COACHES' AND PRINCIPALS' CONCEPTUALIZATIONS OF THE ROLES OF ELEMENTARY MATHEMATICS COACHES

by

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Dedication

This study is dedicated to my family. I would not have been able to accomplish as much as I have in my life without their incredible love and support. My mother, Mary, gave me confidence because she thought everything I did was wonderful. She left us too early, dying of cancer at the age of 44. I know that she is looking down and smiling at me. My father, Jim, instilled in me a love of mathematics. He also taught me to work hard and be the best I can be. My husband, Michael, did lots of housework and missed many social events because I was busy doing school work. I could not have finished this dissertation without his understanding and patience. My sisters, Sharon and Charlene, were eager confidants. They listened when I was frustrated and gave encouragement when I needed it. My stepdaughter, Emily, endured as I compared my college experience to hers, and my stepson, Patrick, understood when I missed his hockey games because I was busy studying. My family's collective love and belief in me is what keeps me going. For this, I am deeply grateful.

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Abstract

COACHES' AND PRINCIPALS' CONCEPTUALIZATIONS OF THE ROLES OF ELEMENTARY MATHEMATICS COACHES

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Many schools employ coaches to support mathematics instruction and student learning. This research study investigated the roles of coaches from five school districts in Virginia. Participants included 125 elementary mathematics coaches and 59 principals. Results from cross-sectional surveys revealed that most coaches did not have a degree in mathematics education or hold a mathematics specialist endorsement. Principals did not value the mathematics specialist endorsement as a selection criterion as much as they valued other criteria. Coaches were serving in multiple roles, predominantly acting as classroom supporters, resource providers, instructional specialists, and data coaches. They were also acting as pull-out teachers, providing remediation to students. Coaches' work with teachers was largely determined by teachers' comfort level and willingness to be coached. Principals thought classroom supporter, catalyst for change, instructional specialist, data coach, and school leader were the most important roles. Statistically significant differences showed that principals and coaches disagreed about the

importance of three coaching roles (catalyst for change, school leader, and resource provider). Many principals were not aware that they did not share common understandings with their coaches about the coaches' roles and responsibilities, their vision of mathematics instruction, and their mutual communication.

1. Introduction

Background of the Problem

Elementary teachers in the United States are, typically, generalists. Their preservice education prepares them to teach many subject areas with no specific focus on any one area. Preservice preparation in mathematics usually includes two or three courses in mathematics content and one course in mathematics pedagogy (Fennell, 2007). While this preservice preparation is "the foundation for mathematics teaching, … it gives teachers only a small part of what they will need to know and understand throughout their careers" (National Council of Teachers of Mathematics [NCTM], 2000, p. 370). Ma (1999) reports that many elementary teachers in the United States lack deep knowledge of mathematics content and pedagogy, and Fennell (2007) agrees that "the pre-service background and general teaching responsibilities of elementary teachers do not typically furnish the continuous development of specialized knowledge that is needed for teaching mathematics today" (p. 2). One way that school districts have tried to address these issues is to hire mathematics coaches to support classroom teachers (Association of Mathematics Teacher Educators [AMTE], 2010; Chandler, 2008).

Statement of the Problem

In Virginia, mathematics professionals who support elementary and middle school teachers and students are called "mathematics specialists." In the U.S., professionals of

this type have been referred to as mathematics coaches, resource teachers, lead teachers, and facilitators. The mathematics specialist movement in Virginia has been growing for the past 20 years and has reached the point where many school districts are hiring mathematics specialists. The Virginia Board of Education has made a recommendation to the legislature to require school districts to employ one mathematics specialist for every 1000 students at the elementary and middle school levels. While this recommendation has not yet been added to the Virginia Standards of Quality, many anticipate that it will happen within the next few years. In the meantime, the legislature has encouraged schools to hire mathematics specialists and allowed districts to use existing funding flexibly to do so (Virginia House Joint Resolution No. 652).

In March 2009, a task force from the Virginia Mathematics and Science Coalition (VMSC) reported that approximately 250 schools in Virginia have full-time Mathematics Specialists. With so many mathematics specialists currently working in Virginia and in anticipation of many more being hired, it is important to investigate what mathematics specialists do on a daily basis. Currently, little is known about the roles and responsibilities of mathematics specialists. Do they act as mathematics coaches or do they teach mathematics to students? If they act as coaches, who do they coach and how do they coach them? Pitt (2005) stated a need to find out what mathematics specialists are and what they do, as well as what elements of school culture and administrative support are necessary to make mathematics specialists successful.

Significance of the Problem

Virginia is not the only state that has focused attention on improving students' mathematics achievement by hiring mathematics specialists. National organizations have recommended using elementary mathematics specialists to improve mathematics instruction and boost student achievement (AMTE, 2010; Conference Board of the Mathematical Sciences, 2001; National Council of Teachers of Mathematics, 2000; National Mathematics Advisory Panel, 2008; National Research Council, 2001). The National Mathematics Advisory Panel recognized that there are three different types of mathematics specialists currently employed in elementary schools: mathematics coaches, full-time mathematics teachers, and pull-out teachers. The Panel found no high-quality research on any of these models of mathematics specialist programs.

The Conference Board of the Mathematical Sciences (2001) recommends the full-time mathematics teacher type of mathematics specialist stating that mathematics in grades 5-8 should be taught by mathematics specialists. The rationale for this recommendation is that it "reduces the educational burden for those teaching mathematics in these grades and provides opportunities for prospective teachers of these grades who like mathematics to specialize in it" (p. 11). The National Mathematics Advisory Panel (2008) also seems to favor this type of mathematics specialist, recently recommending that research be conducted on the use of mathematics specialists who teach mathematics full-time to several classes of students.

Other organizations seem to favor the mathematics coach type of mathematics specialist. The National Council of Teachers of Mathematics (NCTM, 2000) said "there

is an urgent and growing need for mathematics teacher-leaders – specialists positioned between classroom teachers and administrators who can assist with the improvement of mathematics education" (p 375). NCTM envisions these mathematics specialists working with teachers, assisting them in building knowledge of mathematics content and pedagogy.

The AMTE (2010) supports all three models stating that "the specific roles and responsibilities of [elementary mathematics specialist] professionals vary according to the needs and plans of each setting" (p. 1). They say that a mathematics specialist may work with teachers as mentors, teach mathematics to all students at a grade level, or provide remediation or enrichment to particular groups of students.

As school districts across the United States pin their hopes on mathematics specialists, it becomes increasingly more important to define the role of a mathematics specialist and create a clear picture of what successful mathematics specialists do. Such information could help educators and policymakers understand the scope of mathematics specialist programs and how teachers and students benefit from them. Furthermore, a deeper understanding of the roles and responsibilities of mathematics specialists could assist researchers in developing further research on the effectiveness of mathematics specialists programs and how they impact teachers' instructional practice and students' achievement. This study focuses on how elementary mathematics specialists and their principals conceptualize the role of the mathematics specialist. It makes an important contribution to the literature on mathematics teaching and learning.

Definition of Terms

Before moving any further in this dissertation, it becomes necessary to define the terms that are used. There is much confusion about what to call mathematics specialists. Frequently used terms include specialists, coaches, support teachers, resource teachers, lead teachers, liaisons, mentors, peer teachers, visiting teachers, teacher-leaders, coordinators, and facilitators (Ball, et al., 2008; Burns, 2006; Dossey, 1984; Fennell, 2006, 2009; McGatha, 2009b; NCTM, 2000; Reys & Fennell, 2003). For this study, the term *mathematics specialist* is defined as a teacher with specialized knowledge of mathematics content and pedagogy. The term *mathematics coach* is defined as a teacher who primarily works with teachers and does not have classroom duties. Someone who teaches mathematics to students is defined as a *mathematics teacher*. The term *mathematics teacher-leader* is used to describe a teacher with an interest in mathematics who takes on leadership responsibilities for a school. While mathematics specialists may work as mathematics coaches, mathematics teachers, and mathematics teacher-leaders; mathematics coaches, mathematics teachers, and mathematics teacher-leaders may or may not be mathematics specialists. A clear definition of each term is listed below.

1. Mathematics specialist – a teacher with specialized knowledge of mathematics content and pedagogy
2. Mathematics coach – a teacher who primarily works with classroom teachers to improve mathematics instruction (i.e. no classroom duties)
3. Classroom teacher – a teacher who teaches all subjects to students
4. Mathematics teacher – a teacher who primarily teaches mathematics to students

5. Mathematics lead teacher – a classroom teacher who takes on additional duties to provide leadership in mathematics to the school
6. Mathematics teacher leader – any teacher with an interest in mathematics who takes on leadership responsibilities for a school

Purpose of the Study

This study investigates the roles and responsibilities of mathematics coaches from five school districts in Virginia. It examines the roles of mathematics coaches from two perspectives: mathematics coaches and principals. Results from cross-sectional surveys were compared in order to determine how both groups conceptualized the roles of mathematics coaches. Differences and commonalities in those conceptualizations were identified.

There is a real need to understand mathematics coaching. There is much confusion about what mathematics coaches do, the goals of mathematics coaching programs, how mathematics coaches influence teachers' instructional practices, and how they impact student achievement. While there is a great deal of practitioner literature on mathematics coaching, giving advice on how to be a mathematics coach (Felux & Snowdy, 2006; Morse, 2009; Reys & Fennell, 2003; West & Staub, 2003), most coaches are expected to define and conceptualize the role on their own. As yet, there is no empirical research on the subject. This study provides a research base of what coaches do, how they interact with teachers, how their roles vary, and what principals do to support them. It provides a more precise definition of the role of a mathematics coach, from the perspectives of actual mathematics coaches in the field and their primary

supervisors. This information could help educators and other stakeholders make decisions about employing mathematics coaches and articulate clear expectations for their roles. It provides a basis for discussion as mathematics coaches negotiate their roles with their administrators and other district leaders. In addition, the findings from this study could assist researchers in developing research on the effectiveness of mathematics coaching programs and how they impact teachers' instructional practice and students' mathematics achievement.

Research Questions

The following research questions guided this analysis:

1. Who are elementary mathematics coaches?
    a. What educational background, teaching experience, and specific coaching preparation do elementary mathematics coaches have?
    b. What factors influence principals' selection of elementary mathematics coaches?
2. How do elementary mathematics coaches define their roles and responsibilities?
3. How do elementary principals define the roles and responsibilities of elementary mathematics coaches?
4. What differences exist in the way the mathematics coach role is conceptualized by mathematics coaches and principals?

Assumptions, Delimitations, and Limitations

It was assumed that the information provided by the five school districts and used to identify mathematics coaches and their principals in this study was accurate. It was

also assumed that the survey respondents in this study voluntarily participated and answered the survey questions honestly.

Delimitations are characteristics that limit the scope of a study and include inclusionary and exclusionary decisions made about the choice of the problem, the purpose of the study, and the research questions. One delimitation of this study is that it does not examine the impact of mathematics coaches on teachers' instructional practices or students' mathematical achievement. While these questions are important and should be investigated, it was not feasible to do so, given the time constraints of a dissertation. Another delimitation of the study is that mathematics coaches were not observed or asked to document their use of time. These types of data collection techniques would have provided valuable information about the roles and responsibilities of mathematics coaches, but would have been problematic due to time constraints and lack of funding for technological support (e.g., hand-held data collection devices). A third delimitation is that only five schools districts out of 134 in Virginia were selected to participate in the study. The decision to limit the number of participating school districts was made in order to control the scope of the study and limit the amount of time needed to obtain permissions and collect data.

One limitation of this study is that it is only generalizable to mathematics coaches in elementary schools in suburban school districts in Virginia. Another limitation is that the data are self-reported and measure opinion rather than fact. In addition, by constructing standard survey questions that were understandable to all survey

respondents, questions may have been missing that included ideas or concepts that were important to some respondents.

2. Review of Literature

Introduction

The purpose of this chapter is to provide a comprehensive literature review of topics related to this study. This literature review has seven main sections: 1) elementary teachers' preparedness to teach mathematics; 2) the call for mathematics specialists; 3) mathematics specialist program models; 4) research on coaching, mathematics coaching, and other mathematics specialist models; 5) the roles of mathematics coaches; 6) the principal's role in a mathematics coaching program; and 7) success of mathematics coaching programs.

Elementary Teachers' Preparedness to Teach Mathematics

"Teacher quality is the single most important factor in determining the success of children in school, more than race, poverty, or any other outside influences" (The Education Trust, 2003, p. 2). Darling-Hammond's (2000) review of research on teacher effectiveness found six variables that may affect teacher quality: general academic ability, subject matter knowledge, knowledge of teaching and learning, teaching experience, certification status, and teacher behaviors and practices.

While studies are inconsistent in determining which of the six variables has the most profound effect on student achievement (Wilson & Floden, 2003), researchers have found some things of interest. While there seems to be a relationship between teachers'

subject matter knowledge and student achievement in mathematics (Wilson & Floden, 2003), there is a stronger relationship between teachers' education coursework and student performance than teachers' subject matter coursework and student performance (Darling-Hammond, 2000). Additionally, teachers' mathematics methods coursework is a stronger indicator of student achievement than teachers' studies of higher-level mathematics (Darling-Hammond & Youngs, 2002).

Teacher Knowledge

There are three types of knowledge that contribute to a teacher's ability to teach mathematics at the elementary school level: mathematics content knowledge, pedagogical content knowledge, and mathematical knowledge for teaching. The following sections will discuss each type of knowledge.

Mathematics content knowledge. The NCTM's *Principles and Standards for School Mathematics* (2000) states that "to be effective, teachers must know and understand deeply the mathematics they are teaching and be able to draw on that knowledge flexibly in their teaching tasks" (p. 17). In a comparison of Chinese and U. S. teachers, Ma (1999) found that U.S. elementary teachers typically lacked this kind of mathematical knowledge. Moreover, Chinese students typically outperformed U.S. students on tests of mathematical ability. Ma found that Chinese teachers had a "profound understanding of fundamental mathematics" (p. 107) which included a deep knowledge of the curriculum, the sequence in which it is taught, and an understanding of the connections among mathematical concepts and procedures.

Pedagogical content knowledge. Shulman (1986) identified *pedagogical content knowledge* as a specialized form of content knowledge that teachers need for teaching. Pedagogical content knowledge includes knowledge of the topics of instruction within one's subject area, an understanding of what makes those easy or hard to grasp, students' frequent misconceptions within those topics, and a repertoire of the most useful forms of representations that make those topics comprehensible to learners.

Mathematical knowledge for teaching. Teaching mathematics requires more than knowing and being able to do mathematics (Ball, 2003). Studies of teachers' knowledge of mathematics for teaching (Ball, Hill, & Bass, 2005; Hill & Ball, 2004; Hill, Rowan, & Ball, 2005; Hill, Schilling, & Ball, 2004) have identified a kind of mathematical knowledge that is important in the teaching of mathematics. Deborah Loewenberg Ball coined the term "mathematical knowledge for teaching" to describe the unique kind of knowledge and skills that highly qualified teachers of mathematics must have (Viadero, 2004). "Mathematical Knowledge for Teaching" is a deep understanding of mathematics that allows teachers to explain why common algorithms work, evaluate students' problem-solving strategies, anticipate students' misconceptions, and analyze students' errors. Teachers need to know the mathematical content and standards that should be taught and recognize the relationships among those mathematics topics. They must understand mathematical procedures in detail, but also have a clear understanding of why the procedures work. They must be able to represent mathematical ideas in multiple forms, choosing and using mathematical models skillfully. In addition, they must know their students and be able to adjust their teaching techniques according to the

needs of their students. They should be able to interpret students' computational errors, evaluate students' alternative algorithms for usefulness, and understand students' mathematical thinking. Teachers with "mathematical knowledge for teaching" have an extensive and complex set of knowledge and skills that facilitates student learning.

Measures of teachers' knowledge for teaching mathematics. Researchers have had some success in developing reliable measures of teachers' knowledge for teaching mathematics (Hill & Ball, 2004; Hill, Ball, & Schilling, 2004; Hill, Rowan, & Ball, 2005; Rowan, Schilling, Ball, & Miller, 2001). One study measured teachers' content knowledge for teaching mathematics with multiple choice questions about classroom scenarios, but had difficulty developing items and scenarios that measured the full range of teachers' knowledge (Rowan, Schilling, Ball, & Miller, 2001). Results of a subsequent study suggested that measures should be developed in multiple dimensions of knowledge for teaching mathematics including such domains as mathematical content knowledge in different mathematical strands and knowledge of students' mathematical thinking within those strands (Hill, Ball, & Schilling, 2004). A third study found that first and third grade teachers who scored high on tests designed to measure mathematical knowledge for teaching had students who made gains in measures of student achievement (Ball, Hill, & Bass, 2005; Hill, Rowan, & Ball, 2005). In addition, teachers who participated in a summer workshop focused on mathematics for elementary school teaching increased their scores on tests designed to measure teachers' mathematical knowledge for teaching (Hill & Ball, 2004). Taken together, these studies suggest that professional development

designed to improve teachers' mathematical knowledge for teaching could have a positive impact on student achievement.

Teacher Professional Development

There has been quite a lot of research on how to design effective professional development for teachers. Researchers have found that the best professional development is "intensive, ongoing, and connected to practice" (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009, p. 5). This type of professional development is called "practice-based professional development" and is "situated in practice" (Smith, 2001). It involves the work that teachers do every day and includes thoughtful inquiry and reflection about the lessons they plan, the tasks in which they engage children, the instructional strategies they use, and the ways in which they assess students. Ongoing practice-based professional development allows teachers to deepen their understanding of mathematics, examine their own instructional practices, and learn about their students' mathematical thinking (Smith, 2001; Weiss & Pasley, 2009).

While few teachers in the United States have opportunities to participate in this type of sustained high-quality professional development, it makes a difference in student achievement (Darling-Hammond, et al., 2009). It can take the form of centralized workshops (Weiss & Pasley, 2009), but greater numbers of teachers are engaging in job-embedded professional development activities at their own school sites. Job-embedded professional development helps teachers "to implement instructional change in their classrooms" and to "take ownership of their own professional growth" (Weiss & Pasley, 2009, p. 39). It allows teachers to receive support for their own learning on a daily basis

within their own classrooms. It can be provided in a number of ways including collaborative lesson planning, co-teaching with other teachers, working with a coach, and participating in lesson study. Lesson study (Smith, 2001) is a model where groups of teachers design and implement lessons together.

This section of the literature review has examined the extensive knowledge teachers need in order to teach elementary mathematics and the research-based effective professional development practices that may help teachers gain that knowledge. An increasing number of school districts have begun hiring mathematics specialists and coaches in order to provide job-embedded professional development to teachers. The next section of the literature review will outline the history of the mathematics specialist movement in the United States.

The Call for Mathematics Specialists

Mathematics educators have long thought that one way to increase teachers' mathematical knowledge for teaching and students' mathematics achievement was through the use of mathematics specialists. In fact, the mathematics education community has been talking about mathematics specialists for almost 30 years. This section of the literature review will examine the call for mathematics specialists at the national level and in the state of Virginia.

The National Call for Mathematics Specialists

The first mention of mathematics specialists in the literature was in 1981, when the NCTM board of directors recommended that states create mathematics specialists endorsements for elementary teachers (Fennell, 2006). Three years later, John Dossey

(1984) wrote an article for the *Arithmetic Teacher* calling for elementary mathematics specialists. He urged the mathematics community to embrace this idea and recognize that mathematics specialists could do many things to improve mathematics programs at the K-6 level. Five years later, recommendations were again made for states to create special certifications for elementary mathematics specialists, this time by the National Research Council (NRC, 1989).

In 2000, *Principles and Standards for School Mathematics* (NCTM) stated "an urgent and growing need" for mathematics specialists who could "assist with the improvement of mathematics education" (p. 375). One year later, the Conference Board of the Mathematical Sciences (2001) recommended that mathematics be taught by mathematics specialists starting in grade 5. The rationale for this recommendation included limiting the number of teachers requiring professional development in mathematics and allowing teachers who liked mathematics to specialize in it. In 2003, the National Council for Accreditation of Teacher Education (NCATE) added program standards for Elementary Mathematics Specialists. These standards were for candidates preparing to teach only elementary mathematics, rather than all elementary subject areas.

In Johnny Lott's NCTM Presidential Message (2003), he said that high expectations for students' mathematics achievement and elementary teachers who did not have a deep understanding of the mathematics they taught were two reasons to employ mathematics specialists at the elementary school level. His plea, "the time has come for pre-K-5 mathematics specialists," was one of many over the years. In the same year, Reys and Fennell (2003) made a case for elementary mathematics specialists in an article

published in *Teaching Children Mathematics.* Their argument also cited higher expectations for students' mathematics learning and poor preparation of elementary teachers to teach mathematics. They suggested that elementary mathematics specialists could "make a difference in improving mathematics instruction" (p. 281).

In 2006, NCTM president, Skip Fennell, said there was a "crucial need" for mathematics specialists at the elementary level. Fennell again mentioned his concern that elementary classroom teachers do not have the knowledge they need to teach the mathematics that is foundational for children in these early grades.

In 2008, the National Mathematics Advisory Panel made a recommendation that "research be conducted on the use of full-time mathematics teachers in elementary schools" (p. xxii). These teachers would be mathematics specialists who had a strong knowledge of mathematics content and pedagogy. Rather than teach all subjects, they would teach only mathematics to several classes of students each day. The panel suggested that this was a practical approach that could alleviate the need to provide professional development in mathematics teaching to all elementary school teachers by focusing on the professional development of a select few.

Most recently, the Association of Mathematics Teacher Educators (AMTE, 2010) published *Standards for Elementary Mathematics Specialists.* These standards outlined specific knowledge, skills, dispositions, and leadership qualities that are needed by elementary mathematics specialists. The AMTE advocated for states to create formal certificate programs for elementary mathematics specialists. The standards were proposed in order to help states create these certification programs and to assist universities in

creating preparation programs for elementary mathematics specialists. Currently nine states (Arizona, California, Georgia, Michigan, Ohio, South Dakota, Texas, Utah, and Virginia) have special certifications for elementary mathematics specialists (AMTE, 2010).

The History of Mathematics Specialists in Virginia

The history of mathematics specialists in Virginia began in the early 1990's with the concept of Mathematics Lead Teachers. Mathematics Lead Teachers are classroom teachers who take on additional duties as leaders in their schools. The Mathematics Specialist model evolved from the Mathematics Lead Teacher model over the last 20 years.

Mathematics lead teachers. In September 1991, as a measure to increase elementary school teachers' knowledge of mathematics content and pedagogy, the Board of the Virginia Council of Teachers of Mathematics (VCTM) passed an official Position Statement supporting placing Mathematics Lead Teachers in elementary schools in Virginia (Pitt, 2005). The Virginia Mathematics Coalition (currently known as the Virginia Mathematics and Science Coalition [VMSC]) and the Virginia Council for Mathematics Supervision (VCMS) supported VCTM's resolution, and a collaborative effort was made to include a Lead Teacher component in the Virginia State Systemic Initiative, Virginia's Quality Education in Science and Technology (V-QUEST) in 1992.

V-QUEST was a National Science Foundation (NSF) funded program that aimed to improve mathematics and science education across the Commonwealth. The lead teacher component of V-Quest proposed to increase the mathematical and pedagogical

content knowledge of elementary and middle school teachers through intense two-week summer institutes, thereby preparing them to be lead teachers in their schools (Underhill, Abdi, & Peters, 1994; Virginia Mathematics and Science Coalition, 2005). The goal of V-QUEST was to train one mathematics and one science lead teacher for every elementary and middle school in the state of Virginia (Cauthen, 2003). The program was considered to be largely successful in identifying and training mathematics and science lead teachers (Critchfield & Pitt, 1997), but the NSF discontinued funding after three years.

Three years after the conclusion of V-QUEST, Critchfield and Pitt (1997) conducted a study on the effectiveness of lead teacher programs in Virginia. They interviewed representatives from nine school districts. Participants were asked to describe their lead teacher program, identify program strengths and weaknesses, classify the kinds of support the program had received, and describe the effects of the program. The school districts reported that lead teachers served as curriculum experts, acted as resources for other teachers, gave professional development workshops for teachers in their schools, and functioned as liaisons between central administration and their schools. Variations among school district programs were also noted, especially in how the programs were supported and sustained. Some districts had conducted no additional training beyond V-QUEST. Others had designed and implemented their own training programs, some using Eisenhower or ExxonMobil grant funding to do so. Broad agreement by the nine school districts was found on the qualifications of successful lead teachers and the requirements for successful lead teacher programs.

A new idea: mathematics specialists. As information about the achievements and limitations of classroom teachers serving as mathematics lead teachers came to light, mathematics leaders in Virginia began to think about and study the use of Mathematics Specialists (Haver, 2008). Mathematics Specialists are teacher leaders who do not have classroom duties. In 1999, a VMSC working group began conceptualizing the role of the mathematics specialist and developing programs to prepare mathematics specialists for that role (Pitt, 2005). This group formally became known as the VMSC Specialist Partnership.

In 2002, VMSC began hosting statewide Virginia Forums on Mathematics Specialists (Pitt, 2005; Virginia Mathematics and Science Coalition, 2005). The forums were funded by ExxonMobil and focused on the implementation of mathematics specialists programs throughout the Commonwealth of Virginia. The first forum, called "Moving from Teacher Leaders to Mathematics Teacher Specialists," was held on May 20, 2002 in Fredericksburg and was attended by 78 division mathematics coordinators and other central office school administrators. The third forum was held on September 30, 2004 and was called "Improve Teaching and Learning in Mathematics through Content Focused Coaching." "A Forum for Math Specialists and Their Principals" was held on February 10, 2005 at VCU. At this forum principals, mathematics specialists, and classroom teachers shared their reflections on utilizing mathematics specialists in their schools. The dialogue began at these forums fueled the mathematics specialist movement in Virginia.

In the summer of 2002, the VMSC Specialist partnership offered its first Mathematics Specialist Leadership Institute (Pitt, 2005). Thirty-one teachers from 8 school divisions attended. Also in the summer of 2002, a fifteen-member task force, headed by Vicky Inge of Stafford County Schools, was established to write a rationale for creating a K-8 mathematics specialist endorsement and promoting mathematics specialists programs (Pitt, 2005). This task force recommended the following responsibilities for school-based mathematics specialists:

- Translate mathematics standards and research into classroom practice to support implementation of the Virginia *Standards of Learning* and the National Council of Teachers of Mathematics *Principles and Standards of School Mathematics.*
- Plan and facilitate professional development sessions to focus on the needs of staff members in the implementation of a high quality and challenging mathematics program for all students.
- Work collaboratively with building administrators and staff to plan, implement, and evaluate effective mathematics programs that support the improvement of teaching and learning.
- Work collaboratively with teachers to implement a variety of instructional and assessment strategies to meet the needs of a diverse student population.
- Support teachers in identifying, implementing, and refining the use of instructional resources and strategies through coaching, co-teaching, and modeling lessons.

- Work collaboratively with administrators and teachers to analyze student work, to identify students' level of understanding and/or proficiency, to interpret assessment information to inform the instructional program as well as to assist teachers in differentiating instruction.
- Facilitate parent workshops in mathematics and share ways to work with their children in mathematics.
- Provide ongoing assistance to new teachers, especially first year teachers and "career switchers" in mathematics content and mathematics pedagogy. (Virginia Mathematics and Science Coalition, 2005, pp.15-16)

A definition of a Mathematics Specialist was also created:

> 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.
>
> The overarching purpose for Mathematics Specialists is to increase the mathematics achievement of all the students in their schools. To do so, they:

- Collaborate with individual teachers through co-planning, co-teaching, and coaching;
- Assist administrative and instructional staff in interpreting data and designing approaches to improve student achievement and instruction;
- Ensure that the school curriculum is aligned with state and national standards, as well as their school division's mathematics curriculum;
- Promote teachers' delivery and understanding of the school curriculum through collaborative long-range and short-range planning;
- Facilitate teachers' use of successful, research-based instructional strategies, including differentiated instruction for diverse learners such as those with limited English proficiency or disabilities;
- Work with parents/guardians and community leaders to foster continuing home/school/community partnerships focused on students' learning of mathematics; and,
- Collaborate with administrators to provide leadership and vision for a schoolwide mathematics program. (Mathematics Specialists School and University Partnership, 2005, pp. 1-2)

Creating the mathematics specialist endorsement. The Virginia Board of Education approved a recommendation for a new mathematics specialist endorsement in the spring of 2003. Unfortunately, the Board's licensure recommendations were later withdrawn from consideration because of issues unrelated to the mathematics specialist

endorsement (Pitt, 2005). This was a temporary setback and the Board of Education continued on its quest for a mathematics specialist endorsement in 2004.

On January 19, 2005, Senator John Watkins introduced a resolution in the Virginia State Senate requesting the Virginia Board of Education to include the mathematics specialist endorsement in the Licensure Regulations for School Personnel. The resolution was agreed upon by the Senate on February 8, 2005 and by the House of Delegates on February 24, 2005. The licensure endorsement for Mathematics Specialists for elementary and middle education was signed into law by Governor Tim Kaine on September 21, 2007.

Preparing mathematics specialists. In anticipation of the new mathematics specialists endorsement, the VMSC wrote and received a grant from the Virginia Department of Education (VDOE) called "The Virginia Mathematics Specialist Project" (Farley, Haver, & Pitt, 2005; Pitt, 2005). The grant was a Virginia Mathematics and Science Partnership (MSP) grant. The initial grant of $749,581 allowed the Coalition to train the first mathematics specialists in Virginia. Under the direction of Loren Pitt, the funds supported the development of five mathematics courses and the first of three educational leadership courses specifically designed for mathematics specialists at the elementary and middle school levels. The courses were offered in two-week residential institutes at James Madison University (JMU) and the University of Virginia (UVA) during the summer of 2004. The teachers who attend the summer institutes were recipients of partial tuition, books, living expenses, and stipends. The courses were also offered during the academic year at other universities.

This program allowed prospective mathematics specialists who already had master's degrees to complete endorsement requirements for the K-8 mathematics specialist endorsement. Under this grant, the core of the Mathematics Specialist master's degree programs was developed collaboratively by a team from three universities: Norfolk State University (NSU), University of Virginia (UVA), and Virginia Commonwealth University (VCU). The five mathematics courses that were developed were: 1) Numbers and Operations, 2) Rational Numbers and Proportional Reasoning, 3) Geometry and Measurement, 4) Functions and Algebra, and 5) Probability and Statistics. The three lead universities also made commitments to develop a master's degree programs for K-8 mathematics specialists.

Following the success of the 2004 summer institutes, two supplemental grants were awarded in the amount of $295,000. This funding allowed the Virginia Mathematics Specialists Project to hold summer residential institutes at the College of William and Mary and Emory and Henry University during the summer of 2005 and to host a symposium spotlighting and disseminating information about mathematics specialists. The goal of the symposium was to highlight the benefits of employing mathematics specialists and to inform central office school personnel of the mathematics specialists' preparation programs being developed in the state (Farley, Haver, & Pitt, 2005). The May 2005 symposium was held in Roanoke, Virginia with the intent of opening the dialogue about mathematics specialists in the southwestern portion of the state. The one-day conference included remarks by Senator John Edwards and Delegate William Fralin, Jr.

