

Leadership of Mathematics Reform:  
The Role of High School Principals in Rural Schools

by

William Larson and Aimee Howley  
with Solange Andrianaivo, Brian Boyd, Victor Brown, Roni Hayes,  
Marged Howley, Longun Lado, Sue Nichols, Megan Rhodes, and Ron Smith

Ohio University

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## Foreword

No empirical study—not a single one before this one—has bothered to examine the *actual activities of rural principals* on behalf of improving mathematics education. Indeed, in 25 years of reform there have reportedly been fewer than ten studies of what principals do *anywhere* to lead math reform. The professional literature behind this study of principals' leadership of mathematics education reform, in fact, is mostly a *prescriptive* literature, and about ten percent of these prescriptive works reportedly mention rural schools.

This monograph, then, presents the results of the first study of rural principals' engagement with mathematics education "reform." The principal investigator was Ohio University researcher Bill Larson, with Aimee Howley serving informally as co-PI. Most significantly, perhaps, is the fact that the study was assisted by a group of nine students, including six doctoral students, four from the ACCLAIM multi-institutional program in mathematics education (Boyd, Brown, Nichols, and Smith), and three from Ohio's rural school administration program (Andrianaivo, Lado, and Rhodes). Two masters students assisted as well. At this date, the lead authors are also preparing a manuscript for journal publication.

The picture given in this report is not all bad nor all good—and this observation, I think, applies whatever the reader's outlook on good, bad, and indifferent might be. There are happy insights and disturbing ones from a variety of outlooks. Whatever the case, it surely makes sense to know what principals—those charged to manage and *lead* 84,000 or so public schools—do with math reform edicts. It remains curious that the question goes

unexamined generally and was completely untouched in rural schools until now. One has theories, which perhaps some doctoral students in “math ed” and “ed admin” can pursue to some profit.

Mathematics is a wonderful artifact of the human intellect—logical, clear, useful, beautiful, and therefore something about which one ought easily to become *passionate*. Math is something that schools ought to teach, it seems: But is there a connection between the schooling of mathematics and the general lack of passion for this stunning artifact of intellect?

It’s a deep question, even if the answer appears to be “yes.” The claim that the reason for *yes* is “bad curriculum, bad pedagogy, and bad tests” is mostly hypothetical. It might be right, but it might not be right. The problem with schooling might not be mismanagement (of curriculum, teaching, and testing) but the bad uses to which intellect is put, including the most stunning of its artifacts. Perhaps especially that one. Knowing what’s going on with principals in rural schools has as much to tell us about *that* hypothesis as it does about the other one (i.e., mismanagement of the technical enterprise).

Craig Howley  
Albany, Ohio  
January 3, 2006

## Leadership of Mathematics Reform: The Role of High School Principals in Rural Schools

### Executive Summary

Though most empirical studies have shown that principals' time is occupied with a variety of managerial tasks, principals have been asked to act as "instructional leaders" for at least 20 years. The role of "instructional leader" has been described variously, almost always in relationship to general school reform and seldom in relationship to particular disciplines. It should come as no surprise therefore that the professional literature on principals' leadership of mathematics reform is extremely limited, and that consequently the opportunity for empirical study is quite great.

This study took the opportunity therefore to pose three research questions relating to rural high school principals' leadership of standards-based mathematics education reform:

- How do principals of rural high schools think about standards-based mathematics?
- How do principals of rural high schools construct their role with regard to the deployment of standards-based mathematics reform in Ohio?
- What actions do principals of rural high schools take in order to address state requirements (e.g., the Ohio Graduation Test) linked to standards-based reform in mathematics?

The study contextualized its investigations to high schools in three types of rural community in order to develop descriptions of *actual leadership practices* rather than vague generalizations about what all instructional leaders "ought" to do. Moreover,

narrowing the focus to local schools' helps focus attention on *local dialog about the leadership of mathematics education*.

### *Major Themes in the Prescriptive and Empirical Literature*

Of the more than 2,000 entries listed under the ERIC descriptor "Instructional Leadership," only 89 have anything to do with the reform of mathematics education, and only about one-third are classified as research reports. Among the empirical reports, *not a single* one relates to schools in rural areas, and just eight of the non-research documents concern rural schools. In short, attentiveness to context is not evident in this literature.

Nonetheless, the prescriptive and empirical literature presented some common themes associated with principals' support for standards-based reform of mathematics education. Three themes were notable.

The first theme concerned the increasing principals' knowledge about reform of mathematics education. This was the focus of most of the prescriptive literature. Findings from several empirical studies implied that principals with greater understanding of standards-based reform were more likely to support it (e.g., Austin Collaborative for Mathematics Education, 1999; Price et al., 1995).

A second theme focused on principals' efforts to encourage meaningful collaborations among teachers. Teacher collaboration was a prominent recommendation in the prescriptive literature, and evaluation reports of reform initiatives suggested a team effort was useful in stimulating and sustaining reform (e.g., Austin, 1999; Burns, 1999; Huinker et al., 1999).

The third theme construed principals' