INFLUENCES ON HIGH SCHOOL PRINCIPALS’ MATHEMATICS INSTRUCTIONAL LEADERSHIP PRACTICES

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Abstract

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INFLUENCES ON HIGH SCHOOL PRINCIPALS' MATHEMATICS INSTRUCTIONAL LEADERSHIP PRACTICES (147 pp.)

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The types of leadership practices that might work to improve mathematics curriculum and instruction are of interest to people who are concerned about the quality of mathematics education in rural schools. Certain leadership practices have been shown to influence school climate and culture, which indirectly influences student achievement, but there is no agreement regarding their effectiveness. Nevertheless, particular content-specific practices have been recommended for leadership of mathematics education, but little empirical work to date has substantiated the extensiveness of those practices, the conditions associated with their use, or their influence on school culture and performance (Larson et al., 2006).

This study investigated the separate and combined influences of principals’ mathematics knowledge, principals’ knowledge of mathematics education and a set of contextual and organizational variables, including locale, school size, per pupil expenditure, free and reduced lunch rate, and the employment of a mathematics department chair, on principals’ perceptions of effective leadership of mathematics education reform. Gender was included as a control variable because prior literature suggested that gender would likely have an influence on mathematics knowledge and
therefore had the potential to moderate the influence of that variable on the dependent variable, leadership of mathematics education reform.

The researcher mailed a questionnaire to a random sample of 596 high school principals in Pennsylvania, 260 of whom returned questionnaires, yielding an overall response rate of 50.4%. Data were analyzed using descriptive and inferential statistics. Findings based on backwards stepwise regression analyses showed that none of the target variables exerted a significant influence on principals’ perception of effective leadership of mathematics education reform. Moreover, the control variable, gender, exerted a significant influence only in the data set from which outliers had been removed. It exerted no significant influence in the models developed using the full data set.

Although none of the target variables were found to influence leadership of mathematics education reform, results did reveal how much high school principals value certain practices in mathematics instruction and provided insight into the mathematics backgrounds of the principals who responded to the survey and principals’ relative comfort level in performing a variety of mathematics tasks.

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CHAPTER ONE

Introduction

Background of the Study

People who are concerned about the quality of mathematics education in rural schools are interested in the types of leadership practices that might work to improve mathematics curriculum and instruction. As Larson and associates (2006) argue: (1) the instructional leadership of the principal influences overall student achievement; (2) the influence of instructional leadership on student achievement is indirect, through the influence of leadership on climate and culture of the school; (3) certain leadership practices influence school climate and culture; but (4) there is no consensus about which particular instructional leadership practices are most effective. Moreover, these authors make the point that, despite a large and inconclusive literature on instructional leadership in general, there is almost no literature on discipline-specific instructional leadership.

In support of a research question targeting predictors of high school principals’ instructional leadership of mathematics education reform, the discussion in this chapter provides brief reviews of literature on the instructional leadership of mathematics education reform and mathematics education in rural schools. Obvious gaps in this literature provide the rationale for additional research.

Leadership of Mathematics Education Reform

Since the National Council of Teachers of Mathematics (NCTM) Standards were released in 1989, “fewer than ten studies” (Howley, 2006, p. 6) have examined what principals do to lead mathematics reform. Although few empirical studies have been
conducted to investigate such discipline-specific leadership practices, several writers have made recommendations about what principals should do to improve mathematics instruction in schools. Analysis of the prescriptive documents revealed eight recommended practices. These recommendations represent a useful starting point for examining the practices that principals actually use.

According to several authors, instructional leaders of mathematics should work with teachers to ensure that curriculum and assessments are aligned with standards (Cauley & Seafarth, 1995; Leinwand, 2000; McEwan, 2000; Mirra, 2003; NCTM, 2000; Paulu, 1994). At the high school level, moreover, instructional leaders should make sure that the curriculum is sufficiently rigorous and that all students—regardless of their ability levels or prerequisite learning—have access to this rigorous curriculum (Cauley, Van de Walle, & Hoyt, 1993; McEwan, 2000; Mirra, 2003).

Advocates of instructional leadership of mathematics education also believe that this work involves providing teachers with meaningful professional development (Cauley & Seafarth, 1995; Cauley, Van de Walle, & Hoyt, 1993; McEwan, 2000; Mirra, 2003; NCTM, 2000; Paulu, 1994) that is sustained over time (Cauley & Seafarth, 1995; McEwan, 2000; Mirra, 2003). Professional development, in their view, should be focused on specific issues related to the teaching of mathematics (Cauley et al., 1993; Mirra, 2003).

The prescriptive literature also suggests that instructional leaders should promote collaboration among mathematics teachers (Cauley & Seafarth, 1995; Cauley et al., 1993; Glascock, 2003; Leinwand, 2000; McEwan, 2000; Mirra, 2003; NCTM, 2000; Paulu,
1994). These leaders should work in partnership with mathematics teachers (Glascock, 2003) to facilitate meaningful communication about instructional goals and practices (Cauley & Seafarth, 1995; Mirra, 2003; NCTM, 2000).

According to quite a few authors, moreover, instructional leaders should provide mathematics teachers with appropriate resources (Cauley & Seafarth, 1995; Cauley et al., 1993; Glascock, 2003; McEwan, 2000; Mirra, 2003; NCTM, 2000; Paulu, 1994). For example, they should provision professional libraries with relevant journals and books (Cauley et al., 1993, NCTM, 2000), give teachers access to useful technologies (Cauley et al., 1993), and ensure that teachers have and make use of instructional materials that have been shown to be effective (NCTM, 2000). In addition, many authors advise instructional leaders to restructure school calendars and daily schedules in order to allow mathematics teachers to devote more time to classroom instruction, one-one-one tutoring, collegial supervision, and collaborative instructional planning (Cauley & Seafarth, 1995; Cauley et al., 1993; Leinwand, 2000; McEwan, 2000; Mirra, 2003; NCTM, 2000).

Another recommendation is for instructional leaders to provide explicit support for the reform of mathematics education (Cauley & Seafarth, 1995; Cauley et al., 1993; Glascock, 2003; Leinwand, 2000; McEwan, 2000; Mirra, 2003; NCTM, 2000; Paulu, 1994). For example, some authors claim, instructional leaders should initiate the work needed to improve mathematics curriculum and instruction (Glascock, 2003). To do so, they might first need to convince parents and some teachers that change is needed (Cauley & Seafarth, 1995; Mirra, 2003).
Related to such improvement efforts, according to many writers, is the assessment of educational effectiveness (Leinwand, 2000; McEwan, 2000; Mirra, 2003; Paulu, 1994). As some of these writers suggest, instructional leaders should play a major role in monitoring the mathematics achievement of all students and use achievement data to inform curricular and instructional decision-making at the school and classroom levels (Leinwand, 2000; McEwan, 2000).

In the view of some writers, instructional leaders of mathematics education should also share leadership (Cauley et al., 1993; NCTM, 2000; Mirra, 2003). For example, they should identify from among the mathematics staff one or more teacher-leaders to mentor and support the other teachers (Mirra, 2003; NCTM, 2000). At the high school level, the department chair is often the one who takes on this leadership role (Cauley et al., 1993).

Although there is some agreement in the literature that instructional leaders of mathematics education ought to use the practices described above, there is little empirical evidence supporting these practices. Few studies address either the prevalence or the effectiveness of these practices among principals. Four of these studies illustrate the relevant findings reported to date.

In a study of the implementation of a reform curriculum in mathematics, Price, Ball, and Luks (1995) found that principals had very little knowledge of the changes that the curriculum implicated. Moreover, according to the researchers, teachers were making few changes in instructional practices, and principals targeted far fewer resources toward the mathematics initiative than toward the schools’ literacy initiatives. The researchers
also reported that none of the principals had background, expertise, or experience in mathematics instruction, but that two of the principals had previously been reading specialists. The researchers concluded that administrators’ practices, such as allocation of resources for materials, staff, and professional development, were influenced by their prior knowledge, ideas, and commitments. Administrators’ allocation of resources, in turn, influenced the degree to which teachers took the reform of mathematics education seriously (Price et al., 1995).

Also evaluating principals involved with reform initiatives, St. John, Century, Eggers-Pierola, Houghton, Jennings, and Tibbits (1999) identified practices routinely used by the principals who had successfully improved mathematics education at their schools. According to these evaluators, such principals played an active role in the implementation of the reforms. They spent time in classrooms monitoring the goals and outcomes of lessons, the depth and quality of content, the relevance of instructional methods, and the value of the materials used to help student learn. These principals were able to distinguish effective instructional practices from less salutary ones, and they gave recognition and praise to those teachers who implemented effective practices. Moreover, the principals were quick to give support to teachers as well as to remove obstacles that interfered with the implementation of the reform (St. John et al., 1999).

One dissertation study (Benak, 2002) examined conditions that were associated with principals’ instructional leadership of mathematics reform. The researcher found that secondary school principals who had more positive attitudes toward the NCTM standards were more likely to provide support and direction to teachers. Benak also
reported that female principals were more likely to engage in content-specific instructional leadership than their male counterparts. In addition, principals from urban schools were more likely to provide teachers with direction about how to implement standards-based reform than were principals from suburban or rural schools. Urban principals also appeared to have greater awareness of the NCTM standards than principals of rural schools. Principals from schools with formalized department chair positions were more likely to provide support for the implementation of the NCTM standards than principals from schools without formalized department chair positions (Benak, 2002).

Reporting on interviews with 20 principals of rural high schools, Larson and associates (2006) identified strategies commonly used to foster improvement in mathematics performance. Across the schools, curriculum alignment and mapping, support for individualization, encouragement of changes in classroom practices, and support for collaboration were employed most often. These researchers also found that the principals who could most fully explain the reform of mathematics education were those who had themselves taught mathematics. The researchers concluded that principals relied on their teachers to take responsibility for mathematics reform efforts because they perceived their own knowledge of mathematics education to be limited.

Principals’ knowledge of mathematics education and reform. The study conducted by Larson and associates (2006) and several other studies seem to suggest that high school principals may have little knowledge of what reforms of mathematics education entail (Larson et al., 2006; Price et al., 1995). For example, they appear to have
limited knowledge of the NCTM Standards (Benak, 2002), and only some principals seem to understand what is needed in order to support reforms of mathematics pedagogy (St. John et al., 1999).

*Principals’ knowledge of mathematics content.* Research suggests, moreover, that principals’ understanding of mathematics pedagogy may be linked to their knowledge of mathematics. Some studies have shown, for instance, that principals provide more support for academic content areas about which they are more knowledgeable (Price et al., 1995). Larson and associates (2006) also saw a similar pattern: high school principals who had previously been mathematics teachers seemed to be more engaged with and more supportive of efforts to reform mathematics education.

*Mathematics Education in Rural Schools*

According to Howley (2003), there have been many documents written about mathematics education, but few of those have related to the special circumstances of rural schools. In addition, although one-fifth of all mathematics instruction occurs in rural or small town locales (Silver, 2003), “precious little research” (Silver, 2003, p. 1) exists on teaching and learning of mathematics in the rural context, and most of the documents concerning mathematics education make “no mention of rural places at all” (Howley, 2003, November, p. 2). DeYoung and Theobald (1991) contended, however, that if people are serious about rural school improvement, “particularly in depressed or isolated communities, more in-depth understandings of the cultural and social functions of schools in such places needs to be seen in those who would improve (not just ‘reform’) them.” (p. 12)
According to Glascock (2003), the instructional leadership of the principal is the vital link between the generic mathematics curriculum and the local community’s values and concerns. Rural principals who are successful in creating change have traditionally relied on support from the local school system as well as from the community (Harmon & Branham, 1999). This support seems to work best, according to some writers, when the school and community see themselves in partnership (e.g., Fullan, 1997; Glascock, 2003; Nachtigal & Haas, 2000; O’Neal & Cox, 2002). These writers advocate such partnerships because (1) the local school is one of the primary socialization mechanisms available for a community to use to maintain its “unique characteristics” (Bryant & Grady, 1990, p. 26) and (2) the interaction between schooling and context is important (Howley, 2001).

The interaction between schooling and context can be facilitated through the development, in partnership with the community, of local curriculum that directly relates to the lives of students and their families and “validates the culture and experience of students’ families, acknowledging them as worthy of inquiry” (Smith, 2002, p. 588).

According to some advocates of educational reform, the role of the principal is “to ‘cause’ greater capacity in the organization in order to get better results (learning)” (Fullan, 2001a, p. 65). In their view, capacity building involves the interaction of resources, skills, and culture. Fullan (2005, p. 69), for example, claims that building a new culture in which people have a “daily habit of working together” does not occur without purposeful action. Some writers, moreover, argue that in rural communities where principals are “public leaders” (Morris & Potter, 1999, p. 98), these school
administrators have the potential to contribute not only to educational enhancement, but also to community enhancement.

Statement of the Problem

Educators interested in improving mathematics instruction in rural schools assert that schools should partner with communities to develop curriculum directly related to student’s lives, and they view the principal as the key person to facilitate the process. However, it is not known (1) if principals possess the knowledge and skills to foster improvement in content-specific pedagogies, (2) if principals practice instructional leadership that results in reform of content-specific pedagogy, or (3) if principals understand ways to assist teachers in making content relevant to students’ life experience in communities. Moreover, almost nothing is known about the influence of characteristics of contexts on such knowledge, skills, and practices.

Research Question

This study sought to answer the research question: With gender\textsuperscript{1} controlled, what are the separate and combined influences of principals’ mathematics knowledge, principals’ knowledge of mathematics education and a set of contextual and organizational variables, including locale, school size, per pupil expenditure, free and reduced lunch rate, and the employment of a mathematics department chair, on principals’ perceptions of effective leadership of mathematics education reform?

\textsuperscript{1} For quite some time, studies have shown that males tend to feel less anxiety about mathematics than females (e.g., Altermatt & Kim, 2004; Ma, 1999), take more mathematics courses than females (e.g., Horn, 1990; Tindall & Hamil, 2004), and attain higher mathematics achievement than females (e.g., McGraw, Lubienski, & Strutchens, 2006; Webster, Young, & Fisher, 1999).
This research question embeds theories about likely predictors of principals’ knowledge, skills, and practices. Five such predictors—locale, school size, free and reduced lunch rate, per pupil expenditure, and the employment of a mathematics department chair—describe features of a school’s context; and previous research gives clues about their possible relevance to a study such as this. One predictor, gender, needs to be included as a way to increase the internal validity of the models used to answer the research question. As some research shows, gender affects individuals’ attitudes toward, experience with, and knowledge of mathematics, and, at the same time, the representation of men and women in the principalship may vary based on some of the contextual features that are salient to this study. For example, rural communities may employ fewer females as high school principals than do suburban and urban communities. Below, research justifying the choice of the independent variables to be used in this study is reviewed briefly.

**Locale.** Some previous research points to the possibility that locale might impact high school principals’ mathematics content knowledge as well as their knowledge of mathematics education. Studies seem to show that rural principals in general tend to be less well educated than their suburban and urban counterparts (Reeves & Larmer, 1996; Stern, 1994). And a few studies also show that rural principals have fewer opportunities for professional development than principals in other locales (Howley, Chadwick, & Howley, 2002). Because the academic and professional preparation of rural principals tends to be weaker than that of other principals, these school leaders may have less knowledge of mathematics and mathematics education than principals in other locales.
Locale might also influence the *instructional leadership* provided by principals. Hallinger and McCary (1992), for example, argued that leaders must adapt their practices to the needs of particular students, communities, and schools. These authors claimed that effective leadership looks quite different at a small rural elementary school, a suburban middle school, and a large urban high school.

*School size.* According to some scholars, governance is “simpler and more effective” (Lashway, 1999, p. 4) when schools are small, for example, when the principal and teachers can meet around one table (Meier, 1996) in the absence of bureaucratic overload (O’Neal & Beckner, 1981, as cited in O’Neal & Cox, 2002; Walberg & Walberg, 1994). In addition, principals of smaller schools may tend to confront fewer discipline problems. In a U. S. Department of Education report (1999, as cited in Bailey, 2000), 52% of the principals of smaller schools in contrast to 14% of the principals of larger schools reported having either no or only minor discipline problems (Bailey, 2000). Nevertheless, principals of small schools are more likely to be assigned teaching duties (Walberg & Walberg, 1994) and may have less time to devote to instructional leadership. Taken together, these findings suggest that principals of small schools may have more time than principals of larger schools to devote to instructional leadership.

*Per pupil expenditure.* The per-pupil expenditure of a district may affect a school’s ability to recruit and retain highly qualified mathematics teachers, purchase instructional materials, and provide professional development. According to Harmon and Branham (1999), implementation of standards-based curriculum taxes school resources and may require reallocation of resources, possibly affecting some students more than
others. Small rural schools may face critical financial problems and, according to some authors, “inevitably incur higher per-pupil costs due to limited enrollments, small pupil-teacher ratios, higher utility and other operational costs per pupil, and other factors which limit economies of scale” (Bass & Verstegen, 1992, p. 15).

Free and reduced lunch rate. Socioeconomic status (SES) has been found to have a significant correlation with student achievement. Schools in disadvantaged areas have to “work harder” (Muijs, Harris, Chapman, Stoll, & Russ, 2004, p. 150) to improve and stay effective. Hallinger and Heck (1998) cited several studies in which community SES appeared to influence principals’ leadership and to mediate their impact on school effectiveness. Free and reduced lunch rate is a widely accepted measure of community SES.