A definition of mathematics specialists was shared and three school districts spoke on their implementations of mathematics specialists programs.

Two more substantial grants followed the VDOE-MSP grant. The National Science Foundation Teacher Professional Continuum (NSF-TPC) Program awarded $4,444,898 to study the impact of Mathematics Specialists on student learning and the National Science Foundation Mathematics and Science Partnership (NSF-MSP) Program awarded $3,726,915 to prepare cohorts of mathematics specialists (Farley, Haver, & Pitt, 2005; Pitt, 2005).

The five-year NSF-TPC grant was a collaborative project led by VCU and VMSC. The project focused on continuing to develop the mathematics specialists' preparation program and studying the mathematics specialist initiative. The six courses that were developed under the VDOE-MSP project were revised and two additional educational leadership courses were developed. In addition, master's degree programs were developed and offered at VCU, NSU, and UVA.

The five-year NSF-MSP grant, "Preparing Virginia's Mathematics Specialists," provided funding to train two cohorts of mathematics specialists. Teacher participants attended residential four-week summer institutes for three summers and follow-up sessions during the academic year. Cohort members received full tuition, books, living expenses, and stipends. The first cohort, consisting of 28 K-5 teachers, started in the summer of 2005. Cohort members included teachers from the following school districts: Norfolk City (4), Hampton City (1), Portsmouth City (2), Richmond City (5), Hanover County (2), Fairfax County (7), Arlington County (3), Alexandria City (3), and

Culpepper City (1) (Farley, Haver, & Pitt, 2005). The second cohort of 27 teachers started in the summer of 2007 and included participants from the following school districts: Norfolk City (4), Portsmouth City (2), Richmond City (3), Hanover County (2), Fairfax County (6), Arlington County (3), Alexandria City (3), Culpepper City (1), and Stafford (3) (L. A. Sweetser, personal communication, March 23, 2009). The cohort members earned a master's degree from one of three Virginia state universities (NSU, UVA, or VCU) and completed the requirements for Virginia's K-8 mathematics specialist endorsement. The NSF-MSP project also included a research component that investigated the mathematics specialists' perceptions of their roles, the effects of the preparation program, and how mathematics specialists impact teachers and students. To date, no reports have been published from this study.

Legislature supporting the mathematics specialist initiative. In February 2006, the Virginia Senate and House of Delegates passed a joint resolution commending and congratulating Virginia school boards that employed mathematics specialists. According to the resolution, the following school divisions were involved in training and employing mathematics specialists: Alexandria, Arlington, Culpeper, Fairfax County, Hampton, Hanover, Norfolk, Portsmouth, Richmond City, Spotsylvania, Stafford, and Virginia Beach.

In January 2007, the Virginia Board of Education included a requirement for one full-time mathematics specialist for every 1,000 students in grades K-8 in its Standards of Quality Resolution to the governor and the general assembly. The resolution was rejected. Again in November 2008, the Board of Education asked the Governor and the

General Assembly to consider adding a requirement for mathematics specialists to the Standards of Quality. The estimated cost to the state for this initiative for the 2009 – 2010 school year was $28.6 million. On December 5, 2008 a memo to Virginia Division Superintendents from the Superintendent of Public Instruction stated that although mathematics specialists had not yet been incorporated into the Standards of Quality, the Board of Education continued to support the recommendation. Since lack of funding seemed to be the main issue, the Board offered an alternative option to school districts. Mathematics specialists could be hired as part of the Algebra Readiness Initiative, another program that was already funded and operational across the state. The Board of Education's flexibility in this matter showed their commitment to the mathematics specialist initiative.

Mathematics Specialist Program Models

While many organizations have recommended the use of mathematics specialists in elementary schools over the last thirty years, there are many different ideas about what the work of the mathematics specialist should be. This literature review identified three models of mathematics specialists programs: the mathematics coach model, the specialized-teacher model, and the pull-out model (Ball, et al., 2008; Fennell, 2006, 2007; NRC, 1989, 2001; Reys & Fennell, 2003).

The Mathematics Coach Model

In the mathematics coach model, a teacher is released from classroom duties to mentor other teachers and provide school leadership (Ball, et al., 2008; Fennell, 2006, 2007; NRC, 1989, 2001; Reys & Fennell, 2003). Mathematics coaches "act as resource

persons for their coworkers and do not directly instruct students" (Ball, et al., 2008, p. 5-54). They may be school-based or district-based. They may work at one school or multiple schools. This model requires additional resources because it adds an extra position to the school staff.

The Specialized-Teacher Model

Mathematics specialists working under the specialized-teacher model are responsible for the mathematics instruction of students (Ball, et al., 2008; Fennell, 2006, 2007; NRC, 2001; Reys & Fennell, 2003). They usually teach mathematics to students at one grade level in a school (Fennell, 2006). This has also been referred to as *paired teaching* (NRC, 1989) and *departmentalizing* (NRC, 2001). In a paired teaching structure, one teacher teaches language arts and another teaches mathematics and science to the same group of students. Departmentalizing is when each teacher at a grade level teaches a different subject. Another way to organize teachers within the specialized-teacher model is to have all teachers teach reading and language arts to their "homeroom" classes and departmentalize for mathematics, science, and social studies (Reys & Fennell, 2003). Reys and Fennell (2003) listed several advantages of this model. The model is economically advantageous as no additional funding is needed for staffing. It allows teachers to focus on one subject area and prepare fewer lessons. Districts can provide professional development in mathematics to fewer teachers, and teachers can focus their professional development activities on only one subject area rather than four or more.

The Pull-Out Model

The pull-out model is a variation of the specialized-teaching model (Ball, et al., 2008). In this model, mathematics specialists provide supplemental instruction to students who are failing to meet or are exceeding grade level standards. The mathematics specialists usually work with individual or small groups of students outside of the regular classroom setting but may also work with students during the mathematics block in their regular classrooms. This model requires additional funding to hire mathematics specialists. Funding typically comes from Title I or Title II money.

While mathematics specialists can work in all three of the models listed above, the mathematics coach model is more common than the other two (Ball, et al., 2008). However, mathematics coaches "frequently take on responsibilities that cut across all three models" (Ball, et al., 2008, p. 5-53). The roles and responsibilities of mathematics coaches have not been well-defined. An illustration of the confusion can be found in the many terms that are used to name mathematics coaches. Frequently used terms include specialists, support teachers, resource teachers, lead teachers, liaisons, mentors, peer teachers, visiting teachers, teacher-leaders, coordinators, and facilitators (Ball, et al., 2008; Burns, 2006; Dossey, 1984; Fennell, 2006, 2009; McGatha, 2009b; NCTM, 2000 Reys & Fennell, 2003). For this study, the term *mathematics specialist* is defined as a teacher with specialized knowledge of mathematics content and pedagogy. The term *mathematics coach* is defined as a teacher who primarily works with teachers and does not have classroom duties. Someone working within the specialized-teacher model who teaches mathematics to students is called a *mathematics teacher*. The term *mathematics*

teacher-leader is used to describe a teacher with an interest in mathematics who takes on leadership responsibilities for a school. While mathematics specialists may work as mathematics coaches, mathematics teachers, and mathematics teacher-leaders; mathematics coaches, mathematics teachers, and mathematics teacher-leaders may or may not be mathematics specialists.

Research on Coaching, Mathematics Coaching, and Other Math Specialist Models

This section of the literature review examines the current research on coaching in general and the different mathematics specialist models including the specialized-teacher model, mathematics teacher-leaders, and mathematics coaches.

Research on Coaching

In a 1982 *Educational Leadership* interview, David Berliner said that the best way to make teachers more effective would be to employ coaches to work with them in their classrooms. Since that time, many approaches to coaching have been developed. Coaching models include peer coaching, instructional coaching, literacy coaching, Cognitive Coaching^{SM}, coaching classroom management, content coaching, differentiated coaching, and leadership coaching (Knight, 2009a). Cornett and Knight (2009) conducted a recent review of research on coaching. They confined their review to four models of coaching that were frequently mentioned in research literature: peer coaching, Cognitive Coaching^{SM}, literacy coaching, and instructional coaching. Overall, they found that coaching impacts teacher attitudes, teaching practices, teacher efficacy, and student achievement.

Research on peer coaching in the 1980's provided early evidence that coaching makes a difference in teachers' professional practice and student achievement (Cornett & Knight, 2009). Teachers who received peer coaching as follow up to professional development workshops were more likely to transfer new instructional strategies to classroom use than teachers who did not receive follow up coaching. While there seems to be more research on the Cognitive Coaching^{SM} model than any other coaching model, Cornett and Knight (2009) report that "rigorous means of investigation are largely missing" (p. 203). However, research has shown evidence of increases in teachers' efficacy, job satisfaction, and reflective thinking associated with Cognitive Coaching^{SM} (Cornett & Knight, 2009).

The research on literacy coaching is largely speculative. "The term *literacy coach* is used loosely to describe anyone who supports teachers with the goal of increasing literacy" (Cornett & Knight, 2009, p. 203), and therefore, no clear understanding of the role of a literacy coach exists. This makes it difficult for researchers to link improvements in teachers' instructional practices or student achievement to literacy coaching. Cornett and Knight's review of coaching research did not surface any "published, randomized-control-style studies of the effectiveness of literacy coaching on teacher behavior or student academic achievement" (p. 204). They did find two studies that showed increased student achievement, but the findings could not be attributed directly to literacy coaching.

Research on instructional coaching has mainly been formative and used to develop the instructional coaching model (Cornett & Knight, 2009). Studies show that the

majority of teachers who worked with instructional coaches reported benefits from observing modeled lessons and implemented new instructional practices in their classrooms (Cornett & Knight, 2009).

Cornett and Knight (2009) summarize the research on coaching in the following way:

> Many approaches to coaching are relatively new. Consequently, much of the research conducted to date has been exploratory process and development, lacking the rigor of true scientific study. This is understandable. Since the various coaching models were in the early stages of development, their creators were mostly concerned with improving coaching methods through (a) coach and teacher feedback (e.g., through interviews and surveys), (b) quick informal data gathering, and (c) integration and testing of ideas presented in the literature on coaching and related fields.
>
> This means that we must be cautious when we generalize from the research that has been conducted to date. What we know about coaching (like much of what we know about education) is much less than what we need to learn. (p. 209)

Research on the Specialized-Teacher Model

While no studies were found that examined the effects of having mathematics specialists teach mathematics to elementary students, two studies were found that examined departmentalization of instruction at the elementary school level. One study examined the achievement of fifth and sixth grade students in departmentalized classes

over one year (McGrath & Rust, 2002). No significant differences in students' mathematics achievement were found between students taught by their homeroom teachers and students taught by teachers who departmentalized. The teachers who taught the mathematics classes were not mathematics specialists and did not have any specialized knowledge of mathematics content or pedagogy. In another study, principals reported that departmentalizing gave teachers more time to plan effective lessons and allowed them to focus their professional development efforts (Gerretson, Bosnick, & Schofield, 2008). The principals considered the mathematics teachers to be content specialists, but the teachers were, for the most part, self-selected to teach mathematics because they believed that mathematics was a strength. They did not have special preparation or certification to teach elementary mathematics. Much research is needed to determine if the specialized-teacher model of mathematics specialists is a viable alternative to the generalist approach.

Research on Mathematics Teacher-Leaders

Mathematics teacher-leaders are teachers who take on leadership roles in their schools. They may be classroom teachers, mathematics teachers, or mathematics coaches. The presence of mathematics teacher-leaders in elementary schools was found to be a critical element in mathematics reform efforts (Ferrini-Mundy & Johnson, 1996). The roles and responsibilities of the mathematics teacher-leaders in the study varied from school to school. Some of the mathematics teacher-leaders functioned as coaches and did not have classroom duties. Others were classroom teachers who took on leadership roles. The study reported that, regardless of their roles, all helped to maintain a focus on

mathematical issues. “They helped spread ideas, facilitate communications among teachers, plan and initiate staff development, and address political problems with administrators and community members” (p. 119). Researchers cautioned, however, that this evidence was not enough to recommend mathematics specialists programs as a way to improve student achievement.

Research on Mathematics Coaches

The research on mathematics coaching is just beginning to be conducted. This literature review found nine studies that specifically focused on the work of mathematics coaches in elementary schools. Seven studies examined the impact of mathematics coaches on improving instructional practice and student achievement. One study investigated the impact of mathematics coaches on teachers’ beliefs and involvement in professional development activities, and one study examined the design of mathematics coaching programs.

Impact on teachers’ instructional practice. Preliminary research indicates that mathematics coaches impact teachers’ instructional practice. Two studies utilized mathematics coaches as part of larger professional development programs (Campbell, 1996; Race, Ho, & Bower, 2002). Campbell found that 85% of classroom teachers made some change in their instructional practice with about 40% making significant changes in their instruction. Instructional changes included greater emphasis on conceptual understanding, having students share their mathematical reasoning, and incorporating more student discourse. Race et al. found that teachers increased the frequency of best practices (e.g., hands-on approach, addressing a variety of learning styles, higher-order

thinking, and real-world connections) and used a greater variety of instructional formats (e.g., activities, discussions, and investigations). While changes in teachers' instructional practice cannot be attributed solely to coaching in these studies, coaching was a critical component of both professional development programs. Researchers maintained that without the coaching aspect of the programs, teachers would not have made such substantial changes in their instructional practice.

Two studies of mathematics coaching that were not part of larger professional development programs also indicated that coaching can have a positive impact on teachers' instructional practice (Becker, 2001; McGatha, 2008). Becker found that teachers focused more on conceptual understanding of critical mathematics content and emphasized problem-solving over skills development. McGatha observed positive changes in teachers' instructional practice including involving students in classroom discussions, asking students to justify their thinking, and using students' thinking to inform instruction. All four studies, taken together, indicate that mathematics coaches can positively impact elementary teachers' instructional practice.

Impact on student achievement. As mentioned in the previous section, Campbell (1996) studied a large professional development project that included the use of mathematics coaches. She found that student achievement gains were not immediate but once established were maintained. Differences in student achievement between the treatment group and the control group were statistically significant two and a half years into the project, and these differences continued throughout the remaining year and a half. Researchers also found that students in the treatment group had significantly higher

scores in problem solving and reasoning and exhibited more confidence in their mathematics abilities. Since these findings were tied to a comprehensive program of professional development that includes mathematics coaches as one component, differences in student achievement cannot be directly attributed to mathematics coaching.

This literature review also revealed two ongoing studies designed to specifically analyze the impact of mathematics coaches on student achievement. Erchick et al. (as cited in McGatha, 2009a) is currently collecting data on a three-year mathematics coaching project. Campbell and Malkus (2009a, 2009b, in press) are conducting a randomized-control-style study of 36 schools in Virginia. Preliminary results from both studies indicate positive effects of mathematics coaching on student achievement.

Erchick et al. (as cited in McGatha, 2009a) reported modest gains in third and fourth grade students' mathematics content knowledge during the first year of the three-year study. Coaches began working in schools in January. Pre- and post-test scores were collected from students in January and May. In this short period of time, gains were found in students' mathematics achievement. In addition, the average score on the mathematics section of the state achievement test for schools that participated in the study was higher than the state average on the test.

Campbell and Malkus (2009a, 2009b, in press) compared student performance on the Virginia Standards of Learning tests from 12 triplets of schools. Each set of three schools had comparable demographics and similar test scores. Trained elementary mathematics coaches were randomly placed in two of the three schools in each set. As coaches gained experience, there was a significant positive impact on student

achievement at grades 3, 4, and 5 as measured by state-mandated standardized tests. The researchers cautioned that results should not be generalized to settings in which an untrained teacher is named as a mathematics coach. The coaches in this study participated in extensive academic coursework that addressed the specific responsibilities and expertise presumed of elementary mathematics coaches.

Taken together, these studies suggest positive effects of mathematics coaches on student achievement. Continuous data collection and analysis by Erchick et al. and Campbell and Malkus has the promise of providing a deeper understanding of the effect of mathematics coaches on student achievement.

Impact on teachers' beliefs and involvement in professional development activities. Campbell and Malkus (2010) found that trained elementary mathematics coaches had a positive impact on teachers' beliefs and involvement in professional development activities. Scores on an instrument that measured teachers' beliefs on a continuum from "traditional" to "making sense" showed that teachers' beliefs increased towards the making sense side of the continuum. This only occurred for teachers with whom coaches were highly engaged. The same study also showed that teachers in schools with mathematics coaches were more likely to participate in professional development activities than teachers in schools without coaches. The professional development activities were unrelated to the interactions the teachers had with their coaches and included observing other teachers, participating in school-wide mathematics workshops, taking part in mathematics-focused grade-level meetings, and attending district or local mathematics workshops.

Elements of coaching program design. Mangin (2005) conducted a comparative case study of five coaching programs in order to discern effective elements of coaching program design. The majority of the coaches she interviewed were mathematics coaches, however, two of the coaches were responsible for social studies and literacy in addition to mathematics. Mangin found that coaches working in one subject area in one school were more effective than coaches who worked within two or more subject areas or at multiple schools. She also found that broad communication about the roles and responsibilities of the coaches across all stakeholders (supervisors, principals, coaches, and teachers) was "absolutely necessary" to the success of the programs (p. 60).

The Roles of Mathematics Coaches

The focus of this study is on the role of the mathematics coach. While there are very few empirical research studies about mathematics coaching, there is much anecdotal evidence in practitioner journals and other literature that supports coaching as a way to improve instruction and student achievement. Organizations such as the National Council of Teachers of Mathematics (NCTM), the National Council of Supervisors of Mathematics (NCSM), the Association for Supervision and Curriculum Development (ASCD), and the National Staff Development Council (NSDC) frequently publish articles about teacher leadership and coaching. This section of the literature review gives an overview of conventional wisdom and practitioner suggestions about the roles of coaches in general and mathematics coaches in particular.

According to Marilyn Burns (2006), a common goal of mathematics coaches is "to support the mathematics learning of all students by supporting teachers to improve

their teaching of mathematics" (p. ix). This goal is attained by the many roles that mathematics coaches adopt as they go about their daily activities. Killion (2009) described ten roles that coaches take on in their work. Nine of those roles have been used here to conceptualize the roles and responsibilities of mathematics coaches. Figure 1 shows a conceptual framework of mathematics coaches that was used in this study.

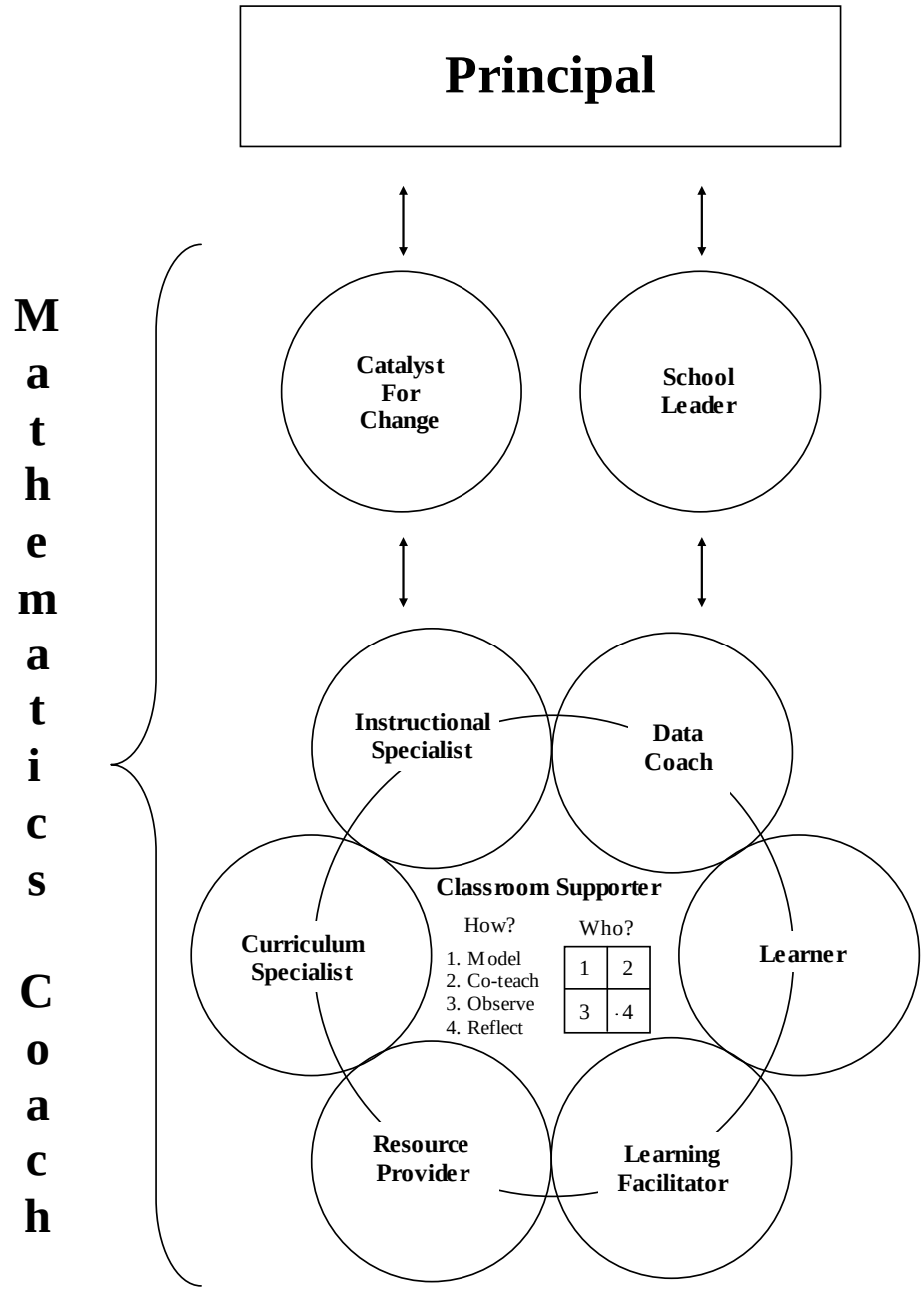

Figure 1. Conceptual framework of the roles of mathematics coaches.

Classroom Supporter

As Figure 1 shows, the role of classroom supporter overlaps many other roles. As a classroom supporter, a mathematics coach works alongside teachers in classrooms. This allows teachers to implement new ideas through observing demonstration lessons, planning and co-teaching with mathematics coaches, being observed while teaching, and reflecting upon lessons after they have been taught (Harrison & Killion, 2007; Reys & Fennell, 2003; Rowan & Campbell, 1995).

As a classroom supporter, mathematics coaches must make decisions about which classroom teachers to support. Killion (2009) defined the role of mentor as a coach who works with novice teachers or teachers new to the school. She included the role of mentor as a distinct role in her ten coaching roles. It is not included in this conceptual framework as a distinct role because as a classroom supporter, new teachers are just one set of many kinds of teachers that mathematics coaches can choose to support. Figure 2 shows a model for thinking about teachers with whom mathematics coaches work. Novice teachers generally fit in Category 2. They usually need assistance in teaching mathematics (and other things), and they usually are more than willing to work with a coach (Killion, 2009). Teachers in Category 1 need assistance in teaching mathematics and are unwilling or resistant to working with coaches. Teachers in Category 3 are competent mathematics teachers who are generally resistant to working with a coach, while teachers in Category 4 are competent mathematics teachers who are willing and eager to work alongside coaches in their classrooms.

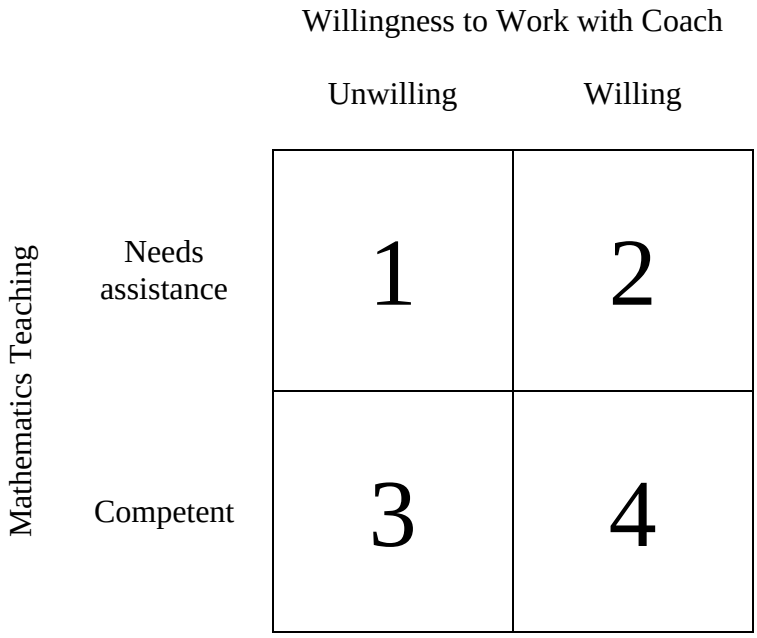

Figure 2. Model for thinking about teachers with whom mathematics coaches work.

One strategy for effecting change in mathematics instruction involves the mathematics coach strategically choosing to work with teachers in Category 4 (Confer, 2006; Smith, 2006). When mathematics coaches begin working in a school, they choose to work with teachers who are already competent at teaching mathematics and who want to learn ways to improve their mathematics instruction rather than new teachers or teachers who need assistance in the teaching of mathematics. In this way, mathematics coaches create momentum in the school's culture of change. As competent teachers learn different ways to teach mathematics through their work with the mathematics coach, their excitement builds, and they talk to other teachers in the school. This creates greater enthusiasm throughout the staff, and more and more teachers become eager to work with

the mathematics coach. Eventually a large portion of the staff is engaged in professional learning and reflection on their teaching.

Another decision that coaches who work as classroom supporters must make is *how* to support teachers in their classrooms. Coaches can model lessons, co-teach with a classroom teacher, or observe as a classroom teacher teaches. It is important that reflection and discussion occur with each form of interaction.

One school of thought on how to work with teachers to effect change is to move away from doing model lessons to co-teaching as soon as possible (Confer, 2006; Silbey, 2006; Williams & Confer, 2006). Confer (2006) states that "teachers are more interested and engaged" when they teach together with the mathematics coach (p. 7). In this type of work, a mathematics coach plans a lesson with a classroom teacher. Part of the planning includes assigning teaching roles during the lesson. The mathematics coach and the classroom teacher teach the lesson together, each doing their planned part. Then they collaboratively reflect on the lesson before planning the next lesson.

Others suggest that how a coach works with a teacher should evolve as the school year progresses. Mathematics coaches should first model lessons for teachers, then co-teach, and finally observe as the classroom teacher teaches (Race, Ho, & Bower, 2002; Rowan & Campbell, 1995). Race et al. believe that "the potential for transfer of best practices from program instruction to classroom teaching … should be greater using this model" (pp. 4-5).

In case studies of two mathematics coaches, both coaches "felt that model teaching was not the best vehicle for supporting their teachers' professional growth"

(McGatha, 2008, p. 148). Model teaching seemed to be more effective when the classroom teacher and the coach planned the lesson together and discussed students' work and misconceptions after the lesson. The coaches thought that having classroom teachers teach lessons with support from their coaches was a better model for improving teachers' instructional practices.

The mathematics coach's role as a classroom supporter involves working with classroom teachers in their classrooms. Coaches must decide who to coach and how to coach those teachers. The next section describes other roles that a mathematics coach may adopt and how those roles overlap with the classroom supporter role.

Roles That Overlap the Classroom Supporter Role

As Figure 1 shows, six mathematics coaching roles overlap the role of classroom supporter: learning facilitator, resource provider, curriculum specialist, instructional specialist, data coach, and learner. When mathematics coaches take on these roles, they may or may not be working within teachers' classrooms.

Learning facilitator. There are many things that mathematics coaches do when they act as learning facilitators. Their work within a teacher's classroom as a classroom supporter is designed to contribute to the teacher's knowledge of the teaching and learning of mathematics. Modeling, co-teaching, and observing mathematics lessons and reflecting upon those lessons with a teacher facilitates the teacher's learning. They may also substitute for teachers so teachers can observe in other teachers' classrooms (Reys & Fennell, 2003; Rowan & Campbell, 1995). There are many ways that mathematics coaches act as learning facilitators outside of the classroom, as well. They may develop

professional development plans (Harrison & Killion, 2007), organize professional development activities (Ball, et al., 2008), participate in professional development communities (Harrison & Killion, 2007), and/or conduct professional development workshops (Dossey, 1984; Fennell, 2006; Reys & Fennell, 2003). They may also share research on the teaching and learning of mathematics with teachers (Ball et al., 2008). Working inside or outside of the classroom, one of the most important responsibilities of a mathematics coach acting as a learning facilitator is "to foster a self-reflective culture of learning among teachers" (Ball, et al., 2008, p. 5-54).

Resource provider. As resource providers, mathematics coaches share instructional resources with teachers (Harrison & Killion, 2007; Killion, 2009). These resources could include mathematics manipulatives and games, professional books, lessons plans, and assessment tools. Coaches may identify, order, and manage instructional materials, seeking out new materials to share with teachers (Reys & Fennell, 2003; Rowan & Campbell, 1995). As shown in Figure 1, the role of resource provider can overlap the role of classroom supporter. A mathematics coach simultaneously acting as a classroom supporter and a resource provider could model the use of specific mathematics manipulatives in a classroom, support a classroom teacher in using a new mathematics game during a lesson, or observe a teacher implementing a new instructional strategy that she read about in a professional article. Organizing and running resource materials check-out libraries and sharing resources at professional development workshops would fall outside the role of classroom supporter.

Curriculum specialist. As curriculum specialists, mathematics coaches help teachers understand and make connections among their state or district mathematics standards (Harrison & Killion, 2007; Killion, 2009; Von Rotz, 2006). As Figure 1 shows, this work can occur inside and outside of the classroom. When mathematics coaches are working with teachers inside their classrooms, the lessons are designed around the mathematics standards and the adopted curriculum. Reflections may focus on understanding the standards that are tied to a particular lesson, using a common pacing guide, or evaluating student work samples for evidence of a student understanding. Outside of the classroom, mathematics coaches may align state and district standards to curriculum materials (Ball et al., 2008; Fennell, 2006, 2007, 2009), share standards with teachers at grade-level team meetings (Reys & Fennell, 2003), develop pacing guides and assessments tied to the standards, or act as curriculum coordinators (Dossey, 1984).

Instructional specialist. When a mathematics coach adopts the role of an instructional specialist, she helps colleagues plan and implement effective lessons. This includes learning about research-based teaching strategies and sharing those strategies with coworkers (Harrison & Killion, 2007; Killion, 2009). As with the other six roles, the role of an instructional specialist may be done inside or outside of the classroom. Inside the classroom, a mathematics coach may model instructional strategies, help teachers differentiate instruction to meet the needs of individual students (Fennell, 2006, 2007, 2009; Killion, 2009), or assist teachers in managing small group work. Outside of the classroom, a mathematics coaching acting as an instructional specialist can lead grade-level planning meetings (Reys & Fennell, 2003; Rowan & Campbell, 1995), facilitate

teachers' discussion about a new instructional strategy, or distribute professional readings about instructional strategies.

