position themselves to facilitate such learning. Upon finishing the program, specialists are armed with essential knowledge and skills necessary to enact their new roles. To be successful, specialists must be accepted by teachers and gain access to what has traditionally been very personal, protected territory. Once accepted, they need to understand how to bring about change in individuals and groups. Specialists use the knowledge they have gained in their program, but their learning and development continues as they begin to work as a mathematics specialist, and determine how they will enact this role.

Professional identity is defined in this paper as how one sees one's self in the performance of one's professional role, and considers how this vision of one's self is constantly interpreted and reinterpreted. To understand how mathematics specialists develop their professional identity, we need to understand how specialists face and adapt to challenges to their attributes, beliefs, values, motives, and experiences. These challenges may be internal or external. Internally, the mathematics specialist needs to confirm personal beliefs that have (or have not) changed or developed significantly as a result of mathematics specialist's preparation. Externally, the mathematics

specialists face challenges from colleagues, administrators, school divisions, and communities. It is helpful to ground challenges in specific contexts and theoretical bases to understand them more clearly. Thus the literature review now moves from the discussion of the preparation undertaken by the mathematics specialists to topics that inform the establishment of professional identity within a community of practice.

Developing Professional Identity

In this study the term "communities of practice' takes on two related meanings. The first meaning is that communities of practice are groups that participate in a sustained effort to facilitate learning and knowledge sharing, and that act as the backdrop for the development of professional identity; the second meaning is that of a theoretical framework with which one can examine the situated learning and identity development that takes place in these groups (Cox, 2005). Later, while discussing the cases of the participants, the study will focus on the second meaning, using the lens of communities of practice to understand the developing identities of the mathematics specialists as a result of participating in such a learning community. At this point, the literature review focuses on the theory that helps us understand communities of practice, participation, and professional development identity development.

Sociocultural learning theory. Earlier in this literature review, learning (as seen through a constructivist's lens) was said to occur as students attempt to reconcile problems that arise when new concepts are encountered, meanings are questioned, or old understandings are applied in new situations. Meaning is developed not in isolation, but as a result of social interaction. Sociocultural learning theory identifies the social environment and social practices as the main structure through which learning takes place (Takahashi, 2011) rather than through an individual's cognitive

processes. Constructivism is one theory of learning that falls under the broader theoretical framework of sociocultural theories. Situated learning (Lave & Wenger, 1991) is another example of a framework that draws on sociocultural understandings. The gist of Lave and Wenger, and later, Wenger (1998, 2000) is that learning is not simply the acquisition of knowledge. Rather, they adopt the view of learning as a situated activity within a social learning system, with learning occurring through a process termed legitimate peripheral participation. Simply put, legitimate peripheral participation refers to the period when a newcomer enters a community and is "learning the ropes" but not yet knowledgeable enough to participate in all aspects of the community. Situated learning allows for the view of learning as emergent; learning comes through participating in, as well as affecting, the practices of a community, and concomitantly developing an identity in relation to the community (Handley, Sturdy, Fincham, & Clark, 2005).

While one may learn to complete tasks, perform procedures or develop new insights into content in isolation if learning is explained through a behaviorist or cognitive psychological framework (Takahashi, 2011), within a sociocultural framework these understandings, tasks, procedures and insights are rendered meaningless outside the social community in which meaning is negotiated (Lave & Wenger, 1991). Thus, situated learning involves becoming an active, fully participating member of a community, defining and being defined by the community. Changing forms of participation bring about the construction of identity, where identity is "the long–term living relations between persons and their place and participation in communities of practice" (Lave &Wenger, 1991, p. 53). Extrapolating from this definition, professional identity is the long-term living relations between person and their place and participation in their profession. To understand how

mathematics specialists learn how to participate in practice and develop professional identities, we will look more closely at the interplay between communities of practice, participation, and identity that arise from situated learning theory.

Communities of practice. "Communities of practice are formed by people who engage in a process of collective learning in a shared domain of human behavior" (Wenger- Trayner & Wenger- Trayner, 2015, para.3). They are the result of people working together and developing collective ways of doing things (practices) (Wenger, 1998). According to Wenger (1998) and Wenger-Trayner and Wenger-Trayner (2015), in communities of practice, people share a common concern, and through social interaction, learn how to move the concern forward. Communities of practice require three elements that develop in parallel. First, a community of practice must have a *domain* that is identified by a shared interest; members of the community have some commitment to the domain, demonstrated by levels of competence that people outside the domain do not exhibit. Second, communities of practice have a *community* in which members participate, interact, share ideas and information, and support one another. Relationships are built within these communities. Third, communities of practice must also have a shared *practice*: members are practitioners, with similar experiences, stories, tools, that combine to form a repertoire of resources. Thus communities of practice are locations where people, through shared interactions focused on the same concern, draw on mutual resources to develop competence and improve knowledge and understanding within and without the practice.

Legitimate peripheral participation. Legitimate peripheral participation originally referred to how a newcomer gradually becomes a full participant in a sociocultural community of practice (Lave & Wenger, 1991). Lave and Wenger use this term in discussing the learning trajectory of apprentices, or newcomers, in a

workplace to "suggest an opening, a way of gaining access to sources for understanding through growing involvement" (p. 37). Legitimate peripheral participation defines the period of building an understanding of the expectations and standards of the community. Legitimate peripheral participation allows a newcomer to learn the repertoires of the community, and to develop relationships that allow for mutual engagement and joint enterprise. Full participation within the community of practice, the result of learning through legitimate peripheral participation, occurs as a result of informal and situated social interaction, with the newcomer developing relations with practicing members in the community, coming to understand the complexities of the community, and adopting and adapting the practices of the community. Through participation, practice and identity develop. Therefore, participation is a central feature of situated learning and communities of practice.

Wenger (1998) backs away from the idea that legitimate peripheral participation always leads to full participation. In particular, he discusses marginality as a form of non-participation. Marginality can either be positive or negative. For instance, a young teacher entering the profession may be marginalized in a school because she does not yet have the experience necessary to complete a certain task. In this case marginalization can lead to learning, as it highlights an aspect of the job the teacher needs to understand. On the other hand, an older teacher might be marginalized because she is not willing to adopt changes to a long held practice. Others in the school may then exclude her from further discussions or meetings about the changes.

Wenger (1998, 2000) claims there are three ways to belong to or participate in a community of practice. *Engagemen*t implies doing things together, and in a community of practice often involves negotiations of meaning, guided by individual

interpretation of the work being done, and a shared accountability. Engagement also results in a "shared repertoire" (Wenger, 1998, p.73), including an understanding of the history and artifacts of the community of practice, and the development of common tools, and processes. This repertoire is the result of the history of mutual engagement. Use of this shared repertoire is important for members of the community to be able to participate in the community of practice, and to develop an identity as a member of the community. When we belong to a community of practice through *imagination,* we develop our identities through envisioning our place within the system, and the connection between a local system and a global system. Finally, we belong to a community of practice through *alignment* by coordinating our perspectives with others and by working with others to align their perspectives with ours. Through alignment we can exist and contribute to broader systems. Through alignment participants in a learning system make connections within and between various learning systems.

Full participation is granted when one displays certain levels of competence, and therefore *knowing* can be considered having the ability to display competence within a social community (Wenger, 2000). Competence is defined within a system by the standards of that system. However, competence is always intertwined with our life experiences, and when the two are not aligned, learning occurs. Importantly, striving for competence guides the experiences one seeks but likewise experiences can challenge accepted levels of competence.

To illustrate, consider the hypothetical experiences of a teacher who becomes a mathematics specialist. When this teacher began his career, he was inexperienced and had to work to align his practice with that of the school and the system. He was mentored, he observed, he developed relationships with others in the school, and he

honed his practice. This period of building an understanding of the expectations and standards of the community is an example of legitimate peripheral participation. At first he may not have participated fully in the workings of the school, because he had not yet demonstrated the competence to do so. But over time, his experiences aligned with competences recognized by the school---he had learned the procedures and policies, both formal and informal, he had demonstrated sound practice, he had developed relationships with colleagues in the school ---and the teacher gradually became a full participant in the school community. In this scenario, through experiencing and understanding all the aspects of the life of the school, the teacher developed competence in that community.

A few years later, this teacher prepares as a mathematics specialist, and his understanding of how children learn math and how math should be taught is changed. He returns to his school, but this time as a novice mathematics specialist, and again in a position where he may not be able to fully participate in the community of practice because he has not developed a complete understanding of the role of mathematics specialist. He must again build competence, and learn how to be a mathematics specialist in that particular social setting. He now recognizes that the community expectations for mathematical learning and teaching, which he once thought were quite good, are not aligned with his own changed beliefs and understandings. In this scenario, his experiences cause him to challenge the community's definition of competent mathematics instruction. He then shares his new understandings with colleagues, with the intent to change how the school views competence in teaching mathematics. He may be allowed to make progress; on the other hand, his ideas may be seen as threats to the established practices of community. His success and identity

will depend upon how well he is able to establish himself in the community in his new role. The realignment of experience and competence is where learning occurs.

Challenges to the idea of legitimate peripheral participation. Several researchers have identified difficulties with some aspects of the concept of legitimate peripheral participation. Hodkinson and Hodkinson (2004) point out that while legitimate peripheral participation has many salient features when considering young workers entering a work place where there will be mentors to guide them, they believe that it is less appropriate for describing the learning of experienced workers either in their normal place of work or in a new job. Contu and Wilmott (2003) argue that many interpretations of Lave and Wenger (1991) understate issues of power that are raised in their writing, suggesting that care should be taken to explore how newcomers may be denied access to full participation by more powerful members of the community. For example, in his study of automobile designers, Carlile (2004) points out that full participants in a community are likely to exert power over newcomers if the newcomers pose a threat to current practice, such as in the scenario in the preceding paragraph.

Identity. For Wenger (1998) identity develops in parallel to the community of practice. Wenger holds that, in the community of practice framework, identity is characterized in six ways. Identity is lived, reflecting experiences. Identity is negotiated through time and throughout contexts. Identity is social, developing as we become more (or less) comfortable in various contexts. Identity is a learning process, with a trajectory that spans from the past to the future. Identity is the basis for connections. Finally, identity is both local and global, and reflects participation in both realms. In the case of mathematics specialists, the realms are the local community of the school and the wider global community that encompasses the

district and greater mathematics community. Through the lens of practice, identity is discussed as how one sees one's self as a member of that practice, through reflecting on the experiences that led to membership in the practice, and examining growth within the practice and across boundaries of related practices. Finally, identity is a definition of who we are, and requires the reconciliation of our personal selves and professional roles we assume within communities of practice.

Professional identity has been studied in many areas of the social sciences, and while it is often said to be ill- defined (Beauchamp & Thomas, 2009; Beijaard, Meijer, & Verloop), there are some definitions that are helpful for this study. Beijaard et al. (2004) write that professional identity is a continuous process of reinterpreting experiences, and can be conceived as a learning trajectory. In a review of higher education literature on professional identity development Trede, Macklin and Bridges (2012) cite various sources (Ewan, 1988; Higgs, 1993; Paterson et al., 2002) that together can be used to define professional identity as the sense of being a professional, being able to use professional judgement to solve problems, self-evaluate, and perform in a manner that is competent and consistent with what is expected by and within the community of practice. However, professional identity does not simply seem to be about performance; Southworth (1995) asks us to consider how the situational self (that self that is developed from interactions with others) and the substantial self (one's core beliefs developed through life's experiences) may conflict with one another, and how a professional identity is most secure when these two selves are most closely aligned. Flores and Day (2006) explain identity as "an ongoing process which entails making sense and (re)interpretation of one's own values and experiences" (p. 220), echoing Southworth. For new teachers professional identity is derived from experiences in and out of schools, and from beliefs about

what it means to be a teacher and about how they want to enact that role (Sachs 2001). Maclure (1993) asserts professional identity is not stable, but is developed as individuals make sense of themselves, to themselves and to others, in the contexts and communities where they work. All of these definitions align with and inform the definition of professional identity used in this study:

> How one sees one's self in the performance of one's professional role based on attributes, beliefs, values, motives, successes and failures, professional trajectories, and experiences. Identities are in flux, so this definition implies a constant interpretation and reinterpretation of one's identity.

Professional Identity in Education Research

There is not a considerable amount of research focused on the development of mathematics specialists' professional identities. However, there is a corpus of research that explores developing professional identities at different times in teaching careers. These moments include: as a student preparing to become a teacher; as an experienced teacher; as a teacher transitioning to teacher education; and as a teacher transitioning to become a mathematics specialists. A selection of studies that highlight challenges to the development of professional identity at different times in a career are described below. This body of evidence provides insights into challenges for the development of professional identity that is applicable to mathematics specialists.

Professional identity of student teachers. De Piper (2014) explored the tensions that exist when teacher education students are exposed to research-based and reform-based mathematics education practices in their courses, and then enter schools where high-stakes accountability measures and pressures encourage instructional practice focused on passing standardized tests and skill-based teaching. De Piper views teacher professional identities as "shaped by political, social, and institutional

forces that structure the mathematics teaching they have experienced and continue to experience" (p. 134). De Piper notes the relation between mathematics teacher identity and teacher practices as well as how accountability measures influence teacher identity elements. These elements include beliefs about mathematics, personal mathematics experiences, understanding of students, interpretations of curriculum and reform, and best practices. The gist of this study is that student teachers may arrive in schools, identifying with and intending to use reform practices, but the culture of the school discourages implementation of such practices.

De Piper (2014) asserts that student teachers experience tensions connected to their personal agency. If their goal is to teach with reform based approaches, their ability to do so is dependent upon their beliefs about mathematics, but also on how they see themselves situated within their context, and how much power they have to teach according to the beliefs and practices they have come to understand outside of school. Student teachers first need to recognize that the school environment affects teaching practice. Then, they need to explore ways to incorporate reform practices into schools where such practices are not the norm. Finally, they need to prepare themselves and develop the confidence that they can provide high quality, reform-based mathematics instruction to all children, and still meet the demands of a high-stakes environment. De Piper concludes "mathematics teacher education can have a role in supporting [student teachers] in understanding their positioning and navigating the socio-political discourses that interfere with their teaching, their relationships with students, and their engagement in ambitious practices" (p. 150). Student teachers will benefit from work that helps them understand reform practices in context; one benefit may be that they will find it easier to reconcile their beliefs and identity with the practices of a school.

Professional identity of experienced teachers. Gresalfi and Cobb (2011) examined how teachers negotiate identities in two or more communities that hold differing definitions of high-quality teaching. In this study they explored what happens when the description of high quality teaching espoused in reform-minded CPD is not aligned with the expectations of the schools where CPD participants teach. Their data showed that teachers established one identity for their work in a school, and another identity while participating in professional development. For teachers to adopt a single professional identity that aligns with the identity developed through the CPD, teachers need to believe it is worthwhile to change. Gresalfi and Cobb conceive of the idea of teacher motivation as "supporting their development of a particular type of identity as mathematics teacher" (p.271). Gresalfi and Cobb recognize that improving practice requires changing beliefs about what it means to teach mathematics, and specifically changing teachers' motivations for teaching. This research is built on the theory that to achieve high quality instruction promoted by reform agendas, teachers must develop a deep understanding of the mathematics they teach, and they must develop new instructional practices that support students as they engage with big mathematical ideas. The research also rests on the assumption that schools and school districts must understand the implications of change, especially what it means for administrators to support teachers in this change process.

Data for this research was gathered from audio recordings of 15 CPD sessions conducted in the first two years of a five year project in which nine teachers participated. Analysis of the data allowed the researchers to describe the collective school based-identity to which teachers were compared to establish whether they were high quality mathematics teachers, the collective identity developed in the group of

teachers involved in the CPD project, and individual identities that emerged as a result of participating in the CPD project.

In their study, Gresalfi and Cobb (2011) found that as a result of all working in the same school district, the teachers worked in schools where expectations of highly effective teaching were similar. One such expectation was that teachers across the district would be on the same lesson objective, teaching the same lesson on the same day. Another was that lesson objectives, correlated to state standards, were always written on the board for administrators to see if they came in the room. The identity of being a good teacher that was derived from working in the school system included meeting state standards, planning in isolation, and using generic teaching practices. However, amongst the teachers in the CPD project the identity of a highly effective teacher included: identifying lesson goals; seeing all students as capable of learning meaningful, relevant mathematics; and teaching in collaboration with others. Thus, the identity of the institution did not match the collective identity of the CPD group. As personal, individual identities began to align more with the collective identity of the teachers in the CPD project, the teachers began to recognize the need to change their instructional practice, and began to challenge the identity of a highly effective teacher established by their schools and districts.

Wilson, Edgington, Sztajn, and De-Cuir-Gunby (2014) identified attributes teachers assign to children's mathematical thinking in the process of examining student work in CPD sessions. These sessions took place over a year, involving 25 teachers from one K-5 elementary school. The intent of the CPD was to help teachers understand the role of a learning trajectory in understanding student mathematics, as well as how to use the learning trajectory to inform instructional practices. The initial conjecture for this research was that as teachers learned more about learning

trajectories, the attributes used to describe student mathematical work would change, and become more focused on mathematical thinking. Data sources included field notes, videos from CPD meetings, and transcripts of audio files of small group discussions.

Overall eight attributes were identified that teachers used when explaining student's mathematical success and failures. Each attribute was classified as: internal or external to the student, meaning the student has control over the attribute or not; fixed or variable with respect to the student; and controllable or uncontrollable by the student or the teacher. The attributes include ability (internal, fixed, uncontrollable), effort (external, variable, controllable), luck (external, variable, uncontrollable), difficulty of task (external, variable, controllable), age or grade level (internal, fixed, uncontrollable) out of school context (external, variable, uncontrollable), teaching (external, variable, controllable) and previous mathematical knowledge (internal, variable, uncontrollable). As teachers learned more about the mathematical learning trajectory there was an increase in the use of research based knowledge to discuss students' mathematical work, but they did not discard previously held attributes.

Wilson et al.'s (2014) study does not discuss teacher identity specifically, however it does provide insight into how teachers view mathematics and mathematics instruction, and how they might view their identity as a mathematics teacher. For example, teachers who attribute mathematical success to innate ability may adopt practices that do not challenge all students because they believe some students will not be able to do the work. Low achieving children might be provided tasks which require little cognitive challenge and provide little in the way of opportunities to develop mathematically. Meanwhile students with a perceived higher ability are asked to complete work that is demanding and allows for the development of new

understanding. Teachers who believe children can only do the mathematics they have been previously taught seem unlikely to employ instructional tasks that ask children to construct mathematical meaning for themselves. Teachers who recognize the connections between mathematical topics will be more likely to design tasks that build upon a students' mathematical knowledge. The attribute a teacher assigns to student success might reflect the teacher's sense about her successes and failures in mathematics, and thus may serve as a reflection of her professional identity. While teachers may focus on more mathematically oriented attributes as a result of CPD, non-mathematical beliefs about what enables students to be successful linger and continue to inform identity.

Professional identity of teachers moving into teacher education. Bullough (2005) describes the challenges faced by a teacher, Barbara, as she straddled the boundary between school teacher and university mentor and struggled to develop an identity as a school based teacher educator. Barbara saw herself as a competent and dedicated teacher, who felt responsible to mentor teacher interns, despite a lack of previously agreed support from her administration. Neither the university nor her school administration had adequately defined the mentor role, and thus there was some confusion between mentors and interns as to expectations. Barbara's model for what made a good mentor was her recollection of how she had been mentored herself. Barbara also identified herself as a "mom", and thus was very nurturing and protective of her interns. Barbara valued her role as supporter, and as interns became more involved in their work and raised more demands, she remained constantly available to help. She had a reputation as one of the strongest teachers in the school, but struggled with feelings of inadequacy. She worried that other teachers thought being a mentor was easy, and that the release time she had for mentoring was seen as

"time off from teaching". Because she believed fervently that interns deserved strong mentoring, she worried that the program might not be seen as effective if interns did not achieve. She began to see her competence as tied to the success of her interns.

Barbara worked to build affinities with different groups. Though she saw herself as a teacher, she felt that teachers did not understand, and in fact resented, her role as a mentor. She was at times torn between making decisions from the perspective of a teacher and making decisions from the perspective of a mentor. She briefly enjoyed the sense that she was working in a partnership with the university supervisor. But as there was no effort on the part of the university to bring the mentors and supervisors together, Barbara came to the conclusion that while her role was to teach and support, the supervisor's role was to evaluate. Barbara did build a relationship with another mentor in the school, and the two were able to discuss issues and challenges together.

Barbara's identity as a mentor was influenced by her identity as a competent teacher, and as a nurturer. Thus her mentor practice mirrored her teacher practice. While this was satisfactory for the interns, it is not a good outcome if the goal is for mentors to serve as a school-university link. The suggestion from this research is that for mentors to develop an identity as a school based teacher educator, structural supports need to be in place that include opportunities for university supervisors and mentors to work together to improve beginning teacher development. An important part of mentor training is in helping them build identities that allow them to envision the work of mentoring as distinct from teaching.

Murray and Male (2005) investigated challenges faced by 28 new teacher educators in their first three years of teaching in higher education. Data for this study was collected from in-depth semi-structured interviews and questionnaires. Data was

subject to content analysis, resulting in a number of emerging themes. Biographical data revealed all of the participants had at least 10 years teaching experience in elementary or secondary school. One candidate had an earned doctorate, and 6 had Bachelor's degrees plus relevant teaching qualifications. The rest of the participants had a Master's degree, which was the baseline qualification for entry into working in Initial Teacher Education (ITE). All participants had experience as mentors of student teachers, while only one had experience in education research beyond the Master's level.

Murray and Male recognize two areas where these challenges to professional identity occurred. First, the teacher educators needed to develop a pedagogy for their Higher Education work, and second, they needed to become research active. Both of these challenges ask new teacher educators to make significant changes to their professional identity, and to see themselves as higher education faculty and not school teachers, a process that took two to three years to accomplish. Participants revealed the first three years of working in higher education to be stressful, leaving them feeling stressed and anxious. Murray and Male report language used by the new teacher educators such as anxious, vulnerable, and inadequate. Though they all had experience teaching, this did not transfer to the work they did in Higher Education: they had to readjust their idea of teaching from that of teaching children to teaching others how to teach children.

Many of these new teacher educators continued to try to cling to their identity as a "good schoolteacher" (Murray and Male, 2005, p.130). Anecdotes from their own teaching career were used in the university sessions, often to substantiate credibility. The new teacher educators felt they needed to update their knowledge base, their pedagogical skills, their understanding of how higher education is organized and

functions, and to develop research skills. Another challenge was learning to work with mentors and students in schools. Yet another challenge emerged for participants in the study who had been in senior posts in their schools, and now found themselves with relatively little influence in their department.

Murray and Male attribute many of the challenges faced by new teacher educators to their continued identification as a teacher and not as a university instructor. Three reasons are posited for this. First, the new teachers did not have a lot of experience or time before entering higher education to prepare for the position, and this lack of comfort with higher education added to the sense of pressure. Second, though the participants in this study had been expert teachers, they were novice teachers of teachers, and thus had to acquire a new set of pedagogical skills and broader and deeper content knowledge. Third, even though most had little experience with research, as a member of a higher education faculty they were expected to take on a research role: thus, they were novices in this area, expected to be experts.

As the participants gained experience in higher education, they gradually began to shift in their identity to that to a university instructor. Murray and Male point to improved induction practices as a way to support this shift occurring more quickly.

Professional identity of teachers transitioning to mathematics specialists. Allen (2010) reported on data gathered from a cohort of over 100 primary mathematics teachers in England who were in the beginning stages of a program preparing them to work as mathematics specialists. The purpose of this study was to examine the beliefs held by participants in the program about mathematics, and to identify whether these teachers already held constructivist beliefs. Findings from this study suggest that these teachers held beliefs that need to be challenged if these teachers are to successfully adopt reform based practices. For example, reflecting on

their own education teachers felt they were successful in mathematics because they were clever, a statement that may reflect a belief that only "clever children" succeed in mathematics. Teachers also thought they were successful in mathematics if they followed an example, indicating a belief that mathematics teaching involves telling students how to solve problems. While this group of teachers attributed some measure of their own students' success to hard work, many teachers stated students did well if they had a natural ability, were given clear well- explained tasks, and if the teaching was high quality. Some teachers linked feelings of success in mathematics to understanding, but many more attributed a sense of success to getting the right answer. Few teachers recognized mathematics as existing outside of school mathematics. The major conclusion of this was report was that facilitators of the mathematics specialist program would need to help teachers change beliefs about teaching and learning of math in order to see improvement in pupil attainment.

Chval et al. (2010) investigated the changes in identity that occurred as 14 elementary and middle school mathematics teachers transitioned to mathematics coaches. Chval et al. argue that becoming a successful mathematics coach requires the establishment of a new professional identity. Data was collected through surveys and semi structured interviews completed at the beginning of the year, and through notes collected at monthly meetings and focus groups. Interview questions focused on the mathematics specialists' perceptions of their training, expected responsibilities and roles, challenges, relationships and interactions with school staff, experiences from their first months of coaching, and support they wanted. Data was coded and the researchers identified four major roles that contributed to the mathematics coaches' identities. These roles included coach as supporter of teachers, coach as supporter of students, coach as supporter of school at large, and coach as learner. All 14 coaches

experienced some aspect of each of these roles, but there was significant variation in how much time each coach spent in the various roles. Each role offered opportunities to develop a strong identity, but also presented challenges to the developing identity. For instance, the beginning coaches had high expectations of working with teachers in their classrooms, and supporting teachers in their pursuit of better mathematics instructional practices. However, expectations were often dashed by teachers who had very different notions of the math coach's role. For instance, coaches were sometimes viewed as experts and the people with the answers, while coaches wanted to be viewed as collegial, as a problem solving partner. Coaches expected to work with teachers, and teachers expected coaches to work with small groups of children. Similar misunderstandings about the role of the coach occurred across the four roles.

While each coach began their first year as a coach believing they understood their job and the various roles the job entailed, the way they enacted the job varied. Differences in how each math coach carried out their job were attributed to the coaches' identities, reflecting their expectations of the job as well as their interactions with school personnel. How roles were enacted was the result of negotiations between the coach and the teachers and staff in each school. Furthermore, the change in identity from teacher to coach was accompanied by many emotions including displacement, guilt and fear. The study concluded that the development of a coaching identity is the result of how the coach's expectations are aligned with reality through negotiations with teachers and administration. A thorough explanation of what the coaches role is, provided to both the coach and staff, can have a positive effect on a coach's self-efficacy. The study also identified the need for a support structure for coaches where challenges, as well as strategies for addressing the challenges, can be shared.

Cataldo (2013) provides a personal account of her transition from classroom teacher to coach. Her days are varied, and she admits that the variance makes it difficult to know how to identify herself. "As the early childhood math coach, specialist, teacher, mentor (sometimes I am not quite sure which title to use) I expect each day to bring its own set of challenges and excitement" (Cataldo, 2013, p.110). Her days include planning with teachers, observing teachers, playing a math game with a small group of students, modelling a lesson, meeting with grade levels, researching content, and finding resources. Cataldo was approached to become a mathematics coach for the preschool and kindergarten in her school, but was provided no job description; she has had to develop this herself, with the support of colleagues and mathematics teacher educators from her local university. She read books on coaching, and developed approaches to working with teachers that proved effective. She also had to adjust to a new role. The school administration was anxious for change in the school's mathematics culture, so Cataldo had to find a path that allowed her to balance respect for the work of long time colleagues and friends, support for new staff, and bringing about wanted change. She recognized the need to gain colleagues trust, and thus spent a lot of time at the beginning of the year observing and noting different teachers' styles and abilities. She established regular meeting times with grade levels, established lines of communication where she worked hard to listen to teachers. She also focused conversations on math concepts and teaching goals, thus supporting teachers' professional development. Cataldo's reflection is very positive, but does highlight issues common to many mathematics specialists: blurry job expectations, the challenges of working with veteran teachers in a manner that may seem invasive to teachers who are accustomed to working in isolation, and the challenge of balancing a number of roles and duties.

Conceptual Framework

Mathematics specialists have an important role to play if the changes in mathematics instruction envisioned by reform efforts are to come to fruition. If a mathematics specialist is employed in a manner that mirrors the expectations of state and national mathematics bodies (AMTE, 2009 and 2013; NCTM CAEP, 2012; VCSM, 2005), their proximity and intimacy with the daily work of teachers positions them to offer job-embedded, consistent professional development. This support is directly related to the work of teachers, as the specialist can plan with teachers, model lessons, discuss student work, or locate appropriate resources. Mathematics specialists can work within their schools to change the beliefs held by teachers and administrators about what mathematics is, and what it means to teach mathematics in a way that is conceptually based, relevant to students' lives, and in a manner that provides all students opportunities to engage in mathematical thinking.

Programs designed to prepare mathematic specialists aim to guide specialists to develop a deep understanding of elementary mathematics, as well as skills required to be a successful mathematics leader. Such skills include the interpersonal skills needed to develop positive relationships with teachers, coaching skills that support teachers in their content and pedagogical growth, and reflective and research skills that are needed for problem solving and personal growth. However, as constructors of their own learning, it is expected that mathematics specialists make sense of what they learn in personal, individual ways. Furthermore, as they move into jobs their knowledge is mediated by the contexts in which they work. Their professional identity and practice are an outcome of negotiations that take place during social interactions within these contexts.

Wenger's (1998) framework of communities of practice provides a lens for exploring the development of professional identity. A key element of communities of practice is the notion of participation. Legitimate peripheral participation describes how a novice in a community comes to understand the routines, expectations, histories, practices, and expectations of competence within a community, eventually leading to full participation status. Full participation in a community of practice is indicated by various levels of engagement, imagination, and alignment. The roles we assume within a community determine the activities with which we engage, influence how we imagine our role developing within the community and what our purpose is within the community, and shape how we align our beliefs with others and move others to align their beliefs with ours. The development of professional identities of mathematics specialists can be analyzed by studying how they participate within their community, and what this reveals about how they view their roles.

Challenges to the idea of legitimate peripheral participation provide another angle from which to approach professional identity. Wenger (1998) examines participation from the point of view of novices entering a profession, taking on the practices of the experts in the community. But Hodkinson and Hodkinson (2004) remind us that new members to a community are not always novices. Mathematics specialists are experienced teachers, but are also novices in the role of mathematics specialists. How they negotiate the perception of being a novice while being expected to perform as an expert will affect how professional identity develops. Unlike apprentices whose job it is to learn from the mentors, mathematics specialists are hired to bring about change in an existing community. Contu and Wilmott (2004) and Carlile (2004) raise the issue of power held by fully participating members of communities of practice. If change is seen as threatening, there is the possibility fully

participating members of the community will use their power to withhold access to new mathematics specialisms.

Research on professional identities of people in various stages of careers in education provide further insights that may be extrapolated to describe challenges to the development of a mathematics specialist's professional identity. Bullough (2005), Chval et al. (2010) and Cataldo (2013) note the challenges to identity brought about by blurry job expectations. Allen (2010) and Wilson et al. (2014) highlight the importance of considering the attributions teachers give to mathematical success and failures, how these attributes reflect teachers' beliefs about mathematics and how children think about mathematics. These attributions are indicators of what teachers find important in mathematics teaching, and may need to be addressed before meaningful instructional changes can occur. DePiper (2014), Gresalfi and Cobb (2011), and Chval et al. point to issues that arise when the beliefs of the mathematics specialist do not match the beliefs of teachers or administrators. Bullough points to issue that arise when induction fails to adequately include the teachers with whom the specialist will work; Murray and Male (2005) point out how a poor induction may lengthen the time required to develop a new professional identity. Other issues raised in the literature that may impede a mathematics specialist's identity development include struggles with negative emotions and self- doubt, the difficulties of balancing multiple roles, and the pressures teachers feel in a high stakes environment that may make them hesitant to embrace change.

Professional identity develops as individuals develop competence in their job, experience success, and see themselves as contributing members of their community of practice. It is helpful to understand how mathematics specialists face and handle challenges in their work in order to explain how their professional identities develop.

Research allows us to anticipate some of the challenges to identity, and provides guidance for exploring and explaining how mathematics specialists have constructed their individual identities.

Figure 1 presents an initial conceptual framework for this study that draws from the literature on communities of learning. The framework suggests that there is not a totally linear trajectory associate with the development of professional identity. The framework illustrates the theory that as a mathematics specialist moves from a period of legitimate peripheral participation to a period where engagement, alignment and imagination are occurring, there may be instances where after the specialist and the teacher have done work on one level, the specialist needs to spend more time building the relationship in order to be able to engage on a different level. Similarly, a specialist will reach the point of full participation, and a new challenge or initiative arises. At this point the specialist may need to engage with this new initiative to develop competence with it, align the new initiative with other work being done, or do some work envisioning their identity given this new initiative.

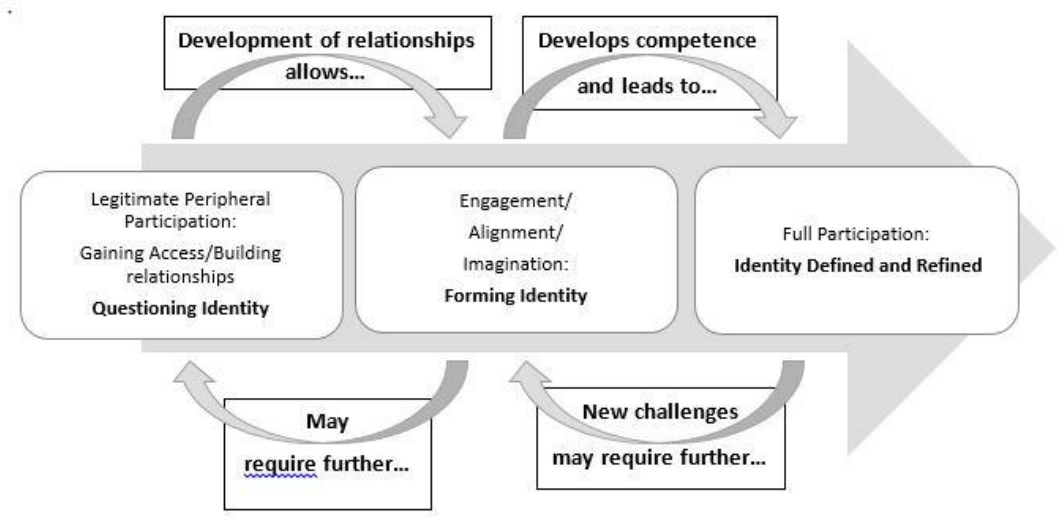


Figure 1. Conceptual framework for exploring the development of professional identities, drawing from Lave and Wenger (1991) and Wenger work (1998, 2000) and their work on legitimate participation and communities of practice.

While not illustrated in this framework, there could be breaks or leaps at any point in the trajectory of professional development. For instance, a mathematics specialist may not be able to gain access to classrooms, or a specialist could be a full participant in one school, and then move to another school or division and find that he or she is starting over, trying to build relationships from start.

Statement of the Problem

The problem investigated in this study is how mathematics specialists develop their understanding of what it means to be a mathematics specialist. In other words, through this study I sought to understand and describe how mathematics specialists develop their professional identities, and how those identities evolve over time, in consideration of various contexts, roles, and experiences. I explored how a small number mathematics specialists developed professional identities, with an eye towards identifying common elements that either support or hinder the development of professional identity over time.

Research Questions

1) Given the different roles mathematics specialists undertake, and the varying contexts in which mathematics specialists enact those roles, how do experienced mathematics specialists perceive their professional identities?
2) In what ways, if any, do professional identities of mathematics specialists change over time, experiences, and contexts?

CHAPTER 3

METHODS

Viewed through the lens of the mathematics reform movement and constructivism, mathematics education is not about imparting a given body of mathematical knowledge to students. It is about helping students construct meaning through a socially shared understanding (Van de Walle, 1999). In this same vein, a social constructivist stance towards teacher professional development requires opportunities for teachers to build an understanding of what it means to teach in a classroom where students are encouraged to structure their mathematical knowledge, aided by sense making activities and social discourse (Cobb, Yackel & Wood, 1995). This study assumed that mathematics specialists construct personal claims and understanding of how to engage teachers and schools in professional development that encourages the reform-oriented beliefs and instruction needed to raise levels of student achievement. Through their personal construction of what it means to carry out their role, mathematics specialists' identities are formed and developed.

This interpretative phenomenological study investigated how individuals make sense of their role as mathematics specialists. It looked at their own experiences teaching elementary mathematics, the reasons for choosing to move from the classroom into a leadership role, and experiences that, in reflection, have been significant in developing a professional identity as a mathematics specialist. This study focused on a body of information provided by five mathematics specialists to elucidate significant experiences that contribute to developing a professional identity as mathematics specialist.

Research Design

The current study accepts the world view derived from a constructivist paradigm. Lincoln and Guba (1994) define a paradigm as " a set of *basic beliefs*" representing a "*world view* that defines, for its holder, the nature of the *"world",* the individual's place in it, and the range of possible relationships to that world and its parts" (p. 107). Interpretative phenomenological analysis (IPA) allows the researcher to explore the world view of individuals.

Interpretative phenomenological analysis (IPA). IPA is an approach to qualitative research that originated in the field of psychology (Smith, 1996; Smith, Flowers, & Larkin, 2009). The objective of IPA is to explore in detail the lived experiences of individuals, how individuals interpret those experiences, and how the researcher makes sense of the individual's interpretations (Smith 2004). Smith, Flowers, and Larkin (2009) explain the theoretical underpinnings of IPA, situating IPA within three areas of the philosophy of knowledge: phenomenology, hermeneutics, and ideography. Phenomenology is an approach to the study of experience: IPA is phenomenological in that studies are interested in exploring the common, everyday events in participants' lives, and the participant's reflections on those events. This study is phenomenological in that it explores the phenomenon of becoming a mathematics specialist, as heard through the voices of mathematics specialists. Hermeneutics is the theory of interpretation: IPA studies are hermeneutical because they involve the participant's interpretation of phenomena, as well as the researcher's interpretations of the participant's stories. This study adopts a double hermeneutical stance, as do most IPA studies, in that the lived experiences are told as interpreted by the participants; then these experiences are re-interpreted by the researcher, giving them meaning outside the individual. Finally IPA is idiographic:

ideography is concerned with the particular. In IPA, *the particular* can be regarded as an event or phenomena, or how an individual, in a specific context, understands the phenomenon. *The particular* also refers to the level of detail in which the reflections and understandings of the individual phenomena are described. This study is idiographic in that it explores individual cases, focused on a particular phenomenon.

In IPA, the subjective views of lived experiences are essential to understanding (Denovan & Macaskill, 2013). The central focus of an IPA study is a thorough exploration of the lived experience as interpreted by the individual, and the meanings this interpretation gives to the individual's personal and social life (Lyons & Coyle, 2007).

Participants. The purpose of this study was to explore the phenomenon of developing a professional identity as a mathematics specialist. Phenomenological studies are interested in those who have experienced or are experiencing the phenomenon in question. Thus, mathematics specialists, and not people who have worked with or taught mathematics specialists, are the participants.

Four practicing mathematics specialists and one former mathematics specialists who has returned to full time teaching participated in this study. All five participants are graduates of the University of Virginia Mathematics Specialist program, though all graduated at different times. Four of the proposed participants are female and one is male. Participants range in age from 33 to 56, range in teaching experience from 8-35 years, and have from 3-10 years' experience as a mathematics specialist. Two of the specialists work in large school divisions (24,000 and 28,000 students), one is in a medium-sized division (11,000), and one is in a small division (4,500). The mathematics specialists who has returned to full time teaching teaches advanced high school mathematics in a division of 10,000 students. All five

participants are employed in a Virginia school division, though one was interviewed following three years as a mathematics specialist in a New England school division. All participants and divisions are referred to with pseudonyms.

Selection of participants. In IPA samples are selected purposively. One reason for a purposeful sample is to uncover a wide array of perspectives (Lincoln & Guba, 1985). Sample sizes are generally small, with recommendations ranging from the single case study with one participant to 4 to 12 interviews, either with individuals or with participants interviewed repeatedly (Smith, Flowers, &Larkin, 2013). The use of a small sample helps maintain the idiographic nature of the study (Hefferon & Gil-Rodriguez, 2011). A small group of participants also allows for a depth of analysis that searches beyond description (Reid, Flowers, & Larkin, 2005). Samples are intentionally homogeneous in order to analyze similarities and differences that arise. In IPA participants are chosen because they offer access into a particular phenomenon.

Description of participants. In this study, participants were chosen because of the certain amount of homogeneity they bring to the sample (Hefferon & Gil-Rodriguez, 2011). In particular, all participants are graduates of the same mathematics specialist program, and thus have had similar preparation. Furthermore, all of the participants were chosen because they were considered strong students in the Mathematics Specialist program, in addition to being successful in their practices as teachers and mathematics specialists. Each participant has been identified by at least one of the instructors of the mathematics specialist program as an outstanding student. All participants have been cited for contributing thoughtfully to discussions, supporting colleagues, developing their own mathematical knowledge, and increasingly applying theory to practice throughout her or his preparation. Each of

the participants has presented at local, state and national conferences, and all have taught CPD courses to other teachers. They are recognized as leaders in their schools and in their divisions. Thus, homogeneity is addressed through each participants' high level of knowledge and expertise.

However, participants were also chosen because of differences in their experiences as perceived by the researcher. These differences allowed for a richer comparison of areas of convergence and divergence amongst the professional identities of the participants. Factors such as length of time teaching, experiences as a teacher, length of time as a math specialist, age, gender, size of school division, level of support within the division, and level of involvement within and access to the wider mathematics specialist community have been taken into account as variables that can affect the development of a professional identity.

Finally, participants were chosen because they represented different contexts: different school divisions, and different schools within those divisions. The differences among these contexts suggests that each participant will experience being a mathematics specialist through a different lens than the others. Cleo is employed in a Title I school, and her position entails working with teachers who recognize change is needed because standardized test scores are low; however, the teachers with whom Cleo works do not all see change as meaning reform. Rosamund began as a specialist in the same division as Cleo, but in a high achieving school. Because children are successful on standardized tests, teachers do not necessarily recognize the need to change. For Rosamund the challenge is to bring about a change in teaching so that children move from a procedural approach to mathematics (which they are good at) to a conceptual approach. In Pearl's division, mathematics specialists are placed in struggling schools, again defined as schools who are not meeting expectations on

standardized measures. For Pearl, this means that teachers understand change is mandated, and they have no choice but to work with her. Like Cleo, the teachers with whom Pearl works do not necessarily see change as meaning reform practices. Gaining access for Pearl is different than for Cleo and Rosamund, but perhaps levels of trust are different as well. As a division-wide mathematics specialist focused, one of Ouida's jobs is to help teachers develop an understanding of the Common Core Standards. The CCSSM are required in her division, so again teachers understand the need to change, and they understand Ouida's role as needing to bring about change, driven by division policy and working to meet new standards and requirements. However, because Ouida's position was division-wide, neither Ouida nor the teachers were clear on how she was to help bring about change. Cleo, Rosamund, Pearl, and Ouida are all in divisions where reform based change was introduced (and at least initially) supported by the division administration. In Sam's case, there was no division-wide support for reform based change. While he was hired as a division-wide mathematics specialist to lead the division's mathematic programs, his vision was not aligned with that of his supervisors. Thus his experiences as a mathematics specialist demonstrate how context can hinder success. By choosing participants from different divisions the role of context can be highlighted in the development of professional identity.

Cleo has been a mathematics specialist for 9 years in the same large elementary school (900 students), in one of the first divisions in Virginia to employ mathematics specialists in all elementary schools. Pearl has been a specialist for 10 years in a neighboring district; however her role as a specialist, as defined by this division, has changed during this time. Rosamund was a specialist in the same division as Cleo for eight years, in a school of 600 students. She moved to another

division for one year, and has now returned to the division with Cleo. Ouida was a division wide specialist for 3 years in a school division in New England, but now works in an elementary school (340 students) in Virginia. Sam was a lead mathematics teacher for three years, then a central office mathematics leader for three years, and has moved back to full time teaching in advanced level high school classes.

Participant consent and notification. To "assure that the risks of social and behavioral sciences research conducted at UVA are compatible with the expected benefits, and that participants always have a free and fully informed choice before giving their consent to participate" (Institutional Review Board, 2015), a protocol was submitted to and approved by the University's Institutional Review Board. The protocol included a description of the project, a proposed timeline, a description of how participants would be contacted, a description of how confidentiality would be maintained, and an informed consent document to be understood and signed by each participant. Informed consent documents are found in Appendix A

Participants were contacted by email and asked to participate in the study. Information about the study was described in the email. The decision to request participation via email was made in order to make it easier to decline the request than if asked in person. All participants agreed, and returned a signed copy of informed consent which had been attached to the email, keeping a copy for their own records. At the beginning of each interview, the participant's rights as a human subject were reviewed. Transcripts of interviews were sent to participants, with the request they review the transcripts for accuracy as well as to be sure they were comfortable with the use of any of the information contained in the transcripts being used in the case study (assuming care to protect the identity of the participant and the participant's division). Furthermore, completed case studies were submitted to participants to

review, again for accuracy as well as assurance that the case studies were not professionally compromising.

Data Collection

The primary method for collection of data for this study was through audiotaped, in-depth semi-structured interviews. The data in this research is largely retrospective. The data represents the recollections of the participants, from events that they recall from their lives. Participants were asked to provide various artifacts from their work that were used to collaborate stories gathered through interviews. Participants were also asked to submit a written statement of their professional identity, including how they thought that identity has developed in their time as a specialist. Table 1 summarizes the data sources collected from each participant.

Table 1: Participants and Data Sources

	Initial Interview, Date and length	*Follow up Interview/ Phone Conversation*	*Email Responses to Queries*	*Historical Artifacts related to Mathematics Specialist Work*	*Written Statement of identity and Change*	*Teaching Videos/ Teaching related artifacts*
Cleo	Aug 2015 (1:13:16)	Sept 2015 (1:03:04)	Sept 2015 Oct 2015	✓	✓	
Pearl	Aug 2015 (1:14:04)	Oct 2015 (20:15)	Oct 2015	✓	✓	
Rosamund	Aug 2015 (1:20:05)					
Ouida	Aug 2015 (51:30)		October 2015		✓	
Sam	Aug 2015 (1:01:55)		Sept 2015 October 2015	✓		✓

Semi-structured interviews. The purpose of IPA research is to develop a detailed understanding of how participants construct personal meaning about events in their lives (Smith & Osborn, 2008). For Smith, Flowers and Larkin (2009), semi-

structured interviews are the best method for accessing participants' "stories, thoughts and feelings about the target phenomenon" (p. 56). Semi-structured interviews are a suitable data collection method for IPA studies because of the flexibility they allow for the researcher and the participant to engage in a dialog about the research topic, and for the researcher to respond to the participant's comments that seem particularly fruitful. Through semi-structured interviews the participant may share in decisions regarding the direction of the interview might take. While partially guided by a protocol established by the interviewer, the participant is likely to raise issues not thought of by the interviewer and thus may alter the direction of the interview (Smith, Flowers & Larkin, 2009).

Each participant was interviewed in person, in their homes or at a school. Participants were given the interview protocol in advance of the interview in order to prepare and consider their responses, as well as to have time to recall and reflect on relevant experiences. Interviews were digitally recorded, and immediately saved to computer. All interviews followed the same protocol (Appendix 2), and the semi-structured nature of the interviews allowed for additional questions to be asked when appropriate. Field notes were taken throughout each interview. The length of initial interviews ranged between 51 and 80 minutes. Reflective notes and memos were written within a few hours after each interview, recording initial reactions, questions raised, interesting points to note, and as well as early identifications of themes. Initial reactions included responding to the places in the interview where the researcher was surprised by an answer to a question. This was most typically the case where the participant revealed something about being a mathematics specialist that was inconsistent with the researcher's preconceived ideas being a mathematics specialist,

or that participant: and a bias needed to be noted. All interviews were transcribed, and then returned to the participant for reasons described earlier.

Follow up interviews/conversations were conducted with two participants, to clarify to clarify points made during the initial interview. These interviews were carried out by telephone, digitally recorded, and transcribed. Follow-up queries were sent by email for to other participants for response.

Artifacts. Participants were asked to provide artifacts that document their work and development of identities as mathematics specialists. Such artifacts came from their academic preparation, their time working as a specialist, or time teaching. Artifacts collected included reflective writing; communications with principals or administrators; evidence of personal mathematical development; agendas or documents that highlight the nature of work carried out with teachers or other mathematics specialists; personal goals; evidence of interactions with parents and/or community stakeholders; conference presentations; and summaries of workshops and courses planned and led by participants, including supporting materials. Sam, the high school teacher, sent a video of a teaching episode.

Written Statement. Participants were asked to submit a brief written statement, describing themselves as a professional, and reflecting on how they believe their professional identity has changed across the years and considering context and roles.

Analysis of Data

Smith and Osborn (2008) provide a thorough description of the process through which the data are handled in IPA. Following their process, analysis of the data began with a detailed examination of a single case. The transcript was read several times to develop familiarity with the account, with notes made in the middle

column annotating areas of interest or significance. The annotated transcript was reread, with additional notes made in the left column to document emerging themes. A sample of a coded transcript is seen in Figure 2.

Developing voice Expert opinion	Claiming authority by challenging requests by admin t "simply model"	show them how to do this. And I'd say, it's not quite as simple as that. Just going in and modelling doesn't change anything with the teacher unless I have the time to really work with them in a different way.
00:20:28	S1	It's a little like procedural teaching. I mean, procedural --
00:20:32 Focus on Collaborative Coaching	S2 Example of how modelling goes wrong; need reflection, discussion Role of coach to help teachers reflect? Change in approach—no longer moedls withut meeting Recognition of limits?	Right. Just do what I do and I do and you'll be fine. And there was one fifth grade teacher that I mentioned earlier, honestly when I go in and do the lesson, she takes notes and tries to write down everything I say and then with her next -- because she taught two math classes -- she would try to replicate it. And so there was never a time for her to think and reflect and to hear what the kids were saying because she was trying so hard to replicate my lesson. So typically now when a teacher asks me to model I would love to. When can we sit down and plan? And that kind of weeds out that they just want me to come in and fix their kids or are they really serious about -- and I try and encourage them, let's sit down. Let me come in for like three weeks. Let's do like a mini co-teach. And some of them will -- the ones that are really ready to change will do that, but I'm not making any headway, to be honest with --
00:21:17	S1	With the others or with --
00:21:18 Strong collaborative relationships--- lead to feeling	S2 Working on mathematical understanding and pedagogy	With many of them. Yeah, many of them wanting to do that. And I've had some teachers that I've worked with that ended up almost same thing, you just loved going into their class so much that they end up being almost a full year co-teach because the working relationship was

Figure 2. Coded transcript

Themes from the first case were listed and then clustered according to similarities. Themes were checked with the original transcripts, and at time the original recordings, to be sure they related to the primary source. This iterative process of interpreting primary sources and then assuring the interpretation is true to the primary sources continued throughout the entire transcript. Themes were also checked against researcher notes. Identified themes were organized to indicate overarching themes and sub themes. Locations of evidence for themes were maintained in a separate list in the research notes. Themes that did not fit within the emerging structure or that were not supported by sufficient evidence were dropped. Artifacts from participants were then considered in order to substantiate emerging themes. When the first transcript case was completely exhausted and themes identified, each subsequent case was analyzed in the same manner. The researcher

was vigilant in looking for repeating patterns, as well as new themes that emerged from subsequent cases. Themes from subsequent cases were checked against the list of overarching themes and subthemes.

Throughout the process, checks were maintained on the analysis. Participants were asked to scrutinize transcripts to ascertain the accuracy of the data as well as to verify inferences and emerging themes. Peer debriefers examined transcripts and case studies to critique and confirm emerging themes.

When all transcripts were analyzed, a case study was written about each participant in order to provide a detailed account of their development as a mathematics specialist. Analysis was then conducted across the cases in which the researcher explored the themes from all the cases and identified locations of convergence or divergence (Smith, 2004). For a theme to be included in the final analysis, it had to reference at least three extracts from the data. The source of these extracts depends on the number of participants (Smith, 2011). In the case of this study, each theme needed to be represented at least three times by abstracts from at least two of the participants. The intention was to provide a measure of the relevance of the themes to ensure themes are representative of the entire corpus.

The result of this analysis was a document from which the reader can identify elements of the individual as well as recognize overarching themes about the phenomenon in question. This document helped develop a narrative account that includes the themes that emerged from the voices of the participants, as well as the researcher's interpretations of the participants' accounts.

Establishing Trustworthiness

Guba (1981) proposes four criteria that should be considered to establish the trustworthiness of a qualitative study. These criteria are credibility, transferability,

dependability, and confirmability. Each of these is discussed below in relation to this study.

Credibility. Lincoln and Guba (1985) argue that one of the most important factors in establishing trustworthiness is credibility. For Merriam (1998), establishing credibility assures that findings reflect reality and that readers can be confident the particular phenomenon has been accurately recorded.

Prolonged engagement. Lincoln and Guba (1994) recommend the researcher should have a familiarity with the phenomenon being investigated, and recommend "prolonged engagement" between the investigator and participants to allow the investigator the opportunity to gain an initial understanding of the participants, as well as to earn the trust of participants. In this study, the researcher has extensive knowledge and experience with the mathematics specialist program in Virginia, has worked as a mathematics specialist, and has a personal and professional relationship with the participants for more than 10 years. The professional relationship with each of the participants varies, and may include engagement with the participant as a student of the researcher, as a co- teacher with the researcher, and/or as a collaborator with the researcher.

Triangulation. Triangulation of data sources (Patton, 1990) is another method for ensuring credibility. Triangulation involves comparing and checking the consistency of data collected from different sources at different times. A number of sources of data were collected, including historical artifacts, recorded and transcribed interviews, written queries, and personal communications. In this study, triangulation was accomplished by corroborating information gathered from interviews with artifacts provided by participants. Triangulation has also been accomplished by comparing the stories of specialists where those stories have

overlapped. Triangulation also happened through multiple analysts (Patton, 1990), as peer reviewers analyze data and compared their findings with that of the researcher.

Peer debriefing. The purpose of peer debriefing is to provide feedback to the researcher from a party who is not connected to the study. Three peer reviewers helped with this study. The first peer reviewer is a university professor with a Ph.D. in Gifted Education, and background in mathematics, gifted education, and foreign languages. As a mathematics educator, she has a clear understanding of the topic of this study. However, she is removed from it as most of her teaching has been focused on the secondary level, and her intimate knowledge of mathematics specialists is limited. The second peer reviewer has an Ed.D. in Elementary Education, with extensive background in middle school mathematics. She has been a system wide coordinator for a Virginia district, as well as a mathematics coordinator for the Virginia Department of Education. She has a broad knowledge mathematics specialists. The third peer reviewer has an Ed.D. in Health Education, with experience with qualitative methods. His expertise is in continuing medical education and job-embedded CPD. All three provided insights that asked me to think about my interpretations from varying perspectives.

Member Checking. Lincoln and Guba (1985) claim that member checking is perhaps the most crucial method for establishing trustworthiness. Member checking occurred throughout this study. During the interviews, participants were asked to confirm the meaning of unclear statements. Following the transcription of interviews, questions that arose were addressed to the interviewee for clarity. Participants were provided the opportunity to approve and comment on transcripts and case studies to in order to assure these documents are accurate portrayals of the evidence collected.

Referential Adequacy. Referential adequacy has been established through the collection of recorded and transcribed interviews. These oral and written sources provide "a benchmark against which analyses and interpretations can be tested (Lincoln & Guba, 1985, p.313).

Transferability. Transferability refers to how well the researcher's findings can be applied to another context (Bradley, 1993; Lincoln & Guba**,** 1985). Transferability in qualitative research depends on the reader being able to recognize similarities between situations described in the research and the reader's own contexts. While it is the job of the reader to ascertain transferability, it is the researcher's role to provide enough data through a rich, thick description that the reader develops a thorough understanding of the contexts. Thick description is found in the detailed cases about the participants and their experiences. These descriptions are enhanced by extracts form interviews and artifacts. Analysis of the cases demonstrates similarities to the larger body of research.

Dependability. Dependability is addressed by reporting the processes within the study in detail (Shenton, 2004). To address dependability in this study, a thorough description of research design and implementation has been written, care has been taken in analyzing data, and research records have been maintained.

Confirmability. The confirmability of a study is dependent on the existence of an adequate audit trail (Lincoln & Guba, 1985; Siegel, 2002). The audit trail should allow an outside examiner to determine if conclusions can be trace to sources and are supported by the inquiry (Siegel, 2002). In this study the audit trail includes raw data in the form of interview transcriptions and participant artifacts; memos and notes developed during data collection and analysis; data analysis records including descriptions of developing themes; and the final report.

Researcher as Instrument

While the use of an interview protocol or other instruments may be used in qualitative research, the researcher herself is the instrument who collects the data; "the researcher is involved in a sustained and extensive experience with the participants (Cresswell, 2014, p. 187). I bring many personal experiences that will inform the interpretation of the participants' stories. My professional background includes teaching middle school mathematics, university level calculus classes, and undergraduate and postgraduate mathematics education methods courses, as well as three years as a mathematics specialist in a PK-4 elementary school. The NCTM and efforts of the mathematics reform movement have influenced my instructional practice from the beginning of my teaching career. *Curriculum and Evaluation Standards* (NCTM, 1989) was published the year I completed my student teaching placements. Thus my personal beliefs about mathematics teaching and learning have evolved throughout my life, and I now view mathematics instruction through a constructivist lens.

I have taught each of the participants in this study, and I have worked alongside each participant in delivering professional development. My personal knowledge of each individual has been useful in gaining access. Furthermore, my personal knowledge of each participant provides me with an important element of familiarity with the phenomenon under investigation (Shenton, 2004). However, I also recognize that familiarity may affect data collection, analysis, and interpretation. Caution will need to be taken to collect data in an unbiased manner, and to analyze

and interpret the data in a way that accurately represents the experiences of the participants.

Moustakas (1994) writes of the Epoche, "the process of setting aside predilections, prejudices, predispositions, and allowing things, events, and people to enter anew into consciousness, and to look and see them again, as if for the first time" (p. 4). For the researcher to enter the Epoche, what was known of the participants was set aside and bracketed off from information gathered from the participants during interviews and through artifacts. This "conscious uncoupling" of what was known of the participants from what was being lerned about them gave space to develop fresh insights into their worlds.

While knowledge of the participants required extra precautions to be taken in collecting data and in the analysis to avoid bias, this knowledge is also helpful. The stories of the participants have been told in a manner which reflects of their realities, because the researcher is part of those realities. Some of these stories the researcher recalls, but they have been looked at them from a fresh angle, and are an accurate reflection of the participant's experience.

CHAPTER 4

FINDINGS AND DISCUSSION

In this study the researcher explored how mathematics specialists perceive their professional identity. In particular, the professional identities were examined as they changed over situation and time. The following questions are at the heart of the study.

1) Given the different roles mathematics specialists undertake, and the varying contexts in which mathematics specialists enact those roles, how do experienced mathematics specialists perceive their professional identities?
2) In what ways, if any, do professional identities of mathematics specialists change over time, experiences, and contexts?

This chapter presents the findings and a discussion of the research conducted to answer these questions. The chapter is divided into two main sections. The first section of the chapter consists of case studies of the five participants. The participants' experiences as mathematics specialists are described in detail. The case studies are largely told in the participants' own words and provide a vivid account of how the individual's perceive their professional identity.

The second section of the chapter describes the main findings drawn from the cases. Four main themes are identified and interpreted, using the cases as supporting evidence. Each theme provides some insight into how identity is perceived and developed across roles, context and experiences, and time. Taken as a whole, the case studies begin to tell a larger story about the development of the professional identity

of mathematics specialists. Finally, a revised conceptual framework is presented that reflects how roles, context and identity are at interplay as mathematics specialists negotiate their roles in their communities of practice

Case Studies

The five cases in this section are Cleo's case, Pearl's Case, Rosamund's Case, Ouida's case, and Sam's case. All the names of participants and school divisions are fictitious.

Cleo's Case. Cleo has worked for her entire career in Lovelace Public Schools (LPS); she taught in the system for 25 years before becoming a mathematics specialist. Lovelace is a school division of approximately 28,000 students, stretched along both sides of an urban corridor. Cleo is now beginning her ninth year as a mathematics specialist, all of which have been in the same large elementary school where she works now. In those twenty five years, Cleo has taught across the elementary and middle school grades. She began as a substitute teacher, then taught sixth grade for a year, seventh grade life science for a year, seventh and eighth grade math for three years, second grade for three years, fifth grade for a year, fourth grade for a year, and then kindergarten for three years. After that she returned to fourth and fifth grade for the remainder of her time as a classroom teacher, preferring these grade levels, except for two years as coordinator for instructional technology.

Cleo earned a Bachelor of Arts in Early Childhood and Elementary Education, with licensure to teach preschool through grade 8. Before entering college, her highest level of mathematics was high school geometry. Cleo recounts, "I took algebra and geometry… and my guidance counselor said, 'Oh honey, if you are going to be a teacher you don't need to worry about taking any more math'….It was such a disservice" (Tape 1, 1:00:57). She completed an elementary mathematics course as

part of her degree, but she admits there was a lot of room for her own development. During her stint as a seventh and eighth grade teacher she relied on support from her husband, but did not seek or receive much support from other teachers. Indicating a sense of isolation, as well as a change she sees now, Cleo said, "My husband helped me with the seventh and eighth grade math, but no other teacher. Teachers didn't converse at that point…Teachers were very closed. You didn't share much and that's---that's part of the transition of opening up the doors and sharing and becoming a community" (Tape 1, 1:02:31).

Moving from seventh and eighth grade mathematics to second grade was a critical point in Cleo's thinking about mathematics. At this point, Cleo recognizes her thinking *about* mathematics and *about* mathematics instruction began to take root. "I was like, are you kidding me? I went from teaching seventh and eighth grade to second grade and I was teaching the same stupid subtraction. They started in second grade, why can't they do it in seventh and eighth grade? So I really started to think at that point, how do I make this math make sense to these kids so they get it in second grade…That's where I kind of internally started to puzzle out how do you really make sense of mathematics. So I started to invent… I started to invent somethings just like the kids do" (Tape 1, 1:01: 14).

Cleo's involvement with mathematics specialists began when she was teaching fourth grade, with the opportunity to work with a mathematics specialist in her own school. This specialist invited Cleo to co-teach with her; Cleo had taken a class from her, trusted her, and together they decided they would spend the year working with the reform-oriented standards-based text the district used. This was a positive experience, and Cleo reports it changed how she taught math, convincing her that she needed to listen to children's ideas and build upon their knowledge and

thinking (Tape 1, 06:10). She found herself on the next mathematics textbook adoption committee, and soon she was being encouraged by the district mathematics supervisor and the mathematics specialist in her school to apply to be a member of the first cohort in a National Science Foundation researched grant focused on developing a mathematics specialist preparation program. She was not sure she wanted to be a mathematics specialist. She describes her journey: "So this opportunity came up, I'll bite. And you know, I interviewed for the grant not knowing if I would really do it or not, but just giving myself that option. So I interviewed, and was actually accepted" (Tape 1, 05:55).

The first year of the grant Cleo took classes and continued to teach in her school. She remembers, "We stayed in our regular job, took classes and then the second year of classes we were moved into the math specialist position. We were taking classes and I was becoming a math specialist at the same time" (Tape 1, 07:45). In the second year she began work as full time math specialist, in a different school. The principal, Cleo recalls, "wanted a mathematics specialist in the worst way. He was so thankful, that honestly, I could have been the worst math specialist in the world and he built me up so much with the teachers about the wonderful things I was going to do with them and for them that he made my transition much easier than my colleagues [*who were beginning similar positions at other schools*]" (Tape 1, 07:55).

In Cleo's initial experience as a mathematics specialist she met with "less resistance than what I'd heard from colleagues about math specialists coming in that teachers resented" (Tape 1, 08:20). The principal arranged her schedule so she could meet with all the teachers each week, and over the course of the year this became an extended planning time. When questioned further, Cleo expanded on the resistance

she felt and ways she handled it. "I was brand new to the school. I had no history with the teachers. They were all very polite. They were all very—very nice, very polite at the meetings. Getting into the classrooms, well I picked C_____ because she was taking math specialist classes so I went the easy route and she and I co-taught. Which was good, so she gave me some PR among her team and I, you know, did the nice thing the first week of school, volunteered to give teachers a break because they didn't have specials...I went into all the classrooms and read a math story and did an activity. One teacher in kindergarten made the comment about 'I'm glad to see that you get the literature part, too' because I brought in a book. She was not wanting this math person to come in and change her whole program and making it all math" (Tape 1, 09:20).

Cleo spent much of her first year building relationships with her new colleagues. She "forced her way into the teacher's lounge, eating lunch with different groups of teachers" (Tape 1, 9:25). She brought food to all of her meetings, and meetings started with fun games or materials teachers could take back to their classroom. "It was all about building relationships with people and getting to know the people, and being really nice and really patient and really taking it slow with the math" (Tape 1,10:15). The goals she set for that first year (Figure 4) confirm that much of her planned work was intended to support teachers in ways that were not focused on their own mathematics or pedagogical development. Most of her efforts were aimed to raise the profile of mathematics in the school by planning math related events, to organize materials for teachers (such as manipulatives, or assessment binders), and to work with groups of students. During this first year, she also planned a number of events to work with parents, including a math theme for Back to School Night, and to parent education evenings (Cleo, letter to principal: September, 2007).

The only new professional development focused on formative assessment (a theme to occur often with Cleo) and training new teachers about support available through Larson's Math (a commercially licensed product). In a letter to her principal, dated September 2007, Cleo wrote about helping early childhood teachers complete assessments of their students, again an activity designed to support and build trust.

Mathematics Specialist Goals for [redacted] 2007-2008
(A work in progress)

SEPTEMBER
- Visit classrooms to introduce myself. Share a math book and activity with students.
- Conduct school-wide inventory of math materials to determine what we have or to
- Organize Exemplar binders for each grade level and offer to model Exemplar lesson in each classroom.

OCTOBER
- Observe each teacher. (Start with Leadership Team)
- Meet with Numeracy committee to set goals and plan meeting dates.
- Continue modeling Exemplars.
- Make mathematics more visible in school. (Work on math "tie-ins" to suggest for special days such as Nursery Rhyme Dress-Up Day, Christa McAuliffe Day, Dr. Seuss Birthday.) *ongoing*
- Use SOL data to target areas of need in mathematics. *Ongoing*
- Work with FOCUS teacher to begin fifth grade problem solving contest. *ongoing*

NOVEMBER
- Use team meetings to conduct professional development on formative assessment and use of Exemplars and benchmarks for formative assessment.
- Have grade levels choose common Exemplars to administer and discuss at team meeting.

DECEMBER
- Focus on use of Larson's math (train new teachers, set up classes and curriculum) *ongoing*

JANUARY
- Begin staff problem solving contest. *ongoing*
- Begin morning or afternoon math puzzle groups in math room. *ongoing*

Figure 3: Excerpt from Cleo's goals during her first year as mathematics specialist

Reflecting on the work she did that first year, Cleo notes her identity was often that of a resource teacher. This was not unexpected as her training had taught her that before she would be able to focus on real change to mathematics instruction, she would need to gain the trust of her new colleagues; however, she understood that being a resource teacher was not the role or identity she wanted as a mathematics specialist. Supporting Cleo in developing her leadership role, her supervisor would

remind her that she was the highest trained mathematics person in the building (Tape 1, 11:40), and needed to transition towards such a role.

Her stated yearly goals notwithstanding, Cleo did have opportunities to work with teachers during her first year on substantive mathematics topics. Cleo revealed the following vignette, shared through an interview as well as by submission of a case she had written for an assignment in the mathematics specialist program. In the vignette, Cleo worked with a team of third grade teachers, leading a planning session for a unit on fractions. She prepared a task for the teachers to complete to help build their knowledge of different models of fractions included in the Virginia SOL the set model, the area model, and the measurement model. She asked the teachers to solve a problem in three ways, using each model. "They looked at me like I was speaking French. They had no clue where to start. So the whole meeting turned to where, you know, I had this vision where it was going, and then I realized they didn't know. That's like being a beginning teacher where you're so focused on what you're going to do with the teachers that you're not listening to what the teachers know" (Tape 1,12:23). Cleo discarded her original plans, and instead worked with the teachers developing the necessary content knowledge.

Over the course of two more meetings in the following weeks, Cleo continued to work on developing concepts of fractions, as well as helping the teachers find ways to teach fractions conceptually. The teachers had initially decided they would cut out fraction pieces to give to students, and then guide the children in labelling parts of fractions. Upon learning this, Cleo planned in the next team meeting for the teachers themselves to "work through a lesson where they had to cut up paper rectangles as if they were brownies to share equally among a number of people. "I had them make a set of fraction cards as directed in the same lesson. The teachers participated

enthusiastically in the lesson and didn't seem afraid to talk about what was confusing them, chatting comfortably about what they were thinking about fractions. After the activity one teacher remarked 'I think having the students cut the paper to make fraction cards is much better than me cutting out fraction pieces and having them label them. They'll really have to think about fractions' (Cleo's Fraction case, pg. 3)

Following these sessions, Cleo was more convinced that her role and identity was to help teachers develop their mathematics content knowledge. Another incident that helped to formulate Cleo's early professional identity happened when she was planning with a teacher, and she realized the teacher was simply working through the text, teaching it page by page. The text was a standards-based text, and did not lend itself to traditional instructional methods; the teacher did not understand how the activities related to the mathematics she thought she was supposed to teach; and material in the text was not always aligned with the SOL. Cleo attempted to coach the teacher on what was and was not a first grade SOL, and the teacher broke down, bemoaning that she just wanted a book she could teach from, where she did not have to change units or make up units. Cleo said to the teacher, "You know, I'm sorry, there's no such book. And so we have to learn the math, and we have to then kind of learn to make those notes in the book and teach the math, not teach the book" (Tape 1, 13:55).

Thinking about this episode, Cleo realized she had had support when she was first trying to use this same text herself, and she had learned, when co-teaching with the mathematics specialist at her school, how to help children talk about math, how to focus on concepts. She realized that the teachers had been given this resource, a very different type of textbook to implement than any they had ever used, a book that was written based on reform beliefs about how children learn mathematics and how

mathematics should be taught; yet they only had the tools of a traditional teacher and traditional pedagogy. At this point, Cleo recalls thinking, "Okay I get why I am here' (Tape 1, 17:00). For the next few years, she says she worked hard to help teachers understand the mathematics in the text, and the concepts that underscored the methods.

Looking back, Cleo reflects that while she did help teachers focus on the mathematical concepts, the teachers were not changing their traditional practice. "I'd laid a lot of groundwork going through the math with them… and I think this is the part where I didn't do such a good job. I saw them teaching very algorithmically. Here's partial products. And they would just teach the kids this is how we do partial products, and here's the next method for multiplication. And so what they're doing---what they were doing was teaching three or four different algorithms algorithmically and then the kids were confused and they [the teachers] were wondering why do we have to teach all these? (Tape 1, 17:33). Cleo realized she had to change the teachers' mindsets. She wanted them to see that teaching different methods of procedures the same way old methods had been taught was not changing instruction. She wanted them to recognize the children's invented algorithms, and learn how to guide conversations that encouraged to discuss different methods and make sense of the, learning to use different methods in appropriate situations.

Early in her mathematics specialist practice, Cleo would go into classes and model lessons. However, over time Cleo has begun to resist "modeling" lessons. Cleo had found that for many teachers, a request for a model lesson means "Can you come in and fix my class? Can you come in and model that, and instead of paying attention they're shuffling papers and doing things thinking that when I leave the kids will be straight." (Tape 1, 19:30). Another scenario: "Teachers think they can just do what I

do. There was one teacher and when I go in to do the lesson, she takes notes and tries to write everything down I say and then with her next class—she teaches two math classes in a row—she would try to replicate it. And so there was never a time for her to think and reflect and to hear what kids were saying because she was trying so hard to replicate my lesson" (Tape 1, 20 :32).

Now when Cleo works in teachers classrooms, she is very much more deliberate about the coaching she does. If a teacher asks for help, Cleo agrees, telling them, "I would love to. When can we sit down and plan? And that kind of weeds out that they just want me to come in and fix their kids. I try and encourage them, let me come in for three weeks. Let's do a mini co teach. And the ones that are ready to change will do that" (Tape 1, 20:50). Cleo believes coaching can be effective: this is revealed when she speaks of different situations where teachers have let her into their rooms. A third year teacher had observed the coaching Cleo did with another colleague the previous year. The third year teacher approached Cleo asking, "Can you do for me what you did for B_____ last year?" Cleo responded, "Let's talk. What do you mean by that? We sat down, the first thing we talked about was let's talk about the classroom. Let's talk about the culture in the classroom. I went in to observe. Let's talk about the community and she was very--- she was a young teacher—very much in control. She liked being the boss, but we ended up rearranging her whole room, you know from rows to groups and talking, and she made a space where everyone could sit on the floor and do math… By the middle of the third month [*the teacher*] said, 'This is amazing. I teach everything now like I teach math. Everything's about inquiry. We're always just talking.' And those kids did amazing things that year" (Tape 1, 22:00).

Developing her practice as a mathematics specialist has given Cleo a voice. Several years ago, Cleo found herself at odds with a school level administrator. The administrator saw Cleo's "role as being much more traditional teaching in a way. I was to be a math specialist the way she was a traditional teacher where you get up there, you tell them exactly how to do it, and then you have them practice doing it and you watch them and you give them feedback. And I rallied against that—that was not going to be an effective way of changing teaching. She wanted me to model, model, model for the teachers. Just go in and show them how to do this. And I'd say it's not quite as simple as that. Just going in and modeling doesn't change anything with the teacher unless I have the time to really work with them in a different way" (Tape 1, 49:00; 20:01). The administrator's vision of mathematics leadership differed from Cleo's in other ways as well. The administrator wanted Cleo to create tests the teachers could use in their classrooms. Cleo balked and argued against this practice, believing the teachers should create their own assessments to inform instruction and show what children know; she also fervently believes children do not get better at taking tests just by taking tests. Fortunately for Cleo, her principal believes instructional practice needs to change, and with her support Cleo was able to stand up to the assistant principal successfully.

Several years ago, Cleo notes that her job role seemed to shift. The school district was emphasizing data analysis as a way to secure children's progress. For several years, Cleo's yearly goals reflected this emphasis. For the 2009 -2010 school year, one of Cleo's goals for herself was to "facilitate data discussions based on results of SOL testing, K-2 assessment, second grade predictor and unit assessments" (Cleo, Mathematics Specialist Vision Statement, 2009-2010). "You know, the role changes as the school changes and we became very data-driven and the job became

much more about data, the meanings. I was starting to find I had very little time to work with the teachers on the math because we were digging into the data and it was great. We were really finding out where the weaknesses were" (Tape 1, 25:10). At the same time, Cleo consistently pointed out that while identifying weaknesses was helpful, unless instruction changed the weaknesses would not be addressed.

Again, Cleo's voice emerges. "Knowing---- spending all this time on data is not changing instruction. That's my big thing. You can get lost in and truly, it took over our lives…. And all we did was data. We had tests and then we'd dig down into the data, It would be the same every time we did it because nothing instructionally changed, and that's where I started to say to the teachers, let's shove that aside. We know where the kids are, it's the same every time. What are we going to change instructionally?" (Tape 1, 25:57). While Cleo still maintains a focus on assessment, she is now using the assessment focused work to support the teachers in her school in changing instruction. Having successfully worked on curriculum maps to the point of satisfaction, Cleo has spent two years leading grade level teams in developing unit tests that use good questions to really let children show what they know. With her second grade team, they were planning a test towards the end of teaching a unit. Cleo recalls, "A couple of teachers who just fought tooth and nail saying 'I didn't teach it my kids won't know how to do that because I didn't teach it that way' and I (Cleo) said 'Wouldn't it be nice to get ahead of these tests? And if you have one ready before the next nine weeks, do you think that would change how you taught your kids? And yes they really agreed that okay, if we know this is what the kids have to do, we would teach it differently!" (Tape 1, 36:30) Following this, summer work with teachers involved teachers creating tests after looking carefully at the SOL. "That in

itself becomes content training for the teachers because they now ask what does that really mean and how do you get there" (Tape 1, 37:00).

Cleo has developed her voice within the mathematics specialist group as well. For many years, the specialists have created benchmark assessments that are given to all children in the district. Cleo believes the tests are too hard, and despite understanding that the benchmarks are an attempt to raise rigor, she thinks they are detrimental to the students at her school because the teachers are not preparing the children for these benchmarks. So her work with creating unit tests that drive instruction challenges some of the practices of the larger specialist team; but importantly the willingness to challenge practices seems indicative of a developing leadership style.

Cleo has also rethought her emphasis on helping teacher's learn to "teach" the adopted text, and is instead emphasizing understanding the curriculum framework and the mathematic to teach. This is another move away from what other mathematics specialists are doing. "We were all about the text as a mathematics specialist team, getting the teachers to use the text, which I think was a big mistake because we have to teach them the math, and the text, as good as the activities are, is only as good as the teacher's content knowledge and pedagogy. And the funny thing—I was never a teacher that could teach out of the book. I was always doing other things. And I was forcing myself to become a "book" person. So instead of going with my strength I was going with my weakness." (Tape 2, 05:15).

In recent years, Cleo has in fact moved her focus back towards changing instruction, and working in a way with teachers she finds more reflective of her own beliefs. She recalled how in her second year as a mathematics specialist she was buoyed by a teacher who said to her "You've changed this school. You've changed

this school to a math school because teachers were getting excited about math, about the 24 club" (Tape 1, 27:10). So for the last two years Cleo has developed school wide, month long focuses on math that involve students and teachers, and the teachers are getting excited again. Activities involve students solving weekly problems, and classes being recognized for "finding the gold coin", or for teachers participating in problem solving activities as well. Participation is made very public, and charts and graphs are maintained in hallways that show success--- and students encourage their teachers to participate.

Students, are in fact, driving change in other ways. This past year, Cleo's school saw unprecedented success on the Standard of Learning mathematics tests, achieving their highest pass rate ever and eclipsing the pass rate from the previous year when the school had been accredited with warning. When asked why, Cleo responded, "I don't think it's one thing. I think I've said this many times, I've been building from the bottom up, and I think a lot of that has come to fruition. And I think over time, that from the time I've been here, you know, these kindergarten and first grade and second grade students have a much stronger foundation. The kids going into third grade had much better decomposing and composing strategies" (Tape 2, 00:24). The children are probably better prepared for the tests. But the children are also asking more of the teachers. Teachers are now asking Cleo to help them develop number talks to use with the children. Teachers are finally understanding how number talks encourage children to develop different strategies for operations. But Cleo also attributes this need to the demands of the children themselves. "A group of kids are coming up who were expecting math talks in some of the teachers' classrooms and being very verbal and wanting to talk and the teacher's starting to say, 'Oh okay, I'm starting to get this' " (Tape 2,16:00). This is a big change from when Cleo first came

to the school. She recalls at that point "the culture in the classroom was that children sit and wait until somebody shows them how to do it" (Tape 1, 01:45)

A teacher who had been recalcitrant to change "got a group of kids again because they are coming out, they are really wanting to talk about the math and she ended up in my hallway and the kids were in my room. Every day, look what we did, look what we figured out. This teacher started to encourage it, it made math really exciting for her this year. She is the one who wanted more math talk" (Tape 2, 12:42)

For Cleo the support within the building is changing in a positive way, and the mathematical culture is beginning to shift. A new academic coach has joined the staff, and helped staff to make realistic goals. Previously, all teachers were told to set the goal that 100% of their students would pass the test. The new coach has encouraged teachers to be reasonable, to really make a prediction based on the knowledge each teacher has of her children. " The teachers were all resistant to say anyone was going to fail, but slowly the new instructional coach changed their mindset, saying this is the hand you were dealt, you realistically can only get 70 percent of your children to pass; however another teacher may get 95% percent of her students to pass. She got them working more as a team and it wasn't support of my mathematics professional development, but it was real support for me as a leader and somebody--- an ear where I can finally get feedback" (Tape 2, 2:55). One can see how this focus on realistic expectations would feel like support to Cleo in light of a response she had submitted to her mathematics coordinator 3 years previously. Cleo wrote, "I am really worried about the way that the administration is going to react to our math SOL scores. I am afraid that we will be looking for a quick fix and that I will have to abandon the long term goals I have been working toward" (End of year summary to Math Supervisor, June 2011).

Cleo also has a very strong mathematics teacher who works at her school as a mathematics interventionist, and offers great support to Cleo. One result of the previous year's accreditation with warning was that specialists were seen as administrators, and some of the teacher's trust and openness and willingness to expose their weaknesses had gone. However, Cleo was able to guide the math interventionist into classrooms of new teachers who wanted and needed support, and these teachers were "brought up to speed". Furthermore several new teachers came to the school who already taught from a reform- minded stance. "They kind of pushed the others to look at things differently" (Tape 2, 7:42).

When asked if she thinks teachers' beliefs about mathematics have changed since she has been in the school, Cleo was generally affirmative. "The ones that have been with me, and we've got a big turnover, I think they've changed quite a bit. I have to look at that in terms of where they were to where they are now as opposed to where I think they should be…. But I see they will defend math talk, how important number talks are and getting kids to talk. The math content may still be weak, but I think their pedagogy has become much stronger, their belief that teaching procedurally is not the right way to go. Do they feel comfortable, not teaching procedurally? Not all of them yet, but they know that's where they are supposed to be, and that's where they want to be, and they are more comfortable seeking help" (Tape 2, 8:09).

Cleo has always had consistent support from her principal. "_____ is always very supportive and she trusts me to do my job. She would never make math decisions without talking to me, but the teachers never see her, but there's never been pressure on the teachers from the administration for them to change" (Tape 2, 24:38). While Cleo does think it is changing, she sees the "true culture of the building is

we're a Title One school and it's all about the test, it's all about the scores, which makes it really hard for teachers to take that leap of faith, that chance I might be right" (Tape 1, 02:45). Cleo sometimes feels as if both the district administration and the school administration have sent mixed messages about the importance of improving instruction so that all children make good progress compared with the importance of SOL scores. For instance, when the new district administrator or the principal wanted to reward those teachers whose classes have done exceptionally well on SOL tests, Cleo (and other specialists) remind them that these teachers often started the year with children who could already pass the test, and that the teacher who should be rewarded is the teacher who has helped all of her children make a lot of progress, even if all students in her class did not pass the test.

Cleo also worries about a lack of commitment to the role of the mathematics specialist in the central administration. Both central administrators who were key in bringing mathematics specialists to the district are gone. The second of these to go was relied upon heavily for leadership, pulling the specialists together in different groups to work on projects, and advocating for mathematic specialists to the central administration and school board. While Cleo thinks that principals will fight to keep mathematics specialists, she fears that due to efficiency aims their roles may be restructured and become more centralized. While Cleo can see a few advantages to this--- many coaches could be placed in a needy school and could help more teachers—she worries about the loss of relationships, and recognizes that it is the building culture that needs to change for lasting change to take hold. She thinks this will not happen if a team is sent in to raise scores.

Cleo claims she continues to figure out her role and her identity. While there a clear mission statement from the district (Figure 5), “The way I try to carry out my role or job is different every year" (Tape 1:34:24).

Mathematics Specialist
Mission Statement

The mathematics specialist takes a leadership role to increase the awareness and value of mathematics for students, teachers, parents and the community. They work with teachers and parents to increase their understanding of how children learn mathematics. In serving as a resource and a coach to teachers, they model best practices in teaching and learning mathematics. They also collaborate with teachers and administrators to collect, analyze, and use data to inform instruction in meeting the needs of all students.

Figure 4: Mission Statement for Mathematics Specialists in Cleo’s District

When asked what she does, Cleo will tell people she is a teacher, “Because that’s what I am. I’m paid as a teacher, I’m a teacher” (Tape 1, 52:50). When probed further she says she is “a mathematics specialist, and I work to improve the teachers’ mathematics, understanding and teaching in my building. I am here to help the teachers overall, so all the children get the math instruction they need” (Tape 1, 53:04). But Cleo, with the additional support she is feeling from colleagues in her school, is also beginning to feel like a school wide teacher leader. “I think most mathematics specialists would agree, it probably takes 10 years to really figure out this job for yourself” (Tape 2, 29:56).

Cleo wrote a passage summarizing how she thinks she has changed over time. She wrote, “I guess the biggest change over time has been the amount of time that I work with a team of teachers, which is a good thing, (team coaching as opposed to individual coaching). I think it helps to move the school forward. Early on I met with teachers individually if they needed help. I only met with teams once per month at

extended learning times. The meetings were more PD focused, (manipulative of the month, modeling fractions to aid in problem solving, alternative strategies). I still include PD in my PLCs, but it is more data driven and also more collegial with teacher leaders emerging. Professionally, I feel like I am more a part of a team of leaders working to improve our overall school program, than as an individual entity-all alone on math island. Also, my schedule is a lot fuller" (Personal email correspondence, October 2015).

Pearl's Case. Like Cleo, Pearl has worked in the same school division her entire 18 year career. Pearl's division, Germaine Public Schools (GPS), is adjacent to Lovelace Public School where Cleo works, and the two divisions are collaborators in the establishment of the statewide mathematic specialist program, and still work together on various CPD offerings. GPS serves approximately 24,000 students, and like LPS straddles an urban corridor. Pearl's first job was as a seventh grade mathematics teacher, and then she moved to teaching sixth grade, where she remained for six years, followed by one year teaching fifth grade before taking on the position of mathematics specialist in the school where she was teaching. At the time of interview, Pearl had worked in her district as a mathematics specialist for ten years.

Pearl enjoyed mathematics a great deal in school. "It was great, easy, loved it. It came easy to me" (Tape 3, 01:21). She remembers what she learned as very procedural, but she thinks she naturally thought beyond the algorithms, looking for meaning. "I loved figuring things out, so for me the procedures were fun. In high school, I liked the problem solving piece, I liked this whole idea of figuring out what something is, doing proofs' (Tape 3, 02:10). She continued to enjoy mathematics courses throughout college, and sought additional coursework in mathematics when it was not required. "You know, because I was going to the elementary ed. route, there

was not a whole lot of [mathematics] course work I had to take. But I took extras just because I was part of the Honors Program. I had elementary methods, but I had a stats class, a functions course, a higher level functions course, and a discrete course" (Tape 3, 03:42).

Through her mathematics methods course, Pearl had opportunities to explore mathematical concepts with a variety of manipulatives for the first time. "I remember we did a lot with Cuisinaire rods, some with pattern blocks. It was a lot of hands on which I enjoyed. It gave a glimpse of what was going on in the math" (Tape 3, 04:21) However, this course "was not as earth shattering as came later in my career" (Tape 3, 05:06).). Asked about what came later and Pearl made specific reference to coursework taken through the mathematics specialist program. She pointed out how some of the explorations developed her own understanding but also her consideration of how she might ask children to think about concepts:

"Evens and odds was a big one because I'd always taught it. That was sixth grade curriculum at that point, the whole idea of primes, composites, and evens and odds and all that. I made them [students] memorize it! Did I ever think to bring out tiles and have them actually build even and odd numbers and see if they can *see* the difference between them? For me being a middle school teacher…working with the base ten blocks that I didn't have experience with other than I would use them for modeling decimals [implying the large cube, measuring ten centimeters cubed, represented one whole]. Seeing them as whole numbers [implying the small cube, measuring one centimeter cubed, represented one whole] was a different experience for me. That changed my flexibility of what is one because I'd always seen them differently" (Tape 3, 11:36).

Pearl embarked on mathematics specialist coursework before the creation of mathematics specialists' positions was (officially) under consideration in her district.

"_____ [the district mathematics coordinator] came to me one day and said there is a class that is going to be offered at UVA. And she's like I really want you to come and I had always been---even when I first started teaching I mean math was definitely it for me. It was very obvious to me that math is where I really enjoy teaching. So I would do a lot of outside extra things for math. I was like a lead teacher. So that's how I got connected to _____. Any course that came available I took it. For me it was coursework at the time to change my teaching and make me a better teacher" (Tape 3, 07:22).

Pearl refers to these early courses as "game changers" (Tape 3, 09:16), and her comments reflect the point where her own beliefs and practices about teaching began to shift. . "I really look back and I think I was a very procedural teacher" (Tape 3, 06:17). After a few mathematics specialist courses "Your first thought is what an awful teacher I've been… I mean you start to feel really bad, holy mackerel I require kids to write all this out and it is my way or the highway! Man, I really should let them talk more. I should let them do it different ways and be okay with it and have them explain their thinking to me. So it was this I think almost kind of letting my students have the opportunities that I would have wanted as a student to figure things out differently" (Tape 3,09:47).

Pearl began taking these courses while teaching 6thgrade. She recalls challenges at this time from within her school. "It was very hard at first because my mindset was changing very differently to those around me; [in middle school] everything was still a procedure. They sat in rows to the point where my principal was very big on kids sat in rows and didn't talk. So you know me having to try some things out, like student interviews. You know, me telling a PE teacher that I needed to hold a kid back so that I could interview them. He was like, 'What? You want to talk

to a kid?' The whole fact that I wanted to carry on a conversation about math was just alien to my fellow teachers" (Tape 3, 13:38). The middle school teachers collaborated quite a bit, sharing assignments and planning, but Pearl has strong memories of not fitting in. "That was a little hard because I became a little alienated in the middle school. You know, the little things, 'Here I've got this worksheet that I know you aren't going to do because you do your own thing.' It really truly became Pearl does her own thing because she's taking these classes, and she's got these other ways of thinking" (Tape 3, 14:48).

Enacting new beliefs and new practices was also challenging for Pearl at first. "I was so traditional and so me stand up here and talk to you, you take notes, the whole class, at some point you'll get homework with 25 problems. It was a huge philosophical shift for me" (Tape 3 16:10). But time and experience worked for her. Describing results when she asked children to write about mathematics, rather than give them a number of problems for homework, Pearl said, "That was frustrating at first and looking back on it a lot of it was I didn't set them up real well for it. I didn't do enough modeling and thinking aloud and how would I write this. I did journals and didn't get good responses. It was a lot of 'I don't knows.' It was frustrating. But I eventually learned. My best year in teaching probably was my year in fifth grade because I had a few classes under my belt, I think I found my niche" (Tape 3, 17:15).

Mathematics specialists were initially not wanted universally in Pearl's district nor were they well received in all schools. "When math specialists first started in GPS they actually had to fight to get them into the buildings. Principals didn't want them" (Tape 3, 26:00). Pearl describes a perception of specialists as "spies, coming into the building because they weren't doing well, we were going to see what was wrong, and then someone was going to come in and fix it" (Tape 3, 26:20). Pearl says

now this attitude has totally shifted. “We formed relationships in the buildings that we worked in to the point where I think we were pretty well trusted and respected. It didn’t hurt that buildings performed better after being there. The data really helped to prove our worth” (Tape 3, 26:49).

Still, acceptance of a mathematics specialist by the school, and defining the job took some time. Pearl describes her first years as a specialist, in the school where she taught fifth grade. She was still teaching full time, so had to use her planning time to work with teachers. She thought, “I’m just going to go and show them all these new ways that I’ve learned in my classes during my planning and teach them all of these meanings behind what are alternative algorithms for multiplication and division and partial products and all these neat things I’m learning in class. I’m going to show [them] was probably my first thought. And I kind of did that for a while… It was all right. I don’t know how well it caught on at first” (Tape 3, 28:15).