Employment of a mathematics department chair. At the high school, the department chair is often the one who takes on the role of mentor and support person for the other mathematics teachers (Cauley et al., 1993). If principals of rural schools perceive their own knowledge of mathematics education to be limited, they may need to rely on their mathematics department chair or lead teacher to take responsibility for mathematics reform efforts (Larson et al., 2006).

Gender of principal. Gender is an important control variable, because women are less likely to be employed as principals of rural schools than as principals of schools in other locales (Howley, personal communication). At the same time, many researchers report that girls have not been afforded the same opportunities to learn mathematics as boys (e.g., Walshaw, 2005), and, as a result, may be less likely to possess mathematics

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2 Howley’s information comes from an unpublished survey of principals in Ohio.
content knowledge. Without a control for gender in the proposed study, the aggregate mathematics knowledge of principals (and the possibly related constructs, knowledge of mathematics education, and mathematics-specific instructional leadership) in different locales might be confounded by the differential gender balance in the principalship across locales.

Significance

This study examined the association of contextual and personal variables with principals’ perceptions of effective leadership of mathematics education reform. Understanding these associations is important for several reasons.

First, if one accepts the premise that content-specific leadership helps to focus a school’s academic mission, then knowing what conditions tend to support content-specific instructional leadership is important.

Second, by using a representative sample to examine important dependent variables relating to principals’ knowledge of mathematics, mathematics education, and leadership of mathematics education reform, the study contributes to a comprehensive description of principals’ competence to support mathematics education reform. Numerous writers, whose points of view were examined in preceding sections of the chapter, argue that such knowledge is an important basis for reform of school mathematics programs. Few empirical studies, however, have thus far investigated the extent to which principals possess knowledge of these domains.

Finally, some writers suggest that rural educators will benefit from an understanding of the conditions that are associated with capacity to reform mathematics
curriculum and instruction. According to these writers, students’ competence in mathematics is especially significant to rural communities whose economic survival may actually depend on cultivating that competence (Long, Bush, & Theobald, 2003). Long and associates (2003) argue, moreover, that mathematics competence must be valued before it can be developed; and, as important community leaders, well-informed principals can mobilize support for strong mathematics programs.

Summary

The types of leadership practices that might work to improve mathematics curriculum and instruction are of interest to people who are concerned about the quality of mathematics education in rural schools. Using logic first offered by Larson and associates (2006), the researcher presented the argument that overall student achievement is indirectly influenced through the influence of leadership on school climate and culture. In addition, certain leadership practices have been shown to influence school climate and culture, but there is no agreement regarding their effectiveness. Moreover, while particular content-specific practices have been recommended for leadership of mathematics education, little empirical work to date has substantiated the extensiveness of those practices, the conditions associated with their use, or their influence on school culture and performance.

In framing this argument, the chapter first listed eight recommended practices summarizing the prescriptive literature concerning what principals ought to do to improve mathematics instruction in schools. Because almost no empirical literature on discipline-specific instructional leadership exists, the researcher used the
recommendations put forth by several authors as a starting point for examining the practices that principals actually use to improve mathematics instruction.

Next, the chapter discussed briefly four empirical studies related to the prevalence or effectiveness of the prescribed content-specific leadership practices. Results from those studies seemed to suggest that high school principals have little knowledge of mathematics education and reform. Moreover, they also seemed to suggest that principals’ understanding of mathematics pedagogy is linked to their knowledge of mathematics.

The sparseness of available research on teaching and learning of mathematics in the rural context was then discussed, followed by suggestions from some writers concerning the value of school-community partnerships in the development of relevant mathematics curriculum and the vital role the school principal has in creating such partnerships.

The problem that was addressed by the study was explained and then conceptualized in the form of a research question. The question focuses on the separate and combined influence of contextual variables and principals’ knowledge of mathematics and knowledge of mathematics education on principals’ perceptions of effective leadership of mathematics education reform. Following the presentation of the research question, the chapter provided empirical support for choosing the independent variables to be tested in the model specified by the research question. Contextual variables of interest were locale, school size, per pupil expenditure, percent free and
reduced lunch rate and the employment of a mathematics department chair. Gender was also discussed as an important control variable.

Finally, the chapter considered the potential significance of the proposed study. If we accept the premise that content-specific leadership helps focus attention on schools’ academic mission and thereby improves schools’ performance, then it is important to know the conditions that tend to support content-specific leadership. By using a representative sample to examine variables found to influence principals’ leadership of mathematics education reform, the study contributes to a comprehensive description of principals’ competence to support mathematics education reform. In addition, knowledge of the conditions that enable principals to mobilize support for strong mathematics programs may be especially significant to rural communities.
CHAPTER TWO

Review of Related Literature

Introduction to the Literature

This study investigated the separate and combined influences of principals’ mathematics knowledge, principals’ knowledge of mathematics education and a set of contextual and organizational variables, including locale, school size, per pupil expenditure, free and reduced lunch rate, and the employment of a mathematics department chair, on principals’ perceptions of effective leadership of mathematics education reform, with gender controlled. The extant literature related to this study (1) examines “instructional leadership” as a construct, (2) makes recommendations for what instructional leaders should do to effectively lead mathematics education reform and (3) discusses discipline-specific instructional leadership in high schools.

Instructional Leadership as a Construct

“Instructional leadership” became a popular idea among educators as an outgrowth of the school effectiveness research of the 1970s and early 1980s (Howley, 1989). According to that research, “instructional leadership” was one of the conditions enabling schools with high poverty to perform above what might be expected on the basis of demographics alone.

Numerous researchers have studied the role of leadership in the improvement of instruction. These studies show associations between particular leadership practices and increased student achievement—associations that nevertheless do not hold up to rigorous scrutiny (e.g., Larson et al., 2006). Still, despite the limitations and contradictions of this
research, it has been summarized via literature reviews and meta-analyses. These summaries of the primary literature reveal 12 domains of practice that seem to characterize instructional leadership.

- Instructional leaders provide and manage resources in ways that enable teachers to be successful (Cotton, 2003; Duke, 1987; Hallinger & Heck, 1998; Hoy, & Hoy, 2003; Marzano, Waters, & McNulty, 2005; Witziers, Bosker, & Krüger, 2003). And they also manage resources well (Cotton, 2003; Duke, 1987; Marzano et al., 2005) through the creative use of personnel and facilities (Cotton, 2003) and the elimination of duplication (Duke, 1987). Principals exercise careful stewardship of resources through their involvement in functions such as class and student scheduling, teacher recruitment and assignment, development of school calendars, textbook adoptions, and acquisition and allocation of instructional materials (Duke, 1987). In addition, they protect instructional time by keeping interruptions to a minimum (Cotton, 2003; Marzano et al., 2005) and by arranging for instructional opportunities for students that extend beyond the regular school day (Cotton, 2003).

- Instructional leaders focus attention on student learning as the primary purpose of schooling (Cotton, 2003; DeBevoise, 1984; Fullan, 2001a; Hallinger & Heck, 1998; Hoy & Hoy, 2003; Marzano et al., 2005). Moreover, they embed this purpose in their schools’ mission and vision statements and communicate this purpose widely, drawing and sustaining everyone’s attention to it (Cotton, 2003; DeBevoise, 1984; Hallinger & Heck, 1998; Hoy & Hoy, 2003; Marzano et al.,
In their efforts to realize such purpose, instructional leaders work with their teachers to establish high expectations for students’ academic performance (Cotton, 2003; Hallinger & Heck, 1998; Hoy & Hoy, 2003; Marzano et al., 2005).

- Instructional leaders recognize student and staff achievement both formally and informally (Cotton, 2003; DeBevoise, 1984; Hoy & Hoy, 2003; Marzano et al., 2005). For example, leaders pay attention to rituals, ceremonies, and other symbolic actions to recognize excellence and honor traditions that are important to the school culture (Cotton, 2003). According to Marzano and associates (2005), instructional leaders base recognition on performance and results rather than on seniority. They also systematically evaluate their school’s performance and acknowledge failures, bringing these to the attention of the school community.

- Instructional leaders develop and nurture meaningful relationships (Cotton, 2003; DeBevoise, 1984; Duke, 1987; Fullan, 2001a; Hallinger & Heck, 1998; Hoy & Hoy, 2003; Marzano et al., 2005) with diverse people and groups (Fullan, 2001a), and they reach out to all stakeholders (Cotton, 2003). They use effective interpersonal skills (Duke, 1987) to maintain open lines of communication (DeBevoise, 1984; Hoy & Hoy, 2003; Marzano et al., 2005). Instructional leaders also create conditions that enable participants to work collaboratively to increase organizational capacity by developing relevant knowledge and skills (Cotton, 2003; Fullan, 2001a; Marzano et al., 2005).
Instructional leaders develop a school culture that promotes academic excellence and on-going improvement (Cotton, 2003; Duke, 1987; Hallinger & Heck, 1998; Hoy & Hoy, 2003; Witziers et al., 2003). They do so by ensuring that the learning environment is orderly and supportive of serious academic work (Cotton, 2003; Hoy & Hoy, 2003).

Instructional leaders continually monitor the school’s curricular, instructional, and assessment practices (Cotton, 2003; DeBevoise, 1984; Duke, 1987; Fullan, 2001a; Hallinger & Heck, 1998; Hoy & Hoy, 2003; Marzano et al., 2005; Witziers et al., 2003). For example, they spend time in classrooms directly supervising instruction (Cotton, 2003; Duke, 1987; Hallinger & Heck, 1998). In addition, they use relevant data in systematic ways to foster the improvement of programs (Cotton, 2003; Duke, 1987; Fullan, 2001a) as well as to track student progress (Cotton, 2003; Hoy & Hoy, 2003; Witziers et al., 2003).

Instructional leaders have extensive knowledge of curriculum and instruction (Cotton, 2003; Hoy & Hoy, 2003; Marzano et al., 2005) and keep up-to-date on current research about effective educational practices (Marzano et al., 2005), particularly those relating to teaching, learning, motivation, classroom management, and assessment (Hoy & Hoy, 2003). Instructional leaders directly involve themselves in decision-making about and planning of curriculum and instruction. For example, they help teachers design curriculum units and lessons to meet particular educational goals (Cotton, 2003; Duke, 1987; Hallinger & Heck, 1998; Marzano et al., 2005; Witziers et al., 2003). Instructional leaders also
provide meaningful feedback to teachers (Cotton, 2003; Fullan, 2001a; Fullan, 2001b) and they share promising practices with teachers (Hoy & Hoy, 2003). In addition, they ask questions that encourage teachers to examine their instructional practices (Cotton, 2003).

- Instructional leaders are visible and easily accessible (Cotton, 2003; Marzano et al., 2005; Witziers et al., 2003). They make systematic and frequent visits to classrooms (Marzano et al., 2005); observe teachers; interact with students (Cotton, 2003); and make themselves accessible to students, teachers, and parents (Marzano et al., 2005).

- Instructional leaders share leadership functions (Cotton, 2003; DeBevoise, 1984; Hallinger & Heck, 1998; Hoy & Hoy, 2003; Marzano et al., 2005). They use leadership teams for decision-making and involve teachers in the development of curriculum (Cotton, 2003) and school policies (Marzano et al., 2005). Instructional leaders also encourage staff members to act autonomously (Cotton, 2003; Marzano et al., 2005). For example, they trust teachers to express divergent opinions, try new methods, and take risks; and they do not punish teachers for doing so (Cotton, 2003; Marzano et al., 2005). In addition, instructional leaders protect staff from intrusions, distractions, and external pressures (Cotton, 2003; Marzano et al., 2005).

- Instructional leaders provide professional development (Cotton, 2003; DeBevoise, 1984; Duke, 1987; Fullan, 2001a; Hallinger & Heck, 1998; Hoy & Hoy, 2003;
Marzano et al., 2005) that is effective (DeBevoise, 1984), continuous (Hoy & Hoy, 2003), and focused on instruction (Cotton, 2003).

- Instructional leaders model the behaviors they expect from others (Cotton, 2003; Fullan, 2001a; Hoy & Hoy, 2003; Marzano et al., 2005) and act in ways that are consistent with their beliefs (Marzano et al., 2005). Moreover, such leaders act with the intention of making a positive contribution (Fullan, 2001a). Their positive attitude conveys the message that staff will also be able to contribute in important ways (Marzano et al., 2005).

- Instructional leaders perform in context (Duke, 1987; Fullan, 2001a; Marzano et al., 2005). Situational awareness enables them to adapt their leadership practices to various circumstances, choosing, for example, to be directive or nondirective as the situation warrants. Instructional leaders are aware of potential problems at their schools (Marzano et al., 2005) and take corrective actions before problems occur or become serious (Duke, 1987).

Examination of these domains of practice reveals them to be somewhat general, lacking detail about the ways principals work with teachers to improve instruction in particular disciplines. Little research, however, has investigated instructional leadership practices that are discipline-specific (Larson et al., 2006). There may have been little interest in making instructional improvements in specific disciplines, including mathematics, because there were few consequences associated with poor student achievement in specific content areas. In response to the federally mandated testing requirements of the Elementary and Secondary Education Act (U. S. Department of
Education, 2001), states have developed a standardized testing program for grades 3-8 reading and mathematics. Student performance data has become readily available to schools and the public; schools and districts are held accountable and are subject to sanctions when students do not reach achievement standards. If student achievement gaps are evident in a specific content area, then it is likely that instructional leaders might focus their attention on that content area.

Recommendations for Leadership of Mathematics Education Reform

Despite the lack of research on discipline-specific leadership practices, especially related to leadership of mathematics reform, several authors have made recommendations for what leaders should do. This section provides a summary of their prescriptions.

The National Council of Teachers of Mathematics (NCTM, 2000) developed the Curriculum and Evaluation Standards for School Mathematics in 1989 in order “to develop and articulate explicit and extensive goals for teachers and policymakers” (p. ix) working to improve mathematics education. NCTM (2000) published the Principles and Standards for School Mathematics as a resource and guide for “all who make decisions that affect the mathematics education of students” (p. ix). In these documents, the role of the school administrator is specified: their role is to ensure “that mathematics expertise and leadership are developed in their schools or systems” (NCTM, 2000, p. 376). In particular, according to the NCTM documents, administrators should influence the quality of mathematics education through the following practices: arranging for meaningful professional development; providing libraries and Web access to instructional and other materials; fostering cross-school conversations about goals and instructional
practices; arranging teachers’ work schedules so that collaboration with colleagues is a part of the school day; establishing programs for teacher-leaders within their schools or systems; hiring and mentoring teachers in order to strengthen the focus on mathematics instruction; working to align curricular materials, technology, and assessments with goals for mathematics education; establishing effective processes for analysis and selection of mathematics instructional materials; and considering the impact of high-stakes assessments on the instructional climate (NCTM, 2000).

Cauley, Van de Walle, and Hoyt (1993) evaluated the extent to which the NCTM Standards had been implemented in the Richmond, Virginia Metropolitan Educational Research Consortium, and concluded that the standards had not been implemented evenly. They surveyed 1,892 teachers and 108 principals and conducted focus groups with 24 selected teachers. The evaluators recommended practices that principals should use to promote implementation: cultivate lead teachers; encourage mathematics department chairs to become instructional leaders; provide time for teachers to observe one another’s teaching and collaborate in the design and evaluation of instruction; provide quality professional development focusing on specific classroom issues related to teaching mathematics; become knowledgeable about the NCTM Standards; supply teachers with professional mathematics journals and books; encourage teachers to attend conferences, workshops and university courses related to mathematics teaching and learning; reward teachers who participate in relevant professional development; and examine issues and concerns related to technology (e.g., student access to calculators) (Cauley et al., 1993).
Paulu (1994) drew on information from a conference to propose recommendations for educators engaging in the reform of math and science instruction and assessment. Among the recommendations were those directed to principals and other educational administrators. With regard to the curriculum, Paulu noted that principals and administrators “will make certain that the curriculum reflects what we want our students to know and be able to do, and they will take steps to assure that the assessment system is consistent with the curriculum” (p. 3). To support the use of new forms of assessment, Paulu claims administrators “will see that resources are available so teachers and other district educators can receive current information and training on using new forms of assessment” (p. 3). According to Paulu, administrators also should “ensure that an appropriate balance is struck between tests (which are used largely for accountability) and assessments (which are used primarily to improve instruction)” (p. 3) and leaders “must recognize the strengths and limitations of varying forms of assessment and take steps to assure that each assessment is used for its intended purpose” (p. 4). The final recommendation is that principals and other administrators “will make certain that new forms of assessment, as well as existing ones, are not used to discriminate against any cultural or ethnic group or individual, or against students of either gender.” (p. 4)

Cauley and Seafarth (1995) called for a “fundamental restructuring of the mathematics curriculum” (p. 22) requiring the “full support” (p. 22) of the principal, urging principals to “familiarize themselves with the [NCTM] Standards and the changes in curriculum, instruction, and assessment they advocate” (p. 23). The authors recommended actions principals should take in order to support mathematics reform. “As
the instructional leader of the school, principals will need to convince some teachers and parents that change is essential.” (p. 28) In addition, principals should provide long-term professional development for teachers, including activities such as discussions on common readings and videotapes, seminars, demonstrations and curriculum revision projects. The authors encouraged principals not only to facilitate collegial coaching among mathematics teachers, but also to “facilitate communication between mathematics and other teachers so that students can learn true problem solving and reasoning in all areas” (p. 28). They also saw the need for administrators to consider restructuring the school day as a way to give students adequate time to engage in inquiry and problem-solving. And, with longer class periods or shared study halls, the authors claimed that teachers would have time to participate in activities such as: observing one another, working to revise curricula, and developing new methods of assessment. According to Cauley and Seafarth, principals should also provide resources to enable teacher to acquire instructional materials such as computers, software, graphing calculators and manipulatives. In addition, these authors believe that principals should deemphasize “the importance of current standardized tests and, most important, convey that message to the community. Unless our expectations for assessment change, the efforts at mathematics reform are in serious trouble.” (p. 29)

In a guide written to “help school leaders help the people they work with to change their beliefs and biases, their perspectives and understandings, and ultimately their behaviors—all in pursuit of higher levels of mathematics achievement by greater numbers of students” (p. x), Leinwand (2000) recommended three leadership strategies to
improve mathematics achievement: “granting permission, validating outliers, and catching the flak” (p. 77). According to the author, principals should give teachers permission to skip unnecessary lessons or even whole chapters in textbooks, try new materials, or experiment with portfolios. As the author noted, “Instead of telling people what to do, an alternative strategy is giving people permission to do what you would like them to do anyway” (p. 77). With respect to validating “outliers,” Leinwand was referring to those teachers who excel with their students of mathematics. This author recommended that school leaders give extra support to efforts undertaken by these exceptional teachers:

We need to assure them that the eccentricity so often ascribed to them is a crucial and valued source of their professional competence. We need to reassure them that their time and efforts truly are appreciated. And we need to provide opportunities for networking and sharing among these atypical educators. (p. 78)

According to the author, principals who accept responsibility for “catching the flak” protect teachers by meeting with disgruntled parents or guidance counselors and “intercede when administrators prevent teachers from moving ahead…. Assume responsibility and don’t leave others holding the bag” (p. 79). Leinwand also explains that administrators can be effective in strengthening a mathematics program “by encouraging experimentation, by facilitating the review and use of school and district assessment data, and by keeping concern for student achievement in mathematics on the front burner at all times.” (p. 92) The author recommends that leaders should maintain focus on classroom instruction, use assessment as a powerful tool, ground everything in
concrete examples, “toot our own horns” (p. 94), and “remember how much difference one person can make” (p. 95).

McEwan (2000) authored a guide advising principals about how to raise mathematics achievement. She encouraged principals to examine a list of manipulable school characteristics and determine which might need to be addressed at their schools: critical mathematics content; coordination and articulation of mathematics content; materials used to teach mathematics; instructional methods used to teach mathematics; expectations for how much content every student can learn; and methods for assessing students’ mastery of the content. Environmental variables were also listed that “if changed could have an impact on mathematics achievement” (p. 29). These included parent-teacher communication, student discipline, and teacher morale. The author also provided recommendations specific to the role of high school principals: offer all students four years of mathematics, regardless of ability level or prerequisite learnings; offer extra help to struggling students, for example through tutorials, Saturday school, or peer assistance; provide for differences in learning rates by offering courses at different levels of difficulty and with variable entry points; carefully monitor the quality and rigor of each course in the high school mathematics sequence; develop a plan to monitor the mathematics achievement of all students and to assess curricular and instructional effectiveness; develop collaborative working relationship; and provide consistent and ongoing training for teachers (McEwan, 2000).

Mirra (2003) also wrote an administrator’s guide that recommended ways for school leaders to support and improve their schools’ mathematics programs. This author
organized a variety of specific leadership practices around the six NCTM Principles: Equity, Curriculum, Teaching, Learning, Assessment, and Technology. In the area of Equity, Mirra said that administrators should create a school climate in which there are high expectations for all students, energize students and teachers in order to change current expectations, and evaluate student placement to ensure that all students receive a challenging mathematics program. In the area of Curriculum, this author explained that administrators should establish processes for the selection of instructional materials that engage teachers and leaders in careful analysis, allow for vertical and horizontal articulation of the mathematics curriculum help families understand the curriculum, and provide access to resources and instructional materials. According to Mirra, administrators should focus on Teaching by supporting sustained professional development that increases teachers’ mathematics and pedagogical knowledge; supporting collaboration among colleagues and supervisors that encourages teachers to analyze, evaluate and improve their teaching; arranging teacher work schedules to include time for collaboration; establishing mentorship programs to provide support for mathematics teachers; spending time observing mathematics classrooms; recruiting qualified mathematics teachers; making teaching assignments on the basis of teacher qualifications; encouraging teachers’ attendance at professional conferences; participating in professional development designed to increase their own knowledge about the goals and methods of effective mathematics instruction. Mirra also claimed that administrators should take particular actions in order to support the NCTM Learning standards: (1) ensure that sufficient time is devoted to mathematics instruction, (2) at the
high school level, ensure that every student has the equivalent of one year of mathematics instruction at each grade level; (3) explain the importance of learning mathematics with understanding to families and teachers; and (4) develop a plan to support struggling students. To support the Assessment standards, this author thought an administrator should make sure that (1) assessments are aligned with the curriculum, (2) high stakes assessments do not have a deleterious effect on the school’s instructional climate, (3) student placement decisions are not made on the basis of a single test, (4) teachers are employing a variety of assessment strategies to measure conceptual as well as factual and procedural understanding, and (5) teachers rely on daily formative assessment in planning and evaluating instruction. Mirra also recommended additional practices for supporting Technology standards: ensuring that technology is being used to enhance learning, ensuring that access to technology is equitable, developing a comprehensive plan for infusing technology into the mathematics curriculum, and providing professional development to help teachers use technology effectively.

In a position paper, Glascock (2003) asserted that, although the principal’s influence on student achievement is indirect, he or she can form the vital link between a generic curriculum developed elsewhere and the concerns and values of a local community. Her paper addressed several issues relating to the principals’ role: the importance of instructional leadership the contribution of community to learning in the rural context, and the value of experiential teaching and learning of mathematics. With regard to specific actions for rural principals, her recommendations include: working in partnership with teachers to “contextualize mathematics learning and teaching to the rural
context” (p. 11); “structur[ing] the learning and teaching environment for actual people, and not for remote and disparate disciplines (p. 14); and develop[ing] the capacity of the school to sustain a climate that supports quality pedagogy for mathematics and other content areas.

Overall, the prescriptive literature provided many ideas about what leaders should do in order to lead reform of mathematics education in their schools. It did not, however, provide insight into the instructional leadership practices that principals actually use.

*Discipline-Specific Instructional Leadership in High Schools*

A search using the ERIC descriptor “Instructional Leadership” resulted in 2339 entries. Delimiting the search to research reports for high schools or secondary education from 1989 to the present reduced the number of entries to 69. Of those, only 18 related to the principal’s role in instructional improvement in general. There were also very few studies focusing on the principal’s role in instructional improvement in specific content areas. An ERIC search for literature since 1989 relating to mathematics reform, educational change and principals’ role yielded 18 entries consisting of descriptive studies, evaluation reports, prescriptive guides, personal accounts, and one complete journal from the Hong Kong Teachers Association.

Because the ERIC searches yielded so few research reports concerning mathematics reform, the literature reviewed in this section is presented thematically, six themes related to the role of the principals were evident in this small body of literature: shaping a vision for reform, inspecting what is expected, distributing leadership, providing structure, providing supports, and building strategic relationships.
Shaping a vision for reform. In many studies, effective principals are those who provide an overall sense of purpose to staff and act as guides who coordinate what has to be done (Verona & Young, 2001). According to most research, instructional leaders see themselves and are viewed by others as having a vision for the future (Campbell & Cordiero, 1996; Kersaint, Borman, Lee, & Boydston, 2001; King, 1991; Leech & Fulton, 2002).

In some studies, part of the principals’ role in shaping and maintaining a vision seemed to involve nurture of the vision as well as commitment to the staff—a stance that was manifested in the principals’ efforts to protect and defend teachers and other educators (e.g., Campbell & Cordiero, 1996). Other school leaders also have appeared in some studies as the ones who play this role (e.g., King, 1991). From the perspective of teachers, principals or other administrators who were instructional leaders empowered them to develop cooperative goals (i.e., a vision), motivated them to work toward the achievement of this vision, and showed them respect and trust (Bobbett & French, 1992; Leech & Fulton, 2002).

Some research reports provided specific examples. In one of these examples, a principal shared assessment data with the school improvement team, and then the entire faculty reviewed and discussed the data as a group and in committees. They determined the major implications of the data and used the information to update the school improvement plan and make adjustments in courses and assignments for the following year (SREB, 1999c). In a case specifically related to mathematics reform, a principal
shared state mathematics assessment data with teachers and a team of teachers developed a plan to improve mathematics education in the school (Vann, 1996).

*Inspecting what is expected.* In studies of instructional leadership, principals described themselves as monitoring teachers to make certain that teachers were providing the type of instruction that was expected (Kersaint et al., 2001; Mitchell, Russell, Benson, Chambers, & Just, 1990). Principals also purportedly use similar strategies for supervising practices relating to curriculum, instruction, and assessment (Farrell, 1989). Principals have been observed or have reported spending time in classrooms to evaluate and supervise teachers (Brown, 1993; SREB, 1999a; St. John, Century, Eggers-Pierola, Houghton, Jennings, & Tibbitts, 1999) in an effort to obtain “firsthand knowledge of what is happening” (St. John et al., p. 16).

In one study, a high school principal who took instructional leadership seriously made 20 to 25 classroom visits per week, reviewed lesson objectives, and provided feedback to teachers about their instruction (SREB, 1999a). In another study, principals who were instructional leaders were able to identify and give praise to teachers who used exemplary practices and thereby helped the school move ahead (St. John et al., 1999).

At one high school that was studied, the principal evaluated teachers based on criteria such as using a variety of teaching strategies in each lesson, actively engaging students in the learning process, making sure students were on task, and connecting content to real-life problems. The principal of the school asked those teachers “who were unwilling to hold students to high standards and teach challenging content” (SREB, 1999a, p. 5) to seek employment elsewhere.
Although principals in many high schools are responsible for evaluating teachers, some studies reveal that department chairs also are expected to provide supervisory leadership of teachers within their own disciplines. In one study department chairs approved examinations and were responsible for making sure that curriculum guidelines were being followed (Brown, 1993). In another study, principals of high schools in which the mathematics department chair had supervisory responsibilities were found to provide more support for mathematics education reform than principals of high schools in which the mathematics department chair did not have supervisory responsibilities (Benak, 2002).

**Distributing leadership.** Principals can delegate or distribute leadership to other professionals in their schools, such as counselors, teachers, and department chairs. Advantages of delegating leadership include improvement of the quality of decisions made, greater commitment from subordinates, and expansion of overall leadership capacity (Yukl, 2002). In one study, a principal delegated leadership of an instructional technology program to teachers; as teachers assumed leadership, the principal played the role of “cheerleader” (Campbell & Cordiero, 1996).

Principals sometimes delegate responsibility to department chairs, and in one study, department chairs worked to ensure “that teachers have input into curriculum decisions, that their ideas are listened to, and that they are provided the support they need” (Brown, 1993, p. 34). In another study, social studies department chairs facilitated team planning, supervised instruction, promoted the practice of peer observation, and taught demonstration lessons (King, 1991).
According to some research, the high school department chair was the one who took on the role of mentor and support person for the other mathematics teachers (Cauley et al., 1993). In other studies, researchers concluded that principals relied on strong mathematics teachers or outside experts to lead mathematics reform efforts because their own knowledge of mathematics reforms was limited (Larson et al., 2006; Price, at al., 1995). In one study principals reported that regularly scheduled mathematics department meetings tended to encourage reform of mathematics education (Larson et al., 2006).

Providing structure. Findings from some studies showed that principals used curriculum alignment and mapping to support mathematics education reform (Larson et al., 2006; Vann, 1996). In one of these studies, principals directed teachers from each grade level to prepare scope and sequence pacing calendars and to develop performance based assessments (Vann, 1996).

In several case studies (SREB, 1997a, 1997b, 1997c, 1997d, 1999a, 1999b, 1999c, 2000), school leaders played a role in structuring the curriculum by replacing the general curriculum track with a more challenging curriculum; increasing graduation requirements in mathematics, science and English; and developing or facilitating the development of a support system for providing extra help to struggling students. For most case study schools examined in this research, the school day was restructured and block scheduling was adopted (SREB, 1997a, 1997b, 1997c, 1997d, 1999b, 1999c, 2000).

Providing supports. Studies of some instructional leaders show that they tend to place high importance on providing support for effective classroom practices (Brown, 1993). According to Price and associates (1995), principals’ allocation of resources for
materials, professional development and staff influence teacher’s priorities and can have “crucial consequences” (p. 22) for any reform agenda. As St. John suggested, when a principal provides visible and noticeable supports, he or she is sending a signal that the reform is important.

In several studies, researchers reported that principals provided teachers with release time for professional development (Hagstrom, 1992; Kersaint et al., 2001; SREB, 1999b; Vann, 1996; Verona & Young, 2001) or the resources needed to enable teachers to enroll in coursework (Kersaint et al., 2001). In one case, the principal approved teachers’ requests for mathematics manipulatives and calculators and also provided other NCTM materials (Vann, 1996). Some research also indicated that principals contact presenters to arrange workshops specifically directed at mathematics reform (Larson et al., 2006; Vann, 1996). Despite efforts such as those mentioned above, researchers have found in general that resources for professional development, materials and support personnel for available for reading and literacy education far surpassed those available for mathematics education (Price et al., 1995).

Building strategic relationships. Some research showed ways that principals built strategic relationships on behalf of instructional improvement. In one study principals of schools with strong mathematics and science programs were found to have “strong relationships with the students, with the teachers, and with the disciplines they are teaching” (St. John et al., 1999, p. 11). In another study principals described themselves as fulfilling the roles of coach and mentor (Kersaint et al., 2001), and in another they modeled the behaviors they expected from others (Mitchell et al., 1990). Some studies
revealed that strong instructional leaders participated in staff development along with their teachers (SREB, 1999b) and spent time talking and working with teachers in team meetings (Huinker & Coan, 1999; Huinker, Coan, & Posnanski, 1999).

Another role of principals who function as instructional leaders is to create conditions that enable teachers to work collaboratively in the development of relevant knowledge and skills (Chance & Anderson, 2003). Principals in one study invited science teachers to talk openly and frequently about science instruction and provided time for science teachers to meet with one another (Chance & Anderson, 2003). Teachers were asked to travel together to conferences and workshops “on how to change what is taught, how it is taught, and what is expected of students” (SREB, 1999b, p. 8).

Some principals who undertake instructional improvement have been found to involve parents, students, teachers and community members in the formulation of school policies (Verona & Young, 2001). In some schools this involvement is institutionalized in a shared decision making council that includes parents and business partners (Huinker & Coan, 1999; Huinker et al., 1999).

A few studies reported on instructional leaders who formed partnerships with local businesses and colleges (Hagstrom, 1992; Larson et al., 2006). Others found evidence that instructional leaders encourage and give support to teacher and community projects involving students (Hagstrom, 1992). In one case, the principal released teachers to work with university professors for professional development in mathematics and science content. The teachers then requested that the professors teach with them in their
classrooms to show them how to adapt the new content to the needs of public school students (Hagstrom, 1992).

Gaps in the Extant Literature

Despite the availability of some relevant information about content-specific leadership, numerous gaps in the literature still exist. The literature concerned with generalized instructional leadership seems inconclusive. The literature related to mathematics reform appears to be mostly prescriptive in nature. The studies relating to instructional leadership in high schools are concerned with generalized practices related to the management of instruction or the distribution of leadership to others, and few have addressed discipline-specific instructional leadership. Few studies have been conducted to determine the extent to which principals actually employ the practices prescribed in the literature or the effectiveness of the prescribed practices when they are used.

Attention to the influence of locale of the schools is missing in the literature, and some school types appeared more frequently than others in both the research reports related to instructional leadership in high schools and in the literature related to reform of mathematics education. (A more detailed description of the limited representation of rural locales in the literature is presented in Appendix A.)

Moreover, principals’ knowledge of mathematics reform, regarded as essential in the some of the prescriptive literature, is only addressed in a cursory way in the extant literature. None of the studies relating to instructional leadership in high schools mentioned the degree to which principals’ knowledge in specific content areas might affect their ability to make informed decisions regarding curriculum, instruction, and
assessment. Of the literature related to the principals’ role in mathematics reform, only two descriptive studies (Larson et al., 2006; Price et al., 1995) and one evaluation report (St. John et al., 1999) specifically referred to principals’ knowledge of mathematics reform.

Summary and Conclusions

The chapter began with a brief explanation of the proposed study and a listing of the way the researcher chose to organize the sections of related literature. The first section was concerned with instructional leadership as a construct and consisted of synopses of literature reviews and meta-analyses that summarized the work of numerous researchers who studied instructional leadership and associated generalized practices to determine the effect of principals’ instructional leadership on meaningful outcomes.

The second section summarized the prescriptive documents that made recommendations for what leaders should do to support mathematics education reform. And the third section of the chapter presented the small body of literature related to actual practices of principals involved in instructional leadership activities. This section was organized according to six salient themes in the literature: shaping a vision for reform, inspecting what is expected, distributing leadership, providing structure, providing supports and building strategic relationships.

Gaps in the extant literature were discussed in the fourth section of the chapter. Especially noted was the lack of attention to two issues: (1) what principals actually do to lead mathematics education reform and (2) the role of locale and type of school on principals’ knowledge of mathematics reform.
From the review of the literature for this study, some generalizations can be made. Instructional leadership from the principal has been found to positively influence student achievement, but there has been no consensus on which generalized practices are most effective. The empirical literature related to instructional leadership in high schools since 1989 is unsystematic, and the subset of studies related to improvement in specific content areas is sparse. The descriptive literature related to instructional improvement in mathematics is also sparse and unsystematic. In addition, little research has been conducted concerning mathematics education in specific locales, especially in rural schools. A vast majority of the literature reviewed for the current study focused on urban schools, and in only three instances was the reader able to distinguish among rural, suburban, and urban locales. Most studies related to the improvement of mathematics instruction focused on elementary schools. Few studies have been conducted that have anything to do with principals’ practices concerning mathematics education at the high school level.
CHAPTER THREE
Methodology

Purpose

The purpose of the study was to examine the association of contextual and personal variables with principals’ perceptions of effective leadership of mathematics education reform. The research question that the study investigated was:

With gender controlled, what are the separate and combined influences of principals’ mathematics knowledge, principals’ knowledge of mathematics education and a set of contextual and organizational variables, including locale, school size, per pupil expenditure, free and reduced lunch rate, and the employment of a mathematics department chair, on principals’ perceptions of effective leadership of mathematics education reform?

Research Design

The study involved a survey of a random sample of high school principals in Pennsylvania. Using data from the survey, the researcher performed statistical analyses that addressed the research question specified above.

Identification of Population

The population examined in the study consisted of principals employed in public high schools in Pennsylvania. The percentage distribution of public elementary and secondary students in rural schools in Pennsylvania in 2003-2004 was 20.7%. The percentage distribution of public elementary and secondary students in rural schools in the nation in 2003-2004 was 21.3%. When compared to the percentage distribution of
rural students for all other states and the District of Columbia, Pennsylvania’s percentage of rural students most closely matched the national distribution of rural students. Differences in percentages of rural students ranged from 0.6 (Pennsylvania) to -32.1 (Maine) (U. S. Department of Education, 2007b).

**Sampling Plan**

*Sample.* The researcher drew the sample from the Common Core of Data (CCD) (NCES, 2006) data base. It consisted of regular schools in Pennsylvania excluding those with grade levels six and below and including those with grade level twelve.

*Sample size.* The sample was stratified by locale. The researcher determined the appropriate sample sizes for city, suburb, town and rural principals by identifying the number of high schools in each locale group based on the operational definitions of high school and locale described in the previous chapter. The researcher used information from the 2003-2004 CCD (NCES, 2006) and discovered that there were 596 public high schools in Pennsylvania of which 83 or 13.9% were city, 220 or 36.9% were suburb, 108 or 18.1% were town and 185 or 31.0% were rural. Using these data and a sample size calculator located at http://www.surveysystem.com/sscalc.htm, the researcher determined that 77 city, 183 suburb, 98 town and 158 rural high school principals were sufficient for responses to be accepted as representative at a 95% confidence level in consideration of a 3% confidence interval.

*Sample selection.* The researcher drew a stratified random sample proportionally representative of the population of city, suburb, town and rural high school principals.
The researcher randomly selected the appropriate number of schools in each grouping using the procedure that follows.

First, the researcher used the “Sampling” feature in Microsoft Excel to generate random numbers corresponding to the number of cases specified for each locale group in the sample size section. The researcher imported the random number list spreadsheet and the school listing spreadsheet for each locale group into Microsoft Access. Next, the researcher used the relational database features of Microsoft Access to query the entire sample for the random numbers, thus producing a listing of only those schools that comprised the stratified sample.

Instrumentation

The instrument used in the study was a questionnaire. It consisted of items related to demographic characteristics of the high school principals and their schools and items related to the principals’ mathematics instructional leadership practices, mathematics content knowledge, and mathematics education knowledge.

Development of the instrument. The researcher consulted with several experts throughout the development of the instrument, beginning with asking for suggestions on the domains of literature that might assist her in item selection and development. As the literature review progressed, the researcher e-mailed several additional researchers to ask for advice or permission to use or adapt items from existing sources. Finally, the researcher sought feedback regarding the validity of the items chosen for the instrument. The researcher also investigated empirical work related to the measurement of the constructs identified in the research question. A brief summary of the findings follows.
The researcher decided to use indirect methods for measuring mathematics content knowledge because it is impractical to ask respondents to complete a mathematics skills test. Adult respondents may feel threatened by knowledge questions (Bradburn, Sudman, & Wansink, 2004) and therefore be reluctant to complete a mathematics skills test, elect not to participate, potentially lowering response rates. Moreover, knowledge questions are generally not appropriate for self-administered surveys, because the respondent might look up correct answers or consult with others (Bradburn et al., 2004). In addition, in order accurately to determine the mathematics skill set of a respondent, it would be necessary to ask many questions, further decreasing the likelihood of respondent’s willingness to participate in the study (Babbie, 2002).

Mathematics content knowledge. Course taking patterns have served as a proxy for knowledge in numerous situations. High school transcripts have been long been relied upon as predictors of college achievement (e.g., Judy, 1975; Sexton & Goldman, 1975). College transcripts have been used to evaluate the educational quality of general teacher preparation programs (e.g., Galambos, 1985; 1986, Fall) as well as the academic preparation of science and mathematics teachers (e.g., Chaney, 1994; Southern Regional Education Board, 1985). Horizon Research (2000) conducted a survey of mathematics teachers for which they developed an item asking respondents to select mathematics courses they had taken from a listing of mathematics courses. Written permission to use the item was obtained from a representative of Horizon Research (I. R. Weiss, 2006, personal communication).
Mathematics self-efficacy, “a situational or problem-specific assessment of an individual’s confidence in his or her ability to perform or accomplish a particular task or problem” (Hackett & Betz, 1989, p. 262), has been found to be a stronger predictor of mathematics-related educational and career choices than mathematical performance and past mathematics achievement (Hackett & Betz). In addition, students’ confidence in performing mathematics tasks has been linked to mathematics content knowledge (Rector, 1993). The researcher investigated the Mathematics Self-Efficacy Scale (MSES), purported to be composed of reliable and valid scales (Langenfeld & Pajares, 1993), but the 52-item length of the instrument caused the researcher to seek a more feasible alternative with fewer items.

Nielsen and Moore (2003) developed a scale designed to measure mathematics self-efficacy at the level of domain correspondence (e.g., algebra, geometry, trigonometry, and so on) rather than at the specific task level employed in previous instruments. According to Nielsen and Moore, measurement of self-efficacy at such a specific task level may mean that every self-efficacy study would require its own tailored instrument, making the research costly and time-consuming. In addition, the researchers contended that it would seem unlikely that a respondent with high self-efficacy for one algebra problem would have low self-efficacy for another algebra problem. Principal component analysis of the scale revealed that all correlations were greater than .40 and one component—mathematics self-efficacy—accounted for 49% of the total variance. The overall internal consistency reliability of the scale was .93 (Cronbach’s alpha). Construct validity was indicated by significantly positive correlations with self-reports of
immediate past grades for mathematics and performance on a mathematics self-concept test. In addition, discriminate score validity was demonstrated by lack of correlation between the scale and self-reported desired grades in English, while concurrent validity was demonstrated by significant correlations between the scale and self-reported desired grades for mathematics. Based on the evidence, the researcher decided to use the scale and sought and obtained written permission from K. A. Moore (2006, personal communication) to use it.

Knowledge of mathematics education. For reasons similar to those provided in the previous section, the researcher decided to use indirect methods to measure knowledge of mathematics education. As suggested by Bradburn and associates (2004), the use of questions that appear to be asking for attitudes can tap into knowledge, especially on self-administered questionnaires.

Horizon Research (2006) developed a questionnaire designed to evaluate the effectiveness of a long-term statewide teacher professional development initiative for mathematics and science. Flora and Panter (1998) performed separate exploratory factor analyses and reliability analyses on random samples from the science and mathematics data sets to eliminate and revise items; however, reliability and validity information for each individual variable was not provided. The potential scales were tested using confirmatory factor analyses on a second and third random sample from the original data sets. Results from comparisons of the two samples indicated that the constructs were “quite similar in content” (p. 6). One variable consisted of ten Likert-scaled items to measure principals’ attitudes toward reform-oriented teaching. The items have been
employed yearly since 1998, and descriptive statistics for principals’ responses have been reported (Crawford & Banilower, 2004). The researcher received written permission from Horizon Research to use or adapt items included in the surveys under the condition that appropriate citations were provided (I. R. Weiss, 2006, personal communication).

**Leadership of mathematics education reform.** According to Babbie (1990), although survey research does not permit the direct measurement of behavior, it does permit the indirect measure of behavior. Reports of past and prospective behaviors of respondents can lead to the generation of useful data (Babbie, 1990).

Benak (2002) developed items designed to measure the degree to which a secondary school principal engaged in mathematics instructional leadership behaviors specifically supportive of the implementation of the NCTM Standards (2000). The researcher decided that several items from Benak’s study could be used in the current study if items were revised to reflect a general reference to mathematics standards rather than a specific reference to NCTM standards. The researcher contacted Benak for written permission to adapt the items, which was granted (D. R. Benak, 2006, personal communication). The researcher chose to expand the construct of mathematics instructional leadership practices to include other authors’ recommendations as well.

Following the development of the content of the questionnaire, the researcher used a web based survey tool (Survey Monkey, 2006) to design the online version of the questionnaire. The researcher decided to use a web-based survey because Internet surveys have been found to decrease the cost of large-scale surveys, accelerate data collection and
retrieval, reduce data transcription errors, and allow for better targeting of respondents (Tingling, Parent, & Wade, 2003).

**Pilot study.** The researcher conducted a pilot version of the survey in order to assess the technical adequacy of the scales, elicit feedback about the wording of items, and gain information about the utility of the online format. She distributed the survey and received responses through a Survey Monkey (http://www.surveymonkey.com) account. Survey Monkey is a web-based tool that enables users to create questionnaires and collect data from respondents.

Using the Ohio Educational Directory provided on the Ohio Department of Education’s website, the researcher located e-mail addresses for all Ohio high school principals. Then she sent e-mail messages to all 594 high school principals, requesting their participation in the pilot study and explaining the purpose of the feedback section of the questionnaire, which included open-ended questions to elicit comments regarding the design and user-friendliness of the web-based approach and the clarity of items (Tuckman, 1999). The e-mail also included a link to the Uniform Resource Locator (URL) at which the questionnaire could be accessed as well as instructions for completing the online questionnaire. A copy of the message is provided in Appendix B.

Within the first week of sending the e-mail message, the researcher received 50 error messages indicating undeliverable e-mail and 34 completed questionnaires. Only five more responses were received by the requested date for submission, so the researcher sent a follow up e-mail message (Appendix C). Twenty more questionnaires arrived in
the days following the second mailing. Altogether the researcher received a total of 59 responses from the 544 principals, for a response rate of 10.85%.

Because there were so few responses from Ohio, the researcher also chose another state to include in the pilot study. She looked for a state where e-mail addresses of principals were readily accessible through a statewide database. The researcher found that she was able to use the Iowa Basic Education Data Survey to locate e-mail addresses for all 357 high school principals in Iowa, and she sent e-mail messages requesting their participation. She followed the same procedures as she had for the Ohio e-mailing. Survey Monkey sent 37 error messages indicating undeliverable messages. Overall, following two e-mail requests, the researcher received 70 responses from the 320 principals for a response rate of 21.88%. The total number of respondents from both states was 129, resulting in a combined response rate for the pilot study in both Ohio and Iowa of 14.93%.

The researcher summarized the information received from the feedback forms and made appropriate adjustments to the wording of items. A summary of the feedback and a discussion of the adjustments made to the study are reported in Chapter Four. Because the online approach yielded such low response rates, the researcher decided to mail the revised questionnaire and conduct multiple mailings and follow up with telephone calls and e-mails until acceptable return rates for each locale were reached in order to maximize the return rate for the actual study.

The researcher decided to conduct the study in a large state with varied locales. By examining information in the Common Core of Data (NCES, 2006), she determined
that Pennsylvania would be a good state in which to conduct the study because it maintained adequate numbers of high schools in rural, town, city and suburban locales. As stated earlier, the percentage distribution of students in rural public schools in Pennsylvania most closely matched that of the national distribution of students in rural schools in 2003-2004 (U. S. Department of Education, 2007b).

Data Collection

For the actual study, data were collected by sending a cover letter (Appendix D), questionnaire and self-addressed stamped envelope to randomly selected Pennsylvania high school principals from each locale. The researcher monitored response rates and sent a second mailing to non-respondents as a reminder. When the response rate from the second mailing waned, the researcher searched the Internet and located school websites for non-respondents. The researcher continued to telephone or e-mail non-respondents until the end of the school year, but no additional questionnaires were received.

Response rate. A total of 516 questionnaires, cover letters and self-addressed stamped envelopes were mailed to randomly selected principals in each locale on March 26, 2007. Participants were asked to return completed questionnaires by April 13, 2007. A second mailing was sent to non-respondents on April 18, 2007 and participants were asked to return completed questionnaires by May 15, 2007. The researcher made telephone calls and sent e-mails to non-respondents until Memorial Day. No responses were received after May 29, 2007. A total of 260 of 516 questionnaires were returned for an overall response rate of 50.4%. Because the sample was stratified by locale, the researcher determined the response rate for each locale group. From city schools, 30 of
260 or 11.5% of the questionnaires were returned. From suburban schools, 96 of 260 or 36.9% of the questionnaires were returned. From town schools, 47 of 260 or 18.0% of the questionnaires were returned. From rural schools, 87 of 260 or 33.4% of the questionnaires were returned. The sample proportions closely resembled the population proportions by locale. Of the 596 public high schools in Pennsylvania, 83 or 13.9% were city, 220 or 36.9% were suburb, 108 or 18.1% were town and 185 or 31.0% were rural.

Data Analysis

The researcher first cleaned and examined the data using frequency analyses and various descriptive statistics. She produced frequency tables for the data set to identify errors and made appropriate corrections. Because regression results may be influenced by extreme values (Allison, 1999) the researcher removed outliers from the full data set prior to analysis. In order to determine the effect outliers might have had on the results, the researcher decided to analyze the full data set using similar procedures and compare the statistics obtained from analyses of both data sets. The researcher defined outliers as those values identified as extreme (values greater than 3.0 interquartile ranges from the median) and those identified as outliers (values ranging from 1.5 to 3.0 interquartile ranges from the median) as described in Chapter Four.

The researcher explored characteristics of the sample with outliers removed by computing simple descriptive statistics. Then she calculated zero-order correlations and analyses of variance in order to examine relevant bi-variate relationships. The researcher reran alpha reliabilities on the scales. Next, the researcher repeated the analysis on the full data set and noted the similarities and differences in the results.
The researcher performed stepwise backward regression using the data set with outliers removed and then using the full data set to determine the combination of independent variables that would account for the greatest variance in mathematics leadership and to determine the effect outliers had on the analyses.

**Delimitations and Limitations**

In this section, validity issues will be discussed. A study has external validity (or generalizability) if its sample is sufficiently representative to enable its findings to apply in other similar real world situations. Delimitations describe the population to which the results of the study can, indeed, be generalized. A study has internal validity if its outcome is a function of the independent variables it tests “rather than other causes not systematically dealt with in the study” (Tuckman, 1999, p. 6). Limitations describe potential threats to validity and what the researcher has done or will do to minimize these threats.

**Delimitations**

The study was delimited to principals of public high schools in Pennsylvania. Results from the Pennsylvania principals might be generalizable to principals across the United States, however, based on three characteristics related to the representativeness of the sample.

First, the percentage distribution of students in rural public schools in Pennsylvania more closely matched the national distribution of students in rural schools in 2003-2004 than the distribution of rural students for any other state (U. S. Department of Education, 2007b), as described earlier. Second, the sample proportions closely
resembled the population proportions by locale (Table 1). Third, the sample proportions closely resembled the national proportions of the secondary public school principals in 2003-2004 by gender (U. S. Department of Education, 2007a), the control variable in the study (Table 2).

Table 1

<table>
<thead>
<tr>
<th>Locale</th>
<th>Sample Percent</th>
<th>Population Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td>11.5</td>
<td>13.9</td>
</tr>
<tr>
<td>Suburban</td>
<td>36.9</td>
<td>36.9</td>
</tr>
<tr>
<td>Town</td>
<td>18.0</td>
<td>18.1</td>
</tr>
<tr>
<td>Rural</td>
<td>33.4</td>
<td>31.0</td>
</tr>
</tbody>
</table>

Table 2

<table>
<thead>
<tr>
<th>Gender</th>
<th>Sample Percent (Outliers Removed)</th>
<th>Sample Percent (Full Data Set)</th>
<th>National Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>25.8</td>
<td>27.2</td>
<td>26</td>
</tr>
<tr>
<td>Male</td>
<td>74.2</td>
<td>72.8</td>
<td>74</td>
</tr>
</tbody>
</table>

Generalizability may be limited across a broad span of time, however, because only those individuals who were high school principals for the academic year (2006-
2007) in which the study was conducted responded to the questionnaire. Finally, the study was delimited to the high schools listed in the Common Core of Data for 2003-3004 version 1a (NCES, 2006); therefore principals of schools that have closed or opened between 2003-04 and the time when the study was conducted were not represented in the data. The number of schools that have opened or closed is likely to be quite small, however, and probably had little effect on the representativeness of the sample.

Limitations

Survey data were self-reported and may have been compromised to some unspecified extent by social desirability bias or the tendency of respondents to represent themselves in what they perceived to be a favorable way. The researcher informed respondents of their anonymity, in order to increase the likelihood that respondents would provide candid responses. In addition, the questionnaire was self-administered rather than being administered by the researcher via telephone, a circumstance that may have made it less likely for respondents to answer in a socially desirable manner. The use of forced-choice Likert-scaled questionnaire items also limited the influence of social desirability bias (Babbie, 2002).

The researcher relied on the respondents’ accuracy in reporting (Babbie, 2002) the contextual characteristics of the school. The urban-centric locale code of the high school, which is available in the Common Core of Data (NCES, 2006) was used as the selection criteria for the stratified random samples and was not self-reported. Respondents were asked, however, to provide other demographic and contextual information: gender, school size, per pupil expenditure, free and reduced lunch rate, and the employment of a
mathematics department chair. Nevertheless, the types of contextual information requested about respondents’ schools is widely reported public knowledge that is generally well known to principals.

Indirect methods, such as using the standardized composite of the number of mathematics courses taken for college credit and responses to the items on the mathematics efficacy scale to measure principals’ mathematics content knowledge, may not provide the insight that a more direct measure, such as a test of mathematics skills, might provide. The researcher decided to use an indirect measure because she judged it to be impractical to ask respondents to complete a mathematics skills test. She was concerned that respondents might be reluctant to complete a mathematics skills test and elect not to participate, potentially lowering response rates. In addition, in order to determine accurately the mathematics skill set of a respondent, it would be necessary to ask many questions, further decreasing the likelihood that respondents would be willing to participate in the study.

Definitions

Operational definitions of the variables in the study are included in this section. The independent variables will be grouped as 1) personal characteristics and 2) contextual characteristics.

Personal Characteristics

Gender of principal. The gender of principal was the self-reported gender of the high school principals who responded to the questionnaire.
Principals’ knowledge of mathematics education and reform. Principals’ knowledge of mathematics education and reform was defined as a total score from responses to the Likert-scaled items found to be reliable measures of the construct in the pilot test. However, this variable was removed from the final study because the scale did not appear to exhibit sufficient technical adequacy when responses from the pilot study were analyzed. Analyses of the pilot study data are reported in Chapter Four.

Principals’ knowledge of mathematics content. Knowledge of mathematics content was operationalized as the standardized composite of the self-reported number of mathematics courses taken for college credit and the principals’ score on the mathematics efficacy items found to be reliable measures of the construct in the pilot test.

Contextual Characteristics

Locale. Locale described the location of the high school in which the principal was employed. The categories were based on the recommended groupings of the twelve urban-centric locale codes specified in the documentation to the Common Core of Data (Geverdt & Phan, 2006).

Rural locale was operationalized as the combination of the following three locale codes:

41 = Rural, Fringe: Census-defined rural territory that is less than or equal to 5 miles from an urbanized area, as well as rural territory that is less than or equal to 2.5 miles from an urban cluster.
42 = Rural, Distant: Census-defined rural territory that is more than 5 miles but
less than or equal to 25 miles from an urbanized area, as well as rural territory that
is more than 2.5 miles but less than or equal to 10 miles from an urban cluster.
43 = Rural, Remote: Census-defined rural territory that is more than 25 miles
from an urbanized area and is also more than 10 miles from an urban cluster.

Nonrural locale was operationalized as the combination of the following nine
locale codes:

11 = City, Large: Territory inside an urbanized area and inside a principal city
with population of 250,000 or more.
12 = City, Midsize: Territory inside an urbanized area and inside a principal city
with population less than 250,000 and greater than or equal to 100,000.
13 = City, Small: Territory inside and urbanized area and inside a principal city
with population less than 100,000.
21 = Suburb, Large: Territory outside a principal city and inside an urbanized area
with population of 250,000 or more.
22 = Suburb, Midsize: Territory outside a principal city and inside an urbanized
area with population less than 250,000 and greater than or equal to 100,000.
23 = Suburb, Small: Territory outside a principal city and inside an urbanized area
with population less than 100,000.
31 = Town, Fringe: Territory inside an urban cluster that is less than or equal to
10 miles from an urbanized area.
32 = Town, Distant: Territory inside an urban cluster that is more than 10 miles and less than or equal to 35 miles from an urbanized area.

33 = Town, Remote: Territory inside an urban cluster that is more than 35 miles from an urbanized area. (Geverdt & Phan, 2006, p. 4).

School size. The size of the high school was each principals’ report of student enrollment in the school in the year in which the questionnaire was completed.

Per pupil expenditure. The per pupil expenditure was the principals’ report of the self-reported average number of dollars expended per student in the high school at the time the questionnaire was completed.

Percent free and reduced lunch rate. The percent free and reduced lunch rate was the principals’ report of the percentage of students in the high school who were receiving free and reduced lunch at the time the questionnaire was completed.

Employment of a mathematics department chair. The employment of a mathematics department chair was the principals’ selection of “Yes” or “No” when asked if the school had an individual designated as mathematics department chair.

Dependent Variable

Leadership of mathematics education reform. Leadership of mathematics education reform was defined as a total score obtained from responses to the Likert-scaled items found to be reliable measures of the construct in the pilot test for the study.

Summary

The study examined the relationships among the contextual variables locale, school size, per pupil expenditure, free and reduced lunch rate, and the employment of a
mathematics department chair and principals’ knowledge of mathematics as well as their perceptions of effective leadership of mathematics education reform while controlling for the principals’ gender. This chapter began with a discussion of the population, the sampling plan for the study and the manner in which the stratified random sample of potential respondents was contacted.

The researcher next explained that an online questionnaire was developed and pilot tested with samples of Ohio and Iowa high school principals. The researcher explained that the pilot test was conducted to elicit feedback regarding the design and user-friendliness of the online survey and the quality of the items, and in addition, to determine the reliability estimates for the various scales included as variables.

Data collection through regular mailings and follow up telephone calls and e-mails was described. The researcher then briefly explained the data analysis procedures and described the limitations and delimitations of the study. Finally, the researcher presented operational definitions of the variables that were investigated in the study.
CHAPTER FOUR

Findings

Introduction

Chapter Four first presents the findings from the pilot study and then discusses changes made to the instrumentation and data collection procedures of the study in response to findings from the pilot study. The final section of the chapter presents findings from the study itself.

Pilot Study

Data Analysis

Responses from the 129 principals who completed the online survey were downloaded from Survey Monkey into Microsoft Excel and formatted for importing into SPSS. The researcher examined the case list and produced frequency tables including descriptive statistics for each item, and she cleaned the data by recoding erroneous responses as missing data.

Quantitative analyses. The researcher conducted a series of reliability analyses for the four groups of conceptually related items on the questionnaire: principal’s knowledge of mathematics education, leadership of mathematics education reform, efficacy in solving a set of mathematics problems, and mathematics courses taken for college credit. In order to refine each scale, the researcher retained the set of items that produced Cronbach’s alpha reliability estimates equaling or exceeding .80, and she systematically removed items that detracted from these reliability estimates. One result was that all items related to principals’ knowledge of mathematics education were eliminated, and the
scale was dropped from the final study. The highest reliability that could be obtained for any set of items relating to their knowledge of mathematics education was .61.

Alpha reliability estimates for the other scales were adequate. The reliability for the set of 10 items measuring the dependent variable, leadership of standards-based mathematics, was .84. The 10 items and the correlation of each with the scale as a whole are presented in Table 3.

Table 3

*Leadership of Mathematics Education Reform Scale Items and Corrected Item Total Correlation*

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Corrected item total correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Making connections to other disciplines.</td>
<td>.47</td>
</tr>
<tr>
<td>Having students work in cooperative learning groups.</td>
<td>.57</td>
</tr>
<tr>
<td>Having students participate in appropriate hands-on activities.</td>
<td>.53</td>
</tr>
<tr>
<td>Engaging students in inquiry-oriented activities.</td>
<td>.56</td>
</tr>
<tr>
<td>Engaging students in applications of subject matter in a variety of contexts.</td>
<td>.47</td>
</tr>
<tr>
<td>Using performance-based assessment.</td>
<td>.56</td>
</tr>
<tr>
<td>Using portfolios.</td>
<td>.50</td>
</tr>
<tr>
<td>Giving teachers time to plan and prepare lessons.</td>
<td>.51</td>
</tr>
<tr>
<td>Giving teachers time to work with other teachers.</td>
<td>.59</td>
</tr>
<tr>
<td>Giving teachers time for professional development.</td>
<td>.56</td>
</tr>
</tbody>
</table>
The pilot questionnaire also included two measures of mathematics knowledge: a mathematics efficacy scale and a scale constructed by asking respondents to mark the mathematics courses they had taken for college credit. The alpha reliability estimate for all of the original items on the mathematics efficacy scale was .92. The initial alpha reliability estimate for the mathematics course-taking scale was .83. When the set of items related to course-taking was narrowed to include only mathematics courses and to omit mathematics education courses, the alpha reliability estimate for the scale increased to .88. The bi-variate Pearson correlation between scores on the mathematics efficacy scale and scores on the mathematics course-taking scale was .54, a moderate but statistically significant relationship. The researcher decided, therefore, to produce a composite variable from the two scales in order to simplify the model that the final study would test and to eliminate the possibility of multicollinearity among the independent variables in the regression equations. She produced Z-scores for both the mathematics efficacy scale and the mathematics course-taking scale, and then added them together to create a composite variable, mathematics knowledge, for which the alpha reliability was .91.3

*Qualitative feedback.* The researcher asked respondents to answer four open-ended questions about the process of completing the questionnaire and about the wording of items. A detailed review of responses to each of these questions is provided in Appendix E. In summary, responses from 114 (approximately 88% of the principals)

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3 The researcher was aware that the use of this approach with the final data set would depend on the relative normality of the distributions for each of the unitary variables in the composite as well as evidence of a threat from multicollinearity.
revealed that the average time to complete the questionnaire was 11.35 minutes. The remaining three questions were answered by fewer than 26% of respondents. Suggestions for improvement of items included the addition of a “not applicable” or “none” option in the listing of college mathematics courses. A number of respondents also recommended the use of a mailed rather than an online survey. Several respondents also indicated that searching for demographic information—school enrollment, percentage of students who receive free and reduced lunch, average per pupil expenditure, and number of mathematics teachers—took extra time.

**Modifications.** Using the findings from the pilot study, the researcher revised the questionnaire by retaining sets of items with reliability estimates equaling or exceeding .80 and removing items that detracted from these reliability estimates. As described earlier, the scale measuring principals’ knowledge of mathematics education was dropped. In addition, the researcher decided to mail the revised questionnaire (see Appendix F), conduct multiple mailings and follow up with telephone calls and e-mail reminders until acceptable return rates for each locale were reached in order to maximize the return rate for the actual study. The researcher decided to conduct the study in a large state with varied locales. By examining information in the Common Core of Data (NCES, 2006), she determined that Pennsylvania would be a good state in which to conduct the study because it maintained adequate numbers of high schools in rural, urban, town and suburban locales.
Findings

This section of the chapter presents descriptive and inferential statistics computed from the data supplied by the principals who responded to the questionnaire.

Data Analysis

The researcher first cleaned and examined the data using frequency analyses and various descriptive statistics. She produced frequency tables for the data set to identify errors and made appropriate corrections.

The researcher decided that because regression results may be strongly influenced by extreme values (Allison, 1999), it would be useful to remove outliers from the data set prior to data analysis. The researcher used the Explore feature of SPSS to create and examine stem and leaf plots and box plots in order to identify the extreme (greater than 3.0 interquartile ranges from the median) and outlier (from 1.5 to 3.0 interquartile ranges from the median) values for each independent variable. She then systematically removed the extreme and outlier values from the data set using the Select Cases feature. In summary, twelve cases with extreme and outlier values for enrollment were removed; nine cases with extreme and outlier values for percent free and reduced lunch were removed; and fourteen cases with extreme and outlier values for per pupil expenditure were removed. The resulting data set included 191 cases.

Allison (1999) recommended a process involving the comparison between statistics obtained using a full data set and statistics obtained using a data set in which outliers had been removed. The researcher adopted this approach. Although similar trends were evident in both sets of analyses, the relationships among variables were
easier to see in the data set from which outliers had been removed. Therefore, analyses using the modified data set (i.e., the one from which outliers have been removed) are included in the chapter first, followed by analyses using the original data set.

The researcher examined the frequencies for each variable to determine if missing data were randomly distributed. Frequencies for missing values are shown in Table 4.

Table 4

<table>
<thead>
<tr>
<th>Variable</th>
<th>Missing Cases</th>
<th>Percent Missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locale</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Math leadership</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Have individual designated as math department chair</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Enrollment</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Gender</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Number of mathematics teachers</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Mathematics knowledge</td>
<td>3</td>
<td>1.6</td>
</tr>
<tr>
<td>Percent free and reduced lunch</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Per pupil expenditure</td>
<td>0</td>
<td>0.0</td>
</tr>
</tbody>
</table>
There were few missing values in the data set from which outliers had been removed and the researcher chose to eliminate cases with missing values listwise throughout the analysis process.

Descriptive statistics. The researcher examined the characteristics of the sample without outliers by computing descriptive statistics for each item on the questionnaire. For the mathematics leadership scale, respondents were asked to rate each item as to whether the practice was “Not important” (assigned a value of 1), “Somewhat important” (assigned a value of 2), “Fairly important” (assigned a value of 3) or “Very Important” (assigned a value of 4) for effective mathematics instruction. The researcher computed means and standard deviations for each item (Table 5). Respondents indicated that giving teachers time for professional development was the most important leadership practice for supporting effective mathematics instruction and advocating the use of portfolios was the least important leadership practice for supporting effective mathematics instruction.
Table 5

**Descriptive Statistics for Leadership of Mathematics Education Reform Items**

Please rate each of the following practices in terms of its importance for effective mathematics instruction.

<table>
<thead>
<tr>
<th>Practice</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Giving teachers time for professional development</td>
<td>3.75</td>
<td>.48</td>
</tr>
<tr>
<td>Engaging students in applications of subject matter in a variety of contexts</td>
<td>3.69</td>
<td>.52</td>
</tr>
<tr>
<td>Giving teachers time to plan and prepare lessons</td>
<td>3.68</td>
<td>.54</td>
</tr>
<tr>
<td>Engaging students in inquiry-oriented activities</td>
<td>3.66</td>
<td>.53</td>
</tr>
<tr>
<td>Giving teachers time to work with other teachers</td>
<td>3.62</td>
<td>.59</td>
</tr>
<tr>
<td>Having students participate in appropriate hands-on activities</td>
<td>3.60</td>
<td>.61</td>
</tr>
<tr>
<td>Using performance-based assessment</td>
<td>3.60</td>
<td>.57</td>
</tr>
<tr>
<td>Making connections to other disciplines</td>
<td>3.50</td>
<td>.67</td>
</tr>
<tr>
<td>Having students work in cooperative learning groups</td>
<td>3.18</td>
<td>.75</td>
</tr>
<tr>
<td>Using portfolios</td>
<td>2.39</td>
<td>.84</td>
</tr>
</tbody>
</table>

Items on the mathematics efficacy scale asked respondents to indicate their confidence level on a scale from 1 (Not at all confident) to 5 (Very confident) to perform different mathematics tasks. Means and standard deviations were computed for each item (Table 6). Respondents expressed the most confidence in being able to work arithmetic problems with decimals and expressed the least confidence in being able to sketch the curve of a quadratic equation.
Table 6

*Descriptive Statistics for Mathematics Efficacy Items*

<table>
<thead>
<tr>
<th>Exact wording of item</th>
<th>$M$</th>
<th>$SD$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work arithmetic problems with decimals</td>
<td>4.80</td>
<td>.51</td>
</tr>
<tr>
<td>Work arithmetic problems with fractions</td>
<td>4.75</td>
<td>.57</td>
</tr>
<tr>
<td>Solve for $x$ in a simple equation</td>
<td>4.71</td>
<td>.67</td>
</tr>
<tr>
<td>Calculate values of area and volume</td>
<td>4.41</td>
<td>.85</td>
</tr>
<tr>
<td>Determine the degrees of a missing angle in a triangle</td>
<td>4.38</td>
<td>.88</td>
</tr>
<tr>
<td>Determine the value of a missing side length of a triangle</td>
<td>4.32</td>
<td>.92</td>
</tr>
<tr>
<td>Solve a system of simultaneous equations</td>
<td>3.89</td>
<td>1.11</td>
</tr>
<tr>
<td>Solve a problem in trigonometry</td>
<td>3.24</td>
<td>1.25</td>
</tr>
<tr>
<td>Sketch the curve of a quadratic equation</td>
<td>3.20</td>
<td>1.40</td>
</tr>
</tbody>
</table>

The questionnaire also asked respondents to check all applicable mathematics courses taken for which they had received college credit. Frequencies and valid percentages were computed for each course (Table 7). No single mathematics course listed was selected by greater than 50% of respondents, illustrating that principals of high schools have somewhat limited experience with college level mathematics. Moreover, respondents may have confused college algebra and abstract algebra when they checked the courses for which they received college credit. It seems very unlikely that 32.6% of principals had actually taken such a course, especially in view of their comparatively low
assessment of their ability to solve a set of simultaneous equations or sketch the curve of
a quadratic equation.

Table 7

Frequencies for Mathematics Courses Taken

<table>
<thead>
<tr>
<th>Course</th>
<th>Yes Frequency</th>
<th>Yes Valid Percent</th>
<th>No Frequency</th>
<th>No Valid Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geometry</td>
<td>95</td>
<td>50.0</td>
<td>95</td>
<td>50.0</td>
</tr>
<tr>
<td>Calculus</td>
<td>93</td>
<td>48.7</td>
<td>97</td>
<td>51.1</td>
</tr>
<tr>
<td>Linear algebra</td>
<td>83</td>
<td>43.7</td>
<td>107</td>
<td>56.3</td>
</tr>
<tr>
<td>Abstract algebra</td>
<td>62</td>
<td>32.6</td>
<td>128</td>
<td>67.4</td>
</tr>
<tr>
<td>Other upper division mathematics</td>
<td>60</td>
<td>31.6</td>
<td>130</td>
<td>68.4</td>
</tr>
<tr>
<td>Number theory</td>
<td>51</td>
<td>26.8</td>
<td>139</td>
<td>73.2</td>
</tr>
<tr>
<td>Differential equations</td>
<td>48</td>
<td>25.3</td>
<td>142</td>
<td>74.7</td>
</tr>
<tr>
<td>History of mathematics</td>
<td>46</td>
<td>24.2</td>
<td>144</td>
<td>75.8</td>
</tr>
<tr>
<td>Advanced calculus</td>
<td>40</td>
<td>21.1</td>
<td>150</td>
<td>78.9</td>
</tr>
<tr>
<td>Real analysis</td>
<td>38</td>
<td>20.0</td>
<td>152</td>
<td>80.0</td>
</tr>
<tr>
<td>Discrete mathematics</td>
<td>34</td>
<td>17.9</td>
<td>156</td>
<td>82.1</td>
</tr>
</tbody>
</table>
The researcher counted the total number \((M = 3.42, SD = 3.11)\) of mathematics courses that each respondent took. Frequencies for the number of mathematics courses taken are reported in Table 8.

Table 8

<table>
<thead>
<tr>
<th>Number of Courses</th>
<th>Frequency</th>
<th>Valid Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>27</td>
<td>14.2</td>
</tr>
<tr>
<td>1</td>
<td>36</td>
<td>18.9</td>
</tr>
<tr>
<td>2</td>
<td>35</td>
<td>18.4</td>
</tr>
<tr>
<td>3</td>
<td>23</td>
<td>12.1</td>
</tr>
<tr>
<td>4</td>
<td>14</td>
<td>7.4</td>
</tr>
<tr>
<td>5</td>
<td>13</td>
<td>6.8</td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>4.2</td>
</tr>
<tr>
<td>7</td>
<td>9</td>
<td>4.7</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td>1.6</td>
</tr>
<tr>
<td>9</td>
<td>8</td>
<td>4.2</td>
</tr>
<tr>
<td>10</td>
<td>7</td>
<td>3.7</td>
</tr>
<tr>
<td>11</td>
<td>7</td>
<td>3.7</td>
</tr>
</tbody>
</table>

The researcher also calculated descriptive statistics for the all of the variables that would be incorporated into the regression model. She calculated means and standard
deviations for the continuous variables (Table 9) and frequencies for the categorical variables (Table 10) for the data set with outliers removed.

Table 9

<table>
<thead>
<tr>
<th>Variable</th>
<th>$M$</th>
<th>$SD$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enrollment</td>
<td>881.23</td>
<td>458.67</td>
</tr>
<tr>
<td>Percent free and reduced lunch</td>
<td>27.50</td>
<td>19.08</td>
</tr>
<tr>
<td>Per pupil expenditure</td>
<td>7981.23</td>
<td>2613.07</td>
</tr>
<tr>
<td>Number of mathematics teachers</td>
<td>7.84</td>
<td>3.93</td>
</tr>
<tr>
<td>Mathematics knowledge</td>
<td>-.04</td>
<td>1.72</td>
</tr>
<tr>
<td>Mathematics leadership</td>
<td>34.73</td>
<td>3.44</td>
</tr>
</tbody>
</table>
The researcher produced frequency tables and histograms for the two derived variables. These analyses revealed that each of the derived variables was skewed to some degree as shown in Table 11.

Table 11

<table>
<thead>
<tr>
<th>Scale</th>
<th>M</th>
<th>SD</th>
<th>Skewness</th>
<th>Std Error Skewness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics Knowledge</td>
<td>-.04</td>
<td>1.72</td>
<td>.225</td>
<td>.177</td>
</tr>
<tr>
<td>Mathematics Leadership</td>
<td>34.73</td>
<td>3.44</td>
<td>.390</td>
<td>.176</td>
</tr>
</tbody>
</table>
Although the ratio of skewness to its standard error was –2.21 for the leadership of mathematics education reform scale and exceeded the recommendations of SPSS, the researcher decided not to transform the scale to avoid compromising interpretation of the results. (The Help section of SPSS 11.0 suggests that the ratio of skewness to its standard error can be used as a test of normality and that normality can be rejected if the ratio is less than -2 or greater than +2.)

Other Exploratory Analyses

The researcher conducted one way analyses of variance and zero-order correlations to examine the relationship among the variables, and she computed Cronbach’s alpha reliabilities for each scale. This section summarizes the results of those analyses on the data set with outliers removed.

One way analyses of variance. The researcher investigated the relationship of the categorical independent variables with the independent variable, mathematics knowledge, and the dependent variable, leadership of mathematics education reform, using one way analysis of variance.

For rural ($M = .18, SD = 1.50$) and nonrural ($M = -.14, SD = 1.85$) locales, the mean difference on the mathematics knowledge scale was not significant, $F(1,186) = 1.014, p = .315$. For rural ($M = 34.70, SD = 3.50$) and nonrural ($M = 34.75, SD = 3.41$) locales, the mean difference on the mathematics leadership scale was not significant, $F(1,189) = .008, p = .927$. 
Females ($M = .10, SD = 1.83$) did not score significantly higher than males ($M = -.10, SD = 1.69$) on the mathematics knowledge scale, $F(1,185) = .479, p = .490$. Females ($M = 35.78, SD = 3.71$) did score significantly higher than males ($M = 34.40, SD = 3.25$) on the leadership of mathematics education reform scale, $F(1,188) = 6.000, p = .015$. A comparison of the means for males and females (eta squared = .031) revealed that gender was responsible for 3.1% of the variance in leadership of mathematics education reform.

Means on the mathematics knowledge scale did not differ significantly, $F(1,185) = .164, p = .686$, between principals of schools that had a mathematics department chair ($M = -.02, SD = 1.80$) and principals of schools that did not have a mathematics department chair ($M = -.16, SD = 1.35$). Means on the leadership of mathematics education reform scale did not differ significantly, $F(1,188) = .801, p = .372$, between principals of schools that had a mathematics department chair ($M = 34.66, SD = 3.50$) and principals of schools that did not have a mathematics department chair ($M = 35.24, SD = 3.03$).

*Zero-order correlations.* The independent variables were significantly correlated in several instances. Per pupil expenditure was significantly correlated with percent free and reduced lunch ($r = -.25, p = .001$), number of mathematics teachers ($r = .33, p = .000$) and enrollment ($r = .20, p = .007$). Percent free and reduced lunch was also significantly correlated with number of mathematics teachers ($r = -.37, p = .000$) and enrollment ($r = -.44, p = .000$). In addition, enrollment and number of mathematics teachers was significantly correlated ($r = .91, p = .000$). To avoid the threat of multicollinearity the researcher decided to exclude the number of mathematics teachers as a predictor variable.
because of its very strong relationship with enrollment. Correlations between the other variables listed were weak and did not appear to pose a collinearity threat.

**Reliability.** The researcher computed alpha reliabilities for the scales to determine if they continued to exhibit sufficient technical adequacy. The Cronbach’s alpha reliability for the number of math courses taken was .85. For the mathematics efficacy scale, the alpha reliability was .88. As explained earlier, the values for the number of math courses taken and the mathematics efficacy scale were standardized and transformed into the composite variable, math knowledge. Reliability for the composite variable, math knowledge, was .90. For the leadership of mathematics education reform scale, the alpha reliability was .73. The scales remained adequately reliable.

*Data Analysis on the Original Data Set*

As stated earlier, the researcher performed analyses on the original data set from which outliers had not been removed. The original data set included 260 cases. This section summarizes the results of those analyses.

The researcher examined frequencies of each variable and discovered that there was a large number of missing values for per pupil expenditure in the full data set (Table 12).
Because 20% of per pupil expenditure values were missing, the researcher created a
dummy variable (1 answered, 0 missing) for per pupil expenditure and performed a \( t \) test
to check for homogeneity of variance. Results of the Levene’s test \( (p = .931) \) suggested
that group variances did not differ, and the \( t \)-test results, \( t(255) = -.211, p = .833 \), revealed
that there were also no group differences in means. The researcher decided to retain per
pupil expenditure as one of the independent contextual variables to include in subsequent
analyses. The researcher chose to eliminate cases with missing values listwise throughout
the analyses on the full data set and to remain consistent with the analyses performed on
the data set with outliers removed so that comparisons between the two analyses could be made.

**Descriptive statistics.** The researcher examined the characteristics of the full data set employing the same testing procedures used with the data with outliers removed. Means and standard deviations for each item on the leadership of mathematics education reform scale are summarized in Table 13. The researcher had listed the items in order of descending means in the analysis of the data set with outliers removed and listed the items similarly for the full data set. The items from the full data set remained in the same order as for the data set with outliers removed.
Table 13

*Descriptive Statistics for Leadership of Mathematics Education Reform Items*

<table>
<thead>
<tr>
<th>Practice</th>
<th>$M$</th>
<th>$SD$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Giving teachers time for professional development</td>
<td>3.74</td>
<td>.49</td>
</tr>
<tr>
<td>Engaging students in applications of subject matter in a variety of contexts</td>
<td>3.69</td>
<td>.53</td>
</tr>
<tr>
<td>Giving teachers time to plan and prepare lessons</td>
<td>3.69</td>
<td>.53</td>
</tr>
<tr>
<td>Engaging students in inquiry-oriented activities</td>
<td>3.64</td>
<td>.56</td>
</tr>
<tr>
<td>Giving teachers time to work with other teachers</td>
<td>3.60</td>
<td>.61</td>
</tr>
<tr>
<td>Having students participate in appropriate hands-on activities</td>
<td>3.58</td>
<td>.63</td>
</tr>
<tr>
<td>Using performance-based assessment</td>
<td>3.56</td>
<td>.60</td>
</tr>
<tr>
<td>Making connections to other disciplines</td>
<td>3.51</td>
<td>.67</td>
</tr>
<tr>
<td>Having students work in cooperative learning groups</td>
<td>3.17</td>
<td>.75</td>
</tr>
<tr>
<td>Using portfolios</td>
<td>2.36</td>
<td>.84</td>
</tr>
</tbody>
</table>

The researcher computed means and standard deviations for each item on the mathematics efficacy scale and listed the results in order of descending means (Table 14). The order of items for the full data set was the same as for the data set with outliers removed.
Table 14

*Descriptive Statistics for Mathematics Efficacy Items*

<table>
<thead>
<tr>
<th>Exact wording of item</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work arithmetic problems with decimals</td>
<td>4.81</td>
<td>.49</td>
</tr>
<tr>
<td>Work arithmetic problems with fractions</td>
<td>4.76</td>
<td>.57</td>
</tr>
<tr>
<td>Solve for x in a simple equation</td>
<td>4.71</td>
<td>.69</td>
</tr>
<tr>
<td>Calculate values of area and volume</td>
<td>4.41</td>
<td>.89</td>
</tr>
<tr>
<td>Determine the degrees of a missing angle in a triangle</td>
<td>4.37</td>
<td>.90</td>
</tr>
<tr>
<td>Determine the value of a missing side length of a triangle</td>
<td>4.30</td>
<td>.97</td>
</tr>
<tr>
<td>Solve a system of simultaneous equations</td>
<td>3.83</td>
<td>1.13</td>
</tr>
<tr>
<td>Solve a problem in trigonometry</td>
<td>3.26</td>
<td>1.28</td>
</tr>
<tr>
<td>Sketch the curve of a quadratic equation</td>
<td>3.21</td>
<td>1.41</td>
</tr>
</tbody>
</table>

Table 15 summarizes the frequencies and valid percentages of mathematics courses taken for the full data set. Results were similar to those obtained for the data set with outliers removed. The courses were listed in the order of descending frequencies of “Yes” responses for the data set with outliers removed. For the full data set, the order was the same. The researcher counted the total number ($M = 3.58$, $SD = 3.29$) of mathematics courses that each respondent took. Frequencies for the total number of courses are reported in Table 16.
Table 15

*Frequencies for Mathematics Courses Taken*

<table>
<thead>
<tr>
<th>Course</th>
<th>Yes Frequency</th>
<th>Yes Valid Percent</th>
<th>No Frequency</th>
<th>No Valid Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geometry</td>
<td>128</td>
<td>49.8</td>
<td>129</td>
<td>50.2</td>
</tr>
<tr>
<td>Calculus</td>
<td>125</td>
<td>48.6</td>
<td>132</td>
<td>51.4</td>
</tr>
<tr>
<td>Linear algebra</td>
<td>114</td>
<td>44.4</td>
<td>143</td>
<td>55.6</td>
</tr>
<tr>
<td>Abstract algebra</td>
<td>91</td>
<td>35.4</td>
<td>166</td>
<td>64.6</td>
</tr>
<tr>
<td>Other upper division mathematics</td>
<td>87</td>
<td>33.9</td>
<td>170</td>
<td>66.1</td>
</tr>
<tr>
<td>Number theory</td>
<td>77</td>
<td>30.0</td>
<td>180</td>
<td>70.0</td>
</tr>
<tr>
<td>Differential equations</td>
<td>70</td>
<td>27.2</td>
<td>187</td>
<td>72.8</td>
</tr>
<tr>
<td>History of mathematics</td>
<td>63</td>
<td>24.5</td>
<td>194</td>
<td>75.5</td>
</tr>
<tr>
<td>Advanced calculus</td>
<td>60</td>
<td>23.3</td>
<td>197</td>
<td>76.7</td>
</tr>
<tr>
<td>Real analysis</td>
<td>54</td>
<td>21.0</td>
<td>203</td>
<td>79.0</td>
</tr>
<tr>
<td>Discrete mathematics</td>
<td>51</td>
<td>19.8</td>
<td>206</td>
<td>80.2</td>
</tr>
</tbody>
</table>
Table 16

<table>
<thead>
<tr>
<th>Number of Courses</th>
<th>Frequency</th>
<th>Valid Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>37</td>
<td>14.4</td>
</tr>
<tr>
<td>1</td>
<td>50</td>
<td>19.5</td>
</tr>
<tr>
<td>2</td>
<td>43</td>
<td>16.7</td>
</tr>
<tr>
<td>3</td>
<td>32</td>
<td>12.5</td>
</tr>
<tr>
<td>4</td>
<td>18</td>
<td>7.0</td>
</tr>
<tr>
<td>5</td>
<td>15</td>
<td>5.8</td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>3.1</td>
</tr>
<tr>
<td>7</td>
<td>9</td>
<td>3.5</td>
</tr>
<tr>
<td>8</td>
<td>7</td>
<td>2.7</td>
</tr>
<tr>
<td>9</td>
<td>17</td>
<td>6.6</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>3.9</td>
</tr>
<tr>
<td>11</td>
<td>11</td>
<td>4.3</td>
</tr>
</tbody>
</table>

The researcher calculated means and standard deviations for the continuous variables (Table 17) and frequencies for the categorical variables (Table 18) that would be investigated in the regression model.
### Table 17

**Descriptive Statistics for Continuous Variables**

<table>
<thead>
<tr>
<th>Variable</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enrollment</td>
<td>985.18</td>
<td>682.90</td>
</tr>
<tr>
<td>Percent free and reduced lunch</td>
<td>30.49</td>
<td>22.55</td>
</tr>
<tr>
<td>Per pupil expenditure</td>
<td>8013.75</td>
<td>2701.21</td>
</tr>
<tr>
<td>Number of mathematics teachers</td>
<td>8.555</td>
<td>5.52</td>
</tr>
<tr>
<td>Mathematics knowledge</td>
<td>.0118</td>
<td>1.81</td>
</tr>
<tr>
<td>Mathematics leadership</td>
<td>34.57</td>
<td>3.64</td>
</tr>
</tbody>
</table>

### Table 18

**Frequencies for Categorical Variables**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Frequency</th>
<th>Valid Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employment of a Mathematics Department Chair</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>208</td>
<td>80.6</td>
</tr>
<tr>
<td>No</td>
<td>50</td>
<td>19.4</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>70</td>
<td>27.2</td>
</tr>
<tr>
<td>Male</td>
<td>187</td>
<td>72.8</td>
</tr>
<tr>
<td>Locale</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>87</td>
<td>33.5</td>
</tr>
<tr>
<td>Nonrural</td>
<td>173</td>
<td>66.5</td>
</tr>
</tbody>
</table>
Frequency tables and histograms were produced for the mathematics knowledge and the leadership scale to examine each of the derived variables for skewness (Table 19).