Data coach. Mathematics coaches act as data coaches when they engage their colleagues in analyzing student assessment data and planning instruction based upon the results (Fennell, 2006, 2007, 2009; Harrison & Killion, 2007; Killion, 2009). As Figure 1 shows, this work can occur inside or outside of a classroom. A mathematics coach can act simultaneously as a classroom supporter and a data coach by helping a teacher use a pre-assessment to group students during a lesson, assisting teachers in conducting student interviews, or observing students for evidence of specific learning goals during a lesson. A mathematics coach can also act as a data coach outside of the classroom setting by helping teachers analyze and discuss student work in grade level teams or teams that include teachers from a variety of grade levels (Van Rotz, 2006) or by analyzing and interpreting state and district mathematics achievement data to identify school improvement goals (Killion, 2009).

Learner. One of the most important roles that a mathematics coach has is that of a learner. Mathematics coaches are learners when they are committed to lifelong learning and strive for continual improvement (Harrison & Killion, 2007; Killion, 2009). When mathematics coaches take on the role of classroom supporter, they learn through their work with students and classroom teachers. As they teach lessons inside the classroom, they gain valuable experience about mathematics teaching and learning. Their reflections with classroom teachers provide a venue for their own thinking and learning as well as the classroom teachers they support. Outside of the classroom supporter role,

mathematics coaches may take on the role of learner when they read professional articles or books, attend professional development workshops or conferences, and network with other mathematics coaches.

As described above, the mathematics coach's roles of learning facilitator, resource provider, curriculum specialist, instructional specialist, data coach, and learner overlap the role of classroom supporter. The remaining two roles shown in Figure 1 are roles that inform the other roles and allow the mathematics coach to act as a liaison between the principal and the classroom teachers.

Roles That Inform the Other Roles

The roles of catalyst for change and school leader are seen as roles that inform the roles of classroom supporter, learning facilitator, resource provider, curriculum specialist, instructional specialist, data coach, and learner. These two roles are also seen as roles that provide a bridge between classroom teachers and the principal.

Catalyst for change. Mathematics coaches become catalysts for change when they have a vision of what instruction could look like, share that vision with colleagues, and support colleagues as they work toward those goals collaboratively (Harrison & Killion, 2007).

> By making observations, stating their point of view, and inquiring into practice, coaches erode stagnant practice and unchallenged routines to spark analysis, reflection, and appropriate change. In this role, a coach is not about change for change sake, but rather for continuous improvement and fine-tuning to meet clearly articulate goals….Coaches have the capacity to question and instill

curiosity and doubt, thereby generating dissonance essential to promote change. (Killion, 2009, p. 13).

A coach's preponderance for change and strategies for change permeate the decisions he or she makes when assuming the other coaching roles. For example, when a mathematics coach chooses a teacher with whom to act as a classroom supporter, that choice may be based upon the coach's strategy for change. If a coach prescribes to the school of thought that working with teachers in Category 4 (Figure 2) promotes schoolwide change in mathematics instruction, then the coach will primarily choose to work with teachers in Category 4. If a coach does not believe that working with Category 4 teachers will promote change, he may decide to work with novice teachers (Category 2) or teachers who need assistance in teaching mathematics (Categories 1 and 2).

The mathematics coach's role of catalyst for change also can be seen as a bridge between school administrators and teachers. The mathematics coach's vision of mathematics instruction and strategies for change are often developed in collaboration with the school principal. The coach's enactment of the catalyst for change role becomes an extension of the principal in the school.

School leader. Mathematics coaches are often school and district leaders. In this role they serve on school improvement committees, advocate for schoolwide reform initiatives, provide leadership and information to teachers, and coordinate mathematics programs (Ball, et al., 2008; Harrison & Killion, 2007; Killion, 2009). They may also represent their schools on district committees (Harrison & Killion, 2007; Killion, 2009)

and work with community leaders to cultivate partnerships focused on mathematics teaching and learning (Fennell, 2006, 2007, 2009).

The school leader role may inform the decisions mathematics coaches make when they take on other roles. For example, when a coach is working as a classroom supporter, she may help the classroom teacher learn about and implement a new mathematics program that the school has chosen to adopt. When a mathematics coach promotes the use of district pacing guides or curriculum materials, she is acting both as a school leader and a curriculum specialist.

As a school leader, the mathematics coach acts as liaison between the school principal and teachers. Killion (2009) says that "coaches walk a delicate line between administration and teachers. They are neither really.…Their allegiance rests most often with teachers. Occasionally, however, they are asked to engage in administrative responsibilities that confuse their identity within a school" (p. 13). While some mathematics coaches are "empowered to officially assess the performance of math teachers in the classroom" (Ball et al., 2008, p. 5-54), many coaches believe that their role should never be evaluative or supervisory (AMTE, 2010; Confer, 2006; Knight, 2009b; Reinke, Sprick, & Knight, 2009; Reiss, 2009; Smith, 2006; Taylor, 2008). Toll (2006) says that "for coaching to be successful, it must be separated from supervision" (p. 3). She suggests that coaches separate themselves from the performance evaluations of other teachers and communicate with supervisors in an impartial manner without divulging confidential information about teachers' instructional practices. When coaches

act in a supervisory way, they undermine the trust of the teachers with whom they work. This, in turn, damages the coaching relationship.

Dimensions on Varying Roles

As Figure 1 shows, the roles of a mathematics coach are complex. Many of the roles overlap. Some of the roles inform others. Each coach's job is a little bit different from the next depending upon how they determine their roles and on which roles they decide to focus. Many factors influence coaches' decisions about their roles. Factors include goals for the coaching program, expectations of administrators, coaches' job descriptions, culture of the school, experience of the coach, and experience of the teachers (Killion, 2009). A coach's job may evolve as the school year progresses. Coaches may spend more time on data coaching, facilitating learning, and providing resources at the beginning of the year and put a greater focus on instruction and curriculum later in the year (Killion, 2009).

Taylor (2008) listed dimensions on which coaching positions may vary. Key dimensions that are relevant to this study are shown in Table 1.

Table 1

Dimensions of Coaching Variations

Dimension	Classification
Type of coach	Specialist ↔ Generalist
Purpose	Organizational ↔ Collegial ↔ Personal Growth
Knowledge and skills	Content knowledge ↔ Pedagogical knowledge ↔ Curricular knowledge
Type of coachee	Novice ↔ Learner ↔ Expert
Form	Technical ↔ Collaborative ↔ Problem-solving ↔ Simple Support
Orientation	Active ↔ Passive
Style	Directive ↔ Facilitative
Location	On-site ↔ Off-site
Ratio	One teacher to: One grade ↔ One school ↔ Multiple schools
Duration	Full-time ↔ Part-time

Note. From "Instructional Coaching: The State of the Art," by J. E. Taylor, 2008, In M. M. Mangin and S. R. Stoelinga (Eds.), *Effective Teacher Leadership: Using Research to Inform and Reform* (pp.16-17), New York: Teachers College Press. Copyright 2008 by Teachers College. Adapted with permission.

As Table 1 shows, each dimension is a continuum between classifications. The dimensions relevant to this study include: type of coach, purpose, knowledge and skills, type of coachee, form, orientation, style, location, ratio, and duration. Each dimension is discussed below.

Type of coach. Coaches can be specialists or generalists. Specialists usually focus on a particular content area or grade level. Generalists may work within all subject areas and facilitate general change. The coaches in this study are specialists and focus on mathematics.

Purpose. The purpose of a coaching program can be organizational, collegial, or to promote personal growth. When the purpose is organizational the coach assists teachers in transferring a theory into practice. In collegial coaching, the coach works collaboratively with teachers in order to build a culture of learning in the school. When the purpose of coaching is to promote personal growth, the coach assists teachers in identifying and solving problems related to their practice.

Knowledge and skills. Coaching can be focused on developing teachers' content knowledge, pedagogical knowledge, or curricular knowledge. A coach may also assist a teacher's growth in all three types of knowledge.

Type of coachee. Coaches' roles may differ according to the types of teachers with whom they work. Coaches may work with novices, learners, or experts. They may adapt their coaching style in order to meet the needs of individual teachers.

Form. Coaching can take four different forms: technical, collaborative, problem-solving, and simple support. In technical coaching, the coach acts as an expert. In collaborative coaching, the coach and the coachee learn from each other. In problem solving coaching, the coach helps the coachee reflect in order to solve problems. While all coaching involves support, simple support coaching is when the coach provides

resource support and encouragement as an end in itself rather than as a way to build rapport or change instructional practice.

Orientation. A coach's orientation is his or her stance to coaching. Coaches can actively seek out teachers with whom to work, or they can wait for teachers to come to them, passively responding to requests and questions.

Style. A coach's style can be directive or facilitative. At one end of this continuum, a directive coach tells teachers what to do. At the other end, a facilitative coach elicits self-reflection from the coachee by asking questions. Coaches may adapt their style to individual teacher's needs and preferences or to their purpose for coaching.

Location. Coaches can be based on-site or off-site. Many coaches are located at just one school. In some coaching models, however, coaches periodically visit a school or teachers travel to another school to be coached.

Ratio. The number of teachers per coach is the ratio. A coach may work with one grade level, one school, or multiple schools. This may involve just a few teacher or many teachers.

Duration. Coaches can be full-time or part-time employees. Part-time coaches may be part-time employees or full-time employees whose responsibilities include coaching for only part of the time. For example, a classroom teacher could be released from the classroom for half of each day in order to coach other teachers.

The roles of a mathematics coach are intricate and complex. Coaches must make tough decisions that define their roles and communicate those decisions to their colleagues. The principal of a school also has a large part in determining the roles and

responsibilities of a mathematics coach. The next section of this literature review focuses on the role of the principal in establishing and supporting a mathematics coaching program.

The Principal's Role in a Mathematics Coaching Program

The principal of a school has an important role in ensuring the success of a mathematics coaching program. The principal must select the mathematics coach, set clear expectations for the roles of the coach, and support the coach in the execution of those roles. The following sections will examine each of those responsibilities further.

Selection of Mathematics Coaches

Since the success of a mathematics coaching program relies heavily on the expertise of the mathematics coach (Reys and Fennell, 2003), the selection of a mathematics coach becomes a very important responsibility of the principal in a school. Rowan and Campbell (1995) suggest that promoting a classroom teacher to a mathematics coaching position is a good idea because the mathematics coach will have an understanding of the unique characteristics and social dynamics of the school. In addition, mathematics coaches who have recently come from the classroom are more accepted by classroom teachers than those who have been out of the classroom for some time (Rowan & Campbell, 1995).

Reys and Fennell (2003) believe that "not every good teacher has the skills necessary to be an effective mathematics [coach]" (p. 281). They list criteria for principals to consider when hiring mathematics coaches:

- Mathematical content and pedagogical background

- Teaching experience at the elementary level
- Interest in serving as a mathematics teacher or specialist
- Acceptance by other teachers
- Ability to lead
- Ability to work with students' parents and the community (p. 281)

They also make the point that "many fine teachers have difficulty mentoring others, or they unknowingly intimidate their colleagues" (p. 281).

Recent research suggests that mathematics coaches must have intensive training in content, pedagogy, and leadership, as well as experience in the coaching position, before they can make a difference in teachers' instructional strategies or students' mathematics achievement (Campbell & Malkus, 2009a, 2009b).

Knowledge of mathematics content and pedagogy, ability to work with teachers, leadership skills, classroom experience, and coaching experience are all important considerations for a principal when hiring a mathematics coach. No research exists that examines principals' actual hiring practices or the factors that influence them when hiring mathematics coaches.

Expectations for Mathematics Coaches

In order for a coaching program to be successful, the coach's role should be well-defined and clearly understood by the coach, the principal, and the teachers in a school (Lord, Cress, & Miller, 2008; McGatha, 2009b). It is important that the coach and the principal have a shared understanding of the work that the coach is doing in the school. In order for them to develop and sustain this shared understanding, they should meet

frequently (Knight, 2009b). When coaches' roles are well-defined, they know the conditions and limits of their involvement with teachers. This enables them to make informed decisions about with whom and how they will work (Lord, Cress, & Miller, 2008). While many agree that the coach's role should be clearly defined and well-understood, this literature review did not overturn any studies that examined the expectations that principals have for mathematics coaches or how those expectations impact the role of the coach or the success of the program.

Supporting Mathematics Coaches

To ensure the success of a mathematics coaching program in a school, coaches must be supported by their principals (Campbell, 1996; McGatha, 2009b; Reys & Fennell, 2003) Campbell (1996) found that differences in principals' support impacted teachers' instructional change in schools with mathematics coaches. In schools where the principal, the mathematics coach, and the teachers were learning together, the mathematics professional development program resulted in "increased student achievement, instructional change in almost every classroom, and a deepening, tangible respect between the teachers and the principal" (p. 468). In schools where the principal supported change but did not understand the reform efforts, some teachers viewed the mathematics coach as their instructional leader, while others ignored the coach. This created conflict and disagreement between the coaches and the principals. In one school where the principal did not support instructional change, the majority of teachers continued to work with the mathematics coach to change their instructional practices without challenging the authority of the principal. The remaining teachers ignored the

coach and did not interfere with the teachers who were attempting change. While this seems like a workable solution, the impact on student achievement in this school was disparate across classrooms.

Campbell's (1996) findings suggest that a mathematics coach and a principal should have a shared vision of what they think mathematics instruction should look like in their school. Along with the shared vision of mathematics instruction, the coach and the principal should agree on change strategies that will enable them to reach their vision. "The fact that everyone wants to improve teaching and learning does not mean that everyone has the same view of high-quality mathematics…instruction, nor that everyone has the same vision of how to go about the improvement efforts" (Weiss & Pasley, 2009, p. 3). One major component of support that a principal can offer a mathematics coach is an opportunity to talk about and shape a shared vision (Knight, 2009b; Reinke, Sprick, & Knight, 2009). Once both understand and can articulate what quality mathematics instruction looks like, they should discuss how the mathematics coach's role supports teachers in reaching this goal. The vision needs to be articulated to the staff by both the mathematics coach and the principal. A shared vision is the most basic form of support.

Other forms of support may include clearly articulating expectations about the role of the mathematics coach to the school staff (Lord, Cress, & Miller, 2008), creating schedules that allow for collaborative planning time and time for the mathematics coach to support teachers in their classrooms (Killion, 2009), and providing time and resources for coaches to participate in ongoing professional development and networking groups (Reinke, Sprick, & Knight, 2009). While many agree that principals must support

mathematics coaches in order to ensure the success of the mathematics coaching program, the kinds of support that principals offer have not been fully investigated. More research is needed on the ways that principals support mathematics coaches and how principal support impacts the coaching program and the overall mathematics program in a school.

Success of Mathematics Coaching Programs

The success of a mathematics coaching program depends on many things. This section of the literature review examines factors that may influence the success of a mathematics coaching program. While few empirical studies have been published that pinpoint factors that influence the success or failure of a mathematics coaching program, many articles have been written that offer suggestions and conventional wisdom. Factors that contribute to the conceptual framework of this study include: clear expectations and well-defined roles of mathematics coaches, adequate time to coach, nonevaluative interaction with teachers, continuous support of mathematics coaches, and ongoing professional development for mathematics coaches.

Clear Expectations and Well-Defined Roles

McGatha (2008) found that it is important for the mathematics coach and the classroom teacher to establish clear expectations about the role of the coach and the coaching relationship. She suggests that the goals for the coaching experience be negotiated collaboratively between the coach and the teacher. Others have recommended that clear expectations about the role of the coach should be established by the principal and the school district (McGatha, 2009b).

Adequate Time to Coach

Once clear expectations have been established about the role of the mathematics coach, adequate time to execute those roles needs to be given (McGatha, 2009b). Often coaches are pulled away from their jobs to do administrative tasks or other school duties such as substitute teaching, lunch duty, or bus duty. The amount of time that mathematics coaches spend coaching (e.g., working with teachers in their classrooms, facilitating team meetings) may impact the success of the mathematics coaching program. It has yet to be determined which coaching activities have the most impact on teachers' instructional practices and students' mathematics achievement.

Nonevaluative Interaction with Teachers

As mentioned earlier in this literature review, many believe that the role of the mathematics coach should be nonevaluative (AMTE, 2010; Confer, 2006; McGatha, 2009b; Reinke, Sprick, & Knight, 2009; Smith, 2006; Toll, 2006, 2009). Coaching should be viewed by coaches, teachers, and principals as a professional development activity (McGatha, 2009b). If teachers believe that coaches are there to evaluate them, they will not open up to the coaches about their professional development needs. This can severely impact the outcome of the coaching experience.

Continuous Support of Mathematics Coaches

Coaches should have continuous support from principals, superintendents, and central office staff (McGatha, 2009b). Principals can support coaches by creating schedules that allow time for teachers to interact with coaches individually and in teams, meeting frequently with coaches to discuss their work and collaboratively examine

assessment data, protecting coaches' time from interruptions that distract them from working with teachers, articulating the coaches' roles and responsibilities clearly to coaches and school staff, holding coaches accountable to those roles and responsibilities, and promoting the goals of the coaching program and the importance of coaching (Killion, 2009). Superintendents and central office staff can support coaching programs by articulating clear goals and expectations for those programs and providing opportunities for coaches to participate in ongoing professional development.

Ongoing Professional Development for Mathematics Coaches

Mathematics coaches should receive ongoing professional development (McGatha, 2009b; Reys & Fennell, 2003; Rowan & Campbell, 1995). They need opportunities to learn about mathematics content and pedagogy, mathematics curriculum, instructional strategies, coaching process, and adult learners (McGatha, 2009b; Reys & Fennell, 2003). Rowan and Campbell (1995) suggest weekly meetings of all mathematics coaches in a school district as one way to support mathematics coaches' learning. At these meetings, mathematics coaches would discuss issues such as strategies for working with teachers, ideas for teaching specific mathematics topics, ways to differentiate instruction and meet the needs of diverse learners, and avenues for communicating with parents and community members.

Conclusion

This literature review identified a number of topics that influenced this study. To begin, the set of knowledge and skills that elementary teachers need to successfully teach mathematics is quite extensive and complex. Professional development that is "intensive,

ongoing, and connected to practice" (Darling-Hammond et al., 2009, p. 5) has been found to deepen teachers' mathematical knowledge for teaching. Many educators in the U. S. believe that mathematics coaches can provide this type of professional development for teachers within their own school sites. The call for mathematics coaches in Virginia has become increasingly more urgent and many believe that a requirement for one full-time mathematics coach for every 1000 students in grades K-8 will soon be added to the Virginia Standards of Quality.

There are many coaching models being used with the U.S., but none are specific to mathematics coaching. Research on coaching in general is in its beginning stages. Preliminary findings suggest that coaching impacts teachers' attitudes, teaching practices, teacher efficacy, and student achievement. There are currently three recognized mathematics specialist models: the mathematics coach model, the specialized-teacher model, and the pull-out model. Research on mathematics specialist models is also in its beginning stages. No studies were found on the specialized-teacher model or the pull-out model in elementary schools. Preliminary research on mathematics coaching suggests that mathematics coaches can positively impact teachers' instructional practices, beliefs, and involvement in professional development activities as well as students' mathematics achievement.

While no empirical research exists about the roles of mathematics coaches, conventional wisdom and suggestions have been published in practitioner literature. Nine roles of mathematics coaches were identified in the literature. They include classroom supporter, learning facilitator, resource provider, curriculum specialist, instructional

specialist, data coach, learner, catalyst for change, and school leader. These roles overlap and inform each other. Important aspects of the classroom supporter role include who the mathematics coach coaches and how that coaching is conducted. Decisions about whom and how to coach may be informed by a mathematics coach's beliefs about effecting change. Some coaches believe that coaching competent teachers who are eager to learn new ways for teaching mathematics creates energy in a school's professional learning community and promotes change throughout the whole school. Many coaches believe that co-teaching with teachers has a greater positive impact on a teacher's instructional practice than modeling instructional techniques.

A mathematics coach's beliefs about their role as a school leader also impacts the way they work with teachers. Many coaches believe that their role should be nonevaluative. Coaches with this belief maintain confidentiality with their coachees and do not divulge negative information about a teacher's instructional practice to their principals. This allows coaches to establish trust and rapport with their coachees, thereby increasing the positive impact of the coaching relationship.

Mathematics coaches' positions can vary in many ways. Taylor (2008) identified dimensions by which coaching positions vary. These dimensions include type of coach, purpose, knowledge and skills, type of coachee, form, orientation, style, location, ratio, and duration. Each dimension has a continuum of classifications on which the coaches' roles can vary.

The principal's role in a mathematics coaching program includes selecting a mathematics coach, setting expectations for the coaching role, and supporting the coach

in that role. In addition, a mathematics coach and a principal should have a shared vision of what they think mathematics instruction should look like in their school. Along with the shared vision of mathematics instruction, the coach and the principal should agree on change strategies that will enable them to reach their vision.

Factors that contribute to the success of a mathematics coaching program have been identified as clear expectations and well-defined roles of mathematics coaches, adequate time to coach, nonevaluative interaction with teachers, continuous support of mathematics coaches, and ongoing professional development for mathematics coaches.

This study extends the research literature cited in this chapter by examining the roles of mathematics coaches from the perspectives of mathematics coaches and principals in the field. Differences and commonalities in those perspectives have been identified. An understanding of what coaches do, how they interact with teachers, how their roles vary, and what principals do to support them will contribute to the research on mathematics teaching and learning. The next chapter focuses on the research methods that were used to conduct the study.

3. Methods

Overview of Methods

This chapter describes the methodology that was used to investigate the nature of the roles and responsibilities of elementary mathematics coaches. A comparative cross-sectional survey design was used to examine the experiences of mathematics coaches and principals who had begun mathematics coaching programs in their schools. Survey responses from mathematics coaches and principals were compared in order to determine how both groups conceptualized the role of a mathematics coach and to identify differences and commonalities in those conceptualizations. The surveys included both closed- and open-ended questions allowing for qualitative and quantitative analysis. Combining qualitative and quantitative research methods provided a comprehensive investigation of the views of both populations. Qualitative and quantitative data were collected simultaneously and equally valued as sources of information.

Research Questions

The following research questions guided this study.

1. Who are elementary mathematics coaches?
    a. What educational background, teaching experience, and specific coaching preparation do elementary coaches have?

b. What factors influence principals' selection of elementary mathematics coaches?

2. How do elementary mathematics coaches define their roles and responsibilities?
3. How do elementary principals define the roles and responsibilities of elementary mathematics coaches?
4. What differences exist in the way the mathematics coach role is conceptualized by mathematics coaches and principals?

Comparative Cross-Sectional Survey Method Design

A comparative cross-sectional survey method design was chosen because it provided an economical and efficient means for gathering and analyzing data from a large number of individuals. "The term *comparative* is used to refer to any research that is designed to compare populations" (Harkness, 2008, p. 56). The term *cross-sectional* means that data is collected at one point in time (Creswell, 2005). Cross-sectional surveys are used to "examine current attitudes, beliefs, opinions, or practices" (Creswell, 2005, p. 356). This survey study compared the attitudes, beliefs, opinions, and practices of two educational groups, mathematics coaches and principals.

Creswell (2005) lists several advantages of using cross-sectional surveys. "You can administer them in a short time, they are economical as a means of data collection, and they can reach a geographically dispersed population" (p. 379). He also reports some limitations. "Survey data is self-reported information, reporting only what people think rather than what they do. Sometimes the response rates are low and researchers cannot make claims about the representativeness of the results to the population" (p. 379).

The goal of this study was to examine the perceptions of mathematics coaches and principals regarding the role and responsibilities of mathematics coaches. Surveying allowed multiple perspectives to be obtained from a large number of participants across a wide-spread geographical area.

Participants and Setting

Participants were recruited from five school districts in Virginia. Four of the school districts were from Virginia's Educational Region IV, and one of the school districts was from Virginia's Educational Region II. Region IV consists of 20 school districts located in the northern part of Virginia. Region II consists of 16 school districts located in the Tidewater area of Virginia. Participants included 125 mathematics coaches and 59 principals from elementary schools in those five districts. Table 2 shows the distribution of participants by district.

Table 2

Number and Percent of Participants by District

	Principals		Mathematics Coaches	
District	Number	Percent	Number	Percent
1	5	8	6	5
2	30	51	76	61
3	7	12	20	16
4	3	5	1	1
5	14	24	22	17
Total	59	100	125	100

As Table 2 shows, the majority of the participants came from District 2 (51% of the principals and 61% of the mathematics coaches). District 4 included only one mathematics coach who worked at three different schools. The following section generally describes the school districts.

The Five School Districts

Four of the five school districts were located in the northern part of Virginia and were part of a large metropolitan area. The fifth district was also part of an urban area located in southeastern Virginia. The districts were of varying sizes. One was very small, serving only 2000 students. One was very large, serving approximately 160,000 students. The remaining three were moderately sized, ranging from 36,000 to 75,000 students. All of the districts served ethnically diverse populations ranging from 40-74% white, 9-24%

Hispanic, 5-23% black, 8-18% Asian, and 1-8% other. The percent of students receiving free/reduced lunch ranged from 6% to 33%. All of the districts provided special education services and services for English Speakers of Other Languages (ESOL).

The Mathematics Coaches

The mathematics coaches were identified by the mathematics coordinators in each district. Any elementary teacher who did not have regular classroom duties and whose job was to support mathematics instruction was identified as a mathematics coach. All identified mathematics coaches in each of the five school districts were invited to participate in the study.

The Principals

The principal of each identified mathematics coach was invited to participate in the study. If a mathematics coach worked at more than one school, the principals from all of the schools were invited to participate.

Data Sources

Two surveys were used to elicit the elementary mathematics coaches' and the principals' opinions about the roles and responsibilities of elementary mathematics coaches. Both surveys included closed- and open-ended questions so that quantitative and qualitative data could be collected. Table 3 shows the quantitative and qualitative methods of data collection and types of data.

Table 3

Quantitative and Qualitative Methods of Data Collection and Types of Data

Quantitative Research		Qualitative Research	
Methods of Data Collection	Data	Methods of Data Collection	Data
Closed-ended questions on surveys	Numeric scores	Open-ended questions on surveys	Text data transcribed from surveys
Likert-scale items on surveys	Numeric scores		

The surveys included questions designed to identify beliefs, opinions, and practices of elementary mathematics coaches and their principals. Since the term *mathematics specialist* was used in Virginia to mean *mathematics coach* as defined in this study, the survey and interview instruments used the term mathematics specialist as a general term to include mathematics specialists and mathematics coaches as defined in this study. Therefore, the Mathematics Specialist Survey (see Appendix B) was given to the mathematics coaches targeted in each district. The Principal Survey (see Appendix C) was given to principals who supervised those mathematics coaches. Each survey took approximately 30 minutes to complete.

Survey Error

There are four types of errors that can occur when conducting survey research: coverage error, sampling error, nonresponse error, and measurement error (Dillman, Smyth, & Christian, 2009). Coverage error "results from all members of the population

not having a known, nonzero chance of being included in the sample and from those excluded differing from those included" (p. 19). Sampling error occurs when all members of the population are not surveyed and those not surveyed are different in an important way from those who were surveyed. Nonresponse error is when the people who respond to the survey are different from the people who do not respond in a way that matters to the study. Measurement error "occurs when a respondent's answer is inaccurate or imprecise. Measurement error is often the result of poor question wording or design and other aspects of questionnaire construction" (p. 18). Coverage error, sampling error, and nonresponse error will be addressed in the data collection procedures section of this chapter. Measurement error occurs due to the design of the survey, so it will be discussed here.

Survey Design

Creswell (2005) states that it is important to use a good instrument in survey research in order to reduce measurement error. He suggests using or modifying an existing instrument. Therefore, some of the questions on the surveys were taken from Blamey, Meyer, and Walpole's (2008) survey of middle and high school literacy coaches. Other questions were modifications of questions from that same survey. The majority of the questions were developed by the researcher to answer the research questions in this study while taking into account the research literature on mathematics coaches' roles.

In order to increase the validity of the surveys, the researcher made an effort to use clear language, avoid answer choices that overlap, and pose questions that were applicable to all respondents. A pilot test of the questions was conducted by

administering the survey instruments to a small group of mathematics coaches and principals. Changes reflecting their feedback were incorporated into the surveys.

When conducting comparative survey research it is important that the surveys used are comparable and equivalent (Harkness, 2008). There are a few basic options for design of comparative surveys. Researchers can use the same questions on the different surveys or they can ask different questions. If the researchers decide to use different questions, they can adapt or modify questions from one survey to another or they can develop new questions (Harkness, 2008). In this study, the Mathematics Specialist Survey (Appendix B) was written first. The questions on the Principal Survey (Appendix C) were either adapted from the Mathematics Specialist Survey or newly written. Table 4 shows how the two surveys compare.

Table 4

Comparability and Equivalence of Mathematics Specialist and Principal Surveys

	Similar Questions															
Mathematics Specialist	4	6	9	10	12	13	14	15	16	17	18	20	22	26	27	
Principal	19	5	6	7	8	9	10	11	12	13	14	16	15	17	18	
	Unique Questions															
Mathematics Specialist	1	2	3	5	7	8	11	19	21	23	24	25	28	29	30	31
Principal	1	2	3	4												

As Table 4 shows, both surveys had questions that were similar and questions that were unique. An example of questions that were similar is “What do you consider your primary role or responsibility?” (Mathematics Specialist Survey) and “What do you

consider the primary role of the mathematics specialist?" (Principal Survey). Another example is "How often during the last year did you engage in the following activities?" (Mathematics Specialist Survey) and "How often should your mathematics specialist engage in the following activities?" (Principal Survey). Questions that were unique to the Mathematics Specialist Survey included, "Which of the following activities prepared you for your role as a mathematics specialist?", "What is your official job title?", and "How do you decide which teachers to work with?" Questions that were unique to the Principal Survey included, "Did you hire the mathematics specialist who is currently working at your school?", "How long has your school had a mathematics specialist?", and "What are your requirements for hiring a mathematics specialist?"

Data Collection Procedures

This section describes the data collection procedures used to carry out the study. It includes procedures that were used to contact study participants and acquire their informed consent, as well as steps that were taken to reduce the risk of different types of survey error. It also includes information about the administration of the surveys and how identification codes were assigned.

Initial Contact

Mathematics coordinators from seven Virginia school districts were initially approached through face-to-face, email, or telephone contacts. In some cases an introduction was made by a third party. The seven districts included six districts from Virginia's Educational Region IV and one district from Virginia's Educational Region I. The initial contacts were informal conversations in which each of the seven mathematics

coordinators was given a brief overview of the study. During the summer of 2009, the mathematics coordinators who expressed interest in the study were formally contacted via email (Appendix A) and asked to participate in the study. Permissions were solicited from research review boards in seven school districts and obtained from five of those districts. Once permission had been obtained, the mathematics coordinators were asked to provide a list of names and email addresses of mathematics coaches working in the district and their respective principals. If regular meetings of mathematics coaches and/or principals were held in the district, the mathematics coordinator was asked to arrange for the researcher to attend one of these meetings in order to explain the study and collect survey data. The research attended two such meetings of mathematics coaches. All other solicitation was conducted through email.

Reduction of Coverage and Sampling Error

To eliminate the risk of coverage and sampling error and because the target population of elementary mathematics coaches and principals in the five districts was a relatively small number of people, all identified mathematics coaches and principals were invited to complete a survey.

Administration of Surveys

Surveys were collected electronically during the fall of 2009. The researcher attended a scheduled meeting of mathematics coaches in two of the participating districts, described the research study, and invited the mathematics coaches to complete surveys. Time was given for the mathematics coaches to complete the electronic surveys during the meetings. The remaining participants, who could not be reached through scheduled

meetings, were contacted via email (Appendix D) and provided a link to the electronic survey. To increase the response rate, the email explained the purpose of the research, emphasized its importance, and asked participants to help. A follow-up request was sent approximately one week after the first request. A second follow-up request was sent after another full week. In one of the districts a second follow-up request was prohibited by the research review committee and, therefore, not sent.

Informed Consent

The mathematics coaches who completed their surveys during a meeting were asked to read and sign an informed consent form before completing the electronic survey. Participants who were contacted through email read the informed consent form electronically. They were required to click a button on the form indicating agreement and giving them access to the survey. Human Subject Review Boards waived the requirement for signing a consent form in these cases.

Identification Codes

Each identified mathematics coach and principal was assigned a unique identification code. The codes were designed in such a way as to identify the districts and schools of the participants (i.e., the first digit identified the district, the next two digits identified the school, and the next three digits identified the participant). The surveys were administered so that identification codes could be assigned after participants completed the surveys in order to eliminate identification coding errors. Electronic surveys were created separately for each district. One of the survey questions asked participants to identify the name(s) of their school(s). The names of the districts and the

schools were removed from the data before the researcher completed the data analysis, thereby protecting the participants from being recognized by the researcher during analysis. The list of participants' names and corresponding identification codes was kept confidential. Codes were used to group participants from the same school district and to link principals to their respective mathematics coaches during data analysis.

Reduction of Nonresponse Error

Dillman et al. (2009) suggest tailoring the design of a survey in order to reduce nonresponse error.

> Tailored design is the development of survey procedures that work together to form the survey request and motivate various types of people to respond to the survey by establishing trust and increasing the perceived benefits of completing the survey while decreasing the expected costs of participation (p. 38).

They suggest four ways to establish trust in respondents: "obtain sponsorship by legitimate authority, provide a token of appreciation in advance, make the task appear important, and ensure confidentiality and security of information" (p. 38). In order to establish trust of the respondents, they were contacted through their mathematics coordinators, a person of authority in their districts. By attending a meeting and explaining the research study to the participants in person in two of the districts, the task was made to appear important. Verbal and written assurances were given that individual responses would remain confidential and that all identifying data would be kept secure.

Dillman et al. (2009) suggest many ways to increase the benefits and decrease the cost of participation. In order to increase the benefits of participation in this study, the

researcher provided information about the survey to the participants, asked participants for their help in this endeavor, showed positive regard for the participants, said thank you, made the survey interesting, and informed participants that opportunities to respond to the survey were limited. In order to decrease the cost of participation, the researcher made it convenient to respond to the survey by making the survey available electronically. In addition, efforts were made to make the survey as short as possible and care was taken with the electronic format to make it easy to complete. By paying careful attention to these details, the researcher was able to motivate many mathematics coaches and principals to respond to the survey, thereby resulting in a high response rate and low nonresponse error. (See Chapter 4 for information on response rates.)

Data Analysis

In order to analyze and interpret the data collected in this study, multiple data analysis methods were used. This section of the methods chapter examines how the survey questions align with the research questions, what types of data were collected, how those data were analyzed, and how the data analyses reflects major themes in the research literature.

Survey Alignment to Research Questions

The two surveys being used in this study were carefully designed to collect data that would answer the research questions. Table 5 shows the alignment of the survey questions to the research questions.

Table 5

Alignment of Research Questions and Survey Questions

	Survey Question Numbers	
Research Question	Mathematics Specialist	Principal
1. Who are elementary mathematics coaches?	1, 6-8, 28-31	1-5
2. How do elementary mathematics coaches define their roles and responsibilities?	2, 3, 5, 9-27	
3. How do elementary principals define the roles and responsibilities of elementary mathematics coaches?		6-18
4. What differences exist in the way the mathematics coach role is conceptualized by mathematics coaches and principals?	9-10, 12-18, 20, 22, 27	6-18

As Table 5 shows, there were multiple survey questions for each research question. The majority of the survey questions concentrated on mathematics coaches' and principals' perceptions of the roles and responsibilities of mathematics coaches. Eight questions on the mathematics specialist survey and five questions on the principal survey served to identify characteristics of mathematics coaches including their educational background, teaching experience, coaching preparation, as well as principals' hiring practices and selection criteria.

Types of Data and Analyses

Multiple analyses were used to examine the survey results. Survey response rates were calculated for each participant group and appropriate subgroups in order to detect

nonresponse error. Since Creswell (2005) states that “many survey studies in leading educational journals report a response rate of 50% or better” (p. 367), the goal for the response rate of this survey was set at 50%. Since the surveys included both closed- and open-ended response items, quantitative and qualitative methods were used to analyze the survey data. Table 6 shows the types of items on the surveys, the types of resulting data, and the types of analyses that were utilized.

Table 6

Survey Item Types, Data Types, and Analyses

Item Type	Data Type	Item Number		Analysis
		Mathematic Specialist Survey	Principal Survey	
Short answer	Numerical	1, 5, 30		Quantitative: Descriptive statistics (means, standard deviations, frequency distributions)
Open-ended	Text	4, 9-11, 17, 23, 25, 27, 31	6, 7, 13 18, 19	Qualitative: Open-coding, content analysis, summary of response types and their frequencies, sample responses
Yes or No	Categorical	6, 18, 19	4, 5, 14	Quantitative: Percentages; cross tabulations, using chi-square tests, for certain demographic variables crossed with responses for certain questions
Checklist	Categorical	7, 28, 29		
Multiple Choice	Categorical	2, 3, 20	1, 2, 16	
Rank	Categorical	8, 21, 26	17	
Likert Scale	Ordinal	12-16, 22, 24	3, 8-12, 15	Quantitative: Percentages; cross tabulations, using chi-square tests, for certain demographic variables crossed with responses for certain questions

As Table 6 shows, there are four types of data that were analyzed: numerical data, text data, categorical data, and ordinal data. Analyses for each type of data are described below.

Numerical data. Numerical data resulted from open-ended questions that asked for a number. For how many years have you been an elementary mathematics specialist? How many mathematics specialists are employed at your school? How many years of classroom teaching experience do you have? Quantitative analyses were used to analyze these data. Means, standard deviations, and frequency distributions were reported when appropriate.

Text data. Qualitative methods were used to analyze open-ended survey questions which resulted in text data. Open coding (Strauss & Corbin, 1998) was used to identify patterns and themes in the responses. As themes emerged, they were coded and organized into manageable categories. A summary of response categories and their frequencies was calculated when appropriate. Noteworthy comments were identified in order to illustrate the nature of the comments. Attention was taken to include comments that were indicative of majority opinions as well as statements that illustrated dissenting or opposing opinions.

Categorical and ordinal data. Many survey item types resulted in categorical data (i.e., yes or no, checklist, multiple choice, rank). Likert scale items are generally considered to result in ordinal data (Creswell, 2005; Fitzpatrick, Sanders, & Worthen, 2004). Categorical and ordinal data were analyzed using the same methods. Quantitative analyses were used to calculate percentages of response categories. Cross tabulations,

using Chi-square tests, were calculated for certain demographic variables crossed with responses for certain questions. Using Chi-square tests allowed the researcher to determine statistically significant differences in responses for particular groups of participants. For example, do principals and coaches differ in their views of the best way to effect change in teachers' instructional practice? Do coaches with mathematics specialist endorsements feel more qualified to coach teachers than coaches without mathematics specialist endorsements? Do novice coaches and experienced coaches differ in their frequency of modeling mathematics instruction? Do full-time coaches spend more time working with teachers in collaborative teams than part-time coaches? Answers were sought for these and similar questions during the data analysis phase of this study.

Major Themes in the Research Literature

The preceding literature review identified major themes about the roles and responsibilities of mathematics coaches. These themes included the three mathematics specialist program models, the nine roles of mathematics coaches, and the nonevaluative nature of the mathematics coach's role. Table 7 shows how the survey questions correspond to these major themes. The numbers and letters in the table represent survey questions and subquestions. For example, 13a refers to a subquestion on the Mathematics Specialist Survey: "How often during the last year did you engage in the following activities? (1 = Frequently, 2 = Sometimes, 3 = Rarely, 4 = Never): (a) Assist teachers in planning mathematics instruction."

Table 7

Correspondence of Survey Questions and Major Research Literature Themes

	Survey Question Numbers	
Topic	Mathematics Specialist	Principal
Roles		
Overall Role	9, 10, 11, 16, 18b, 26, 27	6, 7, 12, 14b, 17, 18
Classroom Supporter		
Who?	21, 22, 23, 26b-c, 26k	15, 17b-c, 17k
How?	12b-c, 13a-f, 13i, 13m, 13p, 13r-s, 20, 24, 25	8b-c, 9a-f, 9i, 9m, 9p, 9r-s, 16
Learning Facilitator	13g, 14g, 14k, 14l	9g, 10g, 10k, 10l
Resource Provider	13p-s, 14a-b	9p-s, 10a-b
Curriculum Specialist	13t-v	9t-v
Instructional Specialist	13a, 13e, 13m	9a, 9e, 9m
Data Coach	13h-l	9h-l
Learner	15, 26a, 26d	11, 17a, 17d
Catalyst for Change	14h-j	10h-j
School Leader	14c-f, 16i, 26e	10c-f, 12i, 17e
Other		
Program Models	12, 13a-d, 13n-o, 16f-g, 19	8, 9a-d, 9n-o, 12f-g
Nonevaluative	16h, 18a, 18c, 18d	12h, 14a, 14c, 14d

Note. The survey questions that correspond to the numbers in the table are listed in Appendices B and C.

As Table 7 shows, survey questions addressed roles and other aspects of coaching. The majority of the questions on the surveys asked about the roles of the mathematics coach. There were survey questions about each of the nine mathematics coaching roles and questions that addressed the overall role of the coach. Survey questions were also included for two other literature themes: the mathematics specialist

program models and the nonevaluative nature of mathematics coaches. Each of these categories will be discussed in turn.

Mathematics coaches' roles. As Table 7 shows, there were multiple survey questions that addressed the role of a mathematics coach. The "Overall Role" questions were open-ended questions about the coaches' roles, questions addressing the coaches' feelings of competency, and questions about how decisions were made concerning the role. Questions specific to the nine coaching roles generally asked the frequency of performing a certain activity assigned to that role. For example, Question 13 on the mathematics coaches' survey asked, "How often during the last year did you engage in the following activities? (1 = Frequently, 2 = Sometimes, 3 = Rarely, 4 = Never)." Question 13g, "share professional articles with teachers" was considered to be an activity associated with the role of learning facilitator. If a coach indicated that he or she frequently shared professional articles with teachers, then the researcher understood that the coach was acting as a learning facilitator. Data analysis of the coaching role includes frequencies and percentages of survey respondents who indicated that they were acting within each of the nine roles. Chi square tests were also conducted to determine if there were differences in responses for different groups of participants. For example, did coaches with a mathematics specialist endorsement co-teach more frequently than coaches without the endorsement?

Mathematics specialist program models. Three mathematics specialist program models were identified in the research literature: the mathematics coach model, the specialized-teacher model, and the pull-out model. As Table 7 shows, a number of

questions on the survey were designed to discern to which mathematics specialist model survey respondents subscribed. Question 12a asked mathematics coaches how often in the last year they taught mathematics to children with no other teacher present (1 = frequently, 2 = sometimes, 3 = rarely, 4 = never). Question 13n asked mathematics coaches how often they provided mathematics remediation or intervention to individual children. Question 16g asked mathematics coaches to strongly agree, agree, disagree, or strongly disagree to the statement, "My primary job is to teach children." Analysis was conducted to discern the frequency to which mathematics coaches were working in the specialized-teacher model or pull-out model (i.e., teaching children with no other teacher present). Chi square tests were also conducted to determine if there were differences in responses for different groups of participants. For example, did novice coaches work within the specialized-teacher model more frequently than experienced coaches?

The nonevaluative nature of the coaching role. Conventional wisdom and anecdotal evidence suggest that mathematics coaches should be nonevaluative (AMTE, 2010; Confer, 2006; Knight, 2009b; Reinke, Sprick, & Knight, 2009; Reiss, 2009; Smith, 2006; Taylor, 2008). This enables coaches to build rapport with their coachees and work confidentially to improve teachers' instructional practices. Table 7 shows that four survey questions on each of the two surveys inquired about this aspect of coaching. On the Mathematics Specialist survey, question 16h asked mathematics specialists to strongly agree, agree, disagree, or strongly disagree with the statement, "It is important for me to tell my principal if I see poor mathematics instruction in a classroom." Question 18c asked mathematics specialists if their principal had ever asked them to evaluate the

performance of another teacher, and question 18d asked if they had every been asked to divulge information about a teacher that they considered to be confidential. Similar questions were asked on the principal survey. Participants' responses to these questions helped the researcher determine if mathematics coaches and principals agreed with conventional wisdom that mathematics coaches should be nonevaluative. It also helped the researcher determine if, in fact, the mathematics coaches in this study were acting in nonevaluative ways.

Conclusion

The research methods described in this chapter allowed for a comprehensive examination of the research questions. Thoughtful consideration was given to the recruitment of participants and the design of the two surveys. Data collection procedures were clearly specified and steps were taken to reduce nonresponse error. Data Analysis methods were aligned with the research questions and the types of data being collected. The careful planning of the research methods and procedures used in this dissertation resulted in a high quality study that examines many aspects of the roles and responsibilities of elementary mathematics specialists.

4. Results

Overview of Results

In this chapter, the research results are presented. The results begin with survey response rates. Research Question 1 is addressed with descriptive data on the educational background, teaching experience, and preparation of the elementary mathematics coaches, followed by factors that influenced principals' selection of mathematics coaches. Research Question 2 is then examined. Mathematics coaches' perceptions of their roles are shared along with data describing differences between subgroups of mathematics coaches. Research Question 3 is answered next with results of the analyses of the principals' perceptions. Finally, Research Question 4 is attended to by examining the differences between principals' and coaches' perceptions.

Response Rates

Creswell (2005) stated that "many survey studies in leading educational journals report a response rate of 50% or better" (p. 367). Therefore, the goal for the response rates of the two surveys in this study was set at 50%. The response rate of the Mathematics Specialists' Survey was 79%, and the response rate of the Principals' Survey was 50%. Overall, these were good response rates that met the established goal. Table 8 shows the response rates for each district.

Table 8

Response Rates by District

	Mathematics Specialists' Survey			Principals' Survey		
District	Coaches	Responses	Rate	Principals	Responses	Rate
1	6	6	100%	10	5	50%
2	83	76	92%	48	30	63%
3	32	20	63%	22	7	32%
4	1	1	100%	3	3	100%
5	36	22	61%	35	14	40%
Overall	158	125	79%	118	59	50%

As Table 8 shows, the response rates for the Mathematics Specialists' Survey were higher than the response rates for the Principals' Survey. The coaches' response rates were higher than 50% in all five districts. The principals' response rates were at or above 50% in three of the five districts. District 4 had a 100% response from both the mathematics coach and the principals. This was likely because of the size of the district and the relationships of the participants in the district. The mathematics coach wanted to participate in the study and personally asked her principals to participate. The differences in the response rates of the other districts can be explained by examining differences in data collection procedures. Very high response rates for mathematics coaches and principals resulted from Districts 1 and 2. These were the two districts in which the

researcher attended a meeting of mathematics coaches and personally asked them to participate in the study. The coaches were given time at the meetings to complete the electronic survey. The principals' response rates in both of these districts were at or above 50%. This also could be a result of the personal attention paid to the coaches even though the researcher did not meet with the principals. The coaches were asked to talk to their principals about the study and request their participation. It seems likely that this happened, given the higher principal response rates in these districts. The lowest response rates occurred in districts where participants only received email requests from the researcher.

Coaches' Experiences, Educational Background, and Preparation

In this section, information about the coaches' teaching experiences and educational background are presented. Coaches' perspectives on activities that prepared them to be mathematics coaches are also examined.

Experience as Classroom Teachers and Mathematics Coaches

The mathematics coaches in this study had all been classroom teachers before becoming mathematics coaches. The mean number of years of classroom experience was 13 years. Years of classroom experience ranged from 2 to 35 years. About half of the coaches (52%) worked at the same school where they had worked as a classroom teacher.

The median number of years experience as a mathematics coach was 3 years. Twenty-two of the 125 mathematics coaches (18%) were working in their first year as a mathematics coach. Number of years as a mathematics coach ranged from 0 to 17 years. Fifty-six percent of the mathematics coaches had less than four years of experience.

About 22% had more than five years of experience, and only 5% had more than 10 years of experience.

Educational Background and Certification

The mathematics coaches in this study reported having bachelor's degrees in elementary education (56%), early childhood education (12%), mathematics education (2%), science education (2%), social studies education (2%), language arts education (2%), special education (2%), and something other than education (29%). About 11% of the coaches reported having more than one bachelor's degree. A large majority of the coaches reported having a master's degree (80%). Coaches had master's degrees in mathematics education (25%), another field of education (57%), and fields outside of education (6%). Six percent of the coaches reported having more than one master's degree.

The mathematics coaches' teaching licenses included endorsements in grades preK-3 (16%), preK-6 (66%), and 6-8 (18%). Twenty-five percent of the coaches had the Virginia K-8 Mathematics Specialist endorsement. Six percent of the coaches had a mathematics endorsement.

Preparation

When asked about activities that prepared them to be mathematics coaches, the most frequent responses were district-level professional development (89%) and professional reading (84%). A large majority of the coaches reported taking graduate-level coursework (75%) and attending professional conferences (63%). More than half of the mathematics coaches (56%) said they had learned from a mentor.

When asked which preparation activities had helped them the most, 62% chose district-level professional development as their first or second choice. About half (49%) chose graduate-level courses as their first or second choice, and 30% chose working with a mentor as their first or second choice. When this information was disaggregated by district, there were statistically significant differences among the districts with high percentages of specialists from District 2 (91%), District 3 (95%), and District 5 (91%) indicating that district-level professional development had prepared them to be mathematics coaches, $\chi^2(4) = 18.18$, $p = .001$. There were no statistically significant differences among districts for coaches participating in graduate-level courses, attending professional conferences, or working with mentors.

Factors That Influence Principals' Selection of Mathematics Coaches

In order to gather information about how coaches were selected and hired, principals were asked three survey questions. Survey Question 2 asked, "Who chooses the mathematics specialists that work in schools in your district?" Survey Question 3 asked, "What are your requirements for hiring a mathematics specialist?" Survey Question 4 asked, "Did you hire a mathematics specialist who is currently working at your school?" Principals who reported that they had hired a mathematics coach were asked additional survey questions about their selection criteria. This section describes the results of the analyses of these survey questions.

Who Hires the Mathematics Coach?

Eighty-five percent of the principals in this study reported that they made hiring decisions about mathematics coaches, and 74% said that they had hired at least one coach

who was currently working at their school. The principals in Districts 1 and 4 reported that the district made the hiring decisions, and coaches were assigned to their schools. In District 5, the majority of the principals reported that they made the hiring decisions for their schools, but a small percentage of principals said that the coaches were hired at the district level and placed at their schools (14%). A few principals from Districts 2 and 5 described a process in which the district screened candidates and selected a pool of candidates from which the principals chose. Some principals also described creating a mathematics coach position and creatively funding it. For example, one principal wrote, "This position was created by trading off clerical, custodial, and art teacher staffing allotments. This year, I had to 'dip into' my instructional supply and textbook money to fund [the] position." Another wrote, "I traded a position in order to have a mathematics specialist in my building." A third said, "I am forced to trade other positions to 'buy' my math coach because I place such value on the work she provides."

Principals' Selection Requirements

The 50 principals who indicated that they were responsible for selecting the mathematics coach at their school were asked survey questions about their selection criteria. Table 9 shows percentages of the 50 principals who considered specific criteria to be important.

Table 9

Percent of Principals Who Found Specific Selection Criteria to Be Important

	Importance		
Selection Criteria	Very Important	Somewhat Important	Not Important
Knowledge of Math Content	98	2	0
Knowledge of Pedagogy	94	6	0
Elementary Teaching Experience	86	14	0
Ability to Lead Others	90	10	0
Acceptance by Other Teachers	78	22	0
Knowledge of How to Differentiate Instruction	98	2	0
Knowledge of Mathematics Instruction for English Language Learners	74	24	2
Knowledge of How to Work Effectively with Adult Learners	88	12	0
Coaching Skills	84	14	2
Ability to Work with Parents and Community	66	28	6
K-8 Mathematics Specialist Endorsement	46	44	10

As Table 9 indicates, almost all of the principals found all 11 criteria to be of some level of importance. Some of the criteria were more important than others, however. Very high percentages of principals found knowledge of mathematics content (98%), knowledge of how to differentiate instruction (98%), and knowledge of pedagogy (94%) very important criteria for hiring mathematics coaches. The ability to lead others

(90%), knowledge of how to work effectively with adult learners (88%), elementary teaching experience (86%), and coaching skills (84%) were also very important criteria for a large majority of the principals. Principals did not place importance on the K-8 mathematics specialist endorsement, however. This selection criterion was valued by the least number of principals. Only about half of the principals thought that it was very important for the mathematics coach to have a K-8 mathematics specialist endorsement, and 10% of the principals thought it was not important at all.

Mathematics Coaches' Perceptions

Research Question 2 asks, "How do elementary coaches define their roles and responsibilities?" This section presents the results of analyses designed to comprehensively answer this research question. The section begins by describing what the mathematics coaches reported about the mathematics specialist program models. Then the results of the analysis of the nine coaching roles are shared. Finally, the results of an analysis of the nonevaluative nature of the mathematics coaches' role are presented.

Mathematics Specialist Program Models

There are three models of mathematics specialist programs: the mathematics coach model, the specialized-teacher model, and the pull-out model (Ball, et al., 2008; Fennell, 2006, 2007; NRC, 1989, 2001; Reys & Fennell, 2003). In the mathematics coach model, the mathematics specialist primarily works with classroom teachers as a resource and a mentor. In the specialized-teacher model, specialists teach mathematics to students. They are usually the sole mathematics instructor for classes of students. In the pull-out model, specialists provide supplemental instruction to students who are failing to meet

grade level standards. They usually work with individual students or small groups of students outside of the students' regular mathematics block. In order to determine which mathematics specialist models the mathematics coaches in this study were working under, coaches' were asked survey questions about their primary jobs. They were also asked how frequently they engaged in specific coaching activities related to each program model.

Coaches' primary jobs. Coaches were asked to what degree they agreed or disagreed that their primary job was (a) to support teachers' professional growth, and (b) to teach children. Supporting teachers' professional growth would fit under the coach mathematics specialist model. Teaching children would be part of the specialized-teacher or pull-out models. Table 10 shows the coaches' responses to these two survey questions.

Table 10

Percent of Coaches' Responses about Their Primary Jobs

Primary Job	SA	A	D	SD
Teach children	25.5	37.6	35.2	1.6
Support teachers' professional growth	49.2	36.3	13.7	0.8

Note. SA = Strongly Agree, A = Agree, D = Disagree, SD = Strongly Disagree.

As Table 10 shows, more coaches agreed that their primary job was to support teachers' professional growth (86%) than to teach children (63%). Almost twice as many coaches "strongly agreed" that their primary job was to support teachers' professional

growth (49%) than “strongly agreed” that their primary job was to teach children (26%). There was considerable overlap between the two questions, however. Almost half of the coaches (48%) agreed to both statements. When the two survey questions were compared and coded in order to assign each coach to one category of primary job description, it was determined that 37% of the coaches thought their primary job was to support teachers, 15% thought their primary job was to teach children, and 48% thought it was both.

Coaching activities that related to the three mathematics specialist program models. Coaches were asked how often they engaged in nine specific activities that related to the mathematics specialist program models. Activities that would be part of a specialized-teacher model or a pull-out model included teaching children with no other teacher present, providing remediation to individual children, and providing remediation to small groups of children. Activities that would be part of a coach model included working with teachers individually, working with teachers in collaborative teams, assisting teachers in planning instruction, modeling instruction, co-teaching lessons with teachers, and observing teachers teach lessons. Table 11 shows the percent of coaches’ responses to each of the nine survey questions.

Table 11

Percent of Coaches' Responses Relating to Mathematics Specialist Program Models

Coaches' Activity	F	S	R	N
Specialized-Teacher or Pull-Out Model				
Teach children with no other teacher present	33.6	20.8	35.2	10.4
Provide remediation to individual children	33.1	30.6	26.6	9.7
Provide remediation to small groups of children	46.8	30.6	17.7	4.8
Coach Model				
Work with teachers individually	60.0	29.6	8.8	1.6
Work with teachers in teams	65.6	25.6	6.4	2.4
Assist teachers in planning	61.6	30.4	5.6	2.4
Model instruction	46.0	41.1	8.9	4.0
Co-teach lessons with teachers	47.2	32.0	17.6	3.2
Observe teachers teaching	20.3	42.3	31.7	5.7

Note. F = Frequently, S = Sometimes, R = Rarely, N = Never.

As Table 11 shows, more coaches were engaged in activities related to the coach model than activities related to the specialized-teacher or pull-out models. More than half of the coaches frequently worked with teachers individually (60%), worked with teachers in teams (66%), and assisted teachers with planning (62%). Almost half of the coaches

frequently modeled instruction for teachers (46%) and co-taught lessons with teachers (47%). Comparatively, only one third of the coaches frequently taught children with no other teacher present and provided remediation to individual children. About half of the coaches frequently provided remediation to small groups of children, however.

When "frequently" and "sometimes" responses were considered, most of the coaches reported working with teachers both individually (90%) and in collaborative teams (91%). Large numbers of coaches also reported that they planned with teachers (92%), modeled mathematics instruction for teachers (87%), co-taught lessons with teachers (79%), and observed teachers teaching lessons (63%). These data seem to indicate that the majority of coaches in this study were working within the mathematics coach program model, but there was also sufficient evidence that coaches were working either within the specialized-teacher model or the pull-out model. More than half of the coaches reported that they taught mathematics to children with no other teacher present (54%), and high percentages of coaches reported that they provided remediation to individual children (64%) and small groups of children (77%). Further analysis revealed that all of the coaches who said they taught children with no other teacher present also said that they were providing remediation to small groups of children. This indicates that coaches were working within the pull-out mathematics specialist model rather than the specialized-teacher model.

Since data indicate an overlap of coaches working within the mathematics coach model and the pull-out model, further analysis was conducted in order to determine if coaches were working exclusively under either model. Twenty-five of the coaches said

they rarely or never did any of the teaching activities (i.e., teach children with no other teacher present, provide remediation to individual children, and provide remediation to small groups of children). This indicates that 20% of the coaches were working exclusively under the coach mathematics specialist model. Only four coaches said they never did any of the four coaching activities (i.e., plan with teachers, model for teachers, co-teach with teachers, or observe teachers). This indicates that very few coaches (3%) were working exclusively under the pull-out model. The remainder of the coaches reported doing both coaching and teaching activities (77%).

Since so many coaches were coaching teachers and teaching children, an analysis was done to determine the overlap in the two types of activities. The coaches who reported engaging in the three teaching activities were disaggregated as separate groups. The percentage of coaches from each group who engaged in each of the four coaching activities was then calculated. For example, 68 coaches said that they "frequently" or "sometimes" taught children with no other teacher present. The percentages of the 68 coaches who reported co-teaching "frequently," "sometimes," "rarely," and "never" were calculated. Calculations were done for each of the three teaching activities crossed with each of the four coaching activities. Table 12 shows the percent of coaches who engaged in the four coaching activities disaggregated by the three teaching activities. The sample sizes (e.g., $n = 68$) in the table represent the number of coaches who reported "frequently" or "sometimes" engaging in the corresponding teaching activity.

Table 12

Percent of Coaches Engaged in Coaching Activities Disaggregated by Teaching Activity

Coaching Activity	F	S	R	N
Teach Children with No Other Teacher Present (*n* = 68)				
Assist Teachers in Planning	48	40	9	3
Model Instruction	42	39	12	7
Co-teach	32	38	24	6
Observe Teachers	26	39	29	6
Provide Remediation to Individual Students (*n* = 79)				
Assist Teachers in Planning	54	35	8	3
Model Instruction	44	41	9	6
Co-teach	42	37	18	3
Observe Teachers	27	39	29	5
Provide Remediation to Small Groups of Students (*n* = 96)				
Assist Teachers in Planning	54	38	6	2
Model Instruction	45	39	11	5
Co-teach	43	33	20	4
Observe Teachers	23	41	30	6

Note. F = Frequently, S = Sometimes, R = Rarely, N = Never

As Table 12 shows, the majority of the coaches who reported that they taught children with no other teacher present and/or provided remediation to students also reported that they coached teachers. Of the 68 coaches who said they taught children with no other teacher present, 88% assisted teachers in planning instruction, 81% modeled instruction for teachers, 70% co-taught lessons with teachers, and 65% observed teachers teaching lessons. Of the 79 coaches that were providing remediation to individual students, 89% assisted teachers in planning, 85% modeled instruction for teachers, 79% co-taught lessons with teachers, and 66% observed teachers teaching lessons. Of the 96 coaches who were working with small groups of students, many were also planning with teachers (92%), modeling instruction for teachers (84%), co-teaching lessons with teachers (76%), and/or observing teachers (64%). These data indicate that very few of the coaches were working exclusively under the pull-out mathematics specialist program model, and many were using a combination of the pull-out and coach model. In order to explore this idea further, a deeper analysis was conducted.

As stated earlier, when asked about their primary job, 37% of the coaches thought their primary job was to support teachers, 15% thought it was to teach children, and 48% thought it was both. These categories of primary job descriptions were compared to seven other survey questions to determine if coaches were performing activities consistent with their primary job descriptions. Three survey questions asked coaches how often they engaged in teaching activities: (a) taught mathematics to children with no other teacher present, (b) provided mathematics remediation or intervention to individual children, and (c) provided mathematics remediation or intervention to small groups of children. Four

survey questions asked coaches how often they engaged in coaching activities: (a) assisted teachers in planning mathematics instruction, (b) modeled mathematics instruction, (c) co-taught lessons with classroom teachers, and (d) observed teachers teaching lessons. Table 13 shows the results of this analysis.

Table 13

Percent of Coaches Who Taught Children and Coached Teachers Disaggregated by Primary Job Description

	Primary Job			
Activity	Teach Children (n = 19)	Support Teachers (n = 46)	Both (n = 60)	Total (n = 125)
Teaching Children				
Teach children with no other teacher present	73.7	39.1	60.0	54.4
Provide remediation (individuals)	88.9	41.3	73.3	63.7
Provide remediation (small groups)	100.0	62.2	81.7	77.4
Coaching Teachers				
Assist teachers in planning	73.7	91.0	98.3	92.0
Model instruction	68.5	89.1	91.5	87.1
Co-teach	52.7	84.8	83.4	79.2
Observe teachers	42.1	60.8	70.7	62.6

Table 13 shows that coaches whose primary job was to teach children reported participating in teaching activities more frequently than coaching activities, and coaches whose primary job was to support teachers participated in coaching activities more frequently than teaching activities. However, Table 13 also shows that the majority of coaches in all categories of primary job description reported participating in both teaching and coaching activities, and many coaches were performing activities that conflicted with their own definition of their primary job.

Coaches in all categories of primary job description performed the three teaching activities at relatively high levels. The largest percentages of coaches who taught children with no other teacher present, provided remediation to individual children, and provided remediation to small groups of children were coaches who reported teaching children to be their primary job description (74%, 89%, and 100%, respectively). However, coaches who said that their primary job was to support teachers' professional growth also performed these three activities at relatively high levels: 39% taught children with no other teacher present, 41% provided remediation to individual children, and 62% provided remediation to small groups of children.

Providing remediation to small groups of children was an activity that a large majority of the 125 coaches performed with almost half of the coaches reporting that they frequently did this and another third reporting that they sometimes did this. Altogether 77% of the 125 coaches reported providing remediation to small groups of children regardless of their primary job description.

Coaches in all three categories of primary job description also performed the four coaching activities at high levels. Coaches who described their primary job to be both teaching children and supporting teachers had the highest percentages of coaching activities with 98% assisting teachers in planning instruction, 92% modeling mathematics instruction for teachers, 83% co-teaching lessons with teachers, and 71% observing teachers. High percentages of coaches who said their primary job was to support teachers also performed these activities. While lower percentages of coaches who said their primary job was to teach children performed coaching activities than coaches who said their primary job was to support teachers, relatively high percentages of coaches who said their primary job was to teach children were performing coaching activities. Coaches whose primary job was to teach children reported assisting teachers in planning (74%), modeling instruction (69%), co-teaching (53%), and observing teachers (42%).

These data show a contradiction between coaches' self-reported primary job descriptions and their professional activities. Almost two thirds of the coaches who said their primary job was to support teachers reported providing remediation to small groups of children. Conversely, almost three quarters of the coaches who said their primary job was to teach children reported assisting teachers in planning. Data show that many coaches were engaged in activities inconsistent with their primary job description.

Under which mathematics specialist model were coaches working? More coaches were engaged in coaching activities than teaching activities, but there was a large overlap between the two types of activities. Large percentages of coaches who reported teaching children also reported coaching teachers, and many coaches performed activities that

were inconsistent with their self-reported primary job descriptions. Overall the data show that the majority of coaches were working under a combination of the coach model and the pull-out model (77%), several coaches were working exclusively under the coach model (20%), and a few coaches (3%) were working exclusively under the pull-out model. An open-ended survey question about coaches' primary roles revealed similar themes.

Coaches' Primary Roles

One survey question asked coaches, "What do you consider your primary role or responsibility?" Qualitative analyses were used to examine the coaches' responses. The 125 coaches who responded to the survey question reported supporting teachers (79%) and teaching children (30%) as their primary job responsibilities. Sixteen percent of the coaches mentioned both in their narratives. These responses were the most frequently reported responses. Other responses included creating common assessments and/or analyzing data (16%), improving mathematics instruction (9%), improving student achievement (5%), and closing the achievement gap (2%). The coaches described many kinds of teacher support in their responses. The most frequently mentioned kinds of teacher support were planning with teachers (34%), co-teaching (25%), coaching (17%), providing resources (14%), providing professional development (13%), modeling instruction (10%), and facilitating team meetings (6%). Many of the coaches said that their support of teachers was aimed at helping teachers to improve their knowledge of mathematics content (14%) and pedagogy (30%).

More than half of the coaches (55%) described multiple roles when discussing their primary job description. For example, one coach wrote, “My primary role is really two-fold. I support teachers through planning, coaching, and co-teaching. I support students directly while co-teaching and working with them in small groups in the classroom, as well as outside the classroom.” Another wrote, “I support teachers through collaborative planning, co-teaching, providing resources, collaborative assessments and analysis of assessments. I support students in the regular classroom by co-teaching and/or working with small groups to provide more guidance and differentiation.” A third coach said:

> My primary role in my building is to coach teachers to build their capacity in mathematics. I meet with these teachers to plan lessons, review resources, and talk about and reflect on their instruction. I also work with … students…either pushing in help in the classroom or doing small group/individual pullout.

Some of the coaches made a laundry list of responsibilities. One wrote:

> The role changes year to year. This year my major role is to organize, facilitate grade level math meetings each week. There are 8 teams K-5, plus 2 multi-age teams. At meetings, teams discuss/analyze data, discuss essential knowledge in SOL objectives, typical student misconceptions, develop student learning goals, and plan lessons drawing from best practices. Other responsibilities include: collect and organize data for grade levels…; help teams (grades 1 and 2 especially) develop common assessments so that the data can be collected in a spreadsheet; order, monitor math resources and distribution; co-teach in

designated classrooms; monitor data to assist with effective use of resources and identification of learning needs, both enrichment and remediation.

Another coach listed the following responsibilities:

- Working in classrooms – co-teaching with teachers
- Planning with teachers at [grade level] meetings
- Analyzing teams and school data
- Collaborating with teachers
- Teaching Math Labs
- Pulling small skills groups
- School-wide staff development
- Turn around training for teams and staff
- Facilitating workshops for parents
- Looking at overall programs and initiating programs that will boost student achievement and professional development
- Write articles
- Write grants

The Nine Roles of Mathematics Coaches

As described in Chapter 2, mathematics coaches have nine roles: classroom supporter, learning facilitator, resource provider, curriculum specialist, instructional specialist, data coach, learner, catalyst for change, and school leader. The classroom supporter role is overlapped by six of the other roles: learning facilitator, resource provider, curriculum specialist, instructional specialist, and data coach. The catalyst for

change role and school leader role are seen as roles that inform the other roles and provide a bridge between classroom teachers and the principal.

In order to determine which of the nine roles the mathematics coaches in this study were serving in their schools, coaches' responses to 27 survey questions were examined. Coaches were asked, "How often during the last year did you engage in the following activities?" Certain activities were associated with each of the nine roles. For example, co-teaching lessons with teachers would be considered part of the classroom supporter role and discussing strategies for promoting instructional change with the principal would be part of the catalyst for change role. Each of the nine mathematics coaching roles had three activities associated with it. Table 14 lists the percentages of coaches who engaged in these activities.

Table 14

Percent of Coaches Who Engaged in Coaching Activities Associated with the Nine Roles

	Response			
Coaching Activity	F	S	R	N
Classroom Supporter				
Model mathematics instruction	46.0	41.1	8.9	4.0
Co-teach lessons with teachers	47.2	32.0	17.6	3.2
Observe teachers teaching lessons	20.3	42.3	31.7	5.7
Learning Facilitator				
Encourage teachers to reflect on their teaching	32.8	44.0	19.2	4.0
Share professional articles with teachers	18.4	53.6	25.6	2.4
Facilitate workshops for teachers at your school	33.9	42.7	12.1	11.3
Resource Provider				
Assist teachers in the selection of instructional materials	52.8	35.2	9.6	2.4
Manage a mathematics resource room	65.3	15.3	4.8	14.5
Recommend mathematics materials for the school	47.6	39.5	8.1	4.8
Curriculum Specialist				
Facilitate teachers' discussion of standards	53.6	32.0	12.0	2.4
Align curriculum to state and/or district standards	40.8	40.0	12.0	7.2
Develop pacing guides or curriculum maps	38.4	30.4	20.0	11.2
Instructional Specialist				
Assist teachers in planning instruction	61.6	30.4	5.6	2.4
Discuss students' mathematical thinking with teachers	55.2	34.4	8.8	1.6
Assist teachers in differentiating instruction	43.2	43.2	9.6	4.0
Data Coach				
Create mathematics assessments	44.0	40.8	11.2	4.0
Analyze student assessment data	71.2	24.8	4.0	0.0
Communicate findings of assessments to teachers	59.2	29.6	8.8	2.4
Learner				
Meet with other mathematics specialists in the district	64.0	30.4	2.4	3.2
Attend professional development workshops or conference	24.8	36.0	36.8	2.4
Read professional articles or books	81.6	14.4	4.0	0.0
Catalyst for Change				
Discuss vision of mathematics instruction with principal	29.8	40.3	23.4	6.5
Discuss vision of mathematics instruction with teachers	48.4	43.5	6.5	1.6
Discuss strategies for promoting change with principal	29.0	42.7	18.5	9.7
School Leader				
Serve on school leadership committees	79.0	12.9	4.0	4.0
Talk about instruction with school's reading specialist	33.9	40.3	20.2	5.6
Talk about mathematics instruction with principal	45.2	40.3	13.7	0.8

Note. F = Frequently; S = Sometimes; R = Rarely; N = Never.

As Table 14 shows, large percentages of coaches were engaged in all 27 activities. More than 40% of the coaches engaged frequently in all three activities associated with the resource provider, instructional specialist, and data coach roles. Additional analysis revealed that 73% of the coaches answered “frequently” or “sometimes” to all three questions for more than half of the nine roles. Fourteen percent of the coaches answered “frequently” or “sometimes” to all three questions for all nine roles.

In order to determine the primary role(s) of each coach, a second analysis was conducted. In this analysis, the number of “frequently” responses was counted for each of the three questions for each role. A coach’s primary roles were the roles with the highest counts. If the highest count any role received was one, any of the nine roles that received a count of one was considered to be a primary role. Similarly, if the highest count any role received was two, then any role that received a count of two was considered to be a primary role. In a like manner, if the highest count any role received was three, then any role that received a count of three was considered to be a primary role. When primary roles were determined in this way, 33% of the coaches had only one primary role, 30% had two primary roles, and 14% had three primary roles. Almost a quarter of the coaches had more than three primary roles. Percentages of coaches that had each role as a primary role were calculated. The highest percentages of coaches had data coach (43%) and instructional specialist (37%) as a primary role. Three other roles were also considered to by primary roles by a large percentage of the coaches: learner (34%), curriculum specialist (33%), and school leader (33%).

The Classroom Supporter Role

The classroom supporter role was not one of the top roles in either of the nine roles analyses. Further reflection revealed that the three activities representing the classroom supporter role (model, co-teach, and observe) were perceived to be mutually exclusive by the mathematics coaches in the study, and this may have caused the low number of coaches who reported that they did all three activities. For example, a specialist who believed that co-teaching was the best way to work with classroom teachers might frequently co-teach, but not model or observe. In addition, the classroom supporter role overlapped many of the other roles, and this may have impacted the results of the nine roles analyses. Therefore, two separate analyses were conducted in order to determine how many coaches were acting as classroom supporters. In the first analysis, coaches' responses about how frequently they modeled, co-taught, and observed in classrooms were examined. In the second analysis, survey questions that asked about overlapping roles were examined. Two of the 125 coaches in the study reported that they did not work with classroom teachers. Therefore, survey data from these two coaches were excluded from these analyses leaving survey data from 123 participants.

In the first classroom supporter role analysis, responses from three survey questions were examined. Coaches were asked, "How often during the last year did you engage in the following activities: (a) model mathematics instruction, (b) co-teach lessons with classroom teachers, and (c) observe teachers teaching lessons?" While the three activities are not mutually exclusive, many coaches believe that one of the three is better than the other two in terms of promoting teachers' professional growth. Therefore, counts

were made to determine how many of the coaches in this study frequently engaged in one, two, or all three of the activities. The largest percentages of coaches (33%) responded “frequently” to only one of the three activities. A lesser percentage of the coaches (29%) responded “frequently” to two of the three activities, and small percentage of the coaches (8%) marked “frequently” for all three activities. A count was also made to determine how many of the coaches frequently engaged in any one of the three activities central to the classroom supporter role. Almost 70% of the coaches reported frequently modeling, co-teaching, or observing in classrooms. In addition, a large majority of the coaches (94%) said they frequently or sometimes modeled, co-taught, or observed in classrooms. These data indicate that a large majority of the mathematics coaches surveyed served their schools as classroom supporters.

In the second analysis, coaches’ responses to eight survey questions were analyzed. The survey questions asked, “How often during the last year did you engage in the following activities: (a) assist teachers in planning mathematics instruction, (b) discuss students’ mathematical thinking with teachers, (c) encourage teachers to reflect upon their teaching, (d) assist teachers in using assessments in the classroom, (e) assist teachers in differentiating instruction to meet students needs, (f) assist teachers in the selection of instructional materials, (g) demonstrate the use of new mathematics materials for teachers, and (h) help teachers use new mathematics materials in their classrooms?” These activities were activities from the nine roles that overlapped with the classroom supporter role. For example, assisting teachers in using assessments in the classroom would be considered part of the data coach role, but because this activity happens in the

classroom during instructional time it can also be considered to be part of the classroom supporter role. Results of this analysis showed that large majorities of coaches frequently or sometimes engaged in all of these activities. Ninety-two percent of coaches assisted teachers in planning mathematics instruction, 90% discussed students' mathematical thinking with teachers, 88% assisted teachers in the selection of instructional materials, 86% demonstrated the use of new mathematics materials for teachers, 86% assisted teachers in differentiating instruction to meet students needs, 82% helped teachers use new mathematics materials in their classrooms, 80% assisted teachers in using assessments in the classroom, and 77% encouraged teachers to reflect upon their teaching. In addition, 59% of the coaches frequently engaged in at least half of the eight activities, and 57% of the coaches engaged in all eight of the activities frequently or sometimes. These data indicate that the majority of the coaches were serving their schools as classroom supporters.

With whom do coaches work? As a classroom supporter, mathematics coaches must make decisions about which classroom teachers to support. Coaches could work with novice teachers or experienced teachers. They could work with teachers who are willing to work with them or teachers who are not. They could work with teachers who are experts at teaching mathematics or teachers who need assistance in teaching mathematics. They could work with all the teachers in a school or focus on just a few. Who were the coaches in this study supporting?

A large number of the coaches reported working with teachers new to the profession (89%) and new to their school (90%). Many coaches reported that supporting

veteran teachers was a challenge with 41% of the coaches ranking supporting the professional growth of veteran teachers as one of their top three challenges and 17% ranking it as their number one challenge.

Figure 2, which was originally presented in Chapter 2, shows a model for thinking about teachers with whom mathematics coaches work. (See Chapter 2 for an explanation of this model.) Novice teachers generally fit into Category 2 because they usually need assistance in teaching mathematics, and they usually are willing to be coached. Veteran teachers could fit into any one of the four categories.

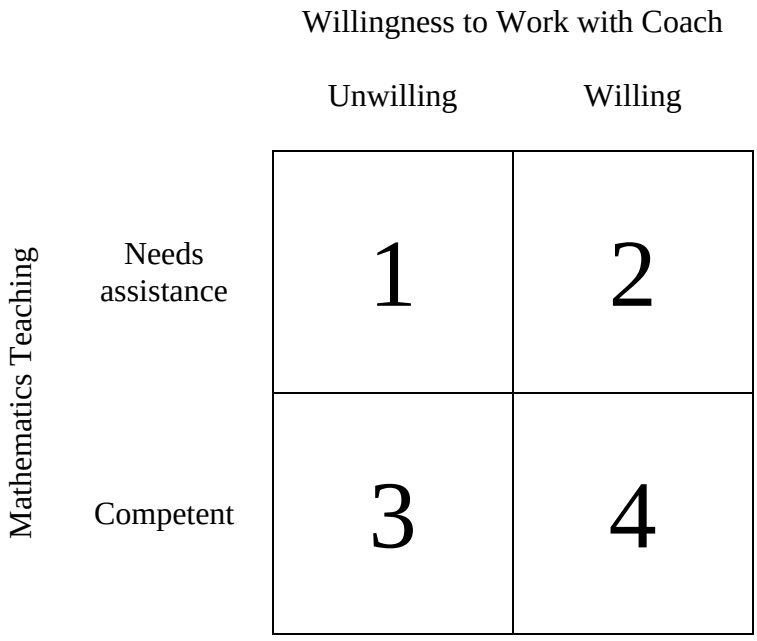

Figure 2. Model for thinking about teachers with whom mathematics coaches work.

Coaches were asked to rank how often they worked with teachers who fit the descriptions of the categories in Figure 3. Table 15 shows the percentages of coaches who worked with each type of teacher.

Table 15

Percent of Specialists Who Worked with Each Type of Teacher

Ranking	Needs Assistance Unwilling	Needs Assistance Willing	Competent Unwilling	Competent Willing
Most Frequently	7.3	57.7	0.0	35.0
Second Most Frequently	14.6	35.8	5.7	43.9
Third Most Frequently	39.8	6.5	43.9	9.8
Least Frequently	38.2	0.0	50.4	11.4

As Table 15 shows, the largest percentage of coaches (58%) reported working most frequently with teachers who were willing to work with them and needed assistance teaching mathematics. A greater percentage of coaches chose to work most frequently with teachers needing assistance teaching mathematics (65%) than teachers who were competent teaching mathematics (35%). Coaches also chose to work with teachers who were willing to work with them more often than teachers who were not willing to work with them. Almost 93% of the specialists worked most frequently with teachers who were

willing, while only 7% worked most frequently with teachers who were unwilling. Conversely, 89% of the coaches reported working with unwilling teachers least frequently. Further evidence of this phenomenon was shown in an analysis of mathematics coaches' top three challenges. The analysis revealed that working with reluctant teachers was a challenge for most mathematics coaches. The greatest percentage of coaches ranked working with reluctant teachers as one of their top three challenges (54%) and as their number one challenge (25%).

An open-ended survey question was asked in order to determine how coaches decided which teachers to support. A qualitative analysis of this question revealed a number of similar themes. Large percentages of coaches worked with teachers who were willing (37%), who needed assistance (31%), and who were new (29%). Some coaches chose to focus on specific grade levels (24%) and others worked with all the teachers in the school (4%). In addition, a number of coaches described a decision-making process in which their principal participated (32%). Each of these ideas will be discussed in turn.

The highest percentage of coaches (37%) indicated that they supported teachers who were willing to work with them. This included 21 coaches (17%) who said that they worked with teachers who sought them out. Coaches' comments included: "I try to work with teachers who are willing first," "I choose who I want to work with based on whether or not they are interested in co-planning and co-teaching," "I work with teachers that are seeking my help – come to me and ask if I can help with a specific unit or skill," and "[I work with] teachers who ask me for help." One coach explained it in this way:

> I work with teachers who want to work with a math specialist. Since there are so many teachers and so few math specialists, I do not push my way into classrooms where I am not welcome. I fill my time working with teachers who are willing to take the time to plan together.

Another said, “My primary goal is to work with teachers who are eager and excited to make changes in their practices and work with them for a longer period to build capacity among competent math teachers.” A third coach said:

> I try to work with the teachers I believe will take my suggestions and incorporate them into their teaching. Some teachers only do something when they know I am looking. I try to make lasting changes, so I choose the teacher that I think will do the right thing even when I am not in their room.

One teacher described how her work had evolved over time:

> In the beginning of my career as a math specialist I worked with teachers who opened their doors. As time has gone on I have built my reputation as someone who can be trusted and can effectively observe students and instruction then provide feedback. Building collegial relationships has allowed me to finally, this year, enter classrooms in which I have previously been unwelcome. This occurred because I consistently went out of my way to plan tight professional development sessions. These sessions moved teachers out of their comfort zones – helping them realize that everyone has room for growth. In these sessions the teachers chose themselves – I already knew who needed help – they finally came around to me.

The second largest percentage of coaches (31%) said that they worked with teachers who needed assistance. Many did not describe how they determined need, but 10% of the coaches said they work with teachers who were struggling and 15% said they worked with teachers whose students were struggling. Comments included: “I try to give the teachers who need the most support top priority;” “I work with…those who need help with instructional strategies…;” “[I] usually work with teachers in SOL tested grades and specifically with teachers who feel a majority of their students are struggling with the content;” “I try to work with teachers who have students who are struggling in math or are below grade level in math;” and “My time is focused in classrooms where the common assessment data shows students are in the most need.” Fourteen percent of the coaches said they decided which teachers to support based upon some kind of data.

Twenty-nine percent of the coaches said that they worked with teachers new to the profession or new to the school. One coach wrote, “I…work with new teachers who need extra support.” Another said, “A new teacher gets priority at the beginning of the year, as well as teachers new to the grade or subject.” A third reported, “Most of the time, I work with new first and second year teachers.”

About 24% of the coaches described working with teachers from specific grade levels. Some worked with testing grades (7%); some had grade levels assigned by their principals (5%); and some split the grade levels with other mathematics coaches in their school (7%). Some of coaches said they worked with all of the teachers in their school (4%) or in their assigned grade levels (9%). In order to accomplish this, they described working with each teacher once a month, once a week, or on some kind of rotation. One

coach wrote, “I include time in my schedule to work with all K-5 teachers in my school who teach mathematics.” Another said, “I have made my schedule so that I can visit all teachers at least one a week.” A third said, “I work with all teachers monthly.” Coaches who were sharing the grade levels said, “We started the school year planning to work with every classroom at least once a week;” “We are going to rotate through all of the teachers throughout the year;” “The other [coach] and I divide the teachers 50/50 and I work with everyone of the teachers I have assigned to me;” and “I rotate every seven to nine weeks with each teacher on the [grade level] team.” One coach described the decision process in the following way:

> Usually the other math specialist and I divide up the grade levels so that each grade level has support. Within the grade level, we talk together to decide which teachers to begin working with. Usually if there is a new teacher on the team, we will start with him or her. If there is no new teacher on the team, we decide which teacher might need the most assistance. From there, we rotate around the team, sometimes working with all of the teachers on the team within one year. And, sometimes we work with only one teacher in the grade level for the entire year. It’s all dependent on the team needs. Also, the principal sometimes indicates a certain teacher she would like us to work with because she’s concerned about that teacher or the teacher is new. But, generally, we have a good amount of autonomy in deciding who to work with.

Thirty-two percent of the coaches described ways in which their principals helped them make decisions about which teachers to support. Most of the coaches described a

decision-making process in which they made the decisions and the principal made suggestions or asked them to work with one or two specific teachers (14%). A few of the coaches said that their principals told them which teachers to support (7%) or assigned them grade levels (5%). Others described a discussion in which the decisions were made collaboratively (6%). One coach wrote, “My principal and I meet at the beginning of each year (and review at each marking period) to discuss where the greatest need is and we go from there.” Another said, “Most of the time my principal decides who he wants me to work with because of what he is observing in the classroom.” A third reported, “Sometimes, my principal asks me to work with certain teachers.” One simply wrote, “I was told by the principal.”

How do coaches support classroom teachers? Along with deciding whom to support, coaches who work as classroom supporters must decide how to support the teachers. A number of survey questions were designed to answer this question. One question asked, “How often during the last year did you engage in the following activities: (a) work with teachers individually, and (b) work with teachers in collaborative teams.” Most of the mathematics coaches reported working with teachers both individually and in collaborative teams. An approximately equal number of coaches reported working frequently or sometimes with individual teachers (90%) as with teams of teachers (91%), but coaches seemed to work with teams slightly more often than with individuals. Data show that 66% of the coaches frequently worked with teams while only 60% of the coaches frequently worked with individuals.

Eleven survey items asked coaches to report the frequency in which they engaged in certain activities within teachers' classrooms. Table 16 shows the percentages of coaches who engaged in each of the eleven activities.

Table 16

Percent of Coaches Who Engaged in Activities in Mathematics Classrooms

	Frequency		
Activity	F	S	F or S
Model mathematics instruction	46.0	41.1	87.1
Co-teach	47.2	32.0	79.2
Observe lessons	20.3	42.3	62.6
Assist teachers in planning instruction	61.6	30.4	92.0
Discuss student thinking with teachers	55.2	34.4	89.6
Encourage teachers to reflect on their teaching	32.8	44.0	76.8
Assist teachers in using assessment in the classroom	44.0	36.0	80.0
Assist teachers in differentiating instruction	43.2	43.2	86.4
Assist teachers in selecting materials	52.8	35.2	88.0
Demonstrate the use of materials	44.0	41.6	85.6
Help teachers use new materials	40.0	41.6	81.6

Note. F = Frequently; S = Sometimes.

As Table 16 shows, large majorities of the coaches engaged in all eleven activities frequently or sometimes. The five top activities that coaches frequently engaged in while acting as classroom supporters were assisting teachers in planning instruction (62%), discussing student thinking with teachers (55%), assisting teachers in selecting materials (53%), co-teaching with teachers (47%), and modeling instruction for teachers (46%).

Large percentages of coaches modeled (87%), co-taught (79%), and observed (63%) in classrooms. Ninety-four percent of the coaches reported doing one or more of the three activities. Seventy percent of the coaches frequently did one or more of the three activities. In order to define the coaches' perceptions of these activities further, a survey question asked which of the three coaching practices was the best way to help teachers improve their mathematics instruction. A large majority of the coaches (83%) believed that the best way to help teachers improve their mathematics instruction was for them to plan and teach lessons together with teachers (co-teach). The rest of the coaches were evenly divided between modeling instruction (8%) and observing lessons (9%).

An open-ended survey question was asked in order to determine how coaches decided how to support teachers within their classrooms. A qualitative analysis of this question revealed a number of themes. A large percentage of coaches (47%) said that they determine the kinds of support they give by discussing it with the teacher. Comments included "we decide together what is going to happen," it is "driven by teacher request and our discussions together," it is "based on a conversation with the teacher and their needs," and "we decide what would work best for each situation." Many of the coaches indicated that the needs (22%) and the comfort level (15%) of the teacher

have a lot to do with how they decide to support the teacher. Comments included, "I usually decide based on what the teacher needs and what they feel comfortable with;" "When co-planning a lesson, I listen to their needs and we decide what role I will take;" "[It] is based on the pre-conference conversations of what the teacher is needing and wanting;" and "It often varies according to the needs of the teacher and their own comfort level teaching a particular skill." One coach wrote:

> I gauge their comfort with me co-teaching, modeling, or just observing lessons. We formulate a plan of how to proceed and generally stick with it. If a teacher is not comfortable with me co-teaching yet, I'll just observe and offer positive feedback and suggest that the next lesson could maybe be taught together.

Another said, "[It] changes throughout the year and is based on planning sessions and what the teacher is comfortable [with]. [I] start out a little light in the beginning of working together, and then gradually release more responsibility to the teacher in teaching the lesson." A third wrote:

> I usually use a co-teaching model in which we plan every lesson together and teach them together. With a brand new teacher, I might do more modeling and then gradually hand techniques and pieces of the lesson over to her as she feels comfortable. With a veteran teacher, I may model new ideas that I bring to the table that she hasn't tried out yet and would like to observe. In a lot of classrooms, once a rapport has been established, we co-teach every lesson and jump in as we go.

The Nonevaluative Nature of the Mathematics Coach's Role

One survey question asked coaches to what degree they agreed that it was important for them to tell their principal if they saw poor mathematics instruction in a classroom. The coaches were almost evenly split on this issue (54% agreed, 46% disagreed). Fifteen percent of the coaches strongly agreed and 11% strongly disagreed. In addition, 74% of coaches reported being asked by their principal to work with a teacher who needed help in improving his or her instruction to a satisfactory level, 13% said they had been asked to evaluate another teacher, and 15% said they had been asked to divulge information that they considered to be confidential to their principal.

Differences Among Mathematics Coaches

This section describes the differences between different sub-groups of mathematics coaches. Differences between specialists and nonspecialists are examined first. Then differences between new coaches and experienced coaches are observed.

Differences between specialists and nonspecialists. In Virginia, there is a special endorsement for elementary mathematics specialists. Survey data revealed that 25% of the coaches in this study had this endorsement. When survey responses from coaches who had a mathematics specialist endorsement were compared to responses from coaches who did not have the endorsement, statistically significant differences were found. For this analysis, the term *specialists* will be used to refer to the coaches who had the endorsement and the term *nonspecialists* will be used to refer to the coaches who did not have the endorsement. More specialists (71%) than nonspecialists (42%) strongly agreed that their primary job was to support teachers' professional growth, $\chi^2(3) = 8.074$,

p = .045. Less specialists (7%) than nonspecialists (32%) strongly agreed that their primary job was to teach mathematics to children, $\chi^2(3) = 13.02$, p = .005.While both specialists and nonspecialists found working with reluctant teachers to be their number one challenge (29% and 23%, respectively), less specialists than nonspecialists found managing time/priorities (10% and 28%, respectively) and supporting veteran teachers (7% and 20%, respectively) to be a top challenge, $\chi^2(10) = 18.55$, p = .046.

Differences between new coaches and experienced coaches. Fifty-six percent of the mathematics coaches in this study had less than four years of experience. When survey responses from new coaches were compared to responses from experienced coaches, some statistically significant differences were found. While all the coaches believed that they had the knowledge they needed to do their jobs, more experienced coaches (76%) than new coaches (41%) strongly agreed that they had the knowledge they needed, $\chi^2(1) = 15.32$, p = .000. While 96% of all coaches felt qualified to coach teachers, more experienced coaches (60%) than new coaches (37%) strongly agreed that they felt qualified to coach teachers, $\chi^2(2) = 8.896$, p = .012. While 93% of all coaches understood their responsibilities, more experienced coaches (75%) than new coaches (40%) strongly agreed that they understood their responsibilities, $\chi^2(2) = 15.46$, p = .000. These results indicate that experienced coaches were more confident in their knowledge and abilities than new coaches.

As well as appearing to be less confident in understanding their responsibilities, new coaches also indicated more disagreement with their principals about those responsibilities than experienced coaches. Forty-eight percent of experienced coaches

strongly agreed with the statement, “My principal and I agree about what my responsibilities should be,” compared to only 21% of new coaches. Twenty-four percent of new coaches disagreed with the statement, while just 6% of experienced coaches disagreed. These differences were statistically significant, $\chi^2(3) = 14.08$, $p = .003$.

Experienced coaches also reported working more frequently with new teachers and teachers new to the school than new coaches. Sixty-six percent of experienced coaches frequently worked with new teachers while only 44% of new coaches frequently worked with new teachers, $\chi^2(3) = 9.83$, $p = .020$, and 56% of experienced coaches frequently worked with teachers new to the school while only 41% of new coaches frequently worked with teachers new to the school, $\chi^2(1) = 15.32$, $p = .000$.

Principals’ Perceptions

Research Question 3 asks, “How do elementary principals define the roles and responsibilities of elementary mathematics coaches?” In order to answer this question principals’ responses to many survey questions were examined. Principals’ perspectives on the three mathematics specialist program models are described first. Then principals’ beliefs surrounding the nine coaching roles are examined. Finally, principals’ views about the classroom supporter role are inspected.

Mathematics Specialist Program Models

Under which program model do principals’ think coaches should be working? A number of survey questions were used to examine principals’ beliefs about the three mathematics program models. Principals were asked questions about their coach’s

primary job, and they were asked how frequently coaches should engage in specific activities related to each program model.

Principals' perceptions of coaches' primary job. Principals were asked three survey questions about mathematics coaches' primary job. Two of those questions asked principals to what extent they agreed or disagreed that their mathematics coach's primary job was (a) to support teachers' professional growth, and (b) to teach children. The third question was an open-ended question that asked, "What do you consider the primary role of the mathematics specialist?" Table 17 shows the principals' responses to the two closed-ended survey questions about coaches' primary job.

Table 17

Principals' Perceptions of Coaches' Primary Job by Percent of Responses

Coaches' Primary Job	SA	A	D	SD
Teach children	11.9	37.3	42.4	8.5
Support teachers' professional growth	62.7	27.1	10.2	0.0

Note. SA = Strongly Agree, A = Agree, D = Disagree, SD = Strongly Disagree.

As Table 17 shows, more principals agreed that their coach's primary job was to support teachers' professional growth (90%) than to teach children (49%). A large percentage of principals "strongly agreed" that their coach's primary job was to support teachers' professional growth (63%), compared to only 12% who strongly agreed that their coach's primary job was to teach children. While about 42% of the principals agreed

to both statements, 22% of the principals "strongly agreed" that the coach's job was to support teachers' professional growth and only "agreed" that the coach's job was to teach children. Since supporting teachers' professional growth is most consistent with the coach mathematics specialist model, these results indicate that the majority of principals surveyed subscribed to the coach model over either of the other two models.

Principals were also asked an open-ended question about their coach's primary role. When these responses were coded and analyzed, similar themes emerged. The majority of the principals (73%) described coaches supporting teachers' professional growth in a way that was consistent with a coach mathematics specialist model. Very few principals (4%) described coaches working solely with students which would be consistent with a specialized-teacher model or a pull-out model. Some principals (20%) described a combination of work with teachers and work with students. One principal described a combination of all three mathematics specialist models by listing a number of duties of the mathematics coach: "staff development (including embedded), small group intervention, small group enrichment, …, modeling best practices, …, sixth grade math instructor." Principals who described coaches working with teachers mentioned many activities including coaching (41%), modeling instruction (39%), planning with teachers (23%), conducting professional development sessions (23%), and co-teaching (9%). Other primary job responsibilities that were mentioned included creating and analyzing assessments (20%), managing mathematics materials (14%), and being an instructional expert in mathematics (5%).

Principals' perceptions of coaches' activities that relate to the mathematics specialist program models. Principals were asked how often their coach should be engaged in nine specific activities that related to the mathematics specialist program models. Activities that would be part of a specialized-teacher model or a pull-out model included teaching children with no other teacher present, providing remediation to individual children, and providing remediation to small groups of children. Activities that would be part of a coach model included working with teachers individually, working with teachers in collaborative teams, assisting teachers in planning instruction, modeling instruction, co-teaching lessons with teachers, and observing teachers teach lessons. Table 18 shows the percent of principals' responses to each of the nine survey questions.

Table 18

Percent of Principals' Responses to Survey Questions Relating to Mathematics Specialist Program Models

Coaches' Activity	F	S	R	N
Specialized-Teacher or Pull-Out Model				
Teach children with no other teacher present	20.7	22.4	41.4	15.5
Provide remediation to individual children	19.3	36.8	38.6	5.3
Provide remediation to small groups of children	28.1	47.4	19.3	5.3
Coach Model				
Work with teachers individually	67.8	30.5	1.7	0.0
Work with teachers in teams	94.8	3.4	1.7	0.0
Assist teachers in planning	88.1	8.5	3.4	0.0
Model instruction	69.5	27.1	3.4	0.0
Co-teach lessons with teachers	69.5	30.5	0.0	0.0
Observe teachers teaching	35.6	52.5	10.2	1.7

Note. F = Frequently; S = Sometimes; R = Rarely; N = Never.

As Table 18 shows, more principals thought that coaches should be engaged in activities related to the coach model than activities related to the specialized-teacher or pull-out models. Almost all of the principals thought that coaches should frequently or sometimes work with teachers individually (98%), work with teachers in teams (98%),

assist teachers in planning (97%), model instruction (97%), and co-teach (100%). Comparatively, only about half of the principals thought that coaches should frequently or sometimes teach children with no other teacher present (43%) and provide remediation to individual children (56%). Three-quarters of the principals thought that coaches should provide remediation to small groups of children.

Under which program model do principals' think coaches should be working? To sum up the two analyses, more principals agreed that their coach's primary job was to support teachers' professional growth than to teach children, and more principals thought that coaches should be engaged in coach type activities than specialized-teacher or pull-out type activities. These results indicate that the majority of principals surveyed subscribed to a coach mathematics specialist model over a specialized-teacher model or a pull-out model.

The Nine Roles of Mathematics Coaches

As mentioned earlier, mathematics coaches have nine roles: classroom supporter, learning facilitator, resource provider, curriculum specialist, instructional specialist, data coach, learner, catalyst for change, and school leader. In order to determine which of the nine roles principals thought mathematics coaches should be performing, principals' responses to 27 survey questions were examined. Principals were asked, "How often should your mathematics [coach] engage in the following activities?" Certain activities were associated with each of the nine roles. For example, assisting teachers in the selection of instructional materials would be considered part of the resource provider role and serving on school leadership committees would be part of the school leader role.

Each of the nine mathematics coaching roles had three activities associated with it. Table 19 lists the percentages of principals who thought their coach should be engaged in these activities.

Table 19

Percent of Principals Who Thought Their Coach Should Engage in Coaching Activities

	Response	
Activity	F	F or S
Classroom Supporter		
Model mathematics instruction	69.5	96.6
Co-teach lessons with classroom teachers	69.5	100.0
Observe classroom teachers teaching lessons	35.6	88.1
Learning Facilitator		
Encourage teachers to reflect upon their teaching	67.8	94.9
Share professional articles with teachers	42.4	89.8
Facilitate workshops for teachers at your school.	69.5	96.6
Resource Provider		
Assist teachers in the selection of instructional materials	62.7	98.3
Manage a mathematics resource room	44.1	71.2
Recommend mathematics materials for the school to purchase	71.2	98.3
Curriculum Specialist		
Facilitate teachers' discussion of standards	78.0	98.3
Help align curriculum to state and/or district standards	69.0	91.4
Develop pacing guides or curriculum maps	37.9	82.8
Instructional Specialist		
Assist teachers in planning mathematics instruction	88.1	96.6
Discuss students' mathematical thinking with teachers	72.9	100.0
Assist teachers in differentiating instruction	78.9	94.7
Data Coach		
Create mathematics assessments	49.2	84.7
Analyze student assessment data	86.2	96.6
Communicate findings of assessments to teachers	69.0	96.6
Learner		
Meet with other mathematics specialists in your district	45.8	98.3
Attend professional development workshops or conferences	42.4	98.3
Read professional articles or books	69.5	100.0
Catalyst for Change		
Discuss his/her vision of math instruction with you	71.2	96.6
Share his/her vision of mathematics instruction with teachers	72.9	96.6
Discuss strategies for promoting instructional change with you	74.6	96.6
School Leader		
Serve on school leadership committees	75.9	94.8
Talk about instruction with the school's reading specialist	54.2	94.9
Talk about mathematics instruction with you	76.3	98.3

Note. F = Frequently; S = Sometimes.

As Table 19 shows, high percentages of principals reported that their mathematics coach should engage in all 27 activities. More than 50% of the principals reported that coaches should frequently engage in all three activities associated with the instructional specialist, catalyst for change, and school leader roles.

In order to determine which of the nine roles each principal thought was most important, the number of "frequently" responses was counted for each of the three survey questions that represented each role. The roles with the highest counts were considered to be the respondent's primary roles. For example, if a respondent marked "frequently" for all three of the survey questions representing one role, then any role that had all three questions marked "frequently" was considered to be a primary role for that respondent. For principals, these primary roles were where they thought their coach should spend the most time. When the number of primary roles was counted for each survey respondent, it was determined that 12% of the principals had one primary role, 22% had two primary roles, and 12% had three primary roles. A large percentage of principals (50%) had more than three primary roles. For each of the nine coaching roles, the percentage of principals who had that role as one of their primary roles was calculated. The roles that the principals found to be most important were catalyst for change (70%), instructional specialist (61%), data coach (51%), and school leader (51%).

The Classroom Supporter Role

Since the three activities representing the classroom supporter role were considered mutually exclusive by a large number of coaches and because the classroom supporter role overlaps other coaching roles, two analyses were conducted to determine

principals' perceptions of the role. In the first analysis, principals' responses about how frequently they thought their coaches should model instruction, co-teach, and observe teachers were examined. In the second analysis, survey questions that asked about coaching activities that overlapped roles were examined. Results from each analysis will be presented in turn.

In the first analysis, principals were asked how often they thought their mathematics coaches should engage in the following activities: (a) model mathematics instruction, (b) co-teach lessons with classroom teachers, and (c) observe teachers teaching lessons. High percentages of principals thought their coach should be co-teaching (70%) or modeling (70%) frequently. A smaller percentage of principals (36%) thought their coach should be observing frequently. Counts were made to determine how many principals thought their coach should engage in one, two, or all three of the activities. The largest percentage of principals responded "frequently" to two (32%) or three (32%) of the three activities. Smaller percentages responded "frequently" to only one of the activities (14%) or none of the activities (22%). A count was also made to determine how many principals thought their coach should engage frequently in any one of the three activities central to the classroom supporter role. Almost 80% of the principals thought their coach should frequently be modeling, co-teaching, or observing in classrooms.

In the second analysis, principals' responses to eight survey questions were analyzed. The survey questions asked principals how often they thought their mathematics coaches should engage in the following activities: (a) assist teachers in

planning mathematics instruction, (b) discuss students' mathematical thinking with teachers, (c) encourage teachers to reflect upon their teaching, (d) assist teachers in using assessments in the classroom, (e) assist teachers in differentiating instruction to meet students needs, (f) assist teachers in the selection of instructional materials, (g) demonstrate the use of new mathematics materials for teachers, and (h) help teachers use new mathematics materials in their classrooms. These activities were activities from the nine roles that overlapped with the classroom supporter role. For example, assisting teachers in using assessments in the classroom would be considered part of the data coach role, but because this activity happens in the classroom during instructional time it can also be considered to be part of the classroom supporter role. Results of this analysis showed that large majorities of principals thought their coach should frequently assist teachers in planning mathematics instruction (88%), assist teachers in differentiating instruction to meet students needs (79%), discuss students' mathematical thinking with teachers (73%), encourage teachers to reflect upon their teaching (68%), assist teachers in using assessments in the classroom (66%), help teachers use new mathematics materials in their classrooms (65%), assist teachers in the selection of instructional materials (63%), and demonstrate the use of new mathematics materials for teachers (63%). These results indicate that the majority of principals thought their coach should act as a classroom supporter.

With whom should coaches work? As a classroom supporter, coaches must make decisions about which classroom teachers to support. Principals were asked how often they expected their mathematics coaches to work with teachers who (a) were new to

the teaching profession, and (b) were new to their school. Almost all principals thought coaches should work with teachers new to the profession (97%) and new to the school (98%) frequently or sometimes.

How should coaches support classroom teachers? There are many ways that coaches can act as classroom supporters. Eleven survey items asked principals how often they thought their coach should engage in activities that happened within a teacher's classroom. Table 20 shows the percentages of principals who thought their coach should engage in those eleven activities.

Table 20

Percent of Principals Who Thought Coaches Should Be Engaged in Activities in Mathematics Classrooms

	Frequency		
Activity	F	S	F or S
Model mathematics instruction	69.5	27.1	96.6
Co-teach	69.5	30.5	100.0
Observe lessons	35.6	52.5	88.1
Assist teachers in planning instruction	88.1	8.5	96.6
Discuss student thinking with teachers	72.9	27.1	100.0
Encourage teachers to reflect on their teaching	67.8	27.1	94.9
Assist teachers in using assessment in the classroom	65.5	29.3	94.8
Assist teachers in differentiating instruction	78.9	15.8	94.7
Assist teachers in selecting materials	62.7	35.6	98.3
Demonstrate the use of materials	62.7	33.9	96.6
Help teachers use new materials	64.4	30.5	94.9

Note. F = Frequently; S = Sometimes.

As Table 20 shows, large majorities of principals thought that their coaches should engage in all eleven of the activities frequently or sometimes. The top five

activities that principals thought coaches should engage in frequently were assist teachers in planning instruction (88%), assist teachers in differentiating instruction (79%), discuss student thinking with teachers (73%), co-teach with teachers (70%), and model mathematics instruction for teachers (70%).

Large majorities of principals thought that coaches should model (97%), co-teach (100%), and observe (88%) in classrooms. When principals were asked which coaching practice was the best way to help teachers improve their mathematics instruction, most of the principals (80%) said that the best way was for coaches to plan and teach lessons together with teachers. Small percentages of principals thought that modeling instruction (12%) or observing instruction (8%) was best.

Principals were also asked how often coaches should work with teachers individually and in collaborative teams. Almost all principals thought that coaches should work with teachers both individually and in teams, but a higher percentage of principals thought coaches should work frequently with teams of teachers (95%) than with individual teachers (68%).

Differences between Mathematics Coaches' and Principals' Perceptions

Research Question 4 asks, "What differences exist in the way the mathematics coach role is conceptualized by mathematics coaches and principals?" In order to answer this question, coaches' and principals' responses to similar survey questions were compared. Chi square tests were used to identify statistically significant differences. Differences about coaching roles and responsibilities, the nonevaluative nature of the coaching role, visions of mathematics instruction, and mutual communication are

reported here. This section also includes coaches' and principals' perspectives on ways principals support coaches.

Mathematics Coaches' Responsibilities

Principals and coaches were asked to what degree they agreed that the coach understood his or her responsibilities. They were also asked if they thought that the principal and the coach agreed about what the coach's responsibilities should be. Statistically significant differences were found in the responses. Principals were more positive than coaches in their responses. Almost all the principals (98%) agreed that their coach understood his or her responsibilities, and 74% strongly agreed. While 94% of all coaches agreed that they understood their responsibilities, only 55% strongly agreed. These differences are statistically significant, $\chi^2(2) = 6.461$, $p = .040$. Similarly, almost all of the principals (98%) agreed that they and their coach had a common understanding about what the coach's responsibilities should be, with 73% strongly agreeing; but only 84% of the coaches thought they had a common understanding with their principal, and only 33% of the coaches strongly agreed. These differences are statistically significant, $\chi^2(3) = 27.146$, $p = .000$.

Primary Job

Principals and coaches were asked to what level they agreed or disagreed that the coach's primary job was (a) to teach children and (b) to support teachers' professional growth. Table 21 shows the principals' and coaches' responses to these two survey questions.

Table 21

Principals' and Coaches' Perceptions of Coaches' Primary Job by Percent of Responses

Coaches' Primary Job	SA	A	D	SD
Teach children[a]				
Principals (*n* = 59)	11.9	37.3	42.4	8.5
Coaches (*n* = 125)	25.5	37.6	35.2	1.6
Support teachers' professional growth				
Principals (*n* = 59)	62.7	27.1	10.2	0.0
Coaches (*n* = 125)	49.2	36.3	13.7	0.8

Note. SA = Strongly Agree; A = Agree; D = Disagree; SD = Strongly Disagree.
[a]Statistically significant differences between principals' and coaches' responses. $p = .028$.

As Table 21 shows, principals and coaches agreed about the primary job of supporting teachers' professional growth but disagreed about the primary job of teaching children. Large percentages of principals (90%) and coaches (86%) "agreed" or "strongly agreed" that the coach's primary job was to support teachers' professional growth. Lesser percentages of principals (49%) and coaches (63%) "agreed" or "strongly agreed" that the coach's primary job was to teach mathematics to children. While about the same percentage of principals and coaches "agreed" that the coach's primary job was to teach children, a much larger percentage of coaches (26%) "strongly agreed" than principals (12%), and a much larger percentage of principals (51%) "disagreed" or "strongly

disagreed" than coaches (37%). These differences were statistically significant, $\chi^2(3) = 9.098$, $p = .028$.

Even though there were statistically significant differences in principals' and coaches' agreement that the coach's primary job was to teach children, there were no statistically significant differences in responses to a survey question that asked about the frequency of teaching children. Most principals thought their coach should teach children with no other teacher present "rarely" (41%). About one-fifth of the principals thought the coach should teach children with no other teacher present "frequently" (21%) or "sometimes" (22%). Similarly, the highest percentage of coaches reported teaching children with no other teacher present "rarely" (35%). About one-third of coaches reported teaching children with no other teacher present "frequently" (34%), and another one-fifth reporting doing this "sometimes" (21%). The differences between principals and coaches were not significant.

The Nine Coaching Roles

In order to discern differences in principals' and coaches' perceptions of coaching responsibilities, survey questions about each of the nine coaching roles were asked. Principals were asked how often their coach should engage in specific coaching activities related to the nine roles, and coaches were asked how often they had engaged in the activities in the last year. Table 22 shows the percent of responses from principals and coaches in each of the frequency categories for each of the specific activities. Note that coaches were describing the frequency of activities that they actually did and principals were describing the frequency of activities that they think coaches should do.

Table 22

Percent of Responses from Coaches and Principals about Coaching Activities Associated with the Nine Coaching Roles

	Coaches		Principals	
Activity	F	S	F	S
Classroom Supporter				
Model mathematics instruction*	46.0	41.1	69.5	27.1
Co-teach lessons with classroom teachers**	47.2	32.0	69.5	30.5
Observe classroom teachers teaching lessons**	20.3	42.3	35.6	52.5
Learning Facilitator				
Encourage teachers to reflect upon their teaching***	32.8	44.0	67.8	27.1
Share professional articles with teachers**	18.4	53.6	42.4	47.5
Facilitate workshops for teachers at your school***	33.9	42.7	69.5	27.1
Resource Provider				
Assist teachers in the selection of instructional materials	52.8	35.2	62.7	35.6
Manage a mathematics resource room**	65.3	15.3	44.1	27.1
Recommend mathematics materials to purchase*	47.6	39.5	71.2	27.1
Curriculum Specialist				
Facilitate teachers' discussion of standards**	53.6	32.0	78.0	20.3
Help align curriculum to state and/or district standards**	40.8	40.0	69.0	22.4
Develop pacing guides or curriculum maps	38.4	30.4	37.9	44.8
Instructional Specialist				
Assist teachers in planning mathematics instruction**	61.6	30.4	88.1	8.5
Discuss students' mathematical thinking with teachers*	55.2	34.4	72.9	27.1
Assist teachers in differentiating instruction***	43.2	43.2	78.9	15.8
Data Coach				
Create mathematics assessments	44.0	40.8	49.2	35.6
Analyze student assessment data	71.2	24.8	86.2	10.3
Communicate findings of assessments to teachers	59.2	29.6	69.0	27.6
Learner				
Meet with other mathematics specialists in your district*	64.0	30.4	45.8	52.5
Attend professional development workshops***	24.8	36.0	42.4	55.9
Read professional articles or books*	81.6	14.4	69.5	30.5
Catalyst for Change				
Discuss vision of math instruction with principal***	29.8	40.3	71.2	25.4
Share vision of mathematics instruction with teachers*	48.4	43.5	72.9	23.7
Discuss strategies for promoting change with principal***	29.0	42.7	74.6	22.0
School Leader				
Serve on school leadership committees	79.0	12.9	75.9	19.0
Talk about instruction with the school's reading specialist**	33.9	40.3	54.2	40.7
Talk about mathematics instruction with principal**	45.2	40.3	76.3	22.0

Note. F = Frequently; S = Sometimes. Coaches were asked how often they did the activities. Principals were asked how often coaches should do the activities.

Differences between coaches' and principals' responses, *$p < .05$, **$p < .01$, ***$p < .001$

Table 22 shows that principals thought that their coaches should engage in the nine coaching roles more often than coaches actually did. More than 50% of the principals reported that coaches should frequently engage in all three activities associated with the instructional specialist, catalyst for change, and school leader roles. There was no role for which more than 50% of the coaches reported frequently engaging in all three of the activities associated with the role. However, more than 40% of the coaches reported frequently engaging in all three activities associated with the resource provider, instructional specialist, and data coach roles. Instructional specialist was a top role for both principals and coaches.

In order to determine which of the nine roles each principal and each coach thought were most important, the number of "frequently" responses was counted for each of the three survey questions that represented each role. The roles with the highest counts were considered to be the primary roles of each respondent. For the coaches, their primary roles were where they spent the most time. For principals, the primary roles were where they thought the coaches should spend the most time. When the number of primary roles was counted for each survey respondent, it was determined that 12% of the principals and 33% of the coaches had only one primary role. Two roles were considered to be primary by 22% of the principals and 30% of the coaches. Three roles were considered to be primary by 12% of the principals and 14% of the coaches. A large percentage of principals (50%) and coaches (23%) had more than three primary roles.

Which roles were considered to be the most important by the principals and the coaches? Table 23 shows the percentages of principals and coaches who choose each of the nine coaching roles as a primary role.

Table 23

Roles Thought to be Most Important by Principals and Coaches in Percents

Coaching Role	Principals (n = 59)	Coaches (n = 125)
Classroom Supporter	35.6	12.8
Learning Facilitator	30.5	8.0
Resource Provider	30.5	29.6
Curriculum Specialist	35.6	32.8
Instructional Specialist	61.0	36.8
Data Coach	50.8	43.2
Learner	32.2	33.6
Catalyst for Change	69.5	24.8
School Leader	50.8	32.8

As Table 23 shows, the percentages of principals who thought each role was important are generally higher than the percentages of coaches who thought each role was important. This is because more principals marked “frequently” for all three of the survey questions representing each role than coaches, resulting in more principals with multiple primary roles than coaches. (Eighty-five percent of principals had more than one primary role, while only 67% of coaches had more than one primary role.) Note that

principals were asked how often coaches should do the activities, and coaches were asked how often they actually did the activities. None the less, these data indicate which of the roles each group thought were most important. The principals' top two roles were catalyst for change (70%) and instructional specialist (61%). The coaches' top two roles were data coach (43%) and instructional specialist (37%). Both groups considered the instructional specialist role to be one of the most important roles. In addition, the coaches' top role, data coach (43%), was the third most important role of principals (51%).

The Classroom Supporter Role

As reported earlier, since the classroom supporter role overlapped other roles and since many coaches considered the three activities closely associated with the classroom supporter role to be mutually exclusive, it was difficult to ascertain if the role was an important role for coaches and principals. The separate analyses of the coaches' and the principals' perceptions of the nine mathematics coaching roles showed that both groups considered the classroom supporter role to be important. A large majority of coaches (94%) reported supporting teachers in their classrooms by modeling instruction, co-teaching, and/or observing. Almost 80% of principals said their coaches should be frequently modeling, co-teaching, and/or observing. High percentages of coaches also reported engaging in eight coaching activities that overlapped the classroom supporter role, and high percentages of principals thought coaches should be engaged in those activities.

While both groups thought the role was important, there were differences in their understandings about the role. Two analyses were used to determine the differences between principals' and coaches' perceptions of the classroom supporter role. In the first analysis, coaches' and principals' responses to a survey question about the best way to effect change in teachers' instructional practice was analyzed along with responses about the frequency of modeling, co-teaching, and observing. In the second analysis, principals' and coaches' responses to survey questions that asked about other coaching activities that supported classroom instruction were examined.

The three main coaching activities associated with the classroom supporter role were modeling instruction, co-teaching with teachers, and observing teachers. Many coaches and principals preferred one of the activities over another when thinking about how to support teachers in their classrooms. In order to discern these preferences, survey respondents were asked to choose the best statement from three statements that described views on how to effect change in teachers' instructional practice. The three statements were, "The best way to help teachers improve their mathematics instruction is for the mathematics [coach] to (a) model good instruction through demonstration lessons, (b) plan and teach lessons together with [teachers], or (c) observe [teachers] teaching mathematics and give them feedback." Large majorities of principals (80%) and coaches (83%) believed that the best way to effect instructional change was for coaches to plan and teach lessons together with teachers. Small percentages of principals (12%) and coaches (8%) thought modeling instruction was best, and even smaller percentages of principals (8%) and coaches (9%) thought observing instruction and providing feedback

was best. When asked about the frequency of doing those three activities (modeling, co-teaching, and observing), however, there were statistically significant differences between principals' and coaches' responses. Table 24 shows the percentages of principals' and coaches' responses to three survey questions that asked about those coaching activities.

Table 24

How Often Do/Should Coaches Model, Co-Teach, and Observe?

Coaching Activity	F	S	R	N
Model*				
Principals (*n* = 59)	69.5	27.1	3.4	0.0
Coaches (*n* = 125)	46.0	41.1	8.9	4.0
Co-teach**				
Principals (*n* = 59)	69.5	30.5	0.0	0.0
Coaches (*n* = 125)	47.2	32.0	17.6	3.2
Observe**				
Principals (*n* = 59)	35.6	52.5	10.2	1.7
Coaches (*n* = 125)	20.3	42.3	31.7	5.7

Note. F = Frequently; S = Sometimes; R = Rarely; N = Never. Responses are reported by percentage. Principals were asked how often coaches should do the activities. Coaches were asked how often they did the activities.
Statistically significant differences between principals' and coaches' responses, *$p < .05$, **$p < .01$

As Table 24 shows, principals thought that coaches should model, co-teach, and observe more often than coaches reported doing so. Seventy percent of principals thought that coaches should model instruction frequently, while only 46% of coaches reported modeling instruction frequently. Similarly, 14% of coaches reported rarely or never modeling instruction, while only 4% of principals thought they should rarely or never do this activity. These differences are statistically significant, $\chi^2(3) = 10.344$, $p = .016$. Seventy percent of principals also thought that coaches should co-teach with teachers frequently, but only 47% of coaches co-taught frequently. All principals thought that coaches should co-teach frequently or sometimes, but 21% of coaches said they rarely or never co-taught. These differences are statistically significant, $\chi^2(3) = 15.965$, $p = .001$. Thirty-seven percent of principals thought that their coach should observe teachers frequently, while only 20% of coaches said they did this frequently. More than one-third of the coaches (37%) reported observing teachers rarely or never, while only 12% of principals thought they should do this rarely or never. These differences are also statistically significant, $\chi^2(3) = 13.528$, $p = .004$.

Even though there are statistically significant differences in principals and coaches responses to the three survey questions shown in Table 24, there is a similarity in how the principals and coaches viewed the three coaching activities. The highest percentages of principals and coaches were equally divided between modeling and co-teaching. The highest percentages of principals thought that coaches should model (70%) and co-teach (70%) frequently. The highest percentages of coaches reported modeling (46%) and co-teaching (47%) frequently. Lesser percentages of principals and coaches

valued observing teachers as a coaching activity. Only 36% of principals thought coaches should frequently observe teachers teaching lessons. Only 20% of coaches said they observed teachers frequently.

Since there was such a large discrepancy between principals' and coaches' frequencies for modeling, co-teaching, and observing, the percent of principals and coaches who marked "frequently" for zero, one, two, or all three of the activities was tallied. The largest percentage of coaches (33%) marked "frequently" for only one of the three activities (model, co-teach, observe), while the smallest percentage of principals (14%) marked "frequently" for only one of the activities. Only 8% of the coaches marked "frequently" for all three of the activities, yet 32% of the principals marked "frequently" for all three of the activities. This data indicate that more coaches considered the three coaching activities to be mutually exclusive than principals.

In the second classroom supporter analysis, principals' and coaches' responses about eight activities from other coaching roles that overlapped with the classroom supporter role were examined. For example, encouraging teachers to reflect on their teaching is part of the learning facilitator role, but, if it happens in the classroom, it is also part of the classroom supporter role. Principals were asked how often they thought their coaches should engage in the eight coaching activities. Coaches were asked how often they had engaged in the activities over the past year. Table 25 shows the percent of "frequently" and "sometimes" responses from principals and coaches.

Table 25

Should/Do Coaches Engage in Activities in Mathematics Classrooms?

	Principals (n = 59)		Coaches (n = 125)	
Activity	F	F or S	F	F or S
Assist teachers in planning instruction	88.1	96.6	61.6	92.0
Discuss student thinking with teachers**	72.9	100.0	55.2	89.6
Encourage teachers to reflect***	67.8	94.9	32.8	76.8
Assist teachers in using assessments*	65.5	94.8	44.0	80.0
Assist teachers in differentiating instruction***	78.9	94.7	43.2	86.4
Assist teachers in selecting materials	62.7	98.3	52.8	88.0
Demonstrate the use of materials*	62.7	96.6	44.0	85.6
Help teachers use new materials**	64.4	94.9	40.0	81.6

Note. F = Frequently; S = Sometimes. Data are reported by percents. Principals were asked how often they thought coaches should engage in the activities. Coaches were asked how often they had engaged in the activities.

Statistically significant differences between principals' and coaches' responses, *$p < .05$, **$p < .01$, ***$p < .001$.

As Table 25 shows, very high percentages of principals thought that coaches should be doing all eight activities frequently or sometimes, and high percentages of coaches had been engaged in those activities during the past year. The highest percentages of principals thought coaches should frequently be engaged in planning

(88%), differentiating instruction (79%), and discussing student thinking (73%). The highest percentages of coaches frequently were engaged in planning with teachers (62%), discussing student thinking (55%), and assisting teachers in selecting materials (53%). The principals and coaches had the same top activity, assisting teachers in planning instruction. Discussing students' mathematical thinking was also in both groups' top three activities.

The Nonevaluative Nature of the Coaching Role

One survey question asked respondents to what degree they agreed or disagreed that a coach should tell their principal if they see poor mathematics instruction. There were statistically significant differences between principals' and coaches' responses to the question. Principals were split between "strongly agree" (41%) and "agree" (41%) for a total of 82% that agreed that coaches should tell if they see poor instruction. Only 15% of coaches "strongly agreed." Another 38% "agreed" resulting in a total of 54% of coaches that agreed that they should tell their principal if they see poor instruction. Almost half of the coaches "disagreed" (35%) or "strongly disagreed" (11%), compared to only 18% of principals who "disagreed" (15%) or "strongly disagreed" (3%). These differences between principals' and coaches' responses are statistically significant, $\chi^2(3) = 19.534$, $p = .000$.

Vision of Mathematics Instruction

Principals and coaches were asked whether or not they had a vision of what mathematics instruction should look like in their schools. There were some statistically significant differences between principals' and coaches' responses. Table 26 shows the

percentages of principals' and coaches' responses to three survey questions about having a vision of what mathematics instruction should look like.

Table 26

Do Principals and Coaches Believe They Have a Vision of Mathematics Instruction?

Survey Question: To what level do you agree that…?	SA	A	D	SD
The coach has a vision				
Principals (*n* = 59)	83.1	16.9	0.0	0.0
Coaches (*n* = 125)	81.6	18.4	0.0	0.0
The principal has a vision*				
Principals (*n* = 59)	71.2	28.8	0.0	0.0
Coaches (*n* = 125)	31.7	56.1	12.2	0.0
We agree on the vision*				
Principals (*n* = 59)	72.4	27.6	0.0	0.0
Coaches (*n* = 125)	33.1	49.2	14.5	3.2

Note. SA = Strong Agree; A = Agree; D = Disagree; SD = Strongly Disagree. Responses are reported by percentage.
Statistically significant differences between principals' and coaches' responses, *p = .000.

As Table 26 shows, principals and coaches agreed that the coaches had a vision of what mathematics instruction should look like, but there were differences in their beliefs

about whether or not the principals had a vision of what mathematics instruction should look like and whether or not principals and coaches agreed about what mathematics instruction should look like. One hundred percent of all principals and coaches surveyed agreed that the coach had a vision of what mathematics instruction should look like. Large majorities of principals (83%) and coaches (82%) "strongly agreed." Whether or not the principals had a vision was a different story, however. One hundred percent of all principals said they had a vision of what mathematics instruction should look like, with 71% "strongly agreeing." Only 88% of coaches thought their principal had a vision of what mathematics instruction should look like, and only 32% "strongly agreed." These differences between principals' and coaches' perceptions are statistically significant, $\chi^2(2) = 27.441$, $p = .000$.

Principals and coaches were also asked if they agreed with each other about what mathematics instruction should look like. One hundred percent of the principals agreed that they and their math coach had the same vision of what mathematics instruction should look like, and 73% strongly agreed. Only 82% of coaches agreed that they and their principal had the same vision of what mathematics instruction should look like, and only 33% strongly agreed. These differences between principals' and coaches' perceptions are statistically significant, $\chi^2(3) = 28.068$, $p = .000$.

A few open-ended survey responses further illustrate the disconnect between principals and coaches. One coach said about her principal, "She doesn't understand what [mathematics instruction] should look like…. She thinks she does. I disagree." Another described her number one challenge as "having a shared vision with a principal about

what mathematics should look like in the school and how to achieve that vision." When asked whether or not they had discussed their vision with their principal, 30% of coaches said they had not. The next section looks further at what principals and coaches reported about their communication with each other.

Communication between the Principal and the Coach

Principals and coaches were asked to what degree they agreed that they had open lines of communication with each other. When the responses were analyzed, statistically significant differences were found. Almost all the principals (98%) agreed that they had an open line of communication with their mathematics coach, with 80% strongly agreeing. Comparatively, only 86% of the coaches agreed that they had an open line of communication with their principal, with only 42% strongly agreeing, $\chi^2(3) = 23.262$, $p = .000$. Table 27 shows percentages of principals' and coaches' responses to survey questions that asked about the frequency of their communications.

Table 27

How Often Do/Should Coaches Communicate with Their Principals?

Activity	F	S	R	N
Discuss mathematics instruction*				
Principals (*n* = 59)	76.3	22.0	1.7	0.0
Coaches (*n* = 125)	45.2	40.3	13.7	0.8
Share vision of mathematics instruction**				
Principals (*n* = 59)	71.2	25.4	3.4	0.0
Coaches (*n* = 125)	29.8	40.3	23.4	6.5
Discuss change strategies**				
Principals (*n* = 59)	74.6	22.0	3.4	0.0
Coaches (*n* = 125)	29.0	42.7	18.5	9.7

Note. F = Frequently; S = Sometimes; R = Rarely; N = Never. Responses are reported by percentage. Principals were asked how often coaches should do the activities. Coaches were asked how often they did the activities.
Statistically significant differences between principals' and coaches' responses, *p = .001, **p = .000.

As Table 27 shows, principals thought coaches should communicate with them more often than they did. Almost all principals (98%) thought their coach should talk with them about mathematics instruction, and 76% said they should do this frequently. Only 45% of coaches frequently talked to their principal about mathematics instruction. These differences between principals' and coaches' views are statistically significant,

$\chi^2(3) = 17.238$, $p = .001$. A large majority of principals (97%) thought that their coach should share their vision of what mathematics instruction should look like, with 71% of principals saying they should discuss their vision frequently. About 30% of coaches reported frequently discussing their vision with their principal, and 30% of coaches rarely or never had this kind of discussion with their principal. These differences between what principals thought coaches should do and what coaches actually did are statistically significant, $\chi^2(3) = 31.575$, $p = .000$. A large majority of principals (97%) also thought that their coach should discuss strategies for promoting instructional change with them, and 75% said they should have this discussion frequently. Only 29% of coaches said they frequently discussed change strategies with their principal. About 30% said they had rarely or never discussed change strategies with their principal. These differences in principals' and coaches' responses are statistically significant, $\chi^2(3) = 36.157$, $p = .000$.

Kinds of Support That Principals Offer Mathematics Coaches

Both principals and mathematics coaches were asked an open ended survey question about the kinds of support that principals offered. Qualitative analysis revealed a number of themes. Major themes of support included regular communication between the principal and the coach, funding to purchase mathematics materials, trust and respect, time for the coach to attend professional development sessions, and time for the coach to facilitate professional development for teachers at their school. Another major theme was lack of support.

Regular communication. The most frequently mentioned kind of support by both principals and mathematics coaches was communication. Fifty-six percent of the

principals described some kind of communication as their main focus of support with 36% describing regularly communication with their mathematics coach. Thirty-five percent of the coaches mentioned communication as a form of support with 11% saying they met with their principals on a regular basis. One principal said, “We meet regularly to discuss how the mathematics program is being implemented.” Another commented, “We meet monthly to discuss how [the coaches] are spending their time, their observations, and what our priorities are.” Coaches’ comments included: “We meet regularly to discuss our school’s instructional goals for mathematics,” “My principal and I communicate on a regular basis,” “My principal meets with us about every six weeks or so to touch base with mathematics instruction,” “My principal and I have monthly conversations as to how math instruction is progressing at my school,” and “We meet at least once weekly to discuss any issues with math.”

Funding to purchase mathematics materials. Thirty-two percent of principals said that they purchase materials to support their mathematics coaches. Thirty-three percent of the coaches also described this form of support. Principals’ comments included: “[I] provide funding for new resources and tools for learning and instruction,” “[I] purchase requested resources,” and “[My coach] has been given additional fund each year to ‘stock up’ on resources and manipulatives that reflect best practices.” One coach said, “[My principal] really allows me to order all the materials and organize all the materials in the building.” Another commented, “[My principal] has always been supportive in purchasing math materials and books for the resource room and for teachers.” Other coaches’ comments included: “willing to spend money on math

materials and professional books," provides money for materials," and "orders materials that I request."

Trust and respect. About 20% of the principals described trusting and respecting their coaches as a form of support. Many coaches (22%) also described this form of support. One principal said, "[I] demonstrate my faith in her to lead the math program." Another principal commented, "I believe she knows what is best for mathematics instruction, therefore, I trust her judgment." A third principal wrote, "The staff is well aware that we trust each other and I value her input and opinions." Coaches' comments included: "respects me as a professional," "values my judgment," "trusts my knowledge of subject matter," and "trusts that I can do my job effectively." Coaches also described being given autonomy over their schedule and/or role. One coach described it in this way: "My principal has given me the freedom to use my professional judgment to structure my day in the way that I think I can make the biggest impact." Another said, "[My principal] lets me make many of the decisions when it comes to what the teachers need for math. She really trusts the math resource teachers to do our jobs."

Time and funding for the coach to attend professional development. Many principals (39%) and coaches (14%) described providing time and/or funding so that coaches could attend professional development sessions as a form of principal support. One principal wrote, "I encourage the specialist to go to conferences and meet with other specialists in the district." Another said, "I support her attendance at trainings, workshops, and conferences." One mathematics coach said, "[My principal] encourages me to attend professional development opportunities." Another commented, "[My

principal] is very supportive of the math team attending professional development meetings and classes during the school day." A similar comment was, "She allows me to attend conference/professional development opportunities on school time."

Time for the coach to facilitate professional development. Some principals (10%) and coaches (21%) thought that providing time for the coach to facilitate professional development sessions for classroom teachers was another form of principal support. One principal said, "[I] allow [the coach] to present at our faculty meetings." Another wrote, "[I] provide opportunities for the math specialist to deliver professional development to faculty and staff." A mathematics coach wrote, "Our principal allows us to have time at faculty meetings to present materials to the entire staff." Another said that the principal "has an expectation for all staff to engage in professional development in team meetings led by the math specialist." A third said, "We have the ability to create and design professional development for our staff."

Lack of support. Even though the survey question was worded in a positive way and assumed that all principals were doing something to support the mathematics coaches, 15% of the coaches described principals' actions that were non-supportive or made wishes for greater support. For example, one coach said, "My principal does not support me in my role as a mathematics specialist. She does not respond to my emails or requests for meetings. I frankly feel abandoned by her." Another said, "My principal usually agrees with my recommendations if we are able to communicate. However, there is very little follow-up." Other comments included "I do not receive much support," "She doesn't pay much attention," "She offers little guidance about my roles and

responsibilities," and "It is challenging guessing what my principal wants me to do/accomplish from year-to-year."

Some coaches thought that more support from their principals would help facilitate their work with teachers. One coach, who worked at more than one school, wrote:

> She has not done anything to facilitate my work with her teachers. They are very resistant and positive that they are doing an awesome job and don't need any help. It has been very uncomfortable and unproductive at that school.

Another said:

> I would appreciate more guidance and interaction from the principal, as it would help to take the onus off me. When I am left to make the decisions, it can result in teachers less likely to completely trust me, since they may view me as one of their evaluators, or as a 'spy' for the administration, neither of which is appropriate or true.

Many of the coaches who indicated that they lacked support from their principals also said that they did not share a common vision about coaching and/or mathematics instruction with their principals. One coach wrote:

> I don't think I get the proper support. Unfortunately, elementary principals are more concerned about SOL scores and passing AYP. Teachers can teach procedure to accomplish this (and often they do)….When a principal doesn't understand the coaching process, they get afraid that their supervisory position is being infringed upon. When the principal doesn't understand where mathematics

is heading in the future, they see different things in a mathematics lesson than a math specialist.

Another said, “There is limited support because our visions are not congruent…. [My principal] offers very little leeway when it comes to implementing my vision that I have for how mathematics instruction should look.”

Summary

This chapter has laid out the results of many analyses designed to examine coaches’ and principals’ perceptions of the mathematics coaching role. The results showed that coaches had various educational backgrounds, teaching experiences, and preparations for their roles. Coaches were working predominantly under the coach mathematics specialist program model, but were also working as pull-out teachers. Coaches served in all nine coaching roles, primarily working as classroom supporters, resource providers, instructional specialists, and data coaches. Principals thought that coaches should be serving in various coaching roles, most importantly as classroom supporters, catalysts for change, instructional specialists, data coaches, and school leaders.

Some statistically significant differences were found between coaches’ and principals’ perceptions. Coaches and principals disagreed about the primary job of teaching children. While both groups agreed that the best way to improve teachers’ mathematics instruction was to co-teach with them, principals thought coaches should be modeling, co-teaching, and observing in classrooms more often than coaches reported. Statistically significant differences were also found in coaches’ and principals’ responses

to survey questions about the nonevaluative nature of the coaching role, having a vision of mathematics instruction, and communication between the principal and the coach.

Key findings and implications of those findings will be discussed in Chapter 5. Chapter 5 also includes recommendations for further research.

5. Discussion

Summary of Major Results

This study examined the roles and responsibilities of elementary mathematics coaches from coaches' and principals' perspectives. Key findings are listed below. Each of these findings will be discussed in turn.

1. Most elementary mathematics coaches are new to coaching and have teaching experience at the elementary level.
2. Coaches are well educated, but most do not have a degree in mathematics education or have a mathematics specialist endorsement.
3. Principals believe that knowledge of mathematics content, differentiation of instruction, and pedagogy are important criteria for selecting coaches, more important than having a mathematics specialist endorsement.
4. Coaches combine two mathematics specialist models, acting as coaches and pull-out teachers.
5. Coaches do not focus on one or two coaching roles but assume multiple roles. The most predominant roles are classroom supporter, resource provider, instructional specialist, and data coach.

6. Coaches believe co-teaching is the best way to improve mathematics instruction, but their work with teachers is largely determined by teachers' comfort level and willingness to be coached.
7. Principals subscribe to the coach mathematics specialist model over the specialized-teacher or pull-out models.
8. Principals believe that coaches should assume multiple roles and that classroom supporter, catalyst for change, instructional specialist, data coach, and school leader are the most important coaching roles.
9. Principals and coaches both subscribe to the coach mathematics specialist program model, but disagree about the pull-out model.
10. Principals and coaches agree that coaches should assume multiple roles. They agree on the importance of three coaching roles (classroom supporter, instructional specialist, and data coach) and disagree about the importance of three coaching roles (catalyst for change, school leader, and resource provider).
11. Principals and coaches believe that co-teaching is the best way to improve teachers' mathematics instruction.
12. Principals and coaches disagree about the nonevaluative nature of the coaching role. More coaches than principals think the role should be nonevaluative.
13. Many principals are not aware that they do not have a common understanding about the coach's roles and responsibilities with their coach, they do not share a common vision of what mathematics instruction should look like with their coach, and they do not have open lines of communication with their coach.

Who Are Elementary Mathematics Coaches?

Research Question 1 asked, "Who are elementary mathematics coaches?" To understand the qualifications of the elementary mathematics coaches who participated in this study, survey questions were asked about their educational background, number of years of teaching experience, and the kinds of teaching certificates they held. In addition, coaches were asked about activities that prepared them to become mathematics coaches. Principals were asked about the hiring practices in their districts and their criteria for selecting mathematics coaches.

Qualification and background of elementary mathematics coaches. All of the coaches in the study had been classroom teachers before becoming mathematics coaches. About half of the coaches had worked as a classroom teacher at the same school where they now coached. Classroom teaching experience ranged from 2 to 35 years, and the mean number of years as a classroom teacher was 13.

The elementary mathematics coach is a new position in the field of education, and this point was illustrated by the demographics of the coaches who participated in the study. More than half of the coaches had less than four years of experience as a mathematics coach. Almost 20% were in their first year of coaching.

The educational background and certification of the coaches varied. The majority of the coaches had bachelor's degrees in elementary education, but degrees in other fields of education and fields outside of education were also reported. A large majority of the coaches had master's degrees, but only 25% of the coaches had master's degrees in mathematics education. The mathematics coaches' teaching licenses included

endorsements in grades preK-3, preK-6, and 6-8. Only 25% of the coaches had the Virginia K-8 mathematics specialist endorsement. These data show that while they were well educated, the majority of the coaches did not have degrees or endorsements in mathematics education.

Coaches were asked about activities that helped them prepare to become a mathematics coach. Most coaches reported participating in district-level professional development, professional reading, graduate-level coursework, and professional conferences. More than half of the coaches said they had learned from a mentor. When asked which activities had helped their preparation the most, district-level professional development, graduate-level coursework, and working with a mentor came out on top.

The selection and hiring of elementary mathematics coaches. Most of the principals in the study said they hired the mathematics coaches at their school. Others reported that the coaches were hired by the district and assigned to their school or that the district gave them a pool of candidates from which to choose. Some principals described creating a mathematics coach position and funding it by trading other positions.

Almost all principals reported that knowledge of mathematics content, knowledge of how to differentiate instruction, and knowledge of pedagogy were very important in the selection of a mathematics coach. Less than half of the principals thought that holding a K-8 mathematics specialist endorsement was very important. This may be because the mathematics specialist endorsement was a new endorsement in Virginia. The principals' mathematics coaches did not hold the endorsement, and the principals were happy with their job performance anyway. It could also be because principals were not familiar with

the mathematics specialist endorsement and the knowledge and skills that a coach with the endorsement might have.

What Were the Coaches' Roles and Responsibilities?

Research Question 2 asked, "How do elementary mathematics coaches define their roles and responsibilities?" The majority of the coaches in the study worked full-time at one school. About half of the coaches reported having more than one mathematics coach at their school. Results revealed that the majority of the coaches combined two of the three mathematics specialist program models, assumed multiple coaching roles, thought co-teaching was the best way to improve mathematics instruction, supported teachers who were willing to work with them, and were divided about the nonevaluative nature of the coaching role. Each of these results will be discussed.

Coaches generally combined two mathematics specialist program models. There are three mathematics specialist program models: the mathematics coach model, the specialized-teacher model, and the pull-out model (Ball, et al., 2008; Fennell, 2006, 2007; NRC, 1989, 2001; Reys & Fennell, 2003). In the mathematics coach model, the specialist works with classroom teachers as a mentor. In the specialized-teacher model, the specialist teaches mathematics to whole classes of students, usually teaching all the students in one or more grade levels. In the pull-out model, the specialist provides remediation or enrichment to individual or small groups of children as a supplement to their regular mathematics instruction.

The coaches in this study predominantly worked with teachers but also worked with students. More coaches said that their primary job was to support teachers'

professional growth than said it was to teach children, but almost half of the coaches said it was both. About 20% of the coaches worked exclusively as mathematics coaches. A few of the coaches worked exclusively as pull-out teachers. The majority of the coaches worked as coaches and pull-out teachers, dividing their time between the two duties. This indicates that there is no clear model of mathematics coaching, but that coaches are working across models. It also raises questions about the impact of mathematics coaching. If there is no clear model for coaching, how can researchers determine if coaching makes a difference? What makes the greatest impact on student achievement in a school—working with teachers or working with students?

More coaches who had a mathematics specialist endorsement than coaches who did not have the mathematics specialist endorsement reported that their primary job was to support teachers' professional growth. Only a small percentage of coaches holding a mathematics specialist endorsement indicated that their primary job was to teach children. This suggests that coaches who have participated in mathematics specialist preparation programs subscribe to the mathematics specialist model of coaching over the specialized-teacher model or the pull-out model.

Coaches did not focus on one coaching role but assumed multiple roles. The conceptual framework that guided this study (see Figure 1) illustrated nine roles in which coaches who were acting under the coach mathematics specialist model might engage. The classroom supporter role was seen as a large role which overlapped six other roles: learning facilitator, resource provider, curriculum specialist, instructional specialist, data coach, and learner. The catalyst for change role and the school leader role were seen as

roles that informed other roles and allowed the coach to act as a liaison between classroom teachers and the principal.

Analyses of the nine coaching roles revealed that the majority of coaches assumed multiple roles. Only 33% of the coaches reported having one primary role. Qualitative data also supported this finding, with more than half of the coaches describing multiple roles when asked to describe their primary role. Coaches were working predominantly as resource providers, instructional specialists, and data coaches. More than 40% of coaches reported engaging frequently in activities associated with these three roles.

Because the classroom supporter role overlapped other roles, it did not present as a primary role until separate analyses were conducted. These analyses revealed that the classroom supporter role was, indeed, a primary role for the majority of the coaches in the study. A large majority of coaches reported supporting teachers in their classrooms by modeling instruction, co-teaching, and/or observing. Almost 70% of the coaches reported frequently engaging in at least one of these three activities. Large majorities of coaches also reported engaging in eight coaching activities that happened within the classroom or directly assisted the teacher in providing classroom instruction. These eight activities overlapped other coaching roles.

Taken together, these results indicate that coaches were serving in a variety of roles rather than focusing on only one or two roles. Coaches predominantly served as classroom supporters, resource providers, instructional specialists, and data coaches. Recall that coaches were also working as pull-out teachers. This suggests that coaches' time and attention were divided among many duties. It raises questions about lack of

focus and the impact of coaching programs. When a coach assumes multiple roles does it help or hinder a school's efforts at improving mathematics teaching and learning? Does a coach's lack of focus impede the coach's ability to perform well?

Coaches believed co-teaching was the best way to improve mathematics instruction, but their work with teachers was determined by teachers' comfort level and willingness to be coached. When asked to choose the best way to help teachers improve their mathematics instruction, coaches predominantly chose co-teaching over modeling and observing instruction. While a large majority of coaches reported co-teaching with teachers, large majorities of coaches also reported modeling instruction for teachers and observing teachers teach lessons. Why did coaches model and observe when they thought co-teaching was best? Coaches said that the way they worked with teachers was determined through discussions with the teachers. Coaches indicated that the comfort level of the teacher had a great deal to do with the kinds of support they were able to provide. If a teacher was not comfortable co-teaching a lesson with the coach, the coach chose to model instruction or to observe the teacher instead.

Correspondingly, coaches predominantly reported working with teachers who were willing to work with them and needed assistance teaching mathematics. Open-ended survey questions shed some light on this phenomenon. Coaches believed that their time was best spent working with teachers who were willing to work with them because they felt they could make an impact on those teachers' instructional practices. As a whole, these data suggest that coaches' were very accommodating in their work with teachers. While coaches thought co-teaching was the best way to improve mathematics instruction,

the way they worked with teachers was largely determined by the teacher's comfort level and willingness to be coached.

Coaches were split on the nonevaluative nature of the coaching job. The *Standards for Elementary Mathematics Specialists* (AMTE, 2010) state that mathematics coaches should "take on collegial nonevaluative leadership roles" (p. 7). Study participants were asked a number of survey questions in order to determine if they considered their roles to be nonevaluative. When asked if they should tell their principals if they saw poor mathematics instruction, 54% of the coaches thought they should, and 46% of the coaches thought they should not. In addition, a large majority of coaches said they had been asked by their principal to work with a teacher because the teacher had difficulty teaching mathematics, some coaches said they had been asked to evaluate another teacher, and some said they had been asked to divulge information about a teacher that they considered to be confidential. While these data do not provide a clear picture of whether or not the coaches in the study were nonevaluative, they do provide evidence that being nonevaluative may be an issue for some coaches.

Principals' Views of the Mathematics Coaches' Roles and Responsibilities

Research Question 3 asked, "How do elementary principals define the roles and responsibilities of elementary mathematics coaches?" Results revealed that most principals subscribed to the coach mathematics specialist model, thought coaches should assume multiple roles, and believed co-teaching was the best way for coaches to support classroom teachers.

Most principals subscribed to the coach mathematics specialist model. Results showed that the majority of principals subscribed to the coach mathematics specialist model over the specialized-teacher model or the pull-out model. More principals agreed that their coach's primary job was to support teachers' professional growth than to teach children. When asked to describe the coaches' primary role, most principals described ways that coaches supported teachers. Very few described coaches working solely with students as specialized-teachers or pull-out teachers. When asked about specific activities related to the three mathematics specialist models, more principals thought coaches should be engaged in activities related to the coach model than the specialized-teacher or pull-out model. All principals thought that coaches should co-teach with teachers; and almost all principals thought coaches should work with teachers individually, work with teachers in teams, assist teachers in planning, and model instruction for teachers. Comparatively, much smaller percentages of the principals thought that coaches should teach children with no other teacher present or provide remediation to children. All in all, these data suggest that principals believe coaches should work to help teachers improve their instructional practices so all students can learn.

Principals thought coaches should assume multiple coaching roles. Results of analyses of the nine coaching roles revealed that principals thought coaches should assume multiple roles. Only 12% of principals thought their coach should focus on just one role. About 50% of the principals thought coaches should have more than three

primary roles. Principals thought catalyst for change, instructional specialist, data coach, and school leader were the most important roles.

As in the analysis of coaches' responses, the classroom supporter role did not present as an important role in the initial analysis of principals' responses. This was because the classroom supporter role overlapped many other roles. Further analysis revealed that principals, in fact, did believe that the classroom supporter role was an important role. Almost 80% of the principals thought their coaches should frequently be modeling, co-teaching, and/or observing in classrooms. All principals thought their coaches should co-teach with teachers at least sometimes. Almost all principals thought coaches should engage in eight coaching activities that were associated with the classroom supporter role and overlapped other roles.

These results show that principals believed coaches should assume multiple roles, rather than focus on one or two roles. Principals thought the most important roles were classroom supporter, catalyst for change, instructional specialist, data coach, and school leader. This suggests that principals expect coaches to divide their time and attention among multiple duties with leadership duties being among the most important.

Principals thought co-teaching was the best way to support classroom teachers. When asked how coaches should support teachers in the classroom, most principals thought that co-teaching was a better approach than modeling or observing instruction. Even though principals thought co-teaching was the best approach, and all principals said coaches should co-teach; large majorities of principals also said that coaches should model mathematics instruction for teachers and observe teachers teaching

mathematics at least some of the time. It is unclear why this discrepancy exists, though it may be related to coaches' views about working with classroom teachers. Coaches indicated that they modeled and observed teachers who were uncomfortable with co-teaching.

Similarities and Differences between Principals' and Coaches' Perceptions

Research Question 4 asked, "What differences exist in the way the mathematics coach role is conceptualized by mathematics coaches and principals?" Results revealed both similarities and differences in principals' and coaches' views. Principals and coaches both subscribed to the coach mathematics specialist program model, but disagreed about the pull-out model. Principals and coaches agreed that coaches should assume multiple roles. They also agreed on the importance of three coaching roles, but disagreed about the importance of three coaching roles. Both principals and coaches believed that co-teaching was the best way to improve teachers' instructional practices. They disagreed on the nonevaluative nature of coaching. Many principals were not aware that they did not have common understandings with their coach about the coach's roles, their vision of mathematics instruction, and their mutual communication. Each of these ideas will be discussed in turn.

Principals and coaches disagree about the pull-out mathematics specialist program model. Results showed that the majority of coaches combined the coach and pull-out mathematics specialist models, but most principals subscribed solely to the coach model. There were no statistically significant differences in principals' and coaches' responses to a survey question about coaches' primary job of supporting teachers'

professional growth, but there were statistically significant differences in principals' and coaches' responses to a survey question about teaching children. More coaches than principals thought that a coach's primary job was to teach children. Almost half of the coaches said their primary job was both to support teachers' professional growth and to teach children, and a large majority said they engaged in both coaching and teaching activities. In addition, results showed that a majority of coaches were working as pull-out teachers. While almost half of the coaches frequently provided remediation to small groups of children, only 19% of principals thought coaches should do this frequently. These data indicate that coaches were working as pull-out teachers more often than principals thought they should. Overall, these results show evidence that coaches and principals disagreed about the pull-out mathematics specialist model.

Principals and coaches agreed that coaches should assume multiple roles. Results from the analyses of the nine coaching roles revealed that principals and coaches believed that coaches should assume a variety of roles. Only 33% of the coaches reported having one primary role and only 12% of principals thought their coach should focus on just one role. About 50% of principals thought coaches should have more than three primary roles, and about 25% of the coaches had more than three primary roles. While these data indicate that principals and coaches agreed that coaches should assume multiple roles, they also seem to suggest that coaches were more inclined than principals to focus on just a few roles.

There are several explanations why this might be true. It may be because coaches are more realistic about the scope of their jobs. Having done the job, they may understand

the difficulties involved in trying to focus on too many things. Principals, on the other hand, may be thinking about the various needs of the school and looking to the mathematics coach to fulfill these many needs. The result could also be because of the differences in the coaches' and the principals' surveys. Coaches were asked how often they engaged in the coaching activities, while principals were asked how often coaches *should* engage in the activities. Principals chose "frequently" much more often than coaches. Coaches may have been more realistic in answering the survey questions, carefully considering the difference between "frequently" and "sometimes." Principals may have been thinking ideally about what coaches could do and, therefore, answered "frequently" more often than "sometimes."

Principals and coaches agreed on the importance of three coaching roles. Principals and coaches had three top roles in common: classroom supporter, instructional specialist, and data coach. A large majority of coaches reported supporting teachers in classrooms by modeling instruction, co-teaching, and/or observing. The majority of principals thought coaches should be modeling, co-teaching, and/or observing in classrooms. More than 40% of coaches reported frequently engaging in activities associated with the instructional specialist role and the data coach role. More than 50% of principals thought coaches should engage in activities associated with the instructional specialist role, and the data coach role was determined to be the third most important role in the analysis of principals' primary roles. All in all, coaches and principals agreed about the importance of these three roles.

Principals and coaches disagreed on the importance of three coaching roles. Two of the principals' top roles were not given high importance by coaches: the catalyst for change role and the school leader role. Large majorities of principals thought coaches should frequently engage in activities associated with the catalyst for change role: discussing strategies for promoting change with the principal, sharing their vision of mathematics instruction with teachers, and sharing their vision of mathematics instruction with the principal. Small percentages of coaches reported frequently engaging in these activities. Large majorities of principals also thought coaches should frequently engage in activities associated with the school leader role: serving on school leadership committees, talking about instruction with the principal, and talking about mathematics instruction with the school's reading specialist. While 79% of coaches frequently served on school leadership committees, much smaller percentages of coaches frequently talked about mathematics instruction with the principal or the school's reading specialist.

Resource provider was one of the coaches' top three roles, and principals did not consider this role to be important. It was one of the two lowest roles in the principals' primary roles analysis. While principals thought coaches should assist teachers in the selection of instructional materials and recommend mathematics materials for the school to purchase, a comparatively small number of principals thought coaches should manage mathematics resource rooms. Large majorities of coaches reported engaging in all three of these activities, making resource provider one of the top three roles for coaches.

These data indicate that principals and coaches disagreed about the importance of three roles. Principals thought catalyst for change and school leader were important roles,

but coaches did not engage in activities associated with those roles as often as they engaged in activities associated with other roles. Coaches engaged in the resource provider role quite frequently, but principals did not find that role to be important. These results may indicate differences in principals and coaches perceptions of the needs of their schools. Principals, being the primary leaders for their schools, may see a need for leadership from within and expect coaches to fulfill those leadership roles. Coaches, having recently come from classrooms, may be considering the time constraints that classroom teachers have and assisting by providing necessary resources. Another explanation is that principals do not realize how much time is involved in managing a mathematics resource room. While it may not be a task with high importance, it needs to be done, and coaches take on the responsibility.

Principals and coaches agreed on the best way to improve teachers' instruction. The majority of principals and coaches thought that co-teaching was the best way to effect change in teachers' instructional practice. Very few principals and coaches thought modeling or observing instruction was best. Principals thought coaches should co-teach, model, and observe more often than coaches reported doing so, however, and those differences were statistically significant. This may be because principals were thinking in the theoretical when they answered survey questions about how often coaches *should* do something, while coaches were based in the reality of how often they *actually had* engaged in the activities. While there were statistically significant differences in principals and coaches views of the frequency of the three activities, there were similarities in how principals and coaches viewed the importance of the three activities.

Both principals and coaches thought modeling and co-teaching were more important than observing. These results suggest that principals and coaches are of like mind when it comes to working with teachers in their classrooms. Both groups believe that co-teaching is the best way to improve teachers' instructional practices, and coaches should model and co-teach more frequently than observe.

Principals and coaches disagreed about the nonevaluative nature of the coaching role. There were statistically significant differences between principals' and coaches' responses to a survey question about the nonevaluative nature of the coaching role. Participants were asked if coaches should tell principals if they see poor mathematics instruction in a classroom. A large majority of principals agreed that coaches should inform their principals, and a considerable number "strongly agreed." Only about half of the coaches agreed that they should tell their principals if they see poor mathematics instruction, and only a few "strongly agreed." While this survey question did not directly inquire about the nonevaluative nature of the role, it asked about an activity that would make a nonevaluative coach uncomfortable. The results suggest that principals and coaches disagree about the nonevaluative nature of the coaching role. It seems that more coaches than principals think the role should be nonevaluative.