In the following year, Pearl’s role changed to full time mathematics specialist, supporting several elementary schools and a middle school. At this time, she had opportunities to spend more time in teachers’ classes. “Honestly, it was when I actually went in and did the lessons for them that it really kind of took off. I think because it took the fear out of them. It was as if it bombs, it’s because Pearl was there. It kind of took it off them” (Tape 3, 28:15). Another aspect of her role was to provide professional development outside of regular school hours. “We had responsibilities too where we had to do a certain amount of professional development out of school for teachers as well. So that was a big part of our job. Now, about that time we had just adopted a [reform based text] so a lot of our professional learning we did after school was geared towards how does this series work, how is this different from a normal basal textbook that you’re used to, how are you going to shift your thinking?”

(Tape 3, 28:48). A typical day for Pearl might include time to prepare, planning with grade level teams, observing teaching, modeling teaching, communicating with administration, and researching and gathering teaching and testing materials (Pearl, Weekly Agenda, May 11-15, 2009). Furthermore, many days included leading system-wide professional development, either during the school hours, or after the regular day. In the 2008-2009 school year, these sessions focused on curriculum, specific mathematics content, pedagogy, and included activities planned for parent education. (See Figure 6.) Reflecting on this time, Pearl considered her role to be that of helping teachers to understand mathematics, and trying to get teachers to adapt beliefs consistent with reform mathematics in order to change how they approached instruction.

Figure 5: Pearl's record of staff development offerings, 2008-2009.

Date	Time	Topic	Number in Attendance
6/16-6/18	8:00-1:00	Problem Solving: Questions for Students and Teachers to think about 4-9 DWPD	18
9/18/2008	4:15-6:15	Focusing on Curriculum: Extensions and Accelerations on the 5th grade map	6
10/9/2008	4:15-6:15	Focusing on Curriculum: Extensions and Accelerations on the 5th grade map	1
10/13/2008	8:30-3:30	Supporting student Needs in Math: Integrating math and technology	30
11/04/2008	9:00-12:00	Math center workshops for teachers/choose your own professional development	10
11/18/2008	6:00-8:00	Fall Curriculum Night-Math Vocabulary games to do at Home	45
12/11/2008	11:00-12:00	Strategies/resources to improve student learning (Boom cans to reach all grade levels)	30
2/10/2009	4:15-6:15	Focusing on Curriculum: Extensions and Accelerations on the 5th grade map	0
2/19/2009	6:30-7:30	Title I workshop Math games to reinforce topics at home	15
2/23/2009	4:15-6:15	Calculators in the Classroom 3-5	4
2/26/2009	4:00-5:00	Faculty Meeting-ideas for Curriculum Night	5
3/16/2009	4:15-6:15	Calculators in the Classroom K-2	12
3/19/2009	4:00-5:00	Faculty Meeting (practice math games that are being demonstrated curriculum night)	5
3/24/2009	6:00-8:00	School A Math/Reading Curriculum Night	20
3/30/2009	6:00-8:00	Math/Technology Night	@30
4/3/2009	10:00-11:30	Math remediation activities for parents	2
4/27/2009	4:15-6:15	Geometry for 5th grade Teachers	4
TBD	4:15-6:15	Algebra for 5th grade Teachers	6
6/16-6/17	8:00-4:00	Rational Numbers DWPD	TBD

Pearl recalled a time when she first felt as if she was truly a mathematics specialist, having an effect on another teacher's mathematical understanding and beliefs. "I was using base ten blocks to show multiplying numbers and I went into a special ed. classroom to do it, a self-contained class. The teacher was not drinking the juice, he was kind of stuck in his way and firmly believed that special ed. kids needed very procedural step -by-step, because they were not going to remember the methods with tools. His kids loved it and did so well, and he was irritated because he was like these kids don't know anything and you come in and all of a sudden they know it all and they can do it all. And I had a conversation with him and said they probably did know how to do it before. I said they just needed to be able to do it another way. They were able to draw ten rods and hundred blocks to make these pictures. Towards the tail end of the year he was pulling some of his kids as a group to test them and some of them drew tens and ones on scratch paper to solve the problem. And he came to me and he's like, it worked, I'm a believer. And he just wanted to know everything" (Tape 3, 51:33).

After five years working as a mathematics specialist, Pearl's division underwent some changes that altered the role of the specialists. A new superintendent was hired who had a different vision for how mathematics specialists would be deployed in the school district, and at the same time the position of district wide supervisor for mathematics (and all content areas) was abolished. At this point, Pearl became a *secondary mathematics liaison*, meaning she continued to do mathematics specialist work in schools, such as observing teachers, modeling lessons, developing mathematical understanding, and providing districtwide staff development, but she also began to take on some system wide administrative roles, along with other

mathematics specialists in the division. A meeting from September 2013 (See Figure 7) listed some of the roles the mathematics specialist assumed.

Review of Math Supervisors former job duties: **{{How will these be accomplished now?}}**

- SOL resource teachers
- algebra readiness grant (only for 7th and 8th graders - no more than 10/class)
- Middle School Teacher Core - school divisions apply to the state to get a stipend for teachers ($10,000 - first year // $5,000 - following years) -- responsibilities have been reworked -- must be certified in algebra to be in this position .Some responsibilities include, doing 3 parent nights (one of which is the 24 tournament), presenting to staff. ---- concerns -- low parent turnout for parent math nights
- Curriculum guides and pacing maps
- summer school
- textbook adoption
- Lenses on Learning Training
- Math for All training (could have been accomplished in less time - too much time out of the building)
- _____-on-Target - We can not find it anymore from the intranet. The intranet home page has been changed. We are still concerned about having 3rd, 4th, and 5th grade _____-on-Target updated correctly
- Math courses for credit - they want to overhaul the course description book for Middle and High school (coming up --- Friday, 9/20)
- Liaison duties regarding VA DOE stuff
- Organizations to keep in contact with (networking):
    - VCMS
    - VCU
    - UVA
    - UMW
    - Radford
    - Math and Science Innovation center
    - VCTM
    - RRATM
- Software Contracts (Moby Math, SMI, Explore Learning…) {{We talked about how some teachers use Sumdog.com because it's free, fun, and focuses on basic facts}}

Figure 6: Excerpt from Mathematics Specialist Meeting, listing administrative duties that need to be continued and assumed by the Mathematics Specialists.

One of these roles was as representative of the division at statewide coordinator meetings and Department of Education meetings. These meetings seem to contribute to part of Pearl's identity, wherein she sees herself as a system wide leader, recognized by parties outside of her district: "I'm more in an official capacity."

Pearl had always felt supported by her district supervisor. When the supervisor left there was a gap. "I had to grow when _____ left. Here was this person who kind of fought our battles for us, who dealt with the politics of things for us, who no longer was above us and we (the mathematics specialists) were on our own. We had to deal with the politics of some stuff. I had to sit in meetings with the superintendent, I had never had to have a conversation with our superintendent before. And now I'm having to fight for math myself and it made me have to grow more. I had to definitely have my ducks in a row because I'm having to go to the superintendent and fight for why I don't think every kid in eighth grade needs to take algebra. I had to start going to conferences--- I was the connection from the State and all that is new (Tape 30, 56:50).

Pearl continued. "One thing that our assistant superintendent kept telling us is you guys haven't been able to grow and have faith in yourselves all this time you have been supported by _____. It was true, we never thought we can run this ourselves, and we did! We stepped up to the plate. We created our own agendas. We figured out what we felt like was our own professional learning we needed to take part in" (Tape 3, 56:50).

"I'm now seen as the lead secondary teacher [for mathematics]. I met with a teacher who said she had an idea that eighth grade needs to meet with the high school algebra teachers and work on vertical articulation so that the high school has a better idea of what's been taught at the middle school. The teacher said to me 'I'm telling

you this because I know you can go and get things done for me. And I'm like, wow, nobody has ever seen me as the person in the division who can go and make this happen!" (Tape 3, 1:00:16).

While Pearl sees herself as a leader in the school division, she is also conflicted about her role. Pearl notes that the placement of mathematics specialist in schools was, and still is, determined by school need based on SOL test results. "We went to the buildings that were the weakest in SOL scores and then we left when they got better. One of my first buildings I had to leave because they were doing so well. So our placement in schools is purely based on data. And that's not really what mathematics specialists are about. We are about getting teachers and students to see math in a different way, and never do we mention I'm going to show you this other way to do multiplication because I want you to get a better grade on a test" (Tape 3, 42:43).

Pearl is quick to point out that just because a school or teacher has high test scores the instruction is not necessarily good or of the type and quality hoped for my mathematics specialists. "We've got some teachers who still need huge philosophical help who get fabulous test scores. And there are a lot of teachers who are resistant, but won't change and are resistant to change because they don't see the need. So we shifted some of our gears and started working with administrations and changing their thoughts. We did Lenses on Learning [a course designed to educate administrators about reform based mathematics instruction], some of them have gone to a principal's institute, so changing their thinking kind of helped them go back to their buildings and say I shouldn't be seeing that. That isn't necessarily what I should see--- I shouldn't see all the kids in rows, have you thought about doing this. So principals are changing the expectations in the building" (Tape 3, 45:38).

Last year Pearl adopted yet another mantle. She maintained her role as district mathematics specialist, and continued to take lead roles in guiding division mathematics. Artifacts she submitted for inspection include presentations she led focused on formative assessment, as well as agendas for mathematics team meetings she chaired. In addition, Pearl was based in a middle school with the title *Teaching and Learning Coach*. This school had been identified through state measures as struggling, and Pearl's job was to help turn the school around. Pearl's duties included improving mathematics instruction, but she had a larger responsibility for improving teaching practice in general. She helped struggling teachers with classroom management; she planned and wrote lessons for the seventh grade team. The sixth grade team was strong, and for them she was a consultant, finding resources, helping to analyze student work. Pearl worked with the eighth grade team on issues such as flexible grouping and differentiation (Tape 3, 34:33).

Pearl alluded to her consultative role in other aspects of her job. While she still leads professional development, she says "Not as much as I used to. A lot of that is embedded in the school day. Secondary is sharing best practices across the division, all the sixth grade teachers get together, all the seventh grade, the whole county come together and they do professional learning. They share student work, they create common formative assessments, and they analyze data. They invite me to come in or do something. If there is new information from the State, I can bring that. I give feedback" (Tape 3, 29:27).

When asked about forging relationships in a situation where she was placed in a school to make changes, Pearl acknowledged there was not a lot of time to do that. "It helps that I've been in the county for so long because your name gets around. And I already know some of the people in the building, I've worked with them and taught

with them. But what made it happen [that she could work with people in the new school] was the fact that we were in year two of being accredited with warning. So whatever Pearl says you have to do because right now we need to do whatever we can to come out of accredited with warning. Because I'm not in a building that is doing okay, everybody needed help. So that made [gaining access] easy for me' (Tape 3, 37:40).

Pearl had another insight related to the topic of building relationships with teachers in the school. "At _____ (where she was the previous year as a teaching and learning coach) the teaching turnover has a play in it too. I could have made all sorts of inroads there, but there are only three people coming back. It took at least three years in the school I was in for 6 years to see changes. So a school with high turnover…" (Tape 3, 50:44).

When Pearl was interviewed for this research, she was just about to begin yet another new position, in a new middle school, as instructional coordinator. In addition to this she was continuing as mathematics specialist and secondary mathematics liaison. When questioned about what she told people who asked her about her job, she replied "Job- embedded professional learning. We still get questions about what's a math specialist, we still get confused with reading specialists that pulls small groups. And in some buildings in other counties math specialists do still pull small groups. So we always try to explain ourselves as we are job embedded professionals for teachers, for admin, for parents and for students. And as instructional coordinator, still job embedded PD" (Tape 3 1:07:23).

Speaking about mathematics specialists, Pearl often uses the plural first person, and she speaks with pride about the group of specialists. "We do take a certain pride in ownership in how things are done. We--- the math specialists have a very

certain persona in our county and I would say it's a darn good one. We have taken ownership of the math specialist group, we take pride in it we have a good name" (Tape 3, 1:01:35). For Pearl that name means "Supportive. If you asked somebody to tell you about the math specialist in this county, they would say supportive: we are supportive in all factors, parent support, admin support, teacher support, student support. I just think support really encompasses it, whether it's content, pedagogical, belief"' (Tape 3, 1:03:24).

Rosamund's Case. Rosamund first worked as a mathematics specialist in Lovelace Public Schools, the same division where Cleo works. Part of the same NSF grant cohort, Rosamund began as a specialist a year before Cleo did. Before becoming a mathematics specialist, she had taught for ten years in kindergarten and first grade. As a military wife, this experience occurred in a number of locations around the country. Rosamund chose not to teach when her own children were young, so the ten years of experience were not in sequential years. At the time of her interview, Rosamund had worked for eight years as a specialist in LPS. After eight years, her position was to be shared between two schools, and instead of continuing under those conditions, Rosamund resigned her post, and took another job as a mathematics specialist in neighboring Agnesi Public Schools (APS), a division of 11,200 students that is mostly rural, but is also a bedroom community for the nation's capital. She worked there for one year, left that position, considered working in GPS (where Pearl works) but instead consulted with various divisions for a year. She has now been re-hired by LPS, again as a mathematics specialist, and will start her new post a few weeks after this interview took place. Her experiences in different divisions offer interesting insights into the development of professional identity.

Rosamund, like Pearl, recalls doing well in high school mathematics. However, she attributes much of her to success to good memorization skills, and not necessarily to thorough understanding. "I remember going through high school and I had, I guess at the time, a good memory. So when they told you the steps or procedure I could remember. I could follow the steps, get the right answer, but it was always those word problems where you'd have to reason that I got stuck. Because I was waiting for them to tell me, what do you want me to do first?" (Tape 4, 8:32). Because she did well in high school mathematics, her only mathematical requirements in college in pursuit of her degree in elementary education were mathematics education courses, and these were focused on pedagogy over content.

Interestingly, Rosamund has a role model in her life whom she recognizes as a different type of mathematical thinker from herself. "I couldn't apply the formulas or procedures that I learned, but my father, he naturally thought about patterns that way. I remember we were getting ready to buy a house and he was saying something about it going to be six percent interest so figure out six percent. I said, 'I don't have paper and pencil.' He said, 'Well think about what 10 percent would be, take half of that and if you know ten percent you can figure out one percent.' Those are just things that made sense for him. He did that naturally in his head" (Tape 4, 09:04). Memories of her father thinking mathematically came back to her when she began taking courses to become a mathematics specialist. "When I started taking classes I thought well that's what he did all along. He took what he knew and used that to solve problems" (Tape 4, 09:34).

Rosamund believes when she first taught mathematics she was very procedural in her approach. "It was probably just something to launch a lesson, what we were going to think about. Then it was probably more procedural, traditional. I

showed them certain things and then they practiced it" (Tape 4, 07:17). Rosamund also recalls a lack of emphasis on math. "I just remember there wasn't a lot of math. I mean, I thought about that when I entered the master's program to get the math specialist's endorsement, there wasn't really a lot to tell about math experience. There wasn't a big emphasis when I taught elementary. I guess most elementary teachers did elementary because they didn't want to think about mathematics" (Tape 4, 07:38).

While Rosamund expressed a lack of interest in her mathematics teaching early on, she still became a mathematics specialist. Asked about her motivation, she responded, "Well, I remember being in a first grade classroom, and having the basal text. I think it was fractions. And when you start going through that kind of rote procedural thing, my top three kids were like, 'We're done. What do you want us to do now?' The middle kids, it was probably good, they were kind of on track, but then that bottom group just said 'I don't get it.' I felt like it wasn't working. So I started taking some of the classes LPS was offering. And it started showing me a whole new way of thinking about how kids learn math and my job is more of a facilitator, rather than you know, this I show you do it, practice these, come back and check your work" (Tape 4, 11:22).

Rosamund applied what she was learning in her own classroom. "And I started trying some of the things that I had learned in the professional development, I was really amazed at what the kids could do and what they were saying to me about how they understood things. I was like, oh, I didn't even think about that way or there was a lot more going on than I realized they were capable of doing. Even in first grade, they were seven, you know, seven. It was amazing" (Tape 4, 11:30).

For Rosamund, seeing the change in how children approached mathematics was a big motivation to continue to develop. "Like when we started doing some of the

math stations and the kids had a certain task at each -- I had one little boy that said, ‘Well when are we going to be doing math?’ I said, ‘Well, we're doing it.’ He said, ‘This can't be math because this is -- I like this.’ So their attitude towards math changed.

Rosamund noticed attitudes changing, but she also noticed children thinking in ways that research suggested they would, and interacting in ways that research indicated.” I remember that we were doing something with hundreds day, but we had two digit numbers. You know, the old way you just, you know, you do all the ones first and then you carry over, but I didn't tell -- I said, ‘Well, how, you know, if we have 12 of these, how would we even go about knowing how many that is all together?’ They got some blocks, they grouped amounts, they helped each other. They naturally didn't even look at the ones. They went for the tens because they could put the tens together and kind of get a rough idea. And all the research and reading I've done and that we were working on, they were doing what the research said they would do. I mean, they didn't look at -- hmm, that's 20 and then 10 more that would make -- so it just made me want to learn more” (Tape 4, 12:07).

Rosamund reflects on how the mathematics specialist courses made her think differently about working with children and adults. “And I think the geometry, there was one day where I was really frustrated and I think I was up at the smart board and _____ was trying to get me to say well just think about and I couldn't see it. And I said I just -- I don't see it yet. So -- but I eventually got it, but at first I was like I don't get how this is going to -- I don't remember what it was exactly, but I was having a hard time with one of the geometry tasks that we were working on. It made me think about -- you know, it does make you think about okay, well if I'm the learner now, how does this apply when I'm the instructor versus the learner? Which is still, I think,

in the math specialist or the math coaching job is still what you want to get teachers to see and they want to have the kids get it quickly, but it doesn't always happen quickly, it takes time and they are always rushed for time and they just want to tell them" (Tape 4, 17:24).

When Rosamund began as a mathematics specialist, she started to grapple with what her new professional identity was, and what it meant to her to be a mathematics specialist. From the time she first began working as a mathematics specialist, she has referred to herself as a coach. "Sometimes instead of math specialist, I say math coach. So I talk about I help teachers with their math instruction. So my job is to coach other teachers instructing students about different ways they can learn mathematics. Because specialist goes back to what a lot of people still think of it when they think about a reading specialist, they think about it as more working with kids and pulling them out of the classroom rather than working with teachers on planning lessons and pushing into the classroom. The first couple of years, I probably wasn't really being a coach at that time because I was figuring it out. I was more go in and would teach the math lesson and did more modeling rather than coaching. So I think the coaching piece has evolved to a greater portion of the job than when we first started" (Tape 4, 02:19).

Rosamund was a math specialist at a fairly high performing school. She had completed two years of training to be a mathematics specialist in one school, and then moved. She describes the transition to full time mathematics specialist as "weird because as a classroom teacher you're busy every moment and everything is -- where there's more flexibility in a math specialist because you're not with students constantly, you're taking them somewhere so that first I was like, "Hmm, what shall I do?" So it's -- yeah and I kind of sometimes felt guilty when I was in my office and I

was working on data or something because I wasn't with kids or teaching. Does that make sense? So that was a real learning process the first probably two years or more and working on those first two years getting into people's classrooms and building those relationships took me a while" (Tape 4, 47:12).

Rosamund was challenged by teachers who felt they were doing a good job with mathematics instruction, and had standardized tests scores to show it. "My school had very strong math scores, so they weren't one of the schools that was like Title I or kids were struggling, their scores looked good. So my biggest challenge was well our scores are good so why do we need to change what we're doing, whereas some of the other math specialist were greeted more with, oh we need your help because we're not doing so well. So mine was kind of a different type of problem" (Tape 4, 43:16).

It turns out LPS was developing performance tasks, and the high achieving children were having difficulties. "They were really struggling with those performance tasks, when kids had a problem to solve, they didn't know what to do. Teachers said, 'I don't know how to get started, I don't know what to do', so I kind of took that as my in. And at that time they were also starting the whole school improvement plan and so they were focusing on problem solving and I was on that team so I forgot how it came up but we started talking about one of our goals for that school was going to be inquiry based learning or problem based learning. So when we decided to go that way to kind of help some of those strong kids about how to think through things, that's where I kind of pushed the math piece in, so that was a little bit of my way in" (Tape 4, 44:16).

Rosamund describes her role of a coach as dependent on her relationship with the teacher with whom she is working. "It depends, too, on the relationship you've

built with the teacher, I think it goes back to that. So co-teaching with a fourth grade teacher, she was really nervous about spending more time on a unit than she usually did and I think it was the -- I'm going to say it was fraction decimals -- and I said, you know, if we spend the time here, really getting stuck in with the fractions, then there's less time we'll need to connect it to the decimals. I think we had worked up to that point during the year and I'd worked with her enough that she -- we had that relationship so she felt a little bit more comfortable with me and that trust factor of okay, I'll give it a try" (Tape 4, 18:56).

Rosamund notes that her role as a coach also changes with the grade level of the teacher she works with, implying a certain level of confidence from her own working in earlier grades. "Even though my background was primary, I still am very -- I feel more comfortable with K, 1, 2, maybe third, but get to fourth and fifth, I still -- some of those veteran fourth and fifth grade teachers, I rely on them because even though I've co-taught that -- those grades -- initially they were in those grade levels a lot longer than I was. So I try to a little bit infuse some of that thinking because I don't want to upset -- it's not like, okay, you're not doing it -- I don't ever want to say you're not doing it the way you should, I just want to slowly infuse well, did you ever think about maybe trying this way and see what the kids will do. And it's the same with the kids in the classroom when they come to the meetings, I usually will say so what do you think -- how do you think kids will react to this?" (Tape 4, 23:57).

Furthermore, Rosamund recognizes that how she works with teachers is dependent on what she knows about them as learners. "I give them a math problem, so what are you thinking about this? Some of them are very comfortable, some of them are not. It's about knowing where they are too, just like you were the teacher with the kids" (Tape 4, 24:55).

Rosamund has a strong sense of purpose. “My role as a coach or -- I guess I want them to experience kind of what I experienced when I went through some of the math specialist courses because it changed my whole philosophy and thinking about how to go about teaching mathematics so that it makes sense. Because even if -- not all math makes sense, but if I know this part of it then that's one piece of the puzzle. So if I get faced with a new problem, I can take what I know and maybe start to solve and figure it out. So I kind of want them to go through that experience and I want them to listen to what kids are saying and thinking and know where their kids are in their understanding of math so that they can figure out what they need to do next” (Tape 4, 22:24). This sense of purpose is partially derived from the support she received from the division mathematics supervisor in LPS. “There was always a county wide focus and then even though there might be little tweaks or different things that schools did differently, there was still kind of a county wide vision. So -- and then we had a mathematics supervisor -- , the role was very well-defined and the supervisor came up to the school and said, ‘This is the role of what we envision the math specialist to be,’ and talked with the principals that initially were getting those specialists. So the groundwork for that was laid, I just had to kind of continue to say this is the role that I was -- this is the vision, this is the role. I’m supposed to help teachers learn best practices so all children ca learn. And in LPS we've tried very hard so that the role looked the same in all the schools, so we kind of were very purposeful in sticking to that” (Tape 4, 28:10).

Rosamund’s identity was challenged in several ways when she moved to APS. While LPS had a strong, division wide vision for the role of mathematics specialist, in APS Rosamund states that the vision of mathematics specialist was determined at school level. “At the school where I worked, I think it had been more of the math

specialists pulled out the kids who weren't doing so well in math and took them to a room and just worked on them. But the year before I got there, this math specialist had retired and I was taking her position. The county seemed -- this is just my interpretation, was moving away from, we don't want to pull kids out, we wanted to be more of like pushed in. But when I got in to the position, I found out when they went from pulling out to pushing in, it was more of she went in and modeled a lesson but there wasn't a collaboration with the teachers. It was more like I don't have to teach math for that day because the math specialist will come in and do a lesson for me" (Tape 4: 31:33).

When asked how these different expectations affected her identity, Rosamund replied, "I remember coming home and said to my husband, "I don't even know why they want a math specialist," because I felt like I was just -- you know kind of how the kids go to art, music, P.E., it was just like -- so there was a master schedule, so I went to 4th grade first and I had a lesson and I would go to one classroom and then Tuesday, go the next 4th grade all week long and then the next week I would do a new lesson kind of like a round -- I called it Round Robin. So that was that year I was there. My principal there was very understanding about where I thought it should go and she was I think -- she was I believe wanted to go that way too but she also was kind of – this was her second year at that building so she said it's going to be baby steps" (Tape 4, 33:39).

In some ways it seems as if Rosamund was prepared for this different vision of mathematics specialists, though perhaps she was not clear how to handle it. "Even when I interviewed, we talked about the different ways a coach works but the teachers were not familiar with co-teaching. They still thought co-teaching was one person teaches, one person kind of drifts, but there's many more ways you can co-teach and

then also the planning part, like well if we're going to co-teach we need to plan together and then maybe after the lesson, talk about it together. And I felt like I kept saying that but I felt like -- I did also say to my husband I felt like am I speaking a different language?" (Tape 4, 36:15).

In APS, the challenge of gaining access to classrooms was different to that of her previous job in LPS. Because the position of mathematics specialist was not understood in this new school as embedded CPD, "it didn't take me a while [to get into classroom] because they wanted me to come in and do the lesson but it was I was in there doing a lesson but it was different. It wasn't the same. They just wanted me to come and teach the math for a day" (Tape 4, 47:12). Despite easy access to the classrooms, Rosamund still had to push her agenda, which required a focus on building relationships. "Once I started doing -- I tried to keep moving it to well, where do you want me to go next because I'm just not going to pick something, or what did you like about -- what do you feel about the lesson we did last time? What do we need to build on? So I tried to slowly get them more involved on what they thought would be -- and then when I did do a lesson, I made the activity or the props or whatever manipulatives I gave to them which I guess people haven't done in the past" (Tape 4, 48:47).

In her year with APS, Rosamund did make some progress. She was able to bring about some change in the teachers' expectations of what to expect of her as a mathematics specialist. "There was some progress in the kindergarten grade. They were trying to set up some of those Kathy Richardson centers, because they came to me and said, you know how we have pals for reading, we really need something for math. I was like, this is my in. So I put together an assessment of different skills that went with the rest. I had done something this with LPS and I got the blessing to kind

of share and made them -- their kids and got them started, but I said, you know if I only come in on Monday, by the time I come back, that's not really helping you see what it looks like and the kids have forgotten the introduction to the station. So I was able to go two days and two days and they were agreeable to that" (Tape 4, 36:30).

Rosamund also began to establish a coaching routine with fourth grade. "I made some inroads there and they had their planning right after math time. I would always send a lesson plan of what -- they'll say to me, 'Do whatever you want. Do number sense or some word problems.' But I want to do something that fits in with what the kids are learning, what you're working on. So right after, I would usually be able to push them to at least talk for 15 minutes or something about what they were doing and how I could dovetail something in so it was kind of meshing with what they wanted to work on and then we would talk right after. So the schedule allowed for that within that group. So that was working" (Tape 4, 37:32).

Not all the fourth grades teachers were amenable to coaching in that year, but Rosamund sensed some breaking down of the armor. "I did have one fourth grade teacher-- because I was trying to do co-teaching with somebody and I did a little bit with this 4th grade teacher. She said, 'Well I feel like I'm taking all of your time, the other teachers want you to come in as well', but she pulled me aside once, she said, 'You know the co-teaching thing is hard because teachers don't feel comfortable letting someone else watching them teach,' which is hard, I know it's hard because it was in the beginning hard for me, it takes time, so she kind of let me in a little bit on that" (Tape 4, 1:05:05)

However, with the second grade there was more resistance. "And then second grade was -- I was so excited because they said, 'Oh our planning time, will you come and plan with us tomorrow,' so I thought, finally, because they were kind of the

resistant, difficult group. I was so excited, so when I got there, I thought finally we're going to plan what they want me to do and I got there and they weren't all there yet and the grade level chair said, 'So we want you to have two or three kids from each class that just really need extra help with math. So at math time, we just want you to take those kids out of each of the classrooms and teach them.' That was the planning" (Tape 4, 38:10).

Rosamund met the request of the second grade with a firm no, but also with offers of other ways she could work with them. "But I did say I can't do that. I said I know the math supervisor when I interviewed with her and the principal, that was not their vision, it's so that I could push in and maybe pull the group to the side during your lesson or I can pull out during their IE, Intervention Enrichment time, but I can't continually pull them out every day out of their math time, they need to be with the group and hear the conversation. So that was a continued discussion. The second grade said 'Well, the assistant principal said it was fine with it.' It was kind of how you get those dynamics within schools. So I said, "Well that's strange because when I talked with them, I got a different feeling altogether." So then this principal says that the teachers and the assistant principal and I should all meet together. So we kind of shifted into -- I pushed in and co-taught with -- kind of co-taught with one teacher and then what they did was they sent those kids that need extra help to our room that I was co-teaching in. But we kind of limited the number of kids that were moving" (Tape 4, 39:01).

Rosamund is proud of how she handled the conflict with the second grade teachers. She claims to be not very outgoing, a little bit shy and reserved, and sometimes lacking confidence. So when the second grade teachers made their request, with statements like "well, she just doesn't understand our instructional strategies or

what's best for our kids" Rosamund held firm with her beliefs about what her role was and the limits to how she could stretch that role. That firmness she says, "That's something that I continue to work on" (Tape 4, 58:36).

Another challenge Rosamund felt within APS was that of maintaining her own personal growth. "In LPS we got to go to different things to help us stay on top of what was new in mathematics instruction. Conferences, assessments, even when we would do the graduate classes for teachers and we were the instructors organizing all that and keeping that going, that was huge and just keeping current on materials and resources, whereas when I went to other districts, they didn't have that math leadership. We also met as a team, at least probably once a month with an organized agenda that everybody was there and certain topics, we had to cover about what was going on in the county, whereas in the other counties they don't have that same level of focus or vision. It seems kind of disconnected. In APS, there also were -- not the resources or funding to -- I didn't go to any conferences. I felt like I was sharing what I had done in LPS but I didn't really grow any. I mean wherever I go, I try to think, okay, well, so what did I learn that I could pull away from this experience? But I don't think I stayed very current there because I was sharing with them what I had learned and used" (Tape 4, 29:55).

Rosamund's work outside of the school and classroom, both developing herself and other teachers, is important for how she perceives her professional identity. She developed and taught a course for the University of Virginia, delivered to teachers in LPS. "We created the early learning math class to focus on pre-K through second grade because what we found with the other classes, some of those primary teachers were hesitant to take it because they thought their math wasn't as strong as maybe the intermediate level there. So just putting that class together I

think helped me grow, understanding the trajectory of the skills kids go through and then also working with the teachers. And I liked doing that, we created the class together and every year we would tweak it, 'Oh let's change this just a bit' and reading the teachers' journals. But our class, once it went out, we typically fill up in 24 hours so that made me feel good that people once we initially presented the class, it was a very popular class, so it made me feel like we were doing a good job because people wanted to take it and they were talking about it. So, that helped me feel like I was doing a pretty good job' (Tape 4, 50:58).

When asked when she first remembers feeling like she was a mathematics specialist, Rosamund responded, "I mean the first two years I probably wouldn't have said -- I probably would have said I'm a math specialist just because that was my title but I didn't really feel like there was a math specialist (Tape 4, 59:57). But then last year "This one kindergarten teacher said -- I forgot where- she goes 'But you just know this like the back of your hand,' she said, 'You just talk like that all the time,' where if I'm doing a lesson, I don't realize that I'm talking like with certain questioning or asking kids, but she said, "That's just how you teach math, that's just you." So that made me feel like I was a math specialist. And I didn't realize that -- that was the first time I thought she thought of me like that" (Tape 41:03:17)

Rosamund continued, "I know when I did [feel like a mathematics specialist] -- this might be later but when I did go to that Deborah Ball event and after the lesson we had lunch and then part of the work with some of the graduate systems, we viewed her lesson and that was the class work part. And there was another participant from -- I want to say Massachusetts, somewhere where -- I've gone to Mt. Holyoke and there's a lot of math coaches up in Massachusetts and we were talking, I said, oh, I've heard about all the great things going on up in Massachusetts and the work math

coaches I've done, and she said, "But I heard Virginia really has some strong --" so they had heard about us and I think there I did feel like a math specialist because certain things during that workshop when I was asked to share -- you know when you're working collaboratively and you're sharing ideas, I just felt like they were respecting what I had to say and I guess that made me feel like I really was a math specialist and I could answer some -- you know when you first start, it's like, 'Oh, can I answer everybody's questions,' but when I have a way to answer people's questions or explain in a different way, I guess that made me feel more like I was a math specialist" (Tape 41:00:14).

Ouida's Case. Ouida is currently in her first year working as an elementary school-based mathematics specialist in Hopper Public Schools in Virginia. Hopper Public Schools serves approximately 4,500 students in a city with a population of 45,000. Immediately prior to accepting the job with HPS, Ouida worked in a New England division for three years as a division-wide mathematics specialist, and before that she had taught for three years in an inner city school in the Greater Metropolitan New York area. Before moving to New England, Ouida taught in HPS.

Ouida has a Bachelor of Arts in English with an education minor, in addition to her Masters in Elementary Education earned with her mathematics specialist coursework. Her undergraduate university did not offer an education major and the education courses she took as an undergraduate focused on the philosophy of education, providing no teaching experience. After her graduation, Ouida worked for a year for an education non-profit whose aim was developing reading volunteers in schools. After a year, she moved to Hopper, and two days before school started. "It was a reading specialist so I was apparently the reading specialist at _____

School with no teaching background. I got hired with no actual education background" (Tape 6, 07:38)

Ouida's first year teaching was stressful, and a steep learning curve. Asked if she had doubts, she replied, "Oh yeah, I didn't know what I was doing. I was reading the basal manual to learn how to put a Venn diagram on the board. It was miserable, it's so bad. These poor kids. I was supposed to be co-teaching the classes I was doing and one of them sort of fell through, so I ended up just teaching my own like small group of kids and they were just like throwing me -- I was working with -- that first year I taught math to the ESL kids because the ESL teacher is part-time and I found my mom's old Van de Walle book and just started going through that and they were just like no English, never been at a school. So I did a lot of stuff for that, really enjoyed doing that. And the way that _____ School is set up with everyone teaches reading and then math, science, history, I knew that if I wanted to move into a regular job, I was going to have to pick one of those and math was definitely what I was more willing to do" (Tape 6, 08:16).

Ouida attended classes at a local college to obtain a teaching certificate. With license in hand, the first regular teaching position that opened up was a history position, and then the next year she began teaching 5th grade mathematics. While a history teacher she had begun to take mathematics specialist courses that were being offered for teachers in HPS, and paid for by the school system as well. After taking three mathematics specialists courses she was encouraged by her supervisor to pursue her master's degree and mathematics specialist endorsement, so she officially enrolled in the mathematics specialist's program.

The first course Ouida took was *Numbers and Number Sense.* She described her reactions to the mathematics content courses. "I had never taught math so I didn't

have any experience other than my own very straightforward procedural learning that I had but I had always understood those connections and so seeing that there was a way to teach it that way, which was fun, I liked doing that work. -- I really think those classes are all really engaging and the different ways of teaching and ways of including more student focused learning, all that seemed like the way that teaching should be" (Tape 6, 11:25).Several years later Ouida's beliefs that it is important for children to be taught in a way that the make connections became more entrenched. For her practicum, Ouida planned a unit for her fifth grade class that aimed to develop conceptual understanding of double digit multiplication. While she met with some success, she felt that children struggle with exploring the concepts because for many years they had taught procedurally. Her response to the leadership courses was somewhat different. 'Yeah, like the first leadership one, the initial part of that, I was like, 'What?' I don't know if -- looking at like the five strands and it just all seemed slow and now I realize I'm really glad that I have all of that background and realized that a lot of that was seminal stuff that I needed to know but I was sad not to be doing math problems anymore" (Tape 6, 11:50).

Ouida continued to reflect on the usefulness of the coursework. "I have used a lot of work from Pittsburgh, the cognitively rigorous tasks and that along with the series of questions, content focused coaching, just having something to fall back on that -- like very clearly to find what I was supposed to be doing because no one else was telling me what I was supposed to do so I needed somewhere to go and realize that stuff is sort of like it, like that's the main place to go seemingly so far as I could find. [The system in New England where Ouida worked] are also partners with University of Pittsburgh so it aligns with a lot of the work that we're doing there which has been nice" (Tape 6, 14:55).

Ouida recognizes that the mathematics specialist program provided a lot of opportunities to learn about how a coach, working in one school, can bring about change over time. However, in her role as division wide mathematics specialist, she has had to rely on work she had done and seen modeled in a school where she taught in New England. “My work at the turnaround school [in New England], we partnered with Expeditionary Learning and they did a lot of -- we had a very strong turnaround leader, really what they call them, school developer or whatever and the amount of -- the skill with which they led professional developments and just tools for leading groups of people, I was able to fall back on a lot of those” (Tape 6, 16:08).

Ouida had to very much define her role as division wide mathematics specialist. To begin with, it was not the role she expected and had trained for: in other words, it was not a school- based specialist. “Well during the interview, when my boss asked me, ‘Did you read the job description?’ because it I thought it was definitely was more of a math coach job. So then she printed it off for me and I read it and became aware that it was more of a coordinator position and so I think I made it -- it would turn into what it is but knew that I also couldn't pass it up. I think I've been able to -- she's way too busy so it's just been left up to me to sort of figure out what on earth I'm doing and recognizing that no one else knows nearly -- as much as I think sometimes I don't know anything, no one else knows anything more” (Tape 6, 21:05). Ouida spent much of the first year and a half trying to stay a step ahead of her boss, trying to figure out her intentions. While this was sometimes tricky, it was also a confidence builder. Ouida noted, “She trusts, me. I’ve proven my worth” (Personal correspondence, May 2014).

Ouida’s experiences as division wide mathematics coordinator are not vastly different from those of classroom based mathematic specialists. For instance, in many

ways she was a resource for the teachers, taking care of many time consuming or tedious tasks for them. During her first year Ouida spent a lot of time and effort getting to know the Common Core School Standards for Mathematics [CCSSM], and helping teachers become familiar with them as well. “The first year they were transitioning to standards so my boss needs someone to help rewrite the curriculum documents, so I spent a lot of time figuring out what a curriculum document looks like and her vision of what a curriculum document is and pulling together a group of teachers who didn't have enough time to do it which ended up meaning that I just spent a lot of time pulling that together for each grade and then rolling that out to staff (Tape 6, 01:59).

The following year, because the system had decided not to adopt a new text or resource to support the curriculum, Ouida helped the teachers by planning units and pulling together appropriate materials for teaching. “Last year we decided we weren't going to adopt a new resource so then everyone -- but Everyday Math which we had and Connected Math didn't sufficiently meet the standards around -- just didn't have anything to use which to me is like okay, well, we have a curriculum document. I put in units like we figure out but we're not keen on that. And so trying to support people just to use whatever we could find to muddle through the year, materials to help with teaching, and then also throughout the year looking to go through an adoption process for any resource” (Tape 6, 2:45).

Like other participants in this study, Ouida had to develop relationships and build trust. With teachers in the division, this has been accomplished largely through being supportive. Though she was administrative, she did not have an evaluative role, and so teachers seem fairly comfortable working with her. “I've always been someone they turned to for, oh these parents are asking for resources, I can answer questions

and I've never had any sort of evaluative role and they all know the role of their reading coaches and so used to relying on in-house staff developer. And I've led after-school professional developments and we've worked through a lot of what's a good task, how do you maintain rigor and done a lot of that work and just what are the standards so they all know me through all those interactions but much more so from a central office side of things" (Tape 6, 4:15).

Building trust and a working relationship with teachers was not always easy. One challenge was that Ouida's role was not explicated clearly by the central administration, and teachers did not know what to expect of Ouida. The division had reading specialists who functioned as school embedded support, much the like role Ouida herself had envisioned as a mathematics specialist. But her role was more curriculum oriented: "My job was not to be a math coach. I'm not in the schools as a coach, but that was never established clearly with the middle school, by administration. They had problems, so I'd go to meetings, but my role wasn't to lead the meetings, it was to be helpful input, but without being there all the time, I felt limited in what I could do. It always felt strained because it was unclear." (Tape 6, 36:03)

As well as building relationships with teachers Ouida also had to build trust with the division principals while beginning to establish a division wide approach to improve mathematics. Negotiating these relationships was a challenge, in part because of a lack of guidance from the division, and also in part because of Ouida's initial lack of confidence in her role. It was largely left up to Ouida to facilitate these relationships, without a lot of introduction from her boss. "It would have been helpful if my boss could have just helped to navigate and get people heading the same way -- I mean no one has time and so often the lack of moving forward is just a lack of being

able to get all the principals onboard, being able to work with a number of teachers to move something forward, so it's like constant miscommunication so I'm just trying to avoid those as often as possible and just trying to navigate when do I pipe up, I need to say something or push and so I think if she [her boss] had been a part of like spearheading some of that, it would be more -- I had to meet everyone, slowly develop those relationships and while I was also at the same time developing my own knowledge. So looking back on some of the first interactions I had, of course they -- and I knew while they were happening that I was just trying to fake it until you make it. I still am but at least know people now" (Tape 6, 22:54)

This sense of "fake it until you make it" was fairly common for Ouida in her first years. As division wide coordinator she works with the middle schools as well as elementary schools, and there have been challenges here. "There is some advanced math I was not super confident with. I wish we had [in the mathematics specialist program] gone into some more algebra and geometry, so they've gone beyond where we touched some on the eighth grade. So that and then going into the middle school classes is somewhat difficult to navigate and I think I'm finally like up to speed with everything but I still don't know, don't have a clear sense of the mathematical trajectory. When I give advice, I'm sort of fudging it. So, that has been frustrating in having to pretend" (Tape 6, 24:29).

Ouida described a certain lack of confidence in her own beliefs. "Insecurity yeah, I think it aired on the side initially of not -- well, I still don't know where the balance is of people have the questions and either leading them to an answer, telling them an answer which sometimes is all that they want and so I think I aired on always just giving them a bunch of information, which I think also is my own insecurity of I don't want to tell you, I might not be right. So there was a lack of confidence, like I'm

just spewing information at people because I don't know how to just get at the heart of what I need to do to move things forward" (Tape 6, 26:06)

Support and guidance for Ouida about what information to provide came from an unexpected place. While she is often not sure she can "tell" someone what to do or how to do it, CCSSM materials provide a reason for teachers to seek her help and advice. Referring to the CCSSM, Ouida says, "That's been a blessing; I'm afraid to go back to Virginia and not have the new standards to sort of push that, so it's been a nice -- like it's not me pushing this, this is what's here now and so that has been such a relief to things like that that are written to the standards and teachers don't know how to do it and so they definitely want to know and are eager for examples to understand how to move kids forward. And it starts younger, so that is a reasonable thing to ask a fourth grader to do a bit of mental math if they've developed enough number sense prior to that but just throwing that at people who haven't been doing that previously that doesn't work" (Tape 6, 19:37).

Through her work writing curriculum based on the CCSSM, Ouida also "had an abundant amount of time to learn the K-4 learning progression (Personal correspondence, October 2015). This process had the effect of increasing her sense of competence regarding the elementary curriculum; furthermore, the CCSSM further convince Ouida that developing conceptual understanding early is a meaningful goal to work towards. Ouida sees the assessment for the CCSSM as an advantage for her and motivating factor for teachers. She admits that there has been growth in the New England division. However, the lack of clarity surrounding Ouida's role means that teachers did not have a sense of accountability to her. When she asked teachers to try new activities or approaches, teachers could decide not to (though many did and increasingly showed flexible approaches to mathematics). But the CCSSM

assessments are different. “You can’t teach to those tests. You won’t be able to for long. They’re too weird and different and you just have to teach kids to be good math thinkers. So I think that is making people feel they need to teach differently and they need help” (Tape 6, 47:24)

Ouida’s confidence grew as her knowledge developed, but she also developed good analytical and research skills for addressing issues. Several such issues involved parents. The first of these issues centered on a decision that had been made regarding allowing children to be placed in Algebra in the eighth grade. The question was whether sixth grade children could enroll in algebra. The placement policy had been made before Ouida was in the coordinator role, but she had to find a way to support the policy. “There are just like a few things that parents would push that -- well for example on the algebra issue, they kept pushing, ‘Well what if kids are ready? What if kids are ready? You're saying that they can't be in it’ and we had said ‘Well if there are kids who are, well they'll join the eighth grade group’ and parents asked, ‘How are you planning to tell if they are ready?’ Okay, fair enough. So we made an assessment and gave it to the students who were finishing seventh, eighth grade accelerated math in their seventh grade year, moving into algebra and gave it to sixth grade students. And so thinking that if there's anyone in sixth grade who does as well some of these seventh grade students, sure, let's put them in algebra and it was just a content test because we had the problem solving, we had basic skills, like all those things were in place but just some of the content knowledge that's now in only seventh, eighth grade standards and it was -- so that at the very end of the year, 7th, 8th grade, most of them scored between 50 and 95 and the 6th graders, one girl scored a 70% and the rest were in the 30s and 40s or below that and just think, okay, this clearly like this is actually a correct decision, these kids have content, they need to learn even if they are strong

math students, there's still things that they need out of this course. And parents accepted that" (Tape 6, 31:36).

The second year Ouida was with the system, a decision was taken to go ahead and adopt a text the following year that would support the teachers with implementing the CCSSM. Parents wanted a particular series because it had been touted in the press. Ouida and her textbook committee had analyzed the series and it did not meet the requirements or needs of the division. Another fairly new series that did meet the needs of the division had little research to support its adoption, and little evidence of its effectiveness. Parents wanted to know how a decision was being made. "So eventually I ended up having to develop the series of questions, calling people around the country who have used it for its first year, talking to superintendents, talking to math coaches, getting their feedback and sort of like summarizing that for people and then they said, "Okay, why do other places, strong places use [the text Ouida had eliminated], why did we rule that out?" So I took the same questions, called a bunch of places and the difference in just the anecdotal stories from those two pools of people was just amazingly different and much more so in support of _____. And so those -- I definitely have learned the need that I like can't just have people trust what I'm saying that it requires some proof (Tape, 33:00).

Ouida was able to make some changes in the manner in which professional development was organized. During her first year professional development meetings occurred weekly after school, with grade levels rotating through the weeks. "I'd see all the kindergarten teachers one week, all the first grade teachers the next, so I'd see each grade level four or five times throughout the year" (Tape 6, 41:01)

Though the meetings were infrequent, Ouida said they were beneficial. "I mean it was an important step as they were transitioning to the new standards because

they needed to know how to read them, they needed to know what are the *practice standards,* So there was some basic information they just needed to receive and then we did a lot with developing -- like what is a rigorous task, developing task, how can we use some of the resources that I've identified to, let's all work together to develop task. Okay now you guys go back, share them and then we'll talk about how it went. But it's too spread out, like there's no accountability in doing that. There were at least conversations going on and it was a way for them to meet and see what the other schools were doing. But by the time they got there, they were 45-minute long sessions, so it always felt a little futile but better than nothing I guess. People definitely are left frustrated sometimes" (Tape 6 41:20).

By her third year, Ouida had convinced the schools to change their schedules to allow her more frequent access to each school and each grade. "Each elementary school had me scheduled to spend one day a week there and they have scheduled it so that the grade level math meetings happen on that day, so it was more frequently meeting with the teachers to help them work through the kinks of rolling out the new resource. So their meetings are throughout the day. So in between those windows, trying to get into classes and actually see what's going on, sharing what's going on in each school, so sort of helping that communication. And then from that, actually being there more often, knowing what are sort of some of the holdups, being able to then more effectively use those Wednesday afternoon professional developments to think about how they build, move the groups forward. So it's being around more and being able to share more of what people are doing with each other" (Tape 6, 46:30).

Throughout her three years in New England, Ouida maintained her own program of professional development. It was important for her to continue to gain knowledge and stay current with research and best practices. "I have been writing

questions with Smarter Balance and going through their training as they're working to develop items and what those tests are going to look like. So some of that has -- some of those interactions have been good interactions thinking about being very specific with the language used in writing math and how they get in more creative ways get some of the math content assessed, so I definitely learned a lot doing that and those were really strong. The school district I'm in does a lot of nice work with just good instruction. There's the principles of learning from the University of Pittsburgh, the Institute for Learning and seeing those in action in a classroom, I learned a lot from that but not too much with respect to math itself. I have enough time to read what's going on and to keep up with changes that are happening and new resources being developed. I like thinking through professional development, and finding better ways to deliver information to teachers" (Tape 6, 50:23).

When asked to describe her role while in New England, Ouida said, "I was a mathematics specialist. That was my title. But it wasn't a specialist in a school. Still the job was similar. I guess it's like trying to gently get teachers to recognize how much they don't know and then how to sort of support them moving forward to like they actually build basic content knowledge independently, mathematical knowledge and so it's the same in some ways" (Tape 6, 01:04)

Ouida is able to apply her experiences and skills developed as a mathematics coordinator to her new job as a school based mathematics specialist. She appears to have adapted quickly to her new job. "The transition into the job has gone relatively well for a couple of reasons. First of all, they had someone doing part time SPED and part time math intervention last year, which meant that she could do neither job completely. They were relieved to meet me and find that I had a rich base of content and pedagogical knowledge and could support them in thinking through issues. The

other piece that has helped with the transition is that the PLCs (which formally started last year in HPS) at _____School have been focusing on math ONLY. The principal has a school-wide math goal and the teams spent all of last year focused on using learning targets in relation to math instruction. Because these teams are already focused on math, I don't have to try to get teachers to pay attention" (Personal Correspondence, October 2015).

Despite a smooth transition, Ouida is still focused on developing good relationships. Part of this process for Ouida is knowing when to work with the practices the school has in place and knowing when to suggest changes or offer ideas and support. "My initial work with building relationships has been around trying to respect the systems they put in place last year and to build off of those as much as possible. They have a WIN (What I Need) time 1st-4th in which the teachers use formative assessments to sort kids into groups and do some small group instruction cross-grade. The formative assessments they used were all relatively low level questions, so I've been working to keep as much of their ideas as possible but to infuse it with some higher level thinking. Because the school goal this year is around getting students to solve problems flexibly, accurately, and efficiently and to be able to communicate their math reasoning, this has been particularly well-received. Teachers have recognized that they aren't sure how to create questions like that and are glad to see the models and to create class tasks off of them. The school also invested a lot of work around learning targets last year. Because I came from an Expeditionary Learning school, I have a fair amount of background in learning targets. I've had to walk a fine line of modeling and bringing a few resources but not going too overboard on them. Not everyone seems on board with the idea and there's

a lot of lip service to them, so I'm treading lightly" (Personal correspondence, October 2015).

Ouida is also negotiating a relationship with the school instructional coach. 'She is an extremely knowledgeable educator and did a lot of great work with the teams last year. We have a sort of shared leadership role in each PLC-- ostensibly I bring the math knowledge and she brings the instructional knowledge. But I also bring the pedagogical content knowledge which she doesn't have with respect to math (she hasn't taught elementary math before). So we are trying to navigate that territory issue. We are both aware of it. It's made somewhat harder in that the principal would like for me to play an instructional role beyond just working with students. The job description is certainly just working with students. (Specialists work with students and coaches work with teachers.) But I'm trying to wear a couple of hats" (Personal correspondence, October 2015). Again, a lack of absolute clarity in Ouida's role seems to be at issue.

Ouida feels well supported, and unlike in New England, has the opportunity to meet often with mathematics specialists from the division. There are several strong specialists who are respected in the division, and Ouida is learning from them. Likewise she is not hesitant to voice her opinions with this group. "The math specialists get together once a quarter to tweak the assessments and create review packets. At the last meeting some questions came up around bigger things to talk about, but we ran out of time. I pushed a bit on that and we now have set up one extra morning during a PD day that we are going to talk about some of those bigger things. A____ is definitely wonderful to work with and has carried on some of the higher level math work across the district for many years. Everyone knows and trusts

her. And with K____ back, they are a dynamic duo trying to do their best with a challenging situation (more on that below). They have done some good PD since the start of the year for all grade levels working on what good math instruction should look like. My teachers have used many of the ideas shared (though they are not so clear on how to link the dots). One of the big things I'd like to work on with the math specialists is how to help teachers have a real picture of what a series of good lessons looks like. It's such a difficult thing for elementary teachers to know how to do and to have the time to do" (Personal correspondence, October 2015).

The challenging situation Ouida refers to is that Virginia does not use the Common Core Standards. "They did teach the teachers so much. And they make SO much sense in the younger grades. The Virginia standards are just a series of skills. When I was still teaching, I always struggled with how much conceptual understanding to pursue with students when they had to master such specific procedural skills. I knew it was RIGHT to teach them the underlying concepts but it took so much time that I couldn't always get them to fluency with the skills, so their scores suffered. It was such a gift to have the required conceptual understanding spelled out IN THE STANDARDS with the CCSSM. It meant that there was no need to rush to the algorithms until it was truly time to do that. It relieved such stress and eliminated so much redundancy. It breaks my heart to see 2nd grade teachers already starting to throw the addition algorithm at students and then watching the 3rd grade teachers struggling with re-teaching it or trying to do something conceptually when the conceptual foundations weren't laid appropriately in 2nd grade. And it just works its way on up through 4th grade and what I know I always saw in 5th grade. It's such a shame watching teachers knowing that they want students to think more deeply, but not being sure that they have time to do that."

Ouida continues, rather philosophically, about the Common Core Standards, and in doing so lays out some of the challenges she, and teachers, face regarding elementary mathematics. “Come to Virginia where the standards are stilted, the assessments don't come anywhere close to higher level, and the teachers are without a resource that aligns to anything, has been a challenging transition. More than any single math specialist could do, it seems like schools can make the most progress if they could adopt a math curriculum that was engaging for students, provided clear, manageable classroom systems, and was educative for TEACHERS. There are so many decisions that teachers need to make with math instruction (planning, during instruction, assessment, etc.)-- and a coach/specialist seems unlikely to ever be able to develop the necessary knowledge in all of the teachers in a school to be able to lead really well run math classrooms. Teachers don't get that kind of training in school-- and then we throw them into teach without a guide beyond their gut, the occasional PD on Math Diet, and a math specialist tangentially working with the struggling students. A strong resource seems like the best solution” (Personal correspondence, October 2015).

Challenges aside, Ouida is thrilled to be working with children again. “I love getting to experience younger student brains for the first time. I know that I'm not getting any of them up to grade level yet, but it is really fun trying. I've been given permission to back fill instead of trying to help them keep up with what they don't understand. After watching them struggle in their classes with material above their heads, it's a joy to bring them instruction at their instructional level” (Personal correspondence, October 2015). Still, when asked about what being a mathematics specialist means to her, Ouida replied, “It’s trying to get teachers to recognize ow much they don’t know and then how to support them moving forward to build content

knowledge , mathematical knowledge. I think a large part of my job is thinking how you build a group of teachers over long period of time." (Tape 6, 05:28),

Sam's Case. Sam is presently a high school mathematics teacher in Somerville County Schools (SCS). SCS is a rural school division with approximately 10,000 students. At the time of his interview, Sam was beginning his twentieth year in this division. His career in education includes: three years teaching second and third grade; five years teaching fifth grade, as well as serving as Mathematics Lead teacher in his elementary school; three years teaching eighth grade mathematics, including Algebra I, as well as serving as Mathematics Lead Teacher in his middle school; three years in Central Office as Mathematics Coordinator; and five years teaching advanced mathematics courses, including Pre-calculus and Calculus. He has a Bachelor of Science in Education, with concentrations in mathematics and psychology, and a Master's Degree in Elementary Education, through which he gained his endorsement as a Mathematics Specialist. Sam has also earned 30 additional credits in mathematics courses to earn an endorsement to teach Algebra 1, and eventually an endorsement in mathematics, allowing him to teach all high school mathematics courses.

Sam's case is different from other participants in this study. While SPS paid for training for many of the teachers in the division to secure a mathematics specialist endorsement, SPS never actually hired any mathematics specialists. For a while, schools had lead mathematics teachers, and Sam was one of these. These roles were abandoned several years ago, though there seems to be efforts to bring them back, and Sam will be part of those efforts. Sam eventually became a division wide coordinator, a role for which his mathematics specialist work prepared him. However, Sam only stayed in this role for three years, when he returned to full time teaching.

Sam recalls his early teaching as being "procedural. Here are the rules, do this. I mean direct instruction, so here is how you do it, follow these steps, I watch you do it, we practice and then you do it on your own kind of thing. When it didn't work, I spoke louder, talked faster, gave them more problems, here try it again" (Tape 5, 02:43). However, Sam gave no indication he felt the need to change his practice, until he experienced mathematics taught a different way.

Sam became involved in the mathematics specialist program when he was asked to attend classes offered through the University of Virginia that were developed specifically to help SPS build a cadre of elementary and middle school mathematics lead teachers. At this time he was teaching fifth grade, and only in his fifth year of teaching. He "figured [he'd] give it a try and see what it was like" (Tape 5, 01:59). Sam says of the first courses he took, "I guess that was my first experience at seeing math done differently. That was when I first realized that I was better at math than I thought I was and just got me interested in the way that kids think about math and looking at different approaches" (Tape 5, 2:30).

Sam took the activities he was exploring in classes back to his own classroom and tried them with his students. Almost immediately, his beliefs about what it meant to teach and learn mathematics began to change. "I guess what really worked for me is the activities that we would do in those classes I would like -- I was one of those people what the heck let's try and see what happens with these kids once and it only took once. And I was amazed at the stuff -- I mean they immediately opened up and said, 'Well this is what I did' " (Tape 4, 3:34).

Sam described an episode when he first became of aware of children thinking. "We were measuring something in feet and maybe we were trying to figure all the ways we could figure out how many inches in 25 yards or something like that. And

they were just throwing it out there in all the different ways that they came up with that. One boy said that five 12s was 60, and he had five groups of 5, so that was 300 and I was just floored that he was able to think that way. Wow. I mean it was, it was a wow. I would never have thought of it that way or do you understand -- and again at that time do you understand -- I remember the kids name J___. Do you guys get what J___ is saying? And they are kind of looking at diagrams on the board of if these are 12s and I do five groups of 12 and then I do -- and that gives me 60 and five of the 60s give me 300. And they are all talking about why it works. And I ask him and I think I remember specifically asking him why did you choose fives and it was the 300 and I think he knew something about five and six and 30 ---- and it was natural for him to kind of see it that way" (Tape 5, 06:58).

Sam explained more about how he felt when he began to see children thinking and reasoning mathematically. "It was in that fifth grade classroom and the UVA special classes and the fact that just -- again I did it myself and I saw it, do you know what I mean. It's not that anybody told me that this is what you need to do. I took a chance and said let's see what happens. And these kids responded and I'm like wow they're thinking. In other words they're not just repeating what I'm saying they're actually thinking. Ever since I've been -- it's been more of a constructive approach. I'm like yeah this is definitely the way you teach and plus I'd seen the way that kids responded" (Tape 5, 08:16).

Despite having a concentration in mathematics from his undergraduate work, Sam was not always confident in his own mathematical understanding. His high school and college coursework was often completed in rote, memorized style. But the early coursework he was taking through SPS was different. "I don't know that anyone had ever said let's take a look at patterns and see what's going on and then relating

that to algebra that kind of stuff. I mean I was really good at patterns. And so a lot of stuff that you guys would pose in classes I'm like oh yeah I get this, it came really easy. I don't know. And I guess it's just taking that -- so once you start opening yourself up to just investigating and what if. I guess one thing that these classes triggered would be its okay to play with math and see what happens. So what if we do this and we're wrong oh well then that's okay it doesn't work so okay we need to go this way. But I think it made me more comfortable in saying oh it's okay just to experiment" (Tape 5, 10:28).

Sam delighted in the mathematics content coursework in the mathematics specialist program. Referring to the mathematical aspects of the courses, he said, "I mean I just enjoyed it. It's actually one of those things where I mean -- because we learned so much just coming to class every week. I mean we did activities, just doing activity based, discovery based. I don't know, it was just -- I enjoyed it" (Tape 5, 09:06). Asked how the training prepared him to be a mathematics specialist, he replied, "Just going -- I mean -- you can't teach what you don't know or -- I don't know -- so it gave me -- I went through the math myself and thought about things in a different way and I'm like oh. And it just gave me the confidence to go ahead and say let's try this with other people and they're going to feel the same way. They're going to discover for themselves oh wow I really do know some stuff about this. I think it gave me the confidence to feel comfortable and I would say that having practiced it long enough in my own classroom -- I mean you just get to a point where it just becomes natural" (Tape 5, 19:51).

Sam points to an interesting source of confidence related to his teaching. "I guess the reason I felt confident is that the math speaks for itself, you know what I mean, it's not me. You're not looking at me and I'm not trying to tell you this new

method and this is my way of doing it. It's let's look and see what happens. It isn't me, it isn't them, the focus is the math and whatever happens, happens. But knowing what is supposed to happen is going to happen" (Tape 5, 21:13).

Due to his developing confidence as a teacher, Sam was very comfortable with some of the leadership aspects of the program, feeling they aligned well with work he was already doing in the division. "I guess I had already done a lot of professional development -- I mean once we started getting into the math specialist courses and then B___ and I and P___ started leading the *Building a System of Tens* classes at SPS, leading these classes, so I think that helped a lot with the leadership components. So by the time I was ready to go into that role I had already done a lot of professional development. To be honest -- I mean to me there is no difference in doing professional development with a group of adults and teaching a math class in front of a bunch of students. It's that same approach with discovery" (Tape 5, 11:56).

When asked, Sam explained further how he teaches teachers. "I mean the same way I would be with students. I provide them -- we'll do a group activity, we'll do an activity, we'll think, we'll discover, we'll do the exact same thing that I would do with a group of students and we'll talk about. And they come up with all those wonderful ideas and oh it's this and it's that. [Sam hesitates] But when it comes to okay now let me transfer this to my own classroom, I couldn't always get teachers to buy in. It just seems to stop there. And unless they try, they are not going to change, the only way they will change their beliefs is if they see it in action. It's a -- which I guess I understand, at the time SOLs had just been introduced. In other words I don't know if there was so much SOL pressure back when I first decided -- and let me see what happens with this -- as there is now. So with me I'm like what the heck I'm going to try and see what happens, I wasn't afraid. But I think there are a lot of

teachers who are afraid to do those kinds of things because what if they don't score as well on the test and what if my principal comes in and sees that we're not working, thinks we're just playing" (Tape 5, 14:48).

The notion of "seeing it in action" was to play a big part in Sam's vision of what his role would be as a Mathematics Coordinator. "So when you're a math specialist in your own classroom, let's just put it that way, a teacher, I mean you have control over your lessons and you approach them in a certain way, you watch the light bulbs go on in your students' eyes and you think wow this is really great. I thought 'This is the way it's going to be at Central Office, I'm going to go to Central Office or I'm going to be a math specialist, I'm going to go into teachers classrooms, I'm going to model these lessons. Their eyes are going to go wow or they're going to see what happens, their eyes are going to open and it doesn't happen like it does with students because it seems that they're not as receptive as -- because I think as adults we are more afraid of change than younger people are. But my expectations were I'm going to go -- I'm going to do these things, people are going to be wow, they're going to start teaching this way, we're going to change the world--- and it didn't happen" (Tape 5, 28:07).

While Sam enjoyed the mathematics courses, other aspects of the mathematics specialist program were more challenging or less enjoyable: "It was the research and writing." Sam also noted that he did not develop enough in terms of working with administrators. "It might just be -- I think it's more the administrator component of how to deal with -- how to deal with opposition, how to deal with not so much -- I think it's easier to overcome teachers that don't agree with the way that you do than it is if their administrator doesn't back you up, then you might as well hang it up. I mean you don't have a prayer, you really don't. So it's that how to deal with the

opposition, how do I convince the administrator that this really will work or -- because it's not something that happens overnight, so there is a risk I think that they feel, do I want to give up doing what we've done for something that might not work" (Tape 5 21:32)

Overall, Sam would have liked more support when working with administrators when he was mathematics coordinator for SPS. "So the type of training I was doing with teachers it was more I'd like you to go back to your classroom and try some of this stuff, but there was no accountability component, no principal expecting to see it. There are just -- I don't know -- I also think -- I mean we spend a lot of time training these teachers, but we haven't done a whole lot if any, at least in the State of Virginia, on training administrators on this is okay. And this is what you should expect actually or this would be a better way to let your teachers teach, they're afraid." (Tape 5, 15:12).

Sam reflected on many challenges from administration at various levels in SPS. One challenge was in the overall lack of time allotted for mathematics lead teachers to work with other teachers, for meaningful job-embedded CPD to occur. He commented on his time as a mathematics lead teacher "Yes, we had release time, I think we had one half a month where we allowed to go into other teacher's classrooms. But the first part of it was we were to bring things back at faculty meetings and then maybe do an occasional activity—it was always an after school in-service where whoever wanted to could come" (Tape 5, 26:10).

When he worked in Central Office, Sam tried to gain more release time for the teachers. Teachers were released half a day in schools, as well as half a day to meet as a team of math leaders. "We met once a month, all 18 math teachers. There are 15 elementary schools and then the three from the middle schools, we would meet, so

there were 18 of us and we would talk about -- because each month they would have to go back and do something and then bring it back and we'd talk. And then I'd give them some professional development. Again their release time was only half a day" (Tape 5, 44:37).

Even bigger challenges stemmed from huge differences in beliefs about what mathematics instruction should look like. For example, in one school, one of the early mathematics lead teachers was named principal. This principal had very different beliefs about mathematics from those held by Sam, and in fact from those hinted at in coursework the principal had taken along with Sam. According to Sam, "He was totally against this way of teaching math. He wanted to shut down the math lead teachers. He thought it was poppycock. I mean -- I don't know -- in other words to him it was all smoke and mirrors and we're not -- we're not teaching them the facts, we're not teaching them how to -- where is the memorization -- because that's what we're used to. And it's uncomfortable for change and I think his perception was they're not going to learn. And in fact the school where he was administrator, he tried to prevent his own teachers from trying different approaches" (Tape 5, 16:58).

Sam mused, "What I saw and what my vision for what math was, was not necessarily what my higher-ups saw math as. So in other words even though I know -- because I've done it and I've seen it and I know that it works. I'm not in control because my administrators control me, my superintendent controls me. You know what I mean, these are the rules and if they don't allow me to do what needs to be done then what do you do?" (Tape 5, 29:18)

The different visons were so far apart that Sam felt helpless. "I can remember going into a meeting and really it came down with special education situation where -- I remember the principal just saying 'Doesn't there come a time where you just tell

the kids this is the way you do it and you memorize it?' Yes maybe, but my response to that question was "Haven't we done that before and how has it worked. What makes you think that this time it's going to work anymore differently?' You know my personal beliefs I don't want to tell if I don't have to. And so it came down to a conflict of they wanted me to go -- in fact I wasn't allowed to use the word discovery learning. I was told specifically by my assistant superintendent you can't say that. You can't say discovery, you can't say hands-on, you can't say… okay what do you want me to go in and do? So the conflict came in, we want you to go in and change everything, but we don't want you -- we're going to tie your hands behind -- I mean that's the way I felt, I really did, that's why I left that job after three years' (Tape 5, 32:38).

Sam points to the school board as a reason for his superintendents' reticence to engage with new ideas about teaching mathematics. "Our school board for whatever reason, they thought that discovery learning ---they were against it, that was bad. The superintendents thought they'd get in trouble. They were afraid of the school board. And so we can't go in and we can't do the group activities like that because word will get back—I mean there was this real fear" (Tape 5, 34:09)

Still, Sam recognizes some change that he brought about as mathematics coordinator. For instance, Sam worked with the principal mentioned earlier. "Some of the same time when I was at Central Office and I was, like, I'll talk to him and I did, but I don't know. I think the county has grown and it started to grow at that point I think. I think he was a little bit more open to some of these things" (Tape 5, 17:31)

Sam continued. "I will tell you one opportunity I had when I was at Central Office. He [the recalcitrant principal] did let me into his school to work with teachers. I was in a classroom at that school. It wasn't him, but it was another

administrator and she was doing an observation at the time that I was co-teaching or helping a teacher with a classroom and she got to see firsthand what happened when we started opening up some questions about -- not that I took over the teacher's lesson, but there was a perfect opportunity to jump in with a specific let me ask this question to a student. And I did and we were doing fractions and we were looking at ways to divide it up and I think it was converting -- it might have been like three-tenths and thirty-hundredths, where do we see both of those in the picture because of what was shaded in. And a student looking either at the three tens that were shaded or the 30 pieces out of the 100 and having a make that connection moment and I specifically remember that administrator going 'wow' because she actually saw it happen instead of just hearing somebody tell her about it" (Tape 5, 17:45).

Sam recognizes growth in teachers as well during the time he was in Central Office. "Again the individual teachers -- I think -- doing those middle school -- like those middle school in-services that I did, I know that there were a few teachers that actually tried the things that we did. Took them back to their classrooms, would come back the next month and share, that kind of thing. In fact there was one specific teacher at F_____ Middle School and she would e-mail me, I want to try this what do you think. I mean I did start getting questions from just a few teachers. I want to do this, what would be a way that I can approach this, how should I, what should I; you know those kinds of things" (Tape 5, 31:07).

In general, however, Sam's experience in Central Office as a mathematics coordinator was not a positive one. "I felt defeated" was his comment (Tape 5, 29:18). "I mean Central Office is very difficult, it was hard. It's like you know what you believe, but, I don't know, it's everybody treats you like, not everybody but you feel

like you're being treated like this who are you, you can't seriously think that this would work" (Tape 5, 43:04).

While Sam may not have developed a strong identity as a mathematics specialists, his professional identity as a teacher is strong. Sam has found a way to express his beliefs through his teaching. He uses what he learned while preparing to be a mathematics specialist in his teaching practice His vision still does not match with other teachers and his administration, but he is able to control what occurs in his classroom, and teach in a manner he thinks most effective. "It's just in my classroom because even as a department -- like we had to come up with some goals as a department last year. And what we wanted to see in one of the goals was we were going to do drills on factoring, you know what I'm saying. So there are teachers that still think it's all skill and drill, a lot of teachers. But I can control my own classroom, so basically what I try to do every single lesson, I don't want to lecture, I don't want to tell. So I don't even -- in fact this is where --like our administration wants us to write objectives on the board for the days lesson every day. Well, I don't necessarily want to do that because I don't want my students to have a clue what I'm going to talk about. I want them to figure it out. So I'm one -- it bothers me -- objectives bother me. Now, at the end of a lesson I should be able to say what do you think the objective was for today and if they can't tell me then I didn't do my job" (Tape 5, 46:20).

Sam submitted a video of a teaching episode that shows his students identifying and summarizing their lesson. Sam commented on the lesson "But at the end I asked them 'What do you think the objective was?' and they nailed it. So how I use the classroom -- I mean it's -- I try and make a discovery as much as possible every day" (Tape5, 47:33). He is proud of evaluations that students in this calculus

class have written. “The one instead of what I'm doing now is -- since I teach dual enrolment, they have to do the course evaluation at the end of each semester. So I mean I teach them basically two -- one math 163 and one math 164. I get those evaluations back and when a high school student can write you're the first teacher that ever taught me how to think or I get a lot of that you teach us concepts, to teach us to memorize anything. I mean they get it” (Tape 5, 49:27).

Sam was involved with local and statewide mathematics organizations several years ago, but no longer to the same extent. He does however, continue to guide his own professional development to keep current and up-to date. He tries to stay on top of articles, and he attends classes when he can. For example, shortly before his interview took place he attended the state sponsored summer session to develop Advanced Calculus teachers (Tape 5, 50:35).

Sam has not given up on the idea of being a mathematics specialist or even a division wide coordinator again. However, he is perhaps a little wiser than he was eight years ago when he first took on such a role. Asked what support he would need to be successful as a mathematics specialist, her replied, “A supervisor or a principal willing to say do whatever you need to do or here's a teacher from each grade level that you can work with that I know would be willing to improve or change; a principal who would be willing to let people change and not so worried about this damn SOL courses” (Tape 5, 41:38)

But for now he is happy and confident. “I know it sounds cocky, but I think I'm a really good math teacher” (Tape 5, 49:14).

Cross-case Analysis and Interpretation

The analysis of the five cases resulted in four themes that provide insights into mathematics specialists' professional identity, and how professional identity develops over time and across roles and experiences. The four themes are presented in Table 2.

Table 2: Themes identified through analysis

First Theme	The professional identity of a mathematics specialist is related to, and strengthened over time by, the specialist's beliefs about mathematics and mathematics instruction. *Professional identities of mathematics specialists are related to how well the specialists can bring into alignment beliefs held by the community of practice about mathematics and mathematics instruction with his or her beliefs.*
Second Theme	The professional identity of a mathematics specialist is related to and changes over time with the relationships forged between the specialist and other members of the community of practice. *Professional identities of mathematics specialists are based in relationships that develop over time. These relationships determine how specialists interact with teachers, schools, and administrators.*
Third Theme	The professional identity of a mathematics specialist is related to the changes over time in the culture of the community of practice, which in turn effects the roles and practices of the specialist. *Professional identities of mathematics specialists are grounded in the specific work and roles they undertake. These roles change as the mathematical vision of the specialist and the community of practice come into and out of alignment, as well as with policy practice and changes brought about by division decisions.*
Fourth Theme	The professional identity of a mathematics specialist is related to and changes over time with the use and recognition of his or her professional voice within the community of practice. *Professional identities are clarified over time and through experience, and are demonstrated through growing confidence, knowledge, and the ability to give voice to opinions and concerns.*

Each theme is discussed below, with supporting evidence drawn from the individual cases. For each theme, the unique case of Sam will be discussed to suggest ways in

which the development of a professional identity of a mathematics specialist can be hindered, as compared to how professional identity is supported and nurtured in the other cases.

The themes are not totally distinct. For example, a specialist's beliefs about mathematics are not disconnected from how the specialist will work to build a relationship with a teacher in order to change a culture in a classroom that initially limits children's abilities to talk about mathematics. However, the connections amongst the themes seem to be related to changes that occur over time, and perhaps need to occur in some kind of order. A specialist must first develop a meaningful understanding of mathematics and mathematics instruction. To transfer this understanding and to work successfully with others, relationships must be forged. These relationships allow the specialist to work to change the culture of the community of practice from within, as well as to handle challenges to the community of practice that originate outside the community. Finally, a professional voice develops, and this voice arises from the specialist's beliefs about mathematics and how he or she has been able to weave these beliefs into the fabric of the community through the process of building relationships and bringing about cultural change.

First theme: The professional identity of a mathematics specialist is related to, and strengthened over time by, the specialist's beliefs about mathematics and mathematics instruction.

This theme considers that the professional identities of mathematics specialists are related to how well the specialists can bring into alignment beliefs held by the community of practice about mathematics and mathematics instruction with his or her own beliefs. All of these specialists were considered strong throughout the mathematics specialist program in terms of developing deep mathematical thinking nd

insights into how children learn mathematics, so it is reasonable that their identities are related to their beliefs about mathematics.

Ellis and Berry (2005) described how a change in beliefs about mathematics is critical for a real change in mathematical instructional practice to take hold. All of the participants in this study experienced a change in their own beliefs about mathematics and mathematics instruction that allowed them to move from a traditional mode of teaching to a more constructivist approach. Each of the participants pointed to a specific time where what they understood about teaching mathematics changed, and when they were motivated to make changes to their practice. Cleo and Rosamund were inspired to find ways to explore children's thinking when they examined their mathematics teaching and found it lacking meaning, for themselves and the children. Pearl, Ouida, and Sam were content with their mathematics instruction until they enrolled in a reform based mathematics class. Reflecting on what they were learning, and experiencing their students respond to tasks with depth and meaning convinced all of the participants that mathematics could be taught in a manner consistent with the reform mathematics agenda. These beliefs were supported and nurtured throughout their preparation to become mathematics specialists. These beliefs are important as they continue to motivate each of these specialists to want to bring about change in other teachers' instruction.

As they began their new roles as mathematics specialists, newly formed and (perhaps) fragile beliefs clashed with the beliefs held by teachers, principals and administrators. The most obvious clash in all cases is the belief held by the specialists that mathematics is learned as a conceptual system, and the common belief in schools that mathematics is a set of procedures to be explained by teachers and memorized by students. For Cleo, working in a low achieving Title I school, it seemed particularly

important to get teachers to realize that all children can and should be successful in mathematics, but that this requires a different approach to instruction, accompanied by a deeper knowledge of the mathematics. In her first year, Cleo realized that teachers needed to develop their own deep understanding of fractions in order to teach the topic in a conceptual manner aligned to the requirements set forth in the SOL. Cleo reported the process of moving teachers towards a conceptual, child centered approach has remained a challenge each year and her main focus, as new teachers join the staff, but also with older teachers who struggle to adopt or accept proposed changes.

Cleo's early identity was based on her beliefs that teachers need to know the mathematics. As the teachers in her school began to look at mathematics more conceptually, she could begin to work on how they taught and thought about mathematics, again infusing her beliefs into the community. At one point she recognized that though teachers were beginning to learn the concepts, instruction was still procedural. Through her coaching, she has seen teachers begin to look for children's mathematical thinking, as well as seen teachers encourage mathematical discussions. She has seen teachers become engaged in mathematics, alongside their students. She has helped teachers move from a textbook oriented approach to instruction to an approach that starts with what children know. Cleo's beliefs about mathematics and mathematics instruction have allowed her to consistently return to a focus on mathematical understanding, as opposed to covering material or trying to improve instruction though increased assessment. As Cleo has seen teachers become engaged with mathematics her own commitment to a reform focused practice has deepened.

Pearl's beliefs were challenged when implementing her own newly-developing, reform-based teaching practice. As she was beginning to allow children to explore mathematics, teachers around her remained focused on procedural instruction, and to some extent excluded her form the grade level community. But as Pearl developed her new skills, she became more convinced that a conceptual approach to teaching, building on children's knowledge, was important and worthy. Like Cleo, she had to challenge and change the beliefs of teachers, and was rewarded when teachers she worked with began to see how children were capable of mathematics when allowed to think for themselves. A notable example is the scenario she described with the special education teacher.

Years after becoming a mathematics specialist, Pearl notes continued concern for teachers whose teaching is very procedural, yet their students maintain high test scores. Until recently, when mathematics specialists in her division were able to extend some power and provide training that developed administrators' understanding of why reform practices are effective, such teachers did not see a reason to change their practice, and were not accountable for doing so. As administrators have become more in line with reform practice, more accountability is in place. Pearl also finds it difficult to maintain a focus on conceptual learning in schools where she is placed to support rapid change. Like Cleo, she sees teachers using multiple strategies (e.g. for multiplication) that are intended to develop conceptual understanding, but are instead taught as distinct unrelated procedures. But also like Cleo, as she continues to witness success like that she had with the special education teacher, she maintains her beliefs about mathematics and mathematics instruction, and these beliefs encourage her to continue to push for change.

In her first school where she worked as a mathematics specialist, Rosamund was confronted with challenges to her beliefs about allowing children to explore mathematics and to construct meaning for themselves through mathematical experiences and discussion. Rosamund's identity as a coach comes from wanting teachers and students to experience the joy she felt when she realized mathematics was about making sense. In her high performing elementary school, Rosamund had to persevere with promoting change in a school where it seemed a procedural based mathematics program was effective; and in fact, children were passing standardized tests and were meeting standards. However, performance tasks developed by Rosamund's school highlighted weaknesses in student achievement that standardized measures did not assess, as they were not learning to reason mathematically, only procedurally. Rosamund's beliefs about mathematics and instruction were thus supported by the children's gaps in knowledge, gaps that required the teachers to start re-evaluating their practice.

More support for Rosamund's developing professional identity related to her beliefs about mathematics was derived from her success teaching professional development for teachers who taught at the Pre-k-2 levels. She and another specialist created the course, and this work helped Rosamund continue to develop her own mathematical understandings. Being able to respond to teachers' questions developed her confidence in her mathematics ability; reading the work teachers submitted that reflected on their work with their students added to her sense of commitment to developing her own and other teacher's reform practice.

For Ouida, this process of aligning the beliefs about mathematics held by her division with her own was aided by the CCSSM assessments that were being introduced to her system. These assessments require children to reason and apply

mathematical concepts. These assessments pushed teachers to change from a procedural approach to teaching to an approach that develops mathematical reasoning. The assessments and curriculum provided through Common Core are aligned with the beliefs Ouida developed in her mathematics specialist coursework. Ouida found that CCSSM documentation helped develop teachers mathematically, and she expressed concerns that moving back to Virginia would mean she would have little in the way of mandated curriculum to support teachers' mathematical development. For Ouida, CCSSM has strengthened her beliefs in reform based mathematics as well as her own knowledge about reform based instruction.

Cleo, Pearl, Rosamund, and Ouida all work in divisions where they have been able to achieve some level of alignment between their beliefs and those of community where in which work. In his work as a mathematics specialist, this did not happen with Sam. While there were some teachers he worked with who began to try new approaches to teaching, there was no division-wide agreement or support for the idea that teachers should begin to adopt reform based teaching. Sam met with resistance from both principals and division side administration when he tried to bring changes to his division. At least one principal held very different beliefs about mathematics and mathematics instruction and attempted to obstruct Sam in his work. The central administration asked Sam to refrain from using reform based approaches with schools. Sam could not align the beliefs of the administration with his own beliefs about best practice in mathematics instruction. In fact, Sam's beliefs were challenged to the point where he needed to resign his post as he could get nothing done. In Sam's case, not being able to align beliefs was a major hindrance to establishing an identity as a mathematics specialist. However, these same beliefs have allowed him to develop a strong classroom practice. In his own classroom he can present student with

challenging questions to consider, and can encourage exploration and discussion. His students learn, deepening his conviction that his approach to teaching is engaging and motivating for both the students and himself, and providing him with a strong professional identity as a teacher.

For each of the participants in this study, personal beliefs about mathematics and mathematics instruction are the basis for the work they do with other teachers and students. These beliefs represent change, and can be threatening to other teachers. Therefore, specialists have to be careful to develop trusting relationships with teachers in order encourage teachers to increase their mathematical knowledge and their practice. These beliefs are the reason specialists assume or discard various roles. These are the beliefs that specialists speak to, and for, as they work to move their schools and divisions towards a reform based vison of mathematics instruction.

Second Theme: The professional identity of a mathematics specialist is related to and changes over time with the relationships forged between the specialist and other members of the community of practice.

This theme considers that professional identities of mathematics specialists are based in relationships that develop over time. These relationships determine how specialists interact with teachers, schools, and administrators.

The process of developing relationships was an important issue for all of the successful mathematics specialists. Cleo, Pearl, Rosamund and Ouida all discuss the importance of developing relationships in their work. Only Sam does not mention relationship building.

As suggested by Wenger (1998) when describing communities of practice, there was a period of legitimate peripheral participation for the mathematics specialists. Cleo, Pearl and Rosamund, based in schools, all spoke of the early years

of their work as specialists as a period where they were getting to know teachers and other colleagues, and they were providing support in order to build trust and gain access into classrooms. Cleo described herself at that early time as a resource teacher, helping teachers locate materials, modelling lessons, planning school wide mathematics events, helping teachers assess students. To build a reputation as someone who could be trusted, she worked in a coaching capacity with one teacher who was beginning to take mathematics specialists courses, and this teacher spoke positively with colleagues about the work Cleo did with her. Cleo also worked with teams of teachers, and through these meetings she was able to get to know the teachers better, particularly identifying how she needed to work to support their mathematical development. She recognized that she needed to listen to the teachers, much like she wanted teachers to listen to children. She found out during this time teachers did not fully understand the Virginia SOL and did not know how the SOL aligned the text. Thus, this period was important for Cleo in determining what she needed to do to help teachers move towards reform practices.

Cleo gradually moved from a place of peripheral participation, to a point where her relationships allowed her to engage more fully. As she became accepted into the community, she was asked by teachers to come and model lessons. Recognizing that modeling lessons was not affecting practice, she began to push for closer and deeper working relationships, and moved to a coaching role, rather than a resource or support teacher. After a few years when teachers asked her to model a lesson, she suggested she come in and co-teach for a few weeks, proposing she and the teacher could plan together and work together. Those teachers who had learned to trust her agreed; and when other teachers saw colleagues working successfully with Cleo, they began to ask Cleo to support them as well. Through the development of

good working relationships, both Cleo and the teachers who trusted her began to find new ways to work together, engaging in mutual activities designed to move teachers' pedagogical practices forward. Due to this increased level of engagement, Cleo began to see alignment between her beliefs about mathematics instruction and the practices of the teachers.

Cleo's school has a high teacher turnover rate, and each year she finds she must begin again to build new relationships. At times, relationships must be repaired. Two years ago when her school was accredited with warning due to low test scores, some of the trust Cleo had established was damaged as she was asked to work in an administrative, evaluative role with teachers. Even though she has attained a level of full participation as a mathematics specialists within her community, Cleo must constantly return to efforts to build relationships.

Rosamund's experiences within LPS were similar to those of Cleo. Like Cleo, Rosamund began her career as a mathematics specialist in a new school, and she spent several years supporting teachers before she felt as if she were in a position to start changing mathematics instruction. Like Cleo, Rosamund spent several years building relationships as she gained access to classrooms. She, too, learned where teachers were comfortable with mathematics, and where their needs lay. Rosamund spoke about how her role was dependent on the relationship she had built with individual teachers.

When Rosamund first became a mathematics specialists in LPS, because her school was perceived as being successful and the children were performing well on standardized tests, teachers were reluctant to change their practice. Supporting teachers in other ways, Rosamund earned their trust so that when teachers did want to develop different practices as a result of seeing their students underperform on

conceptually oriented tasks, she had developed relationships that allowed her to work more closely on their practice. When Rosamund moved to APS, she found that gaining access to teachers' classes was not an issue because the teachers did not consider her role as one of working with them to improve practice, but rather of teaching their children for a day. For Rosamund, building relationships meant changing how teachers understand her intent as a mathematics specialist. Rosamund would try to engage the teachers in planning, and she would leave the teachers materials she used to teach the lesson.

Her experience as a mathematics specialist in another school was helpful for forming relationships. For instance, Rosamund had expertise in developing math centers and assessments she shared with the kindergarten grades. When the techers were implementing these ideas, Rosamund offered to come to their classes more often to help the teachers work though and understand the new resources. Because this was support the teachers had sought, they were agreeable to her increased support.

Rosamund's previous successful experiences co-teaching were an incentive for her to move to co-teaching quickly in her new school. She was able to develop a good enough relationship with one teacher through working with the grade level consistently during planning. This teacher admitted that other teachers were uncomfortable having someone watch them teach. For Rosamund, this was not surprising as she had once felt the same way. It was also reminder to her that building relationships was instrumental to successful work as a coach.

Similar to both Cleo and Rosamund, in her first years as a specialist Pearl focused on developing relationships with teachers by supporting them with materials, by providing professional development after school, and by modeling lessons. For Pearl this initial process of building trust was perhaps more difficult. In LPS where

Cleo and Rosamund worked, the mathematics coordinator had paved the way and carefully explained the roll of mathematics specialist to teachers and administrators. Though teachers were reluctant to work individually with Cleo and Rosamund at first, Cleo and Rosamund did feel welcomed into the school. In GPS, mathematics specialists were not wanted in the schools, and were seen as "spies" to identify issues that could be fixed. In GPS, all the mathematics specialists worked hard to form relationships and earn respect. As the years passed and achievement improved, acceptance increased. Like Cleo and Rosamund, Pearl found once a teacher saw his or her students begin to think and reason about mathematics, and develop their own understanding of mathematics, then that teacher was more open to guidance and support. Pearl noted that it took her the first three of the six years she was placed in her school to build relationships and get to a point where she felt she could make a difference.

In more recent years, Pearl has not had the luxury of remaining in a single school for multiple years. Because her division has redesigned the role of mathematics specialist, Pearl now spends only one or two years in a school with a goal of a quick turnaround in standardized tests scores. Access to teachers' classrooms is not a question as the teachers realize Pearl is there to work with them. By definition if Pearl is there, the school is not performing well mathematically. Pearl admits she does not have a lot of time to build relationships. However, she is able to draw on her longevity and history within the county. Many of the teachers know her through system-wide professional development she has led, or from having worked with them in schools. Pearl also points out that the schools that are struggling often have very high turnover rates. In a recent school only three teachers (out of 20) are returning. When Pearl thinks of the three years it took to build relationships at her

previous school, she realizes that she needs to become more intense, more quickly, if she is to help bring about rapid change. Relationships are important, but they are a sacrifice of this model of mathematics specialist. It remains to be seen whether improvements in these schools are lasting, which could provide evidence supporting the importance of building relationships.

Despite being a division wide mathematics specialist rather than a school based specialist, Ouida's experiences building relationships are similar to those of Cleo, Rosamund and Pearl. Ouida's job was curriculum oriented, and required her to provide support for teachers in non-coaching ways. She helped teachers understand the CCSSM by writing curriculum for her division. She gathered materials to support teaching when the division opted to not adopt a text for implementing to support CCSSM, and she over saw the adoption of a text the following year. When teachers had questions from parents, they could turn to Ouida to answer them. Likewise, because Ouida's role was administrative but not evaluative, and because the schools had reading specialists who provided embedded CPD, teachers seemed less hesitant to seek support in their classrooms.

Ouida notes a challenge to building relationships and developing trust was that her job was not well defined. She was not a coach, and thus when she attended meetings at schools, teachers were not always clear what to expect from her. Ouida also had to develop relationships with principals in the division in order to bring about a system-wide approach to mathematics instruction. Where Cleo, Rosamund and Pearl all had many years of teaching experience, as well as a clearly defined role, Ouida was still relatively inexperienced and was unclear about her role and initially lacked confidence in her beliefs.

As Ouida developed a better understanding of what her job entailed, she spent a lot of time researching mathematical issues and gaining confidence in her own abilities. Because she had to help teachers understand CCSSM, she had to develop her own knowledge of CCSSM. In order to help teachers, she needed to be in the schools more. Because she had spent two years building relationships with principals across the division, she was able to convince them to reorganize teaching schedules to allow her more time planning and observing in schools. Once she had more frequent access to teachers and schools, Ouida found, like Cleo and Rosamund, she could more clearly identify teachers' needs and address them through professional development.

Ouida had a smooth transition to her most recent position as a school based specialist, but still commented on the need to carefully construct relationships. The teachers in her school have had embedded support for several years, so like Rosamund when she moved to a new school, Ouida has not had difficulties gaining access to classrooms. For Ouida, building relationships in her new school means being careful to respect what the school is already doing, while gradually trying to implement some of her ideas from her previous job. Again, the knowledge Ouida has developed in the past few years is useful to the school. Like Rosamund, Ouida is finding she is able to work with techers because they realize she has knowledge that will help them.

Ouida must also negotiate a relationship with the school instructional coach. Again, for Ouida this is about finding her place without intruding into the responsibilities of the coach. Ouida's job description is to support teachers by working with students, while the instructional coach is meant to develop instructional, pedagogical knowledge. But both Ouida and the coach recognize that of the two, Ouida understands more about mathematics instruction. Ouida understands there is a

possibility of a conflict, but also knows enough about building relationships, and she is working with the coach to find negotiate roles.