Table 19

<table>
<thead>
<tr>
<th>Scale</th>
<th>M</th>
<th>SD</th>
<th>Skewness</th>
<th>Std Error Skewness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics Knowledge</td>
<td>.01</td>
<td>1.80</td>
<td>.251</td>
<td>.153</td>
</tr>
<tr>
<td>Mathematics Leadership</td>
<td>34.57</td>
<td>3.64</td>
<td>-.541</td>
<td>.152</td>
</tr>
</tbody>
</table>

The ratio of skewness to the standard error of skewness for the mathematics leadership scale was -3.56, much greater than the similar ratio computed for the data set without outliers. The researcher decided not to transform the scale, however, in order to be able to compare the results obtained from the two data sets.

Other Exploratory Analyses

The researcher performed one way analyses of variance and zero-order correlations and computed Cronbach’s alpha reliabilities for each scale just as she did with the data set with outliers removed. This section summarizes the results of the analyses on the full data set.
One way analyses of variance. The mean difference on the mathematics knowledge scale was not significant, $F(1,253) = .042, p = .838$, for rural ($M = -.02, SD = 1.59$) and nonrural ($M = .03, SD = 1.91$) locales. The mean difference on the leadership of mathematics education reform scale was also not significant, $F(1,256) = 1.210, p = .272$, for rural ($M = 34.92, SD = 3.42$) and nonrural ($M = 34.39, SD = 3.75$) locales. The results were similar for the data set from which the outliers had been removed.

Females ($M = .10, SD = 1.91$) did not score significantly higher than males ($M = -.03, SD = 1.78$) on the mathematics knowledge scale, $F(1,251) = .258, p = .612$ when the analysis was performed on the data set with outliers removed. Females ($M = 34.99, SD = 4.27$) did not score significantly higher than males ($M = 34.43, SD = 3.39$) on the leadership of mathematics education reform scale, $F(1,253) = 1.168, p = .281$. Females scored significantly higher on the leadership of mathematics education reform scale than males for the data set with outliers removed, so the results for the full data set differ in that no mean difference on the leadership of mathematics education reform scale was found.

Means on the mathematics knowledge scale did not differ significantly, $F(1,252) = .005, p = .942$, between principals of schools that had a mathematics department chair ($M = .01, SD = 1.89$) and principals of schools that did not have a mathematics department chair ($M = -.01, SD = 1.45$). Means on the leadership of mathematics education reform scale did not differ significantly, $F(1,254) = .003, p = .955$, between principals of schools that had a mathematics department chair ($M = 34.59, SD = 3.67$) and principals of schools that did not have a mathematics department chair ($M = 34.56,$
When compared to the results for the data set with outliers removed, the results obtained for the full data set are similar.

**Zero-order correlations.** Per pupil expenditure was significantly correlated with percent free and reduced lunch \((r = -.29, p = .000)\), number of mathematics teachers \((r = .32, p = .000)\) and enrollment \((r = .21, p = .002)\). Percent free and reduced lunch was also significantly correlated with number of mathematics teachers \((r = -.18, p = .011)\) and enrollment \((r = -.17, p = .019)\). Enrollment and number of mathematics teachers was significantly correlated \((r = .95, p = .000)\) and as occurred with the data set with outliers removed, the researcher decided to exclude the number of mathematics teachers as a predictor because of the very strong relationship with enrollment.

**Reliability.** The researcher computed Cronbach’s alpha reliabilities on the scales as she did for the data set from which outliers had been removed. The alpha reliability for the number of math courses taken was .87. The alpha reliability for the mathematics efficacy scale was .88. As discussed previously, the number of courses taken and the efficacy scaled were standardized and transformed into a composite variable, mathematics knowledge, and the alpha reliability for the composite scale was .90. For the leadership of mathematics education reform scale, the alpha reliability was .77. Values for both data sets were very similar; the scales remained adequately reliable.

**Regression Analyses**

Multiple regression models were used to examine the influence of the high school principals’ personal characteristics, gender and mathematics knowledge, and the contextual variables, locale, enrollment, percent free and reduced lunch, per pupil.
expenditure and having an individual designated as math department chair on principals’ perceptions of effective leadership of mathematics education reform. The researcher created a dummy variable to represent the categorical variable locale (rural = 1, nonrural = 0). Results for the data set with outliers removed are presented first, followed by results for the full data set.

The researcher used stepwise backward regression to determine the best fit combination of independent variables, that is, the combination that would account for the greatest variance in leadership of mathematics education reform. Values for adjusted $R^2$ ranged from .020 to .033. Results for the best fit model, significant at the .05 level, $F(3,183) = 3.139, p = .027$, are reported in Table 20.

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>$B$</th>
<th>$SE$</th>
<th>$\beta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>31.458</td>
<td>1.193</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>1.403</td>
<td>.564</td>
<td>.180*</td>
</tr>
<tr>
<td>Per pupil expenditure</td>
<td>.000</td>
<td>.000</td>
<td>.088</td>
</tr>
<tr>
<td>Percent free and reduced lunch</td>
<td>.023</td>
<td>.013</td>
<td>.127</td>
</tr>
</tbody>
</table>

Note. Adj. $R^2 = .033$ ($p < .05$)  
*p = .014
The researcher examined tolerance values which ranged from .791 to .983 for this model, suggesting that there was no multivariate multicollinearity.

The researcher performed a similar stepwise backward regression on the full data set. Values for adjusted $R^2$ ranged from -.003 to .013. Two models explained 1.3% of the variance, although neither model was significant at the .05 level. Results for each model are summarized below.

Results for the first model, $F(2,199) = 2.320, p = .101$, are reported in Table 21.

Table 21

<table>
<thead>
<tr>
<th>Summary of the First Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Independent Variables</td>
</tr>
<tr>
<td>(Constant)</td>
</tr>
<tr>
<td>Gender</td>
</tr>
<tr>
<td>Enrollment</td>
</tr>
</tbody>
</table>

Note. Adj. $R^2 = .013 \ (p > .05)$

Results for the second model, $F(1,200) = 3.721, p = .055$, are reported in Table 22.
Table 22

Summary of the Second Model

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>$B$</th>
<th>$SE$</th>
<th>$\beta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>33.315</td>
<td>.754</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>1.088</td>
<td>.564</td>
<td>.135</td>
</tr>
</tbody>
</table>

Note. Adj. $R^2 = .013$ ($p > .05$)

For the first model, tolerance values ranged from .881 to .986. For the second model, tolerance values ranged from .990 to .996. For neither model was multivariate multicollinearity suggested.

Summary of Findings

Of the independent variables investigated, gender was the only independent variable found to have a significant influence on leadership of mathematics education reform. Females scored higher on the leadership of mathematics education reform scale than did males. No more than 3.3% of the variance in leadership of mathematics education reform was accounted for in any of the regression models. Moreover, this result became significant only in the analyses with the data set from which outliers had been excluded.

Although the contextual variables, percent free and reduced lunch and per pupil expenditure, appeared in the best fit model using the data set with outliers removed, neither variable was found to be a significant predictor of leadership of mathematics education reform.
This study sought to answer the research question: “With gender controlled, what are the separate and combined influences of principals’ mathematics knowledge, principals’ knowledge of mathematics education and a set of contextual and organizational variables, including locale, school size, per pupil expenditure, free and reduced lunch rate, and the employment of a mathematics department chair, on principals’ perceptions of effective leadership of mathematics education reform.”

The influence of high school principals’ knowledge of mathematics education could not be investigated in this study. As explained earlier, the researcher retained as scales only sets of items that produced Cronbach’s alpha reliability estimates equaling or exceeding .80 in the pilot study. Systematic removal of items that detracted from these reliability estimates resulted in the elimination of all items related to principals’ knowledge of mathematics education; therefore the scale was dropped from the final study.

As this chapter explained, regression analyses revealed that the target variables had no significant influence on principals’ perception of effective leadership of mathematics education reform. Moreover, the control variable, gender, exerted a significant influence only in the data set from which outliers had been removed. It exerted no significant influence in the models developed using the full data set.
CHAPTER FIVE

Discussion and Recommendations

Introduction

This chapter summarizes findings from the study and interprets them in consideration of the related literature. It also provides recommendations for future research about the leadership of mathematics education reform.

Summary of Findings

After some minor modifications made in response to findings from a pilot test, this study investigated the separate and combined influences of principals’ mathematics knowledge and a set of contextual and organizational variables, including locale, school size, per pupil expenditure, free and reduced lunch rate, and the employment of a mathematics department chair, on principals’ perceptions of effective leadership of mathematics education reform. The models used to investigate these influences included gender as a control variable, because prior literature suggested that gender would likely influence mathematics knowledge and therefore would have the potential to moderate the influence of that variable on the dependent variable, leadership of mathematics education reform.

Findings based on backwards stepwise regression analyses showed that none of the target variables exerted a significant influence on principals’ perception of effective leadership of mathematics education reform. Moreover, the control variable, gender, exerted a significant influence only with the data set from which outliers had been
removed. It exerted no significant influence in the models developed using the full data set.

Interpretation

This section examines the findings for each target variable more closely and offers possible explanations for the results obtained.

Mathematics Knowledge

Despite previous research suggesting that principals’ mathematics knowledge influenced their perspectives on mathematics education reform, in this study their mathematics knowledge had no such influence. This finding seems quite plausible considering the organizational characteristics of high schools, which tend to be large and complicated. Principals in such organizations cannot be expected to have expertise related to all technical operations. Rather, they must rely on the expertise of other professionals. As a consequence, department chairs and experienced teachers may often function as the content experts who guide curricular reform. Principals’ involvement might actually turn out in most cases to be indirect and generic.

Another possible explanation of the finding is that there may be little variability in principals’ views about ways to support reform of mathematics education. For example, principals may share similar beliefs about how to go about providing support—offering professional development to mathematics teachers, providing time for mathematics teachers to meet, and providing funding for the purchase of instructional materials. Indeed, findings from the study suggested modest concordance of beliefs about such matters among the principals who responded. These principals seemed to agree that
giving mathematics teachers time to engage in professional development, to plan and prepare lessons, and to work with other teachers were important parts of the leadership role. Descriptive statistics confirmed respondents’ tendency to share similar perspectives: The distributions of responses to these items were negatively skewed and tended to be somewhat leptokurtic, with high means and small standard deviations.

**Locale**

Findings from previous research suggested that locale might be associated with principals’ perceptions of leadership of mathematics education reform, but findings from the current study did not confirm this association. In this study, locale (operationalized as rural and nonrural) had no significant influence on principals’ perceptions of leadership of mathematics education reform. A possible explanation for this finding relates to recently adopted accountability requirements. In Pennsylvania, where the study was conducted, high schools are held accountable for students’ performance on a statewide test that is administered to students in the eleventh grade. Because all schools in Pennsylvania are subject to the same accountability requirements, principals of schools in all locales might be expected to hold similar views about the need for and methods of leading mathematics education reform.

**School Size**

Previous research suggested that principals of small schools might be more likely to function as instructional leaders than principals of large schools; however, in this study, school size was not significantly associated with principals’ perceptions of leadership of mathematics education reform. Perhaps principals in large and small
schools have similar views because they are socialized to agree with the same professional norms. Or perhaps, as suggested above, they are all responding to the same accountability system and therefore tend to treat instructional reform in similar ways. It is, of course, also possible that, irrespective of school characteristics, many of those who responded to the questionnaire provided answers that they thought the researcher was looking for, thereby introducing a strong enough social desirability bias to mask actual differences in perspective.

*Per Pupil Expenditure*

In this study, per pupil expenditure was not significantly related to principals’ perceptions of leadership of mathematics education reform. This finding may not be particularly disjunct from earlier findings, however. Results from several previous studies indicated that per pupil expenditure may have little effect on meaningful educational outcomes. For example, in a meta-analysis of nearly 400 studies, Hanushek (1997) concluded that there was neither a strong nor consistent relationship between student performance and school resources when family characteristics were controlled. He argued that despite the doubling of per pupil expenditure (adjusted for inflation) in the past 25 years, there has been little improvement in student achievement. Expenditures for smaller class sizes and increases in teacher qualifications, for example—reforms purported to improve student achievement—have had little effect (Hanushek, 1995). Results of the current study appear to agree with the consensus in the literature that per pupil expenditure alone does not exert a significant influence on outcomes related to school improvement.
Free and Reduced Lunch Rate

In this study free and reduced lunch rate was not associated significantly with principals’ perceptions of leadership of mathematics education reform. This finding appears to differ from earlier findings coming out of “effective schools research,” which suggested that community SES did influence principals’ leadership. One possible explanation for this finding is that linear regression may underestimate the correlation of the independent and dependent variable when they come from different underlying distributions (Garson, 2007). The distribution for percent free and reduced lunch in this study was significantly positively skewed, with most of the values clustering below the mean. The distribution for the leadership of mathematics education reform scale was significantly negatively skewed, with most of the values clustering above the mean. Because the underlying distributions were different, the influence of free and reduced lunch rate on principals’ perspectives on leadership of mathematics education reform may have been underestimated in this study.

Employment of a Mathematics Department Chair

Although previous research suggested that principals from schools with formalized department chair positions showed more support for the implementation of standards-based mathematics than principals from schools without formalized department chair positions, in this study employment of a mathematics department chair had no significant influence on principals’ perceptions of leadership of mathematics education reform. This finding might make sense if the principals who responded to the questionnaire shared similar perspectives on leadership of mathematics education reform,
irrespective of the characteristics of the schools in which they worked. Moreover, it is possible that, when schools lack resources to employ department chairs, experienced teachers step in to fill the void. Research has shown that the role of department chair does implicate instructional leadership (Brown, 1993; King, 1991). Few studies, however, examine the instructional leadership of experienced teachers whose leadership occurs informally. Nevertheless, one might expect such individuals to provide some type of instructional leadership to less experienced teachers.

**Gender**

Results from previous research indicated that female principals might be more likely than male principals to direct attention toward implementation of standards-based reform of mathematics education. In this study, gender exerted a significant influence on principals’ perceptions of leadership of mathematics education reform only in the data set from which outliers had been removed, but it exerted no significant influence in the models developed with the full data set. While it is certainly possible that the removal of outliers produced a more representative data set, this possibility has not been explored empirically. Further examination of the data using sophisticated methods for handling outliers would allow for a more definitive interpretation, but these types of investigations were beyond the scope of the current study.

**Connection of Findings to the Literature**

This section briefly summarizes the findings from the study and connects them to related literature. It begins with a discussion of principals’ responses to the items used to construct the dependent variable, leadership of mathematics education reform. The
section then situates results related to the independent variables and their relationship to leadership of mathematics education reform within the context of findings from the related literature.

Leadership of Mathematics Education Reform

Many authors have made recommendations about what leaders should do to support mathematics reform (Cauley et al., 1993; Cauley & Seafarth, 1995; Glascock, 2003; Leinwand, 2000; McEwan, 2000; Mirra, 2003; NCTM, 2000; Paulu, 1994), but few studies provide evidence about what principals actually do to support such reform. Available evidence does show, however, that mathematics education standards have been unevenly implemented (Cauley et al., 1993) and that in general teachers have implemented very few reform measures in their classrooms (e.g., Price et al., 1995). Although this study did not speak directly to classroom practice, it did provide insight into the importance high school principals attached to certain practices associated with the reform of mathematics education. Moreover, it is reasonable to infer that principals’ level of support for these practices probably has some bearing on teachers’ willingness and interest in implementing them. As a result, it does make sense to examine the extent to which the principals who responded to this survey supported reform practices.

Leadership of mathematics education reform was operationalized as the total score on the ten items found to be reliable measures of the construct in the pilot study. The researcher ranked the items in order of descending means and found that the order of the items was the same for both the data set with outliers removed and the full data set.
Principals appeared to be only moderately supportive of the reform practices, illustrated by the modest values of their mean ratings and the limited variability in their responses.

The three practices that principals rated as most important for effective mathematics instruction were giving teachers time for professional development, engaging students in applications of subject matter in a variety of contexts, and giving teachers time to plan and prepare lessons. The three practices rated least important by principals who responded were making connections to other disciplines, having students work in cooperative learning groups, and using portfolios. The practices for effective mathematics instruction that principals rated lowest were all related to changes in pedagogy that have been recommended to increase students’ understanding of mathematics while only one of the highest rated practices had anything to do with classroom practice. This finding may indicate that principals are unfamiliar with the changes in pedagogy that have been recommended as necessary to the reform of mathematics education.

**Mathematics Knowledge**

Principals’ mathematics knowledge was measured with a composite scale as detailed in Chapter Four. Analyses of the two component scales, the number of mathematics courses taken for college credit and the mathematics efficacy scale, provided insight into the mathematics backgrounds of the principals who responded to the survey. Statistics related to each component scale are interpreted in this section in consideration of the limited extant literature.
Number of mathematics courses taken. The researcher asked respondents to check all mathematics courses for which they had received college credit. The method used for selection of the eleven courses on the list was explained in Chapter Four. The researcher listed the courses taken in descending order according to their frequencies and found that the order was the same for the data set with outliers removed and the full data set. No single mathematics course listed was selected by greater than 50% of respondents, illustrating that principals of high schools have somewhat limited experience with college level mathematics. In addition, the researcher counted the total number of mathematics courses the respondents took and found that the average number of mathematics courses taken was fewer than four courses. Moreover, over 12% of the principals reported that they had taken no mathematics courses for college credit.