Many principals were not aware that they did not have common understandings with their coach. There were statistically significant differences between principals' and coaches' responses to survey questions that asked about understanding the coaching role, having a vision of what mathematics instruction should

look like, and communication between the principal and the coach. More principals than coaches thought that they had common understandings about these things.

While almost all principals and coaches said that the coach understood his or her responsibilities, there were differences between groups on the strength of that agreement. Seventy-four percent of principals strongly agreed that their coaches understood their responsibilities, but only 55% of the coaches strongly agreed that they understood their responsibilities. When asked if there was a common understanding between the principal and the coach about the coaching role, large percentages of principals and coaches agreed, but 73% of principals strongly agreed and only 33% of coaches strongly agreed. Interestingly, only 2% of the principals said that that they disagreed with their coach about the coaches' responsibilities. A much larger percentage of coaches (16%) said they disagreed with their principal about what their responsibilities should be. These results suggest that coaches are not as confident in understanding their roles and responsibilities as principals think they are. In addition, it seems that many principals are not aware that they do not have a common understanding about the coach's roles and responsibilities with their coach.

Although principals and coaches agreed that coaches had a vision of what mathematics instruction should look like, they did not agree that principals had a vision of what mathematics instruction should look like. They also did not agree about sharing a common vision. One hundred percent of the principals surveyed said they had a vision of what mathematics instruction should look like. Only 88% of the coaches agreed. One hundred percent of the principals also thought they shared a common vision with the

mathematics coach at their school. Again, only 82% of the coaches thought they shared a common vision with their principal. These differences were statistically significant. These results suggest that many coaches do not know that their principals have a vision of mathematics instruction. In addition, many principals are not aware that they do not share a common vision of what mathematics instruction looks like with the coach at their school.

When principals and coaches were asked if they had open lines of communication with each other, more principals than coaches thought they did. Almost all principals agreed that they had an open line of communication with their mathematics coach, and 80% strongly agreed. Only 86% of coaches thought they had an open line of communication with their principal, and only 42% strongly agreed. These differences were statistically significant. Results also showed that principals thought coaches should communicate with them frequently about the mathematics instruction in their schools, their visions of what mathematics instruction should look like, and their strategies for promoting change in instructional practice. Many coaches reported rarely or never discussing these things with their principals. These results indicate that many principals are not aware that they do not have open lines of communication with their coach. They also suggest a need for better communication between principals and coaches.

Overall, these results suggest that many principals are not aware that (a) they do not have a common understanding about the coach's roles and responsibilities with their coach, (b) they do not share a common vision of what mathematics instruction should look like with their coach, and (c) they do not have open lines of communication with

their coach. This indicates a need for better communication between principals and coaches. It may also indicate that coaches need to be more assertive in talking to principals about their beliefs about mathematics teaching and learning and how their coaching responsibilities could impact mathematics instruction and student achievement in their schools.

Relationship of Results to Existing Studies

Deborah Ball et al. (2008) reported that mathematics coaches frequently take on roles that cut across all three mathematics specialist models. This study supports that finding with the majority of the coaches taking on roles within the coach model and the pull-out model.

Results revealed that coaches frequently acted as pull-out teachers and resource providers. These findings corroborate those of Campbell and Malkus (in press) who found that elementary mathematics coaches spent more than half their time engaged in duties other than coaching including teaching students and managing materials.

Campbell and Malkus (in press) also found that the effect of elementary mathematics coaches on student achievement was not significant in the first year of coaching. They suggested that this may be because it takes time for coaches to develop collaborative interactions with teachers and administrators that are focused on improving teaching and learning. The present study provides information about why it takes time for coaches to develop collaborative interactions with school staff. Coaches described paying attention to teachers' comfort-levels and willingness when determining the kinds of interactions in which they engaged with teachers. They modeled and observed

instruction, even though they believed co-teaching was best because teachers were more comfortable with those activities. It took time for a teacher to trust a coach enough to co-teach with them. Weiss and Pasley (2009) agree that "in the initial stages of professional development, it makes sense to concentrate on teachers who are receptive to change" (p. 11), but caution professional developers that it would be a mistake to exclude teachers who are resistant to change. In the first year, coaches can gain credibility, build rapport, and establish cadres of supporters who can help encourage other teachers to participate. In subsequent years, coaches must reach out to resistant teachers and find ways to elicit their active participation.

Limitations

The data in this study are self-reported and measure opinion rather than fact. They give a valid measure of the coaches' and principals' perceptions of the roles and responsibilities of elementary mathematics coaches, but they do not provide an empirical measure of the frequency of coaches' activities. Coaches reported the frequency of their activities based upon their memories. Coaches did not document the activities as they happened, and they were not observed conducting those activities.

Because principals were asked what coaches *should do* and coaches were asked what they *had done*, principals' responses about the frequency of specific coaching activities may have been inflated. Principals chose "frequently" much more often than coaches. Coaches may have been more realistic in answering the survey questions, carefully considering their time constraints and the difference between "frequently" and "sometimes." Principals may have been thinking ideally about what coaches could do,

and, as a result, answered “frequently” more often than “sometimes.” This phenomenon leads one to be cautious when considering statistically significant differences in principals’ and coaches’ responses to similar survey questions. A more accurate assessment may be to compare the categories with the highest and lowest percentages from each group. This type of analysis was used as much as possible in the analyses of the differences between the two groups.

Implications for Coaches and Administrators

Coaches and administrators should establish open lines of communication. They need to talk frequently about their visions of mathematics instruction and their strategies for instructional change. Efforts should be made to develop a common vision of mathematics instruction, short- and long-term goals for change, and strategies for stimulating change. Change strategies include determining coaching roles and responsibilities that make the most impact on the school. Coaches and administrators need to talk openly and honestly about the different coaching roles and determine which of the roles best suit the culture, climate, and needs of the school. They should come to a common understanding about what the coaches’ responsibilities are and how those responsibilities impact teachers and students in the school. Administrators should then facilitate the work of the coaches by providing clear expectations about the coaches’ roles and responsibilities to other school staff.

This aligns with Weiss and Pasley’s (2009) guidance for mathematics professional development. They maintain that a common vision of mathematics instruction is very important. “Each leader should understand what effective instruction

looks like and how professional development helps classroom teachers learn to provide this kind of instruction" (pp. 3-4). They also advocate for principals to provide guidelines to help coaches focus their work and gauge their progress. "Without direction, teacher leaders may feel overwhelmed, frustrated, and inefficient" (p. 60). They say that principals should avoid being too rigid in their guidance, however. Coaching programs evolve over time. As coaches work with teachers and develop a common vision with principals, they become more skilled at determining the needs of the teachers and students in their school. This, in turn, helps to focus their vision and clarify their roles.

Many coaches and principals in this study thought that coaches should inform principals if they see poor mathematics instruction. A few coaches had been asked to divulge confidential information to their principals. These findings suggest that there is some confusion among coaches and principals about whether or not coaches should be nonevaluative in their interactions with teachers. If teachers believe that coaches are there to evaluate them and are reporting inadequacies to their principals, they will not open up to coaches about their professional development needs. This can undermine the coaching relationship and prohibit teachers' professional growth. Coaches and principals need to understand, accept, and support the idea of nonevaluative coaching interaction with teachers.

Very few of the principals in this study believed that having an elementary mathematics specialist endorsement was an important criterion for the selection of a mathematics coach. Principals need to be educated about the elementary mathematics endorsement. Once they understand the requirements to obtain the endorsement and the

special knowledge and skills that perspective coaches gain in mathematics specialist preparation programs, they will understand how valuable a coach with this endorsement is. That knowledge will help principals to find and employ coaches that can make a positive impact on the teachers and students in their schools.

Implications for School Districts

District policymakers should develop clear job descriptions of elementary mathematics coaches so that all stakeholders know what to expect when a coach begins work. These descriptions should include necessary knowledge, skills, and leadership qualifications based upon the *Standards for Elementary Mathematics Specialists* (AMTE, 2010), as well as a description of the roles and responsibilities that a coach may assume in a school.

The coaches in this study indicated that district-level professional development was an important part of their preparation. Since coaches are usually isolated from their peers and do not have much opportunity to talk to coaches in other schools, it is important that school districts provide these opportunities. Districts should require elementary mathematics coaches to attend professional development sessions with coaches from other schools. At these sessions, coaches would share information about their roles and responsibilities, explore important elementary mathematics concepts together, discuss pedagogical considerations, and develop leadership skills.

Implications for Mathematics Specialist Preparation Programs

Since elementary mathematics coaches are functioning in a variety of roles, mathematics specialist preparation programs need to provide information about these

roles. Specialists should learn about the nine coaching roles, explore how those roles overlap, and be taught how to juggle multiple roles. Along with preparation for coaching, programs should prepare specialists to be specialized-teachers and pull-out teachers. In addition, specialists who have graduated from preparation programs should be articulate about the various mathematics specialist roles and be able to advocate for the role that they believe would make the biggest impact in students' mathematics achievement in their schools.

Implications for Future Research

Questions remain about who elementary mathematics coaches are, what they do, and whether they are effective. Further research needs to be conducted to determine which of the mathematics specialist program models and which of the nine coaching roles are the most effective in terms of improving students' mathematics achievement and boosting the overall success of a school.

The specific knowledge and skills of effective coaches must be determined in order to aid principals and school districts in the selection of high-quality coaches and universities in the development of preparation programs. Principals in this study reported that the mathematics specialist endorsement was their least important criteria for selecting mathematics coaches. Researchers should examine the differences between coaches who have mathematics specialist endorsements and those that do not. Does a coach with a mathematics specialist endorsement have a greater impact on students' mathematics achievement than a coach who does not have the endorsement? Does a coach with the endorsement have a greater effect on teachers' instructional practices than

a coach who does not have the endorsement? These questions have yet to be answered and could give support to the elementary mathematics specialist movement across the United States.

About 50% of the coaches in this study worked at the same school where they had worked as a classroom teacher before becoming a mathematics coach. Studies should be conducted that examine this phenomenon. Some educators believe that promoting a classroom teacher to a coaching position is a good idea (Rowan & Campbell, 1995); others disagree (Reys & Fennell, 2003). Is it difficult for classroom teachers to transition into a coaching role in their building? Does having a mathematics coach who was a classroom teacher at the school make it easier or harder to build rapport with teachers? Do these coaches make a greater or quicker impact on student achievement or on teachers' instructional practices? This kind of information could help principals decide whether to continue the practice of hiring coaches from within their instructional staff.

Coaches in this study reported their perceptions of their roles and responsibilities, giving recollections of the frequency in which they engaged in specific coaching activities. Campbell and Malkus (2010, in press) have conducted a study in which elementary mathematics coaches documented their daily activities using handheld computer devices. While both studies give information about what coaches do, other studies should be conducted in which coaches are observed in the execution of their jobs. These types of studies would provide empirical data on what coaches actually do based upon observation rather than self-report.

Campbell (1996) found that the effect of mathematics coaches on student achievement did not occur until coaches had been working at a school for two and a half years. Killion (2009) suggested that a coaches' role changes as the school year progresses. Researchers should investigate the evolution of mathematics coaches' roles and responsibilities. Do those responsibilities change as coaches become more comfortable in their jobs, as they build rapport with teachers, or as the needs of the school change? Do coaches function in different roles at different times of the school year? This information could help coaches and other stakeholders learn how to make the greatest impact on mathematics teaching and learning with the most efficiency.

Other studies might focus on coaches' interactions with principals and teachers, how coaches determine their roles, how teachers' understandings about mathematics teaching and learning align or conflict with their coaches' understandings, and how those differences impact the quality of coaching interactions. Studies such as these would help stakeholders understand the coaching role and maximize the effect of coaching on teachers' and students' learning.

Overall Significance of the Study

In defining the roles of elementary mathematics coaches through the eyes of coaches and principals, this study contributes to the growing research base on elementary mathematics coaches. It provides valuable information about what coaches are doing in their schools and the expectations that principals have for them. These results inform researchers about the roles of elementary mathematics coaches and provide direction for future research studies. The perceptions of coaches and principals reported here have

implications for coaches, district and school administrators, providers of professional development for coaches, and state and local policymakers.

Final Comments

Elementary mathematics coaches are serving many roles in their schools. They are charged with improving their school's mathematics instructional program, many times under the leadership of a principal who does not understand current research in mathematics education. They work hard to understand and meet the needs of administrators, teachers, and students. A large part of their job is to assist classroom teachers in building mathematics content knowledge, pedagogical content knowledge, mathematical knowledge for teaching, and knowledge of children's mathematical thinking. Many coaches also work with the lowest achieving students, providing mathematics instruction that enables them to pass high-stakes standardized tests. In addition, coaches educate their principals about best practices in mathematics education, negotiating their roles with their principals at the same time. These are difficult tasks.

It is important that elementary mathematics coaches have the expertise and knowledge they need to do their jobs well. This expertise includes a deep understanding of mathematics content at the elementary grades, pedagogical knowledge specific to the teaching of mathematics, knowledge of children's mathematical thinking, and the ability to facilitate the professional growth of adult learners. They must also be able to communicate effectively and build productive relationships with their principals.

Coaches and principals must work in close partnership to support and improve the mathematics programs in their schools. They must choose the mathematics coach's roles

carefully in order to ensure the greatest impact on mathematics teaching and learning. This includes have a common vision of what mathematics instruction looks like and a strategic plan for helping classroom teachers learn how to provide this kind of instruction. Working closely with principals, elementary mathematics coaches have the potential to strengthen teachers' instructional practice and, ultimately, improve mathematics learning for all students.

Appendix A

E-Mail Request to District Mathematics Coordinators

Dear Mathematics Coordinator:

The purpose of this email is to request your district's participation in a study of elementary mathematics specialists/coaches. This study will result in a description of the roles and responsibilities of mathematics specialists in Virginia. The project title is *Coaches' and Principals' Conceptualizations of the Roles of Elementary Mathematics Coaches in Six Virginia School Districts*.

Your district was selected because of your commitment to delivering high quality mathematics instruction to all students. If you choose to participate, the name of your district and the names of all participants from your district will be kept confidential. At the conclusion of this study you will receive a summary report of the findings.

I would like a list of names and email addresses of all the elementary mathematics specialists in your district and their respective principals. My intention is to invite these individuals to participate in an online survey designed to identify beliefs, opinions, and practices of elementary mathematics specialists. The survey will take approximately 30 minutes to complete. The participants' names will not be included on the survey, and participants will not be individually identified with their responses. If at all possible, I would like to attend a meeting of your mathematics specialists and/or principals to tell them about my study and invite them to participate.

If you are willing to share your district's experiences in determining the roles and responsibilities of elementary mathematics specialists, please respond to this email by August 30, 2009.

This research is being conducted by Gwenanne Salkind, a student at George Mason University. She may be reached at 703-569-5582 for questions or to report a research-related problem. The research is being supervised by Dr. Jennifer Suh, Mrs. Salkind's faculty advisor. You can reach Dr. Suh at 703-993-9119. You may contact the George Mason University Office of Research Subject Protections at 703-993-4121 if you have questions or comments regarding your rights as a participant in the research.

This research has been reviewed according to George Mason University procedures governing your participation in this research.

Thank you for your time and consideration,
Gwenanne Salkind

Appendix B

Mathematics Specialist Online Survey

Mathematics Specialist Experience

1. Excluding this year, for how many years have you been an elementary mathematics specialist? Note: For the definition of this study, a mathematics specialist does not have regular classroom duties.
2. I am employed as a mathematics specialist:
   - □ full-time
   - □ part-time
3. I work at:
   - □ one school
   - □ more than one school
4. Give the name(s) of your school(s).
5. Including yourself, how many mathematics specialists are employed at your school?
6. Were you a classroom teacher at your school before you took on the role of the mathematics specialist? (yes or no)

Mathematics Specialist Preparation

7. Which of the following activities prepared you for your role as a mathematics specialist? (Check all that apply.)
   - □ Graduate-level course(s)
   - □ National conferences
   - □ State-level professional development
   - □ District-level professional development
   - □ Professional reading
   - □ Study groups
   - □ Work with mathematics specialist mentor
   - □ None of the above
   - □ Other, please specify
8. Out of the above activities, which 3 activities do you feel have helped you develop the most as a mathematics specialist?

Roles and Responsibilities

9. What do you consider your primary role or responsibility?
10. Are there unique circumstances at your school that influence your role as a mathematics specialist? If so, please explain.
11. What is your official job title?

12. How often during the last year did you engage in the following activities?
    (1 = Frequently, 2 = Sometimes, 3 = Rarely, 4 = Never)
    a. Teach mathematics to children with no other teacher present
    b. Work with teachers individually
    c. Work with teachers in collaborative teams

13. How often during the last year did you engage in the following activities?
    (1 = Frequently, 2 = Sometimes, 3 = Rarely, 4 = Never)
    a. Assist teachers in planning mathematics instruction
    b. Model mathematics instruction
    c. Co-teach lessons with classroom teachers
    d. Observe teachers teaching lessons
    e. Discuss students' mathematical thinking with teachers
    f. Encourage teachers to reflect upon their teaching
    g. Share professional articles with teachers
    h. Create mathematics assessments
    i. Assist teachers in using assessments in their classrooms
    j. Analyze student assessment data
    k. Communicate findings of mathematics assessments to teachers
    l. Conduct meetings with classroom teachers to examine student work
    m. Assist teachers in differentiating instruction to meet student needs
    n. Provide mathematics remediation or intervention to individual children
    o. Provide mathematics remediation or intervention to small groups of children
    p. Assist teachers in the selection of instructional materials
    q. Gather materials for teachers
    r. Demonstrate the use of new mathematics materials for teachers
    s. Help teachers use new mathematics materials in their classrooms
    t. Facilitate teachers' discussion of the Virginia Standards of Learning and/or district standards
    u. Help align curriculum to state and/or district standards
    v. Develop pacing guides or curriculum maps

14. How often during the last year did you engage in the following activities?
    (1 = Frequently, 2 = Sometimes, 3 = Rarely, 4 = Never)
    a. Manage a mathematics resource room
    b. Recommend mathematics materials for the school to purchase
    c. Serve on school leadership committees
    d. Represent your school on district or state committees
    e. Talk about instruction with the reading specialist at your school
    f. Talk about mathematics instruction with your principal
    g. Share professional articles with your principal
    h. Discuss your vision of what mathematics instruction could look like with your principal
    i. Share your vision of what mathematics instruction could look like with other teachers at your school
    j. Discuss strategies for promoting instructional change with your principal
    k. Facilitate professional development workshops for teachers at your school
    l. Facilitate professional development workshops for teachers from other schools in your district

15. How often during the last year did you engage in the following activities?
    (1 = At least once a month, 2 = About every other month, 3 = Once or twice during the year, 4 = Never)
    a. Meet with other mathematics specialists in your district
    b. Attend professional development workshops or conferences
    c. Read professional articles or books

16. To what level do you agree or disagree with the following statements?
    (1 = Strongly Agree, 2 = Agree, 3 = Disagree, 4 = Strongly Disagree)
    a. It is important that my colleagues trust me.
    b. I intentionally try to build rapport with my colleagues.
    c. I have a vision of what mathematics instruction should look like.
    d. My principal has a vision of what mathematics instruction should look like.
    e. My principal and I agree about what mathematics instruction should look like.
    f. My primary job is to support teachers' professional growth.
    g. My primary job is to teach children.
    h. It is important for me to tell my principal if I see poor mathematics instruction in a classroom.
    i. I have open lines of communication with my principal.
    j. I have the knowledge I need to do my job.
    k. I feel qualified to coach teachers.
    l. I understand my responsibilities as a mathematics specialist.
    m. My principal and I agree about what my responsibilities should be.

17. How does your principal support you in your role as a mathematics specialist?

18. Has your principal ever asked you to do the following? (yes or no)
    a. Work with a teacher who needs help in improving his or her performance to the satisfactory level
    b. Substitute for a teacher who is absent
    c. Evaluate the performance of another teacher
    d. Divulge information about a teacher that you consider to be confidential

19. Do you work with classroom teachers?
    □ Yes (Go to Question 20)
    □ No (Skip to Question 26)

20. Which statement best describes your views on how to effect change in teachers' instructional practice? (Choose one.)
    a. The best way to help teachers improve their mathematics instruction is for me to model good instruction through demonstration lessons.
    b. The best way to help teachers improve their mathematics instruction is for me to plan and teach lessons together with them.
    c. The best way to help teachers improve their mathematics instruction is for me to observe them teaching mathematics and give them feedback.

21. Please rank the following in order of frequency (1 = most frequently, 4 = least frequently) How often do you work with teachers who…
    _____ Need assistance teaching mathematics and are reluctant to work with you?
    _____ Need assistance teaching mathematics and are willing to work with you?
    _____ Are competent mathematics teachers and are reluctant to work with you?
    _____ Are competent mathematics teachers and are willing to work with you?

22. How often do you work with teachers who…
    (1 = frequently, 2 = sometimes, 3 = rarely, 4 = never)
    a. Are new to the teaching profession?
    b. Are new to your school?

23. How do you decide which teachers to work with?

24. When you support teachers in their classrooms, how often do you…
    (1 = frequently, 2 = sometimes, 3 = rarely, 4 = never)
    a. Teach a lesson while the classroom teacher observes?
    b. Co-teach a lesson with the classroom teacher?
    c. Observe while the classroom teacher teaches the lesson?
    d. Other? Please describe.

25. How do you decide how to work with teachers inside their classrooms?

26. What are your top 3 challenges as a mathematics specialist? Place a 1 next to the item that is most challenging, a 2 next to the second most challenging item, and a 3 next to the third most challenging item.
    - ☐ Keeping informed in current mathematics education research
    - ☐ Supporting the professional growth of new teachers
    - ☐ Supporting the professional growth of veteran teachers
    - ☐ Developing a support network for my own professional growth
    - ☐ Keeping a positive and productive relationship with my principal
    - ☐ Developing a positive school culture
    - ☐ Managing time/priorities
    - ☐ Working with adult learners
    - ☐ Advocating for students
    - ☐ Navigating the mathematics specialist role with no formal authority
    - ☐ Working with reluctant teachers
    - ☐ Other, please specify

27. Is there anything else you would like to share about your role as a mathematics specialist?

Educational Background

28. Check all that apply:
    - ☐ I have a bachelor's degree in early childhood education.
    - ☐ I have a bachelor's degree in elementary education.
    - ☐ I have a bachelor's degree in mathematics education.
    - ☐ I have a bachelor's degree in science education.
    - ☐ I have a bachelor's degree in social studies education.
    - ☐ I have a bachelor's degree in English/language arts education.
    - ☐ I have a bachelor's degree in special education.
    - ☐ I have a bachelor's degree in music, art, or physical education.
    - ☐ I have a bachelor's degree in something other than education.
    - ☐ I have a master's degree in education with an emphasis on mathematics.
    - ☐ I have a master's degree in education with an emphasis on something other than mathematics.
    - ☐ I have a master's degree in something other than education.
    - ☐ I have a PhD or EdD.

Certification

29. Check all that apply:
    - ☐ I have a Virginia teaching license.
    - ☐ I have an Early/primary Education preK-3 endorsement.
    - ☐ I have an Elementary Education preK-6 endorsement.
    - ☐ I have a Middle Education 6-8 endorsement.
    - ☐ I have a K-8 Mathematics Specialist endorsement.
    - ☐ I have a Mathematics endorsement.
    - ☐ I have a Mathematics – Algebra I endorsement.

Teaching Experience

30. How many years of classroom teaching experience do you have? (Do not include years as a mathematics specialist.)
31. At what grade levels?

Appendix C

Principal Online Survey

Selection of Mathematics Specialist

1. For how many years has your school had a mathematics specialist? Note: For the definition of this study, a mathematics specialist does not have regular classroom duties.
   - □ Less than 1 year
   - □ 1-3 years
   - □ 4-5 years
   - □ 6-10 years
   - □ More than 10 years
   - □ Not sure

2. Who chooses the mathematics specialists that work in schools in your district?
   - □ Principals decide who to hire and hire them.
   - □ Principals decide who to hire, but the actual hiring is done at the district level.
   - □ Someone at the district level decides who to hire, and the mathematics specialists are assigned to the schools. (Skip to question #6)
   - □ Other (please explain)

3. What are your requirements for hiring a mathematics specialist?
   (1 = Very important, 2 = Somewhat important, 3 = Not important)
   a. Knowledge of mathematics content
   b. Knowledge of pedagogy
   c. Teaching experience at the elementary level
   d. Ability to lead others
   e. Acceptance by other teachers
   f. Knowledge of how to differentiate instruction
   g. Knowledge of mathematics instruction for English Language Learners
   h. Knowledge of how to work effectively with adult learners
   i. Coaching skills
   j. Ability to work with students' parents and the community
   k. K-8 mathematics specialist endorsement or certification
   l. Other, please specify

4. Did you hire a mathematics specialist who is currently working at your school?
   - □ Yes
   - □ No (Skip to question #6)

5. If so, was the mathematics specialist a classroom teacher **at your school** when you hired them?
   □ Yes
   □ No

Roles and Responsibilities of Mathematics Specialist

6. What do you consider the primary role of the mathematics specialist?
7. Are there unique circumstances at your school that influence the role of your mathematics specialist? If so, please explain.

8. How often should your mathematics specialist engage in the following activities? (1 = Frequently, 2 = Sometimes, 3 = Rarely, 4 = Never)
   a. Teach mathematics to children with no other teacher present
   b. Work with teachers individually
   c. Work with teachers in collaborative teams

9. How often should your mathematics specialist engage in the following activities? (1 = Frequently, 2 = Sometimes, 3 = Rarely, 4 = Never)
   a. Assist teachers in planning mathematics instruction
   b. Model mathematics instruction
   c. Co-teach lessons with classroom teachers
   d. Observe teachers teaching lessons
   e. Discuss students' mathematical thinking with teachers
   f. Encourage teachers to reflect upon their teaching
   g. Share professional articles with teachers
   h. Create mathematics assessments
   i. Assist teachers in using assessments in their classrooms
   j. Analyze student assessment data
   k. Communicate findings of mathematics assessments to teachers
   l. Conduct meetings with classroom teachers to examine student work
   m. Assist teachers in differentiating instruction to meet student needs
   n. Provide mathematics remediation or intervention to individual children
   o. Provide mathematics remediation or intervention to small groups of children
   p. Assist teachers in the selection of instructional materials
   q. Gather materials for teachers
   r. Demonstrate the use of new mathematics materials for teachers
   s. Help teachers use new mathematics materials in their classrooms
   t. Facilitate teachers' discussion of the Virginia Standards of Learning and/or district standards
   u. Help align curriculum to state and/or district standards
   v. Develop pacing guides or curriculum maps

10. How often should your mathematics specialist engage in the following activities? (1 = Frequently, 2 = Sometimes, 3 = Rarely, 4 = Never)
    a. Manage a mathematics resource room
    b. Recommend mathematics materials for the school to purchase
    c. Serve on school leadership committees
    d. Represent your school on district or state committees
    e. Talk about instruction with the reading specialist at your school
    f. Talk about mathematics instruction with you
    g. Share professional articles with you
    h. Discuss his/her vision of what mathematics instruction could look like with you
    i. Share his/her vision of what mathematics instruction could look like with teachers at your school
    j. Discuss strategies for promoting instructional change with you
    k. Facilitate professional development workshops for teachers at your school
    l. Facilitate professional development workshops for teachers from other schools in your district

11. How often should your mathematics specialist engage in the following activities? (1 = Frequently, 2 = Sometimes, 3 = Rarely, 4 = Never)
    a. Meet with other mathematics specialists in your district
    b. Attend professional development workshops or conferences
    c. Read professional articles or books

12. To what level to you agree or disagree with the following statements? (1 = Strongly Agree, 2 = Agree, 3 = Disagree, 4 = Strongly Disagree)
    a. It is important that teachers trust my mathematics specialist.
    b. My mathematics specialist should intentionally try to build rapport with colleagues.
    c. My mathematics specialist has a vision of what mathematics instruction should look like.
    d. I have a vision of what mathematics instruction should look like.
    e. My mathematics specialist and I agree about what mathematics instruction should look like.
    f. My mathematics specialists' primary job is to support teachers' professional growth.
    g. My mathematics specialists' primary job is to teach children.
    h. It is important for my mathematics specialist to tell me if he or she sees poor mathematics instruction in a classroom.
    i. I have open lines of communication with my mathematics specialist.
    j. My mathematics specialist has the knowledge he/she needs to do his/her job.
    k. My mathematics specialist is qualified to coach other teachers.
    l. My mathematics specialist understands his/her responsibilities.
    m. My mathematics specialist and I agree about what his/her responsibilities should be.

13. How do you support your mathematics specialist in his/her role?

14. Have you ever asked your mathematics specialist to do the following? (yes or no)
    a. Work with a teacher who needs help in improving his or her performance to the satisfactory level
    b. Substitute for a teacher who is absent
    c. Evaluate the performance of another teacher
    d. Divulge information about a teacher that he/she might consider to be confidential

15. How often do you expect your mathematics specialist to work with teachers who… (1 = frequently, 2 = sometimes, 3 = rarely, 4 = never)
    a. Are new to the teaching profession?
    b. Are new to your school?

16. Which statement best describes your views on how to effect change in teachers' instructional practice? (Choose one.)
    a. The best way to help teachers improve their mathematics instruction is for the mathematics specialist to model good instruction through demonstration lessons.
    b. The best way to help teachers improve their mathematics instruction is for the mathematics specialist to plan and teach lessons together with them.
    c. The best way to help teachers improve their mathematics instruction is for the mathematics specialist to observe them teaching mathematics and give them feedback.

17. What do you think are your mathematics specialist's top 3 challenges? Place a 1 next to the item that is most challenging, a 2 next to the second most challenging item, and a 3 next to the third most challenging item.
    □ Keeping informed in current mathematics education research
    □ Supporting the professional growth of new teachers
    □ Supporting the professional growth of veteran teachers
    □ Developing a support network for their own professional growth
    □ Keeping a positive and productive relationship with you (their principal)
    □ Developing a positive school culture
    □ Managing time/priorities
    □ Working with adult learners
    □ Advocating for students
    □ Navigating the mathematics specialist role with no formal authority
    □ Working with reluctant teachers
    □ Other, please specify

18. Is there anything else you would like to share about the role of a mathematics specialist?

19. What is the name of your school?

Appendix D

E-Mail Request to Participants

The purpose of this email is to request your participation in a study of elementary mathematics specialists/coaches. This study will result in a description of the roles and responsibilities of mathematics specialists in Virginia. The project title is *Coaches' and Principals' Conceptualizations of the Roles of Elementary Mathematics Coaches in Six Virginia School Districts*.

You were selected because you have a mathematics specialist/coaching program in your school. Your district mathematics coordinator gave me your name. If you choose to participate, your name, the name of your school, and the name of your district will be kept confidential.

The attached link will take you to a survey about the roles and responsibilities of a mathematics specialist/coach. The survey will take about 30 minutes to complete.

Your response would really help me out. Thank you in advance for your participation.

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Curriculum Vitae

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