As mentioned at the beginning of this section, Sam does not talk about building relationships. This does not necessarily mean he does not see the process of building relationships as important, and it does not mean he was not building relationships. For example, in his classroom he is careful to form strong, supportive relationships with his students, built on his respect for their mathematical thinking. Sam also spoke about teachers who were trying in their own classrooms what they had learned from Sam in afterschool workshops, and were asking questions of him and sharing what their students were doing with other teachers Sam may not have spoken about relationships because the structure of his job simply did not allow for strong, individual relationships to develop in the time he worked as a specialist. He was responsible for 15 elementary schools and three middle schools. This number of schools makes it difficult to be anywhere for long, or to devote a lot of time to any one teacher or even any one school. Furthermore, there was resistance from many schools to any sort of mathematical change, and thus Sam did not feel welcomed. Sam's own language is indicative of certain hostility he felt when he spoke of school administrators as the opposition.

Sam left the mathematics specialists position after three years. This is the time that Cleo, Pearl, and Rosamund claimed was necessary to build relationships in their schools. Perhaps Sam was not patient enough; perhaps the fact that teachers were beginning to try new practices is an indicator that he was more effective than he felt.

For Cleo, Pearl, Rosamund and Ouida, building relationships is an essential aspect of gaining entrance into the practices of the school and divisions. Without these relationships, trust is not built, and substantive work does not occur. With these

relationships they can work and move towards full participation in their communities of practice. The lack of supported and supportive relationships seems to have prevented Sam from gaining this vital access.

Third Theme: The professional identity of a mathematics specialist is related to the changes over time in the culture of the community of practice, which in turn effects the roles and practices of the specialist.

This theme considers that professional identities of mathematics specialists are grounded in the specific work and roles they undertake, in the ways they choose to provide support for teachers. The role of the specialists shift in response to the needs of the community. These needs may be determined by the specialists as necessary for aligning beliefs of the community with the goals of the specialist, or these needs may be brought about by change in policy or practice in the community. Community suggests many contexts, including the classroom, the school, and the division. The mathematics specialist is often the person who decides when it is time to refocus his or her work, altering his or her role and providing different support as required to meet teachers' needs and make progress in these various contexts. However, specialists are not always in control of the work they do, as they are accountable to principals and administrators. Therefore this theme further considers that professional identities of the mathematics specialists can be affected by changes in culture brought about by circumstances not under the specialists' control, including the type of support and demands they receive from teachers, schools and the division.

Mathematics specialists *provide* different types of support to teachers, schools, and divisions. The type of support offered varies from year to year, school to school, and specialist to specialist. The changing beliefs and culture of the school and division are factors in determining the type of support that specialists provide. For

instance, early in their work we have seen the specialists' support was designed to build relationships and trust with the teachers. Over time, support has become more targeted, as the specialists and the teachers have learned what each other needs and can provide, though specialists are always cycling back to build relationships with new teachers and administrators in schools.

When she first started as a mathematics specialist, Cleo taught math lessons for each teacher in the school at the beginning of the year to give the teachers a break in that busy time. For team planning, Cleo would prepare activities and materials teachers could take back to their classrooms and use, and teachers were grateful for these. Cleo soon discovered though that teachers in her school did not have a good understanding of the curriculum framework. Teachers were not confident with what was in the framework at any given level, nor did they understand all of the concepts children were expected to develop. For several years, Cleo supported teachers in developing an understanding of the framework, and in understanding the available resources to teach content in the framework. Recently, she feels that the teachers in her school are finally comfortable with the content of the curriculum, and has shifted to helping them design assessments that inform instruction. Cleo still will teach a lesson for a teacher to help out, but it is more often planned with the teacher, and it is a much smaller part of her role. The type of support Cleo provides has changed as the culture the school and the knowledge and needs of the teachers have changed.

Cleo discussed how she had to make a conscious decision about her role early on. She did not want to be a "resource teacher", and she had to assume the stance that she was indeed the highest trained mathematics teacher in the school; furthermore, she believed her role was not to merely support, but to bring about change in mathematics practices in her school. Her beliefs about the purpose of her role

propelled her to gradually change the way she enacted her role. For one thing, she noticed there was little change in instruction or in teacher's beliefs about how children learn mathematics occurring as a result of modelling lessons. She reported that she ceased to model lessons, and instead invited teachers who asked her to model a lesson to plan with her and enter into a coaching relationship with her. This often required further work building the relationships and trust needed to gain this level of access. Through her work as a coach with teachers, teachers began to change their beliefs about children's mathematical abilities and how to develop them. In turn, Cleo could extend the coaching she did with teachers to include working with teams and improving assessment practices. There is a strong connection between beliefs, relationships, and roles.

For Cleo, the teacher culture had to change to one that was focused on collegiality, not on working alone. As teachers began to allow her in the classrooms, culture within the classrooms changed as well. Cleo recounted a story of a young teacher who had seen her friend's positive response to Cleo's coaching, and had approached Cleo the next year for support. Cleo worked with the teacher to change the culture of her classroom to one where the teacher encouraged and allowed the children to construct knowledge by building upon their thinking. After several months, the teacher told Cleo that her entire approach to teaching had changed, and that she now taught everything like she taught mathematics. Scenarios like this have provided Cleo with confidence over the years that her beliefs are indeed valid, and that she can make a positive change in teachers' practices. Furthermore, a story like this validates the notion that how a specialist works with teachers will need to be flexible, and will be dependent on culture of the context and community.

Rosamund, like Cleo, and as discussed previously, spent her first years building relationships with teachers. Her efforts changed when teachers realized they needed help with teaching children in a manner that prepared them to reason mathematically on performance tasks. Just as Cleo's support began to focus on curriculum, Rosamund's support efforts changed and became pedagogically oriented as she facilitated lesson study with teachers and guided the teachers as they looked at their practice. When Rosamund moved to a different district, she found that once again, belief and the culture of the school returned her to building relationships and supporting teachers rather than working with them to change. Rosamund's experience shows that roles of the mathematics specialist fade and reappear; they do not develop in a linear fashion,

Ouida is another example of how the type of support offered by a specialist is related to the culture of the school division. In New England, Ouida's job was to provide curricular support to teachers. Like Cleo, she helped teachers to understand their division framework: in her case this was guided by CCSSM. Like Rosamund, Ouida worked on pedagogy to support the delivery of the curriculum, in particular focusing on helping teachers understand how to maintain high cognitive-demand tasks. She also supported teachers when parents raised concerns by formulating well researched arguments for division decisions that were called into question. Unlike Cleo and Rosamund, her position was centralized, and so her support was often more administrative. For example, as part of helping teachers understand the CCSSM, Ouida wrote curriculum and searched for supportive resources. Ouida would have preferred teachers write more of the curriculum for its benefits as CPD, but demands on their time simply made it more expedient for her to do the writing. For Ouida, being centralized meant she was seen as a source of information; as she often had to

find that information, the organizational culture was a benefit for her knowledge and identity.

Ouida is now a mathematics specialist in a school. Her job description is to work directly with children, so her main support for teachers is through working with different groups of children in small, carefully planned groups, in the classroom with the teacher. Again, the beliefs and practice of the division dictate to some extent the support she provides, but working with young children does align with her own beliefs that children need to be taught to consider concepts and reason mathematically from the beginning of their education. Ouida plans with the teachers, and provides guidance implementing curriculum. In planning, Ouida makes some suggestions about pedagogy, but this is supposed to be a role reserved for an instructional coach in her school. However, Ouida is envisioning her role to expand and include more work with developing and changing teaching practices. Ouida is biding her time, but also plans to increase her support of work the school has done previously on learning target. Some teachers have reservations about the idea of learning targets, so Ouida may need to work to change their beliefs. Meanwhile, as she builds relationships with new colleagues, she does not want to offend by suggesting too many changes too soon.

When Pearl began as a mathematics specialist, she worked in schools in much the same way as Cleo and Rosamund, first by building trust though modeling, and then by working more specifically with teachers who came to her and wanted to make changes. Schools in GPS were less open to mathematics specialists, fearing they were "spies", so Pearl had different challenges of access. Like Cleo and Rosamund, building relationships paid off, and she supported teachers with observations, team planning, modeling lessons, and planning math events. Beyond her own school,

Pearl also supported mathematics across the division by delivering frequent and varied afterschool workshops to teachers in her school and across her division; this work proved important in developing relationships across her division. As the division culture has changed, so has the type of support Pearl is expected to provide. Teachers in the division are now leading more of their own professional development, and it is embedded into their daily work. For instance, teams of teacher gather to analyze student work; when this happens now, Pearl attends as a consultant. Pearl's role has expanded in other ways. Because there is no longer a division wide coordinator of mathematics, Pearl is a liaison between schools, and between her division and the state department of education. The mathematics specialist team continues to work to support mathematics instruction, and but information sessions are outside of the school on workdays or after school. Perhaps because Pearl wears so many hats, it is natural that she thinks of herself professionally as support!

The culture of classrooms, schools, and divisions can present challenges to the professional identity of mathematics specialists. Culture is linked to the beliefs of teachers and administrators. DePiper (2014) noted tensions that arose for teacher education students when the culture of the school was traditional, but student teachers were trying to use reform methods. For instance, student teachers sometimes felt as though they did not fit in because their methods were different, and they exhibited a loss of confidence in the value of reform methods. Similar tensions are apparent with the participants in this study.

The culture of the school can be attributed in part to the beliefs and actions of the principal. While leadership generally supported Cleo, the culture of the school was to *not* hold teacher's accountable for making changes to their instructional practices. In fact, several years ago, Cleo noted the culture of her school was that "it

was a Title I school', and the measure of the school's worth was the standardized test score. This test-focused culture was heightened by a constant focus on benchmark tests, and by leadership that believed children perform better on a test simply by practicing tests and test taking skills. Cleo worked hard to change the culture around assessment. She held fast to beliefs that better instruction, not more testing, would be best for children. The cultural shift that took place involved her aligning teachers' beliefs about assessment with practices that see assessment guiding instruction. To do this, she found her role involved working more with grade level teams of teachers rather than individuals. A large portion of the work she did with teachers involves creating performance tasks and assessments. Teachers are now creating these assessments before the material is taught, and are teaching in different ways, using methods that will help children develop the reasoning skills needed to successfully complete these tasks.

In Cleo's school the cultural shift is propelled by the students themselves. For instance, during the annual "Math Month", children are excited to solve the challenges and puzzles that Cleo creates, and the students encourage their teachers to take part as well. Perhaps more important is the change students themselves are causing in classrooms. Teachers are starting to have children in their classes who expect to explain their thinking in mathematics, and who want to explore and conjecture and prove. The children themselves are forcing the teachers to change, because the children do not expect nor want a more traditional approach. Teachers have commented to Cleo that she has changed the culture of the school, and it is now a math school. Gresalfi and Cobb (2011) pointed out that for new teachers to feel successful their identities need to align with the identity of the school. In Cleo's case,

it appears that as the identity and culture of the school is changing, to one of a "math school", so is the identity and culture of the teachers themselves.

Culture is important in other participants' stories as well. Rosamund recounts how she always knew her job in LPS was to support teachers. This was made clear by the division-wide mathematics coordinator who went to every principal and every school to explain the role. Thus, a division-wide cultural sense of what mathematics specialists were meant to do was created. Specialists met regularly, and developed a culture of support amongst themselves. When Rosamund moved to APS, there was no division culture or expectation of the role of mathematics specialist; in fact the culture in that division was to leave those expectations up to the school. When Rosamund arrived, she was met by a school culture that thought of the math specialist as a type of resource teacher, functioning like the art or physical education teacher and teaching the class once a week while the teacher was engaged elsewhere. Unlike Cleo who draws a sense of achievement from the culture she has created, Rosamund became unsettled and unsure of her purpose in the new division. Much of her work the year she was in LPS was in aligning the culture of the school and her beliefs about her role.

When Pearl began taking mathematics specialist courses and changing her own teaching, she was challenged by the culture of the school where she taught. As she tried new approaches, she became alienated from teachers on her team. It became difficult to participate in activities like team planning because she was thinking about mathematics and planning differently. In the centralized culture of GPS, the beliefs of the central administration regarding how mathematic specialist should be used to help struggling schools turn around test scores has had an effect on the culture of that system. As discussed earlier, when Pearl goes into schools now, she expects to be

there only one or two years, and a rapid change is expected. Pearl says teachers understand that specialists and coaches are coming in to schools because they are underperforming, and so the teachers realize they have to accept help. For Pearl, this makes gaining access to classes easier. It also means that her role is much more of support--- for teachers who need help with classroom management, for teams who need materials—than it is working to change practice by changing beliefs, because she knows it takes longer to change beliefs.

Pearl does, however, seem to have some control in shaping the culture of GPS. Along with members of the mathematic specialist team, Pearl helped to change the beliefs of principals about mathematics instruction. As principals and administrators attend professional development like Lenses on Learning, they are increasingly looking for students to be working in groups and discussing mathematical reasoning. The expectations of principals are helping to change the mathematical cultures of schools, and Pearl can fan this change when she is working in schools, even if she is only in a school for a brief time.

Specialists also *receive* support, and the type of support they receive is a factor in developing the beliefs and culture of the school. Cleo has always felt supported by her principal in that she is given free rein to make mathematical decisions and to pursue her own agenda. However, Cleo has never felt that the support extended to the principal holding teacher's accountable for making changes, until the school became accredited with warning. The school has recently added an instructional coach to the staff. In this person, Cleo has found a peer who she is able to share ideas with, and who provides her with valuable feedback. The pair are working together, along with a math interventionist who targets specific teachers to develop, and Cleo feels she is part of a team that is having a very positive affect on mathematics instruction in her

school. Evidence of this for her is that teaching is becoming more reform-based and standardized test scores have recently shown marked improvement.

Rosamund recognized that the mathematics supervisor in the district where she first worked was essential in introducing teachers and principals to the role of a mathematics specialist. When she move to the second division, she had spoken with the division mathematics coordinator, and understood from the coordinator her role to be similar as in her previous job. When challenged by teachers who wanted her to pull struggling children from their classes and teach them separately, Rosamund was supported by the principal and division in refusing to do this. For Rosamund, the support she received was essential in her being able to maintain her beliefs about how children should be taught. On the other hand, Rosamund felt change at this school would be slow; the principal was new and did not want to make too many big changes. So when Rosamund spoke of co-planning and co-teaching, she was not fully supported by a principal who just want to "take baby steps" for now.

Both Cleo and Rosamund have benefitted from strong division wide support. The mathematics coordinator has provided consistent messages to all of the specialists in the district, so they feel as if they are all working towards the same goal. Furthermore, the community of specialists provides support to each other. New specialists are mentored by more experienced specialists. All specialists work on various on division wide projects, and they learn from each other through the sharing of ideas.

Unlike Rosamund, Ouida did not feel she had the necessary support to do her job. There was a lack of clarity about her role, she was sometimes expected to be in classrooms coaching, while her boss wanted her focusing on curriculum and CCSSM. Ouida also did not have an induction to the division she would have liked from her

supervisor. Ouida was left to her own devices to make introductions, get to know key personnel such as building principals, and to set the mathematics agenda. Ouida worked hard to gain support from principals. In her last year with the New England division, principals had agreed to coordinate schedules in such a way as to allow her to be in each school and to meet with each grade level in each school on a weekly basis. Between meetings, she could observe in the classrooms, and she was able to tailor her support more towards individual teachers. The principals' support in this was important. Support like this is instrumental in enabling specialists to adopt their roles to be more responsive and thus to be able to bring about change.

Ouida feels much more support in her new position. The division has recently established professional learning communities (PLCs), and in Ouida's school these are focused solely on mathematics. Unlike other schools in her division, Ouida does not have to contend with other content areas for the teachers' attention when in working with PLCs. Ouida also benefits from the culture of the school which has had a mathematics specialists before, but one who was only part time. Teachers are welcoming of the extra support Ouida can provide in terms of both time in the class and in terms of knowledge. The teachers are already used to the idea of having a specialist in their classrooms, so for now Ouida has by-passed the issue of access. However, she knows she will need to have those relationships when she begins to support in a manner that brings change.

Pearl initially had a very strong coordinator who supported the mathematics specialists. When the coordinator position was eliminated, Pearl and the other specialists initially felt abandoned by the division, and also felt they needed the support of a coordinator to continue their work. Then an interesting thing happened. With the encouragement of the assistant superintendent, the specialists began to

provide their own support. They started to plan for their own professional development, and to take charge of their work as specialists. They organized themselves to take on the tasks that had previously been the purview of the coordinator. Thus the removal of the coordinator resulted in the creation of a very strong group team of mathematics specialists that now provides its own support. By removing the coordinator, Pearl feels more empowered about her professional growth, about her role as a specialist, and her role as a leader.

Professional identity is about how one enacts his role, how one engages with members of the community, and how one imagines a trajectory of growth within the community. The role a specialist plays is subject to his or her beliefs, the beliefs, needs and fears of the teacher, and the demands of the school and division. Strong professional identity occurs when a specialist merges beliefs and culture in the context and sees progress happening

For Sam, division culture posed a difficult challenge for him in establishing a role he was comfortable with. The beliefs of the community, as represented by the school board, influenced the beliefs of the administration about what was desirable mathematic instruction. This created a culture where traditional teaching practices were favored above reform practices, and perhaps, as suggested by Sam, a culture that feared change. Sam struggled to support all teachers in his division because of restrictions placed on him by the structures in the division. The culture in the division was so strongly against change that Sam often felt helpless. Unlike other participants in this research, Sam was not able to bring about broad cultural changes that allowed him to develop a strong professional identity as a mathematics specialist. However, he has developed a classroom culture of his own where students investigate mathematics daily, discuss their reasoning, and are very successful. For Sam, the establishment of

this classroom culture and the students' response to it is an affirmation of his beliefs and professional identity.

Fourth Theme: The professional identity of a mathematics specialist is related to and changes with the use and recognition of his or her professional voice within the community of practice.

For all of the participants, a professional voice is emerging, or has emerged. These voices are becoming stronger as the participants confront challenges and find solutions. Their voices are an indicator of the level of competence or expertise they feel in their professional work, and are a vehicle for expressing the imagining and envisioning they do to plan for future growth and change. With these voices, the specialists are able to argue for changes they believe should be made, as well as provide the research basis and resources that allow the changes to come about. This is true for the participants who remain as mathematics specialists, as well as for Sam in his classroom teaching practice.

Cleo's voice can be heard when she speaks of changes she has made in her approach to her role as a specialist in her school. She is now clearly making decisions that she feels are appropriate for her school, and feels less need to follow the path of all the schools in her division. Her belief that increased assessment does not improve instruction, and that benchmarks that are too rigorous for her school's students are not helpful have empowered her to make decisions about professional development she plans with teachers in her school. As mentioned earlier, she and her teachers are looking at assessment to drive instruction, not to just measure what children know (or as is often the case, do not know). Cleo was not afraid to question an assistant principle who wanted her to model lessons; Cleo's beliefs about how to best move teacher's forward differed from this AP, and she stood firm. For some time, her

division was focused on helping teachers use the standard based textbook. Cleo was not comfortable with this as *the* way to get her teachers to teach better, and it felt unnatural to her as she had never been a teacher who relied on a book over other resources. Again, Cleo diverged from what other specialists were doing in favor of what she felt was best for her school.

Rosamund's voice was apparent in her work with APS. Her beliefs about how children learn were clearly heard as she worked to find other ways to help second grade teachers. Ouida began to develop her voice in New England when she realized she had the knowledge to successfully defend decisions the division had made regarding mathematics. Ouida's voice continues to grow, as she sees opportunities to share her knowledge in her new division, both at a school level, as well as through working with the division mathematics specialists. She wants that group to start helping teachers see what a series of good lessons looks like, and will push to see that happen. Even as a relatively new mathematics specialist, Ouida has the confidence to work towards what she believes. This is different from three years before when she was hesitant to tell someone how to do something for fear she would be wrong, or when she claimed she would "fake it". Pearl's voice is strong when she speaks of the reputation of the mathematics specialists; she speaks confidently of using skills she has developed as mathematics specialist to improve teaching throughout a school, in all subject areas. Sam has a strong voice when he speaks of the power of constructivist teaching in his classroom; while his voice has not convinced leaders in the district, it is welcomed by students. All of these voices are bred in competence and assurance.

As part of being professional, each one of these participants reflected in some way on the importance of maintaining their current knowledge. For instance, for Cleo,

being a mathematics specialist means staying current with the literature, and sharing that information with teachers in her school. One reason Rosamund left APS after one year was because she was not developing professionally, she was only able to share what she knew, but she was not provided opportunities to develop her own knowledge. Developing her knowledge was essential to Ouida for performing her job when she first began her position in New England, and she recognizes the strength that comes from a current knowledge base. For Pearl and her team of specialists, planning for and developing their professional knowledge is necessary for their work with schools, and the work they do for wider CPD in their division. Possessing up-to-date knowledge is essential in convincing others, and thus is one aspect of developing a professional voice.

The voice of the specialists is strengthened by changes they have seen occur in their schools and divisions, or in Sam's case in his classrooms, and the realization these changes are a result of their expertise. The strength of these voices also comes from recognition by others of the work they have done. Cleo has been told by teachers that she has changed the culture of her school and made it a math school. Rosamund has been able to answer questions in a room of other mathematics specialists from around the country and been confident; she has been recognized as being a "mathematics specialist from Virginia" by someone for whom she had respect. Rosamund senses teachers recognize her expertise when classes she is teaching fill up quickly. Pearl moves back and forth between schools, central administration and the state department, and is recognized by others outside her division as a leader in her division. Pearl has been told by colleagues that she can get things done; she sees herself as a person who can make things happen. Ouida has seen teachers respond to her work she did with CCSSM in New England, and is confident of the knowledge

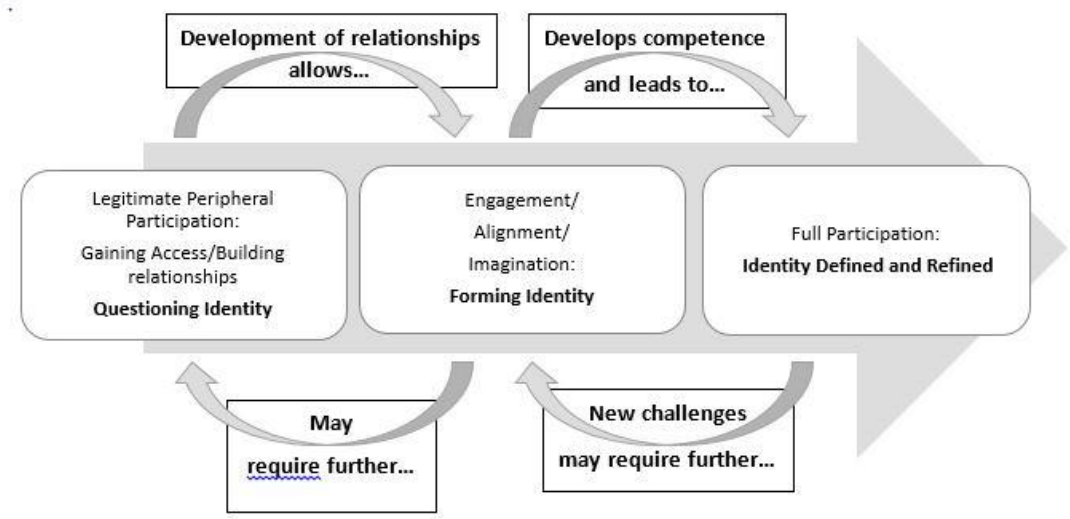
she has gained about the need for teachers to have curriculum that is directly connected to concepts, not just skills. She is prepared to begin encouraging change in her new school when the time is right.

Sam's voice may be heard best through his teaching; through his teaching, he has seen reticent students blossom, learning to use their own voices to support their reasoning and to question the reasoning of others. Students have told him he is the first teacher they have ever had to teach and not tell. Sam also continues to use his voice as a provider of teacher training and staff development. He has been held back from supporting more teachers in his division, either as a school based specialist, or as a division-wide leader, but his beliefs continue to impel him to encourage the move towards reform based curriculum.

For all of the participants, the effect of this recognition is to enhance and strengthen each of their identities as an expert. The result of this is a strong belief in themselves in the roles they perform.

Revised Conceptual Framework

The original conceptual framework (Figure 1 and shown again here)



implies that the trajectory of building a professional identity is not a completely linear process. This framework suggests that the development of identity can sometimes move forward, but can sometimes take a step" backwards". What it does not provide insight into is the factors and contexts that promote (or prevent) movement along this progression.

In this study, four themes were identified that affect the development of a mathematics specialist's professional identity. One of these themes, the importance of developing relationships, is included in the original framework. Other themes that emerged are shown in the outer circles of the revised framework. The theme related to cultures is divided into two parts, emphasizing the importance of considering the context and support the specialist receives, as well as the importance of considering how the culture of the community effects the role of the specialist at any given time.

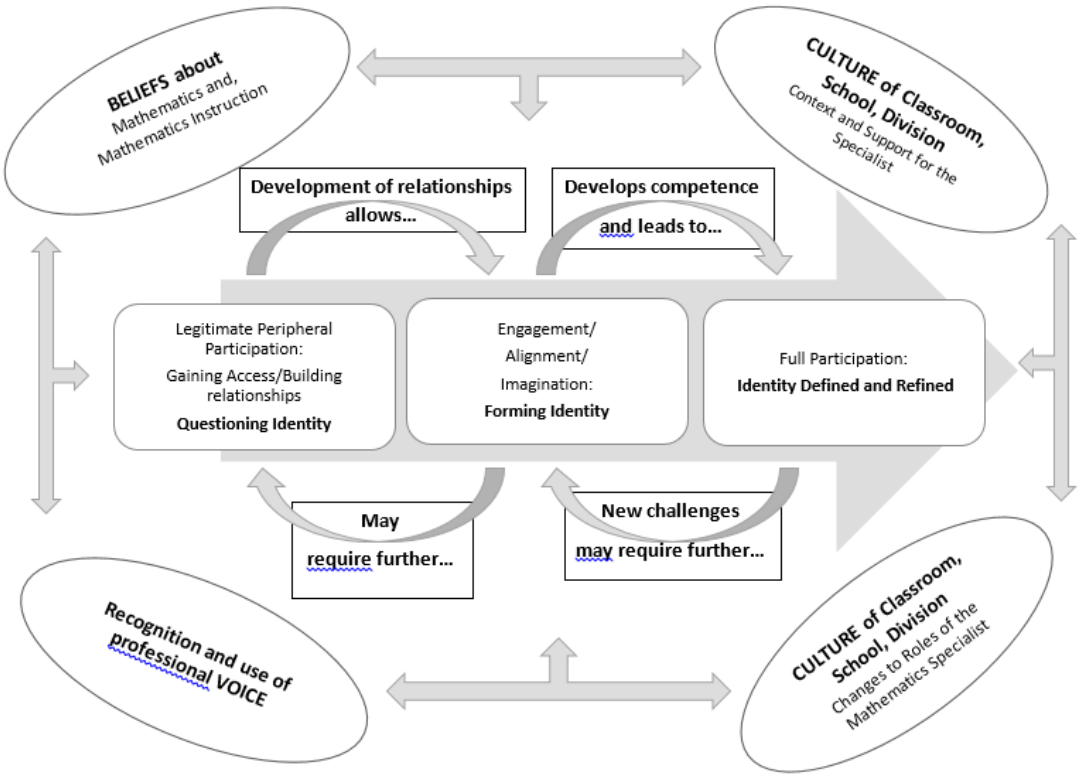


Figure 8: Revised conceptual framework for exploring the development of professional identities, drawing from Lave and Wenger (1991) and Wenger work (1998, 2000) and their work on legitimate participation and communities of practice.

Each of the themes provides a lens through which we can interpret what occurs at each stage in this professional identity trajectory, and see what various factors contribute to identity. Thus, the revised conceptual framework incorporates the vision of a not strictly linear trajectory with these four themes. The inner part of the diagram illustrates the general nature of the trajectory, with possibilities of non-linear progression, while the outer ovals represent the themes through which we can look at this progress and decode identity development. Arrows indicate that the themes interact with each other, as well as with the trajectory.

CHAPTER 5
CONCLUSION

This chapter begins with a summary of this study. This summary includes a review of the purpose of the study, the methodology, and findings. The summary then addresses the research questions, and answers those questions. Following the summary are implications, recommendations for future research, limitations of the study and the conclusion.

Summary

The purpose of this study was to explore the development of professional identities of experienced mathematics specialists. Professional identity development occurs when personal knowledge and beliefs merge with expectations and demands raised by preparation and the job context (Beijaard, Meijer, & Verloop, 2004). Developing a professional identity occurs over time, in a process that eventually integrates personal and professional aspects of becoming a mathematics specialist (Olsen, 2010). In this study, professional identity is defined as "how one sees one's self in the performance of one's professional role based on attributes, beliefs, motives, successes and failures, professional trajectories, and experiences. Professional identity reflects how well an individual has been able to align his or her personal and professional values with the values of others in the community; how the individual has been able to successfully engage with the practices of the community; and how the individual has been able to imagine his or her self as part of the community." It is important to keep in mind that identities are in flux, thus it is reasonable to look for and expect to find evidence of changing identities.

An interpretative phenomenological analysis methodology was used to research the following questions:

1) Given the different roles mathematics specialists undertake, and the varying contexts in which mathematics specialists enact those roles, how do experienced mathematics specialists perceive their professional identities?
2) In what ways, if any, do professional identities of mathematics specialists change over time, experiences, and contexts?

Data sources included interviews, artifacts of mathematics specialists' practices, and written communications. Four themes emerged from the analysis of the data.

First theme: The professional identity of a mathematics specialist is related to, and strengthened over time by, the specialist's beliefs about mathematics and mathematics instruction.

Second theme: The professional identity of a mathematics specialist is related to and changes over time with the relationships forged between the specialist and other members of the community of practice.

Third theme: The professional identity of a mathematics specialist is related to the changes over time in the culture of the community of practice, which in turn effects the roles and practices of the specialist.

Fourth Theme: The professional identity of a mathematics specialist is related to and changes over time with the use and recognition of his or her professional voice within the community of practice.

These themes were overlaid on a conceptual framework developed from considering research on communities of practice. This revised framework enables us to develop an understanding of professional identity by considering how the many roles assumed by mathematics specialists have

allowed them to engage in a community, bring their values and principles and the values of the community into alignment, and envisioning their ongoing presence within the community.

Addressing the First Research Question

Given the different roles mathematics specialists undertake, and the varying contexts in which mathematics specialists enact those roles, how do experienced mathematics specialists perceive their professional identities?