Mathematics efficacy scale. As explained earlier, respondents were asked to indicate their confidence level on a scale from 1 (Not at all confident) to 5 (Very confident) to perform different mathematics tasks. The researcher listed the tasks in order of descending means and found that the order remained the same for the data set with outliers removed and the full data set. However, the corresponding standard deviations associated with each mathematics task steadily increased as the perceived comfort level with performing the task decreased. The larger variability associated with the tasks perceived to be more difficult (e.g., sketch the curve of a quadratic equation) indicates that the principals’ comfort levels spanned a range from comfort with simple arithmetic to comfort with second-year Algebra. The finding suggests that few principals would be
sufficiently comfortable with the mathematics content taught in high schools to provide meaningful instructional leadership to teachers of that subject.

Composite mathematics knowledge. The composite variable, mathematics knowledge was found (for the data set with outliers removed and the full data set) to have no significant relationship with locale of the school, leadership of mathematics education reform, employment of a mathematics department chair or gender of the principal. In addition, mathematics knowledge had no significant influence on leadership of mathematics education reform and did not appear in any of the regression models that accounted for the greatest amount of variance in perceptions of leadership of mathematics education reform. Results of this study appear to correspond with those obtained by Benak (2002) who found that the degree to which principals engaged in mathematics instructional leadership behaviors was not related to their undergraduate major or minor.

In addition, this study supports results reported by other researchers (Larson et al., 2006; Price et al., 1995) who found that principals did not typically have strong grounding in mathematics.

Locale

Locale was found to have no significant relationship with principals’ scores on the scale measuring mathematics knowledge. This result seems to contradict findings reported by Reeves and Larmer (1996) and Stern (1994), who found that rural principals were less well-educated than principals from other locales and would be expected, therefore, to be less knowledgeable about mathematics.

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4 Principals who had majored in mathematics would most likely have taken many mathematics courses for college credit and would most likely feel comfortable when solving complex mathematics problems, so Benak’s variable was more or less comparable to the mathematics knowledge included in the current study.
Locale also had no significant influence on principals’ perceptions of leadership of mathematics education reform. This finding appears to differ from the results of Hallinger and McCary’s (1992) study, in which leadership appeared to differ across locales. Results of the current study also seemed discordant with results from a study in which principals from urban schools scored significantly higher than did principals from suburban or rural schools on a mathematics leadership scale (Benak, 2002).

School Size

School size was found to be significantly correlated with per pupil expenditure, free and reduced lunch rate, and number of mathematics teachers. The relationship between enrollment and number of mathematics teachers was so strong that the latter variable was excluded as a predictor variable to avoid the threat of multicollinearity.

Enrollment did not have a clear association with principals’ perceptions of leadership of mathematics education reform. It was excluded from the best fit regression model using the data set from which outliers had been removed. Enrollment did contribute to variance in the dependent variable in one of the regression models constructed with the full data set, but the influence of this variable was not significant. Other researchers have found that principals of small schools are more likely to be instructional leaders than principals of larger schools (Bailey, 2000; Lashway, 1999; Meier, 1996; O’Neal & Beckner, 1981, as cited in O’Neal & Cox, 2002; Walberg & Walberg, 1994), so findings from this study appear to differ from findings reported previously.
Free and Reduced Lunch Rate

High school free and reduced lunch rate was found to be associated significantly with per pupil expenditure, enrollment, and number of mathematics teachers. Percent free and reduced lunch also appeared in the best fit regression model that resulted from analysis of the data set from which outliers had been removed. Although the model itself was significant, percent free and reduced lunch did not have a significant influence on principals’ perceptions of leadership of mathematics education reform. Percent free and reduced lunch did not appear in the models resulting from analysis of the full data set. This finding seems to disagree with earlier findings reported in several studies cited by Hallinger and Heck (1998) in which community SES was found to influence principals’ leadership and to moderate its impact on school effectiveness.

Employment of a Mathematics Department Chair

Respondents were asked if the schools in which they were principals had individuals designated as mathematics department chairs. The employment of a mathematics department chair was found to have no significant relationship with principals’ scores on the mathematics knowledge scale. Also, employment of a mathematics department chair had no significant influence on principals’ perceptions of the leadership of mathematics education reform. This finding differs from what Benak (2002) reported, namely that principals from schools with formalized department chair positions scored significantly higher than other principals on a scale measuring leadership related to support for the implementation of the NCTM standards.
Gender

Among rural principals in the data set with outliers removed, 20.8% were female and 79.2% were male. Among non-rural principals in the data set with outliers removed, 28.8% were female and 71.2% were male. These proportions reflect a phenomenon that has been discussed elsewhere (Howley, personal communication): Women are less likely to be employed as principals of rural schools than as principals of schools in other locales.

As well as these differences, gender also may have had an influence on principals’ perceptions of leadership of mathematics education reform. Using the data set with outliers removed, females scored significantly higher than males on this scale. A comparison of the means for males and females revealed that gender was responsible for 3.1% of the variance in perceptions of leadership of mathematics education reform. This finding seems to support findings from a study in which female principals scored significantly higher on a mathematics leadership scale measuring orientation toward the implementation of the NCTM standards (Benak, 2002).

One explanation for these findings is that female educational leaders may be more likely than their male counterparts to use contemporary approaches (e.g., facilitative or relational approaches) to leadership (Boone, 1997; Haskin, 1995). Moreover, they have been found in other studies to provide active support for educational change (Gill, 1995; Holtkamp, 2002; Katz, 2004; Wesson & Grady, 1993). Their general supportiveness for reform might also translate into specific support for mathematics education reform.
Recommendations

This section includes recommendations for future research based on the results of the study reported here.

Recommendations for Future Research

Enrollment, per pupil expenditure, and the employment of a mathematics department chair have been found in previous studies to influence the leadership of mathematics education reform, but results from this study did not support these earlier findings. Variables other than these may actually turn out to be better and more useful predictors of leadership of mathematics education reform.

This study could not investigate the influence of knowledge of mathematics education reform on the leadership of mathematics education reform because the scale developed to measure knowledge of mathematics education reform did not demonstrate sufficient technical adequacy in the pilot study. It is probable, however, that an association exists between doing what is recommended and knowing what the recommendations are. Future studies might use better instrumentation to explore the possible influence of knowledge of mathematics education reform on principals’ perceptions of the leadership of mathematics education reform.

Another promising condition, school climate—student-centered or teacher-centered—might influence the way principals approach leadership of reform efforts. Reforms might be easier to implement in a more student-centered environment. In a more teacher-centered school, climate changes might be required before a principal is able to
initiate reform of mathematics education. Future studies might explore the relationship between school climate and leadership of mathematics education reform.

The level of parent and community involvement in the educational process might also influence leadership of reform efforts. Those parents who are most concerned about their children’s future educational and employment opportunities might pressure their children’s schools to adopt reform measures.

The number of existing school improvement initiatives already underway might also influence principals’ perceptions of leadership of mathematics education reform. If improvement of mathematics teaching and learning is just “one more thing” added to a long list of reforms, few human and financial resources might be available to devote to the effort.

In addition, characteristics of mathematics teachers might influence principals’ perceptions of leadership of mathematics reform. Teachers’ awareness of and receptivity to the pedagogical recommendations included in the reform agenda, their skill levels, and their levels of content knowledge might all affect the ways that principals approach the supervision of reform initiatives, including those related to mathematics education.

Summary

This study provided some insight into the relative importance high school principals who responded to the survey assigned to certain practices in mathematics instruction. It also provided insight into the mathematics backgrounds of the principals as well as their relative comfort level in performing a variety of mathematics tasks.
Although the regression analyses computed using the data collected in this survey revealed no significant influence from any of the target variables other than gender on principals’ perceptions of effective leadership of mathematics education reform, some findings from this study differed from findings reported in earlier literature. These discordant findings pointed to areas in which further investigation might be needed. The fact that a set of well-established conditions thought to influence the leadership of mathematics education reform actually exerted no such influence suggests that other variables might be better predictors of leadership of mathematics education reform than the ones included in the current study.
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Appendix A: Description of Rural Representation in the Literature

A total of 193 schools were represented in the results from the studies relating to instructional leadership in high schools for which the sample was described. Fifty-eight or 30.0% of those schools were identified as urban; 134 or 69.4% were identified as representative samples of urban, suburban and rural schools; and only one school or 0.5% was identified as rural. In addition, in the literature related to mathematics reform, a total of 471 schools were represented for which the sample was described. One hundred ninety seven schools or 41.8% were identified as urban; thirty-seven or 7.9% were identified as suburban; one hundred two or 21.7% were identified as rural; and 135 schools or 28.7% were identified as representative samples of urban, suburban and rural schools. In addition, for the schools represented in the literature related to the principals’ role in mathematics reform, 193 schools or 41.0% were identified as elementary schools; nine schools or 2.0% were identified as middle schools; 176 schools or 37.4% were identified as high schools; and 93 schools or 19.7% were identified as representative samples or were unidentified with regard to school type.
Appendix B: E-mail to Ohio Principals

September 18, 2006

Dear Ohio High School Principal:

I am a doctoral candidate in the Educational Studies department at Ohio University. I am sending this e-mail to all Ohio public high school principals to request assistance with a pilot test to refine the online questionnaire about mathematics education I will use to complete my dissertation study later this year. Your responses will be completely anonymous as there is no way to identify anyone’s responses through the online system. Data will be encrypted so your responses cannot be viewed by others during transmission. Analysis of the information will be at the group level only and will be confidential. Your participation in this pilot study is voluntary and the initial screen of the questionnaire will state that by clicking on “Next” and completing the questionnaire you consent to participate in the study. Please go to the following URL: http://www.surveymonkey.com/s.asp?u=741642561585 and complete the online questionnaire. You will also be asked to provide feedback about your experience. Your comments will be used to make adjustments in the design and user-friendliness of the web-based approach and the clarity of items. If possible, please complete the questionnaire by September 30, 2006.

Should you require more information, you may contact my committee chair, Dr. Aimee Howley, howley@ohio.edu or myself, huberdo@cybqrtown.com. Thanks in advance for your help.

Sincerely,
Donna Huber
Appendix C: Reminder E-mail to Ohio Principals

October 10, 2006

Dear Ohio High School Principal,

If you have not yet responded to the Mathematics Education Questionnaire I asked you to complete in early September, could you please go to the following link: http://www.surveymonkey.com/s.aspx and assist me with the refinement of my questionnaire for my dissertation?

The average time it has taken to complete the questionnaire has been about ten minutes. I am a doctoral candidate in the Educational Studies department at Ohio University. Should you require more information, you may contact my committee chair, Dr. Aimee Howley at howley@ohio.edu or myself.

Thanks in advance for your help.

Sincerely,

Donna Huber

Please note: If you do not wish to receive further emails from us, please click the link below, and you will be automatically removed from our mailing list.

http://www.surveymonkey.com/optout.aspx
March 26, 2007

Dear High School Principal:

I am a doctoral candidate in the Educational Studies department at Ohio University. I am sending this letter and enclosed questionnaire to high school principals in Pennsylvania to request participation in my dissertation study about mathematics education. The purpose of my study is to examine any relationships that might exist between certain demographic features and mathematics education.

Your participation in this study is voluntary and at minimum risk. Although I hope you choose to complete the entire questionnaire, you may choose to respond to any portion or portions if you wish. Returning the questionnaire will signify your consent to participate in the study for research purposes and no signature will be required.

Tracking numbers on the cover sheet of the questionnaires will be used to determine which questionnaires have been returned so that your time will not be wasted with follow-up contacts. Responses will not be identifiable by school in the data analysis process as I will tear off the cover sheet and assign a new code corresponding to the order in which questionnaires are received. Analysis of the information will be at the group level only and findings will be reported at aggregate levels.

Please take a few minutes to complete the questionnaire and return it to me in the enclosed self-addressed stamped envelope. Without your assistance, I would not be able to conduct this research project, which hopefully will provide insight into current conditions surrounding mathematics education. When the study is completed, I will provide you with a description of the results should you request it. My e-mail address is listed below. If possible, please complete the questionnaire by April 13, 2007.

Should you require more information, you may contact my committee chair, Dr. Aimee Howley, howley@ohio.edu or myself, huberdo@cybrtown.com. Thanks in advance for your help.

Sincerely,

Donna Huber
Doctoral candidate, Ohio University
Appendix E: Review of Qualitative Feedback from Pilot Study

How long did it take you to complete the questionnaire?
114/129 or 88.37% of the respondents indicated a time for how long it took them to complete the questionnaire. When a time span or the words “less than” were used, the upper time limit was used to compute the average time required to complete the survey, which was 11.37 minutes. Respondents were not required to answer the feedback questions. 11/129 or 8.5% did not respond to the question. Two respondents reported “too long” in response to the question, one respondent “was interrupted” and another typed “Sorry, I didn’t keep track.”

Please provide suggestions regarding the design of the questionnaire.
70/129 or 54.26% of the respondents did not answer this question. 32/129 or 24.81% of the respondents indicated that the design of the questionnaire was good or had no suggestions for improvement. Specific comments included that the design was “user friendly” and “easy to complete.” 23/129 or 17.83% of the respondents provided suggestions or comments regarding the design of the questionnaire. Two respondents suggested that a choice of “not applicable” be added to the Likert-scaled items. Five respondents had comments similar to the following, “data on percentage of students on free and reduced lunch and per pupil expenditure may not be known without looking it up.” One respondent suggested that a range of values from which to choose should be included. Five respondents provided suggestions concerning checking the mathematics courses they had taken for college credit. Two respondents took no college mathematics courses and suggested that an option such as “none” be added so that the next page could be accessed without being required to choose a mathematics course. One respondent typed, “Are you sure all of your questions are worded neutrally?”

Please provide suggestions regarding the wording of the items.
91/129 or 70.54% of the respondents did not provide an answer to this question. 33/129 or 25.58% of the respondents had no suggestions for improvement or that the wording was “clear.” One respondent suggested that there be an area to list grades covered and said, “I was not sure how to answer since I have grades 7-12.” Another respondent suggested, “Provide a mechanism by which Principals can feel comfortable answering questions related to departments when the school is too small to have departments.”

Please use this space for any other comments regarding your experience with this online questionnaire.
94/129 or 78.87% did not respond to this question. 23/129 or 17.83% typed “none” or indicated that the experience was “good.” One respondent indicated that he or she had to search for the demographic information and that it took extra time. One respondent suggested that a paper form be used because “Many people do not trust online survey material.”
Appendix F: Revised Questionnaire

Mathematics Education Questionnaire

Tracking # _____

*Please do not remove this sheet. The tracking number will be used to reduce follow-up mailings.*

Go on to the next page.
1. Please rate each of the following practices in terms of its importance for effective mathematics instruction. (Circle your choice.)

<table>
<thead>
<tr>
<th>Practice</th>
<th>Not important</th>
<th>Somewhat important</th>
<th>Fairly important</th>
<th>Very important</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Making connections to other disciplines.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Having students work in cooperative learning groups.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Having students participate in appropriate hands-on activities.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Engaging students in inquiry-oriented activities.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Engaging students in applications of subject matter in a variety of contexts.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. Using portfolios.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>h. Giving teachers time to plan and prepare lessons.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. Giving teachers time to work with other teachers.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>j. Giving teachers time for professional development.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Go on to the next page.
2. If you were given a quiz, how confident are you, on a scale of 1 (Not at all confident) to 5 (Very confident), that you could perform each of the following mathematics tasks? (Circle your choice.)

a. Simultaneous equations
   - Not at all confident
     - 1
   - 2
   - 3
   - 4
   - Very confident
     - 5

b. Work with decimals
   - Not at all confident
     - 1
   - 2
   - 3
   - 4
   - Very confident
     - 5

c. Determine the degrees of a missing angle in a triangle
   - Not at all confident
     - 1
   - 2
   - 3
   - 4
   - Very confident
     - 5

d. An algebra problem
   - Not at all confident
     - 1
   - 2
   - 3
   - 4
   - Very confident
     - 5

e. A problem in trigonometry
   - Not at all confident
     - 1
   - 2
   - 3
   - 4
   - Very confident
     - 5

f. Calculate values of area and volume
   - Not at all confident
     - 1
   - 2
   - 3
   - 4
   - Very confident
     - 5

g. Sketch a curve
   - Not at all confident
     - 1
   - 2
   - 3
   - 4
   - Very confident
     - 5

h. Work with fractions
   - Not at all confident
     - 1
   - 2
   - 3
   - 4
   - Very confident
     - 5

i. Determine the value of a missing side length of a triangle
   - Not at all confident
     - 1
   - 2
   - 3
   - 4
   - Very confident
     - 5

Go on to the next page.
3. Which of the following college courses have you completed? Include both semester hour and quarter hour courses, both at the graduate and undergraduate level. Include courses for which you received college credit, even if you took the course in high school. (Choose all that apply.)

- Calculus
- Advanced calculus
- Real analysis
- Differential equations
- Geometry
- Abstract algebra
- Number theory
- Linear algebra
- History of mathematics
- Discrete mathematics
- Other upper division mathematics
- None

4. Demographic Information.

Please supply exact numbers for your answers to a. – d. below. (Please avoid answers such as “less than 10%” or ranges such as “20-25%”. If necessary, provide estimates rather than ranges.)

- a. What is the enrollment of your school?
- b. What percentage of students in your school receives free and reduced lunch?
- c. What is the average per pupil expenditure for your school?
- d. How many mathematics teachers do you have in your school?

Please circle your choice for e. and f. below.

- e. Does your school have an individual designated as a mathematics department chair?
  - Yes
  - No

- f. What is your gender?
  - Male
  - Female

This concludes the Mathematics Education Questionnaire. Please place all four pages in the self-addressed stamped envelope and mail by April 13, 2007. Thanks in advance for your help!