The participants in this study have assumed a number of roles through their positions as mathematics specialists. These roles have been school based, and based in central offices, and they have extended outside of the school divisions into the wider mathematics specialist community. Roles include supporting teachers in a variety of ways; supporting children in learning mathematics; supporting schools in implementing new initiatives; developing curriculum; developing assessment; analyzing data; leading CPD activities for teams of teachers, schools, and divisions; and acting as conduits for information from one level of the division to another. This list is reflective of the findings of Chval et al (2010) in their study of the professional identities of beginning specialists, where participants described the components of their professional identities as supporter of teachers, supporters of students, learner, and supporter of the school- at –large. It is not a surprising that the list drawn from the current study mirrors the identities in Chval et al given that mathematics specialists are hired to support mathematics teachers and mathematics instruction.

In Chval et al (2010) the participants were hired by a school district as a way to support mathematics teachers when achievement data indicated that support was

warranted. The teachers who were hired as mathematics specialists were considered expert mathematics teachers; however none had any particular preparation to become a coach. Their mission was "to partner with teachers and administrators in creating and sustaining instructional practices that increase student achievement and understanding in mathematics." They did not have images of what the job would be, nor did they have any expectations of what they would accomplish other than provide support.

The participants in the current study were well prepared for their roles as mathematics specialists. Perhaps one of the most important aspects of their preparation, at least for the results of this study, is the beliefs they developed about what mathematic is, how children learn mathematics, and how mathematics should be taught to allow children to develop as fluent and flexible mathematical thinkers. The participants in this study entered their first position as a mathematics specialist knowing they were to support teachers. But for each specialist in this study, that support was understood personally as *supporting teachers to bring about change*. They were to change teachers by developing their conceptual understanding of mathematics, and to change classroom practice from a focus on procedural learning to a focus on helping children build their understanding of mathematics. This understanding is grounded in conceptual development and sense making. In this regard, one component of the professional identity for each participant in this study is that of change agent. This element of their identity is part of what caused them to become a mathematics specialist in the first place. It does not seem to have wavered.

The cultures of the communities of practice in which the specialists have worked are important to consider when looking at the development of professional identity, because the culture of the community of practice determines the roles a

specialist will undertake. However, the roles a specialist adopts are not identity; identity is drawn from those roles, but it is how the specialist enacts those roles, and with what purpose and measure of success, that builds identity. Perhaps more importantly than determining roles, the culture of the community of practice determines how a specialist is able to build relationships to begin the process of working with teachers, and what actions they take once that relationship is brokered. In other words, the culture defines how a mathematics specialist initially participates in a community of practice, and how the specialist engages further with members of the community to bring about change. The culture is important when considering how the specialist envisions his or her identity evolving within the community, and considering how the specialist brings his or her beliefs and values into mutual alignment with those of other members from other community of practice.

Entering into her tenth year as a mathematics specialist, Cleo still identifies herself as a teacher. Within her context, she is classified as a teacher, and she is paid as a teacher. However, as a teacher she says she "works to improve the teachers' mathematics, understanding and teaching in my building. I am here to help the teachers overall, so all the children get the math instruction they need" (Tape 1, 53:04). Thus, Cleo also sees herself as a school wide teacher leader, supporting teachers to change their practices. She has always worked as a mathematics specialist in the same school, within the same context. In doing so, she has been able to translate her beliefs about mathematics instruction into practices that many teachers have adopted, and she has worked to change the culture of the school to reflect those beliefs; she has managed to align the beliefs of her school with her own beliefs about mathematics instruction. She has been supported in her beliefs, and has been supported as she continues to negotiate her role in the school. She has a professional

voice that is recognized and listened to. The larger context in which she works, her division, is and always has been clear that mathematic specialists are school leaders who are to bring about change in mathematics instruction, not to simply support. Though her job description has always said she was a school leader, only recently has her professional identity caught up.

One aspect of Pearl's professional identity is that she provides support: to teachers, to students, to parents, to administration. Pearl has been a mathematics specialist in the same division for ten years, but in those years the expectations for her role have changed several times. Given the context of her position, this identity at this time makes sense. Pearl has many official roles within her division at one time. She is a kindergarten through eighth grade mathematics specialist, she is the mathematics liaison for the high schools, and she is an instructional coordinator based in one middle school. With such a variety of responsibilities, it seems a daunting task to do much more than provide support. However, Pearl recognizes her presence is felt across the division and like Cleo, sees herself as a division leader. She believes that as a mathematics specialist her job is to help teachers and students learn mathematics in a sense making manner, but her job is no longer focused on just this. Her identity as 'support' is related to the culture in her division that has shifted from providing long term school-based professional development directed by the mathematics specialist (in the form of school-based specialists) to a system that provides pinpointed support at areas of greatest need, directed by the division. Her identity as a leader is derived from her work across the division.

Sam's identity is that he is a "damn good mathematics teacher." This identity is also related to the community of practice in which he works. First, when employed as a mathematics coordinator for the division, his strength was teaching mathematics

professional development courses to teachers. He believes that for mathematics instruction to change, teachers first and foremost need to understand and trust the mathematics, and he is successful in helping teachers develop this knowledge. Sam is also a successful, well regarded high school teacher. Thus, his experiences teaching warrant this professional identity. Sam does not identify as a school-based mathematics specialist at all. Again, the lack of identity in this area is connected to a context in which Sam was marginalized. His beliefs differed too greatly from the division; the trajectory of his professional identity as a mathematics specialist could not progress as he was essentially denied access to the community. However, he is recognized across the division as a very good provider of mathematics professional development, and this confirms his identity as a teacher.

All of these situations provide good evidence that the context in which specialists enact their roles are influential and related to the specialists' professional identity. The contexts define what roles the specialists take, and the defining of roles is based on how the context itself conceives of the role of mathematic specialist. For Cleo, the larger division context has always been aligned with her beliefs about her role, and through the years she has been able to change the culture and beliefs of the school to align with her own. For Pearl, the context changed, and the expectations for her job changed; so while she is provider of general support, she does this across the division and sees herself as a division-wide instructional leader. For Rosamund and Ouida, professional identity has been affected as they have moved across school districts and assumed different jobs. For Sam, context had a detrimental effect on his professional identity as a mathematic specialist, but that same context has allowed him to develop as a mathematics teacher, to both children and teachers. Because they

work in such different contexts, it is natural that the trajectories of their developing professional identities will have diverged after many years of practice.

Addressing the Second Research Question

In what ways, if any, do professional identities of mathematics specialists change over time, experiences, and contexts?

In the previous section of this chapter the claim was made that the mathematics specialists in this study all began their work as a specialist with an expectation and identity that they were a change agent: their purpose was to bring about change in mathematics instruction in their divisions. In each interview, and in each case study, the actions of the specialists support this claim. Furthermore, each of the specialists has specifically said that this is part of what they do. This element of their identity has remained constant.

However, alongside this constant identity as an agent of change there are parallel identities that seem connected to bringing about that change. These identities are connected to the roles teachers play at any given time, relationships with others in the community, and a developing sense of confidence and competence. Again some examples follow to illustrate.

Rosamund left LPS because the context of her job changed: she was asked to share her time between two schools rather than one, and she did not want to do that. Her early identity in her school was as a provider of support for mathematics instruction. Though she believed there were areas in which teachers could change instruction for the better, teachers did not have the same beliefs. Her very first years she says she was probably not a coach, and did not feel like one. Instead, she modeled lessons, trying to help teachers but not challenging their practice much. Eventually,

teachers recognized a need to change, and Rosamund's identity changed from one of support, to a provider of necessary information and training. She says her identity changed depending on the grade she was working with. She was confident with the early grades, and her identity with teachers at that level was as a collaborator in change. In the older grades, where she was less confident with the mathematics, she adopted an identity of a facilitator. She did not feel as if she had the level of mathematical knowledge needed to say "You should try this", so her guidance was more along the lines of "What if we thought about this?" By the time she left her school, she was leading of lesson studies, she had developed and taught (several times) a well-received course for the division, and she had received recognition from outside her division. She saw herself as a leader.

When Rosamund changed jobs and moved to her second position as a mathematics specialist, her identity faltered. The school held different expectations for her role than those held by Rosamund. At one point she questioned her identity, and wondered why she was at the school at all; at another point she found herself identifying with the role of the teachers who taught enrichment classes like music and art. Because of the culture of the school, elements of her identity were knocked. The element that remained strong was that she was there to change instruction. She also maintained a competent, professional voice, and was able to move her own agenda for improvement forward by rallying support from her administration. Rosamund was able to envision the change she wanted to begin in that year, and though challenged, managed to emerge feeling again like a school leader. Rosamund is a good illustration of how the trajectory associated with the development of professional identity is not linear.

Ouida began her work as a specialist as a division leader. Having no experience working as a mathematics specialist at a school or division level, her professional identity was that she was a fake! Her job was also poorly defined, so she wavered between identifying as a curriculum developer (her job) or as support for teachers in their classrooms (what she wanted to be). For three years she developed knowledge about curriculum, assessment, and how to gently bring about change. In her new job, her role is defined as a supporter of teachers by working with students in the classroom. Part of her identity is as the person who helps children who are struggling with mathematics catch up. Ouida imagines her role in the school and the division as one that will bring about changes in teaching. She does not yet claim she is a school or division leader, but her identity might be said to be as a visionary. She has ideas, and she shares them. She receives support for her ideas by colleagues and her administration. Where Ouida once regarded herself as a fake, she has developed a respected voice, grounded in the knowledge that she worked so hard to develop.

Sam again provides a unique case in that his professional identity as a mathematics specialist did not develop over time. For Sam, work as a mathematics specialist focused on providing in-service activities, either to lead teachers, or through system-wide professional development. He maintains a professional identity of a teacher, both in his classroom, and as a teacher to preservice teachers. However, Sam was not able to align his beliefs about mathematics instruction with those of his community. Over the time he was a mathematics specialists he did not have experiences that developed enough strong relationships or that produced enough change to convince him of his efficacy. Furthermore, challenges from a division that held different beliefs about mathematics and mathematics instruction created a culture that did not support being a mathematics specialist in the way Sam envisioned the job,

nor did it allow him to develop in order to imagine other ways to be a mathematics specialist.

Despite the fact that Sam has not developed a professional identity as a mathematics specialist, the professional identities of Cleo, Pearl, Rosamund, Ouida, and Sam have all changed in the same important way. They all view themselves as competent, knowledgeable professionals and leaders. Insecurities have vanished, and each of these participants speaks with a voice of someone who knows what they believe is valued by others. This confident stems first from their strong beliefs about mathematics For all of them the development of their professional identity as a leader happened over time, gradually, as a result of assuming a variety of different roles, but by always maintaining a focus on the goal of promoting mathematics reform. They have arrived at this point along different paths, but all of these paths involved sharing their beliefs with others, and working to change the beliefs of others. These paths involved offering support, and gradually changing the type of support offered as the culture of classrooms and schools warranted or accepted the change. The paths involved seeking support for themselves from other specialists and administrators, but also from knowing where and how to seek information and answers. The paths all include an ability to think independently about their job, and to make decisions that are right for them, their school, and their division. For each participant, the path also involved being recognized as a leader, and accepting that role.

Implications

This research has looked at how experienced mathematics specialists perceive their professional identity, and how this identity is a result of time, contexts, experiences, and the specialists' unique relations with members of their communities of practice. This research also looked at how alignment and changes in beliefs,

support, and culture result in the development of a confident, competent professional voice. Mathematics specialists who have a strong professional identity have a sense of efficacy that is derived from seeing change being made in the way teachers think about mathematics and mathematics instruction. They are supported by their division through policy that allows this professional identity to develop

Coburn, Mata, and Choi (2013) conducted research examining the role teachers' social networks play in bringing about educational change. Social networks in school systems provide ways for teachers to interact with colleagues. Often the professional norm of teaching is to work alone, without seeking support. To seek help is to open oneself to criticism or to being identified as lacking in some regard. Borgatti and Foster (2003) found that for teachers to seek help and build relationships that focused on improving practice, there needs to be a bond based on trust. Furthermore, Coburn, Mata and Choi found that such bonds were enhanced if there was a proximity to the expert providing support, and that bonds moved beyond seeking help from the expert, by also expanding the circle of colleagues that teachers spoke with about mathematics. Coburn and Russell (2008) noted that mathematics coaches were an important element in establishing these bonds, by both serving as experts as well as providing the conduit for networks to develop. In the district where they carried out their research, mathematics specialists were an important piece of the policy that promoted a reform agenda. When the district changed policy and deemphasized the work of the specialists, efforts to adopt reform measure slowed greatly.

The mathematics specialists in this study all shared the same intent of bringing about educational change. Evidence form this research indicates that for those mathematics specialists who have developed a strong professional identity, one reason

may be that they have been effective in supporting teachers in the development of social networks, thus creating multiple avenues for teachers to seek advice for change. Efforts to build relationships resulted in establishing bonds where teachers trusted the specialists and could seek advice for change. Furthermore, as specialists worked with teams of teachers, they provided an environment that was conducive to sharing ideas and problems. This helped teachers establish further professional bonds, not only with their grade level but with teachers with whom they did not have as much proximity, including teachers from other schools, and in some cases, other divisions. With the support of these social bonds, engaging with mathematics became safer, and the mathematical cultures of schools also changed.

An important finding form Coburn, Mata and Choi (2013) is that when the school division they studied changed policies and ceased providing opportunities for teachers to work together on a reform mathematics agenda, teachers' social networks stopped expanding, and often reverted to previous levels of interaction. This had the effect of stymying reform efforts. This suggests that school districts need to consider the ramifications of how support is provided to teachers. Cleo mentioned she was wary of possible changes to the structure of the mathematics specialists' positions in her division. She worries if they were moved to a central position and then placed in schools only when the school needs help, mathematics specialists will have less effect changing teachers' beliefs and practices. In Pearl's division, the central administration has already made a policy change to move specialists to a central position rather than to be base mainly in schools. However, other structures seem to be in place to continue to allow professional networks to continue to function. It is still to be seen if the mathematics improvement that is brought about by specialists working in schools only briefly, as needed to raise scores, will bring about long lasting change.

Social network theory provides an insight into why Sam has had less success in developing as professional identity as a mathematics specialist. Policy in his division seemed to work against the formation of increased social networks. Lead teachers in schools who could support teachers were not given time to work with them, and in turn Sam was not allowed enough time to work with and develop lead teachers. Furthermore, Sam did not have the opportunity to spend extended time building relationships within any one school and developing the trust he needed to guide teachers towards change. In Sam's district the norm remains for teachers to work alone: Sam has admitted that this is how he operates as a teacher. For Sam to have developed a strong professional identity as a mathematics specialist, he would need to see that his efforts were effective. Perhaps the lack of a strong teacher social network in schools in his division is one reason for Sam having a different outcome as a mathematics specialist than the other participants.

School and district policy play an important part in the success of a mathematics specialist. For instance, DePiper (2014) noted that school environment affects the ability to introduce and sustain reform based practices. This ties directly to the idea of social network theory, and the mathematics specialist's ability to develop a professional environment where exploring mathematics change is accepted by teachers. But DePiper's claim also shines a light on the need for a school or division to be consistent in practices that promote change leading to mathematical reform. In Cleo's case, a focus on testing for procedural fluency in her school did not support the development of conceptual teaching. Likewise, schools that adopt traditional texts, will find it a challenge to move teacher towards reform-based approaches. In Sam's case, his division did not support mathematical reform. No matter how strong the

beliefs of the mathematics specialist, change will not be made unless support can be garnered for change to be made.

The mathematical standards that guide the curriculum of a school or division may also have important implications related to the development of a mathematics specialist's professional identity. While social networks can provide necessary support for change, it is standards, and how those standards are assessed, that may be the motivating factor for teachers to identify a need to make changes. In Rosamund's case, teachers did not move to make changes until they realized that their students did not fare well on performance assessments. For Ouida, teachers were willing to consider reform approaches to teaching because the CCSSM Standards and assessment demand a different way of thinking about mathematics if children are to be successful. Virginia has not adopted the CCSSM, but changes to the test items that make the items less procedurally oriented will encourage teachers to make substantive changes in their mathematical understand and their teaching practice. Working with teachers who want to make changes will in turn make it easier for specialists to see progress and feel efficacious.

Murray and Male (2005) found that teachers transitioning to university teaching took three or more years to develop a strong professional identity. Time is an important implication in the development of a strong professional identity. In this research Cleo claimed that she thinks it takes anyone about ten years to figure out the job of a mathematics specialist. One wonders if that amount of could be shortened. In Cleo's case, she appeared to make progress towards bringing about change, but was often hampered by the administrator not holding teachers accountable to change, or by encouraging beliefs or practices that clashed with what the specialist was trying to do. Cleo, Pearl, Rosamund, and Ouida all alluded to time, and the need to be patient

in bringing about change with teachers; the implication is it takes time to see change occur. It is through years of experience that one develops a confidence in beliefs, and it takes years of consistent efforts for cultural changes to occur. As school cultures change, specialists adopt new roles and continue to align their beliefs and visions about mathematics instruction with those of the division. Progress is made, but teachers leave and new teachers arrive, and so the process of developing relationships and changing beliefs does not end. Time plays a function in the specialist developing a strong professional identity; furthermore, across time and contexts the strength of that identity may wax or wane.

A further implication of the time factor is that it is important for schools and divisions to remember that is takes time for a mathematics specialist to transition into the job and feel and function like a specialist, and to see change in teaching practice. Divisions that change policy without providing enough time to see any change take place may feel as though the reform effort has been futile, when in fact it just needed more time to mature. Similarly, divisions that expect change to be long lasting without investing time in developing social networks and without attending to the need to change beliefs may find increases in standardized test scores to be short lived.

Finally Pearl's case raises a significant point about the difference between general instructional or curriculum specialists, and specialists who are trained in mathematics and mathematic instruction. While Pearl is capable of providing general instructional and curricular support, few people are capable of delivering effective mathematics professional development, or of working with a teacher on specific mathematics pedagogical methods. Her division made a decision about how to use her that perhaps does not make the best use of her skills and talents. Whether this decision is the best one in this case is unknown, but it does seem that with mathematics

teachers and specialists in short supply, reassigning one to a position that requires less specific training should be done advisedly.

Recommendations for future research

There is little research available regarding the development of professional identities of mathematics specialists; with this in mind it appears there is a lot of scope for adding to this body of literature. This study explored the development of professional identity of mathematics specialists who were deemed to be strong and effective, both during their preparation and in their job performance as a specialist. To increase an understanding of how specialists develop their professional identity, it would be helpful to explore the identities of specialists who have not developed strong beliefs about mathematics and mathematics instruction. Other additions to the literature would include exploring the professional identities of middle school and high school specialists. With specialists at the secondary level there are likely to be a different set of challenges to their identity, beginning with the idea that there will be many teachers whose mathematical understanding is at the same level or higher than the specialist .

Another issue to explore considers the importance of standards and assessments in encouraging teachers to change. When working in New England Ouida was heavily involved in helping teachers to understand and implement the CCSSM. It would be interesting to explore how mathematics specialists in states that adopt CCSSM are accomplishing this work, as well as how divisions without mathematics specialists are managing the transition. Furthermore, Ouida claimed that because teachers had to come to grips with CCSSM her work as a specialist was clearer, and her ability to gain access to teachers made easier. It will be important to find out how what the effect CCSSM has on the training and support of specialists, as

well as CCSSM effects the development of mathematics specialists' professional identities.

The mathematics specialists in this study all had well developed beliefs about reform-based approaches to mathematics, and these beliefs shaped their professional identity. These beliefs were nurtured in their mathematics specialist degree program. Mathematics specialists are a response to the need to support reform-based mathematics in schools, so it seems essential that specialists develop beliefs needed to carry out this mandate. In what ways do other mathematics specialist programs, in the United States and other countries that have such programs (such as the United Kingdom) develop these beliefs in their trainees? If these beliefs are not held by the specialists, in what ways do their professional identities differ or resemble those of the specialists in this research?

Limitations

This study has several limitations. First, as is common with IPA studies, the sample is necessarily small. While this means the results of the study are not generalizable, the depth and richness of the cases allows the reader to make comparisons to other situations.

The participants in this study were chosen because they are recognized as being successful, strong specialists (with the exception of Sam, who was chosen because of the challenges he faced when a specialist). Again, this amount of homogeneity is indicated in IPA studies. As mentioned in suggestions for further reserch this limitation can be followed up by exploring how specialist who are not perceived as being strong fare when developing professional identity.

Finally, while attempts were made to gather artifacts from all participants, not all participants submitted additional documents. The additional documents might not

have added much to the stories, they would contribute further support to the claims made herein.

Conclusion

This purpose of this study was to explore the development of professional identities of experienced mathematics specialists. The study began by claiming it might fill part of the knowledge gap describing the preparation of mathematics specialists, how mathematics specialists transform preparation into practice, how practice itself provides continued development for the mathematics specialist, and finally, how mathematics specialists develop a professional identity. This study has described one particular progam that prepares mathematics specialists. This study has shown how mathematics specialists use the knowledge they gain through their preparation to establish beliefs about mathematics and mathematics instruction, and use these beliefs to guide the work they do with teachers in their schools, as well as interactions with other members in the community. This study has described how specialists develop as a result of their experiences, as well as out of a need to maintain advanced levels of knowledge. Finally this study has seen how different specialists have developed different professional identities as a result of their beliefs, relationships they are able to build, and changes they are able to bring about in their communities of practice, all resulting in a strong voice for supporting mathematics reform.

As there are no studies that have looked at the professional identities of *experienced* mathematics specialists, it begins to fill a gap in the literature. The mathematics specialists in this study had early professional identities that are reflected in one study that looked at the identities of beginning mathematics specialists. These early identities included supporter of teacher, and supporter of the school in general.

However, unlike the earlier study, it was noted that the specialists in this research supported teachers specifically to make changes in their mathematical knowledge and practices. As theorized, the participants in this study did not follow a linear trajectory to their current professional identity. The most marked change in the professional identity of each participant is that each one of them now sees themselves as a school and division leader of mathematics, capable of bringing about change in the way teachers think about mathematics and mathematics instruction.

Arriving at this professional identity took time, and involved challenges, some of which might have been addressed with better support from principals or administrators. One reason the specialists identify as school and division leaders is because they have each achieved a certain measure of success. Perhaps in finding more ways to support mathematics specialists in their work, more specialists might develop a professional identity of a successful school leader in a shorter period of time. This could only be good news for bringing mathematical change to schools.

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Appendix A

IRB-SBS Documentation

UNIVERSITY of VIRGINIA

OFFICE OF THE VICE PRESIDENT FOR RESEARCH
INSTITUTIONAL REVIEW BOARD FOR THE SOCIAL AND BEHAVIORAL SCIENCES

In reply, please refer to: Project # 2014-0186-00

June 3, 2015

Megan Murray
Robert Berry
CISE (Curriculum, Instruction & Special Ed)
University of Hull
Scarborough School of Education
Scarborough,United Kingdom

Dear Megan Murray and Robert Berry:

The Institutional Review Board for the Behavioral Sciences has approved your CONTINUATION for the research project entitled "The Development of Professional Identities of Mathematics Specialists." You may proceed with this study. Please use the enclosed Consent Form(s) as the master for copying forms for participants.

This project # 2014-0186-00 has been approved for the period June 12, 2015 to June 11, 2016. If the study continues beyond the approval period, you will need to submit a continuation request to the Review Board. If you make changes in the study, you will need to notify the Board of the changes.

Sincerely,

Tonya R. Moon, Ph.D.
Chair, Institutional Review Board for the Social and Behavioral Sciences

One Morton Drive, Suite 500 • Charlottesville, VA 22903
P.O. Box 800392 • Charlottesville, VA 22908-0392
Phone: 434-924-5999 • Fax: 434-924-1992
www.virginia.edu/vpr/irb/sbs.html

Informed Consent Agreement

Please read this consent agreement carefully before you decide to participate in the study.

Purpose of the research study: The purpose of this interpretative phenomenological study is to explore the development of professional identity in mathematics specialists. The general intent is to begin to learn about and describe those experiences and contexts seen as significant by mathematics specialists for developing professional identities, and likewise, those experiences and contexts mathematics specialists view as a challenge or hindrance to the development of their professional identities. In particular, this research will look at individual biographical data, similarities and differences in training programs undertaken to become a mathematics specialist, and experiences working as a mathematics specialist that have led to the development of a new professional identity for each participant in the study.

The specific intent of this research is to examine how you (and some of your colleagues) have developed your content and pedagogical knowledge of mathematics, how you continue to develop professionally through the practice of teaching other teachers, and how your understandings, beliefs, and practices have led to your professional identity as a mathematics specialist. By examining the pathways taken by you to develop your professional identity as a mathematics specialist, and through comparing and contrasting your pathway to the pathway of others, I want to identify preparation and practices that support individuals as they move from the role of classroom teacher to the role of mathematic specialist.

What you will do in the study: As a participant in this study you will be asked to participate in one semi – structured interview, and a shorter follow-up interview if any clarifications are needed. You may also be contacted by email for clarification.

Time required: The total time for the initial interview and debriefing should not exceed 2 hours. The time for a possible follow-up interview, or to respond to email questions should not exceed 30 minutes.

Risks: All information obtained will be reported confidentially, using pseudonyms; there will be no personal connection to you and your responses.

Benefits: There are no direct benefits to you for participating in this research study. The study may help us understand how to improve training and support for mathematics specialists in general and for teachers moving into leadership roles in general.

Confidentiality: Your interview will be reported using pseudonyms, and any other identifying information (e.g. names of schools attended, place worked, school districts) will be referred to with pseudonyms as well. Data will be collected through recorded interviews and transcribed using these pseudonyms. As there are only three to five participants in this study, and as data will be analyzed through a narrative case study of each participant's story, you may be recognizable to people who know

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SBS Staff	MQ	

you in your context as mathematics specialist trainee or as mathematics specialist. Be mindful that while all attempts will be made to maintain confidentiality, there is a possibility of recognition. You will be provided an opportunity to read your case and edit it before publication to insure that if your identity is surmised by a reader, you should expect no negative effects.

Data linked with identifying information: Audio recordings will be made of interviews. Recordings will be transcribed, and then destroyed at completion of the project. The transcript will be retained for future use.

Anonymous data: Data collected from interviews in the study will be handled confidentially. Your data will be confidential which means that your name will not be linked to the data. Because of the nature of the data, it may be possible for readers very familiar with the Virginia Mathematics Specialist program to deduce your identity; all attempts will be made to write up individual cases in such a way that identification of individuals is difficult. As cases are developed, all care will be taken to respect the personal and professional personas of the participants. Once written, you will be given the opportunity to review your case and to request changes or deletions of information if you feel they might be harmful to you professionally or personally.

Voluntary participation: Your participation in the study is completely voluntary.

Right to withdraw from the study: You have the right to withdraw from the study at any time without penalty. Should you choose to withdraw from the study, your interview recording and transcript will be destroyed.

How to withdraw from the study: If you want to withdraw from the study, please contact Megan Murray (see contact information below.) There is no penalty for withdrawing.

Payment: You will receive no payment for participating in the study.

If you have questions about the study, contact:

Researcher:

Megan Murray
University of Hull, Scarborough School of Education
Scarborough, United Kingdom
Telephone: 011 44 7564 718221
Email address: mek2v@virginia.edu

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Faculty Advisor
Robert Q. Berry III
CISE
PO Box 400273
University of Virginia
Charlottesville, VA
434-924-0767
Rqb3e@virginia.edu

If you have questions about your rights in the study, contact:
Tonya R. Moon, Ph.D.
Chair, Institutional Review Board for the Social and Behavioral Sciences
One Morton Dr., Suite 500
University of Virginia, P.O. Box 800392
Charlottesville, VA 22908-0392
Telephone: (434) 924-5999
Email: irbsbshelp@virginia.edu
Website: www.virginia.edu/vpr/irb/sbs

Agreement:
I agree to participate in the research study described above.

Signature: _____ **Date:** _____

You will receive a copy of this form for your records.

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Appendix B

Interview Protocol

The Development of Professional Identities of Mathematics Specialists
Semi Structured Interview Protocol

1) To begin this interview, I'd like to understand the story of your professional experiences that brought you to the point of becoming a mathematics specialist. Please tell me about:
   a. your background in education, including where and when you received your training (initial degrees and any other degrees or programs);
   b. your experiences in the classroom and schools;
   c. events that motivated you to become a mathematics specialist.
2) Now I'd like to talk to you about your training to become a mathematics specialist.
   a. Tell me about your initial reactions to coursework in the program. What surprised you? What challenged you? What do you feel came easy to you?
   b. Were you part of a cohort? What were the benefits of that for you? What were challenges to being part of a cohort?
   c. In what ways did your training prepare you to be a mathematics specialist? In what areas would you have liked more training? Are there contexts that arise as a mathematics specialists for which you think no training would prepare you? What are they?
   d. Tell me about a "transformative" experience in your training. What happened? How did it transform your thinking?
3) I'd now like to talk to you about early experiences in the role of mathematics specialists.
   a. What did you expect your job would be like when you began as a mathematics specialist? How did you expect to use your time? How did you actually use your time?
   b. What did you see as your strengths? What did you see as your weaknesses?
   c. What was your main focus in your first year as a mathematics specialist? What did you see your role as being?
   d. Tell me about a time when your personal beliefs conflicted with what was asked of you. How did you deal with this?
   e. What were the biggest challenges to your identify as a mathematics specialist when you first began this role? Please tell me a story about one of these challenges and how you handled it.
   f. What support did you receive in your first year as a mathematics specialist? Please tell me a story about a time when you did (or did not) feel supported.
   g. What is an example of a time when you first believed in yourself as a mathematic specialist? What is an example of a time when you doubted yourself in the role of mathematic specialist?
4) Since becoming a mathematics specialist, what experiences have you had that have developed your beliefs and identity? How have you continued to develop into the role?
   a. How has your role within schools become structured to suit you as well as the needs of your school/district? What has been your role in structuring your position? What control have others had?
   b. What roles outside of school have you taken to enhance your professional identity as a mathematics specialist? How have these roles developed your sense of being a mathematics specialist?
   c. What are your strengths now? Weaknesses?
5) Please describe how work as a mathematics specialist has changed you as a professional. How has your content knowledge grown? How has your understanding of teaching children grown? How has your understanding of your school district grown? How have your professional skills as a teacher of teachers developed? How has your work within your school changed?
6) In what ways do you see yourself as mathematics specialist now that are different from when you first took on the role?
7) When someone asks you what you do, what do you tell them?
8) What thoughts would you like to finish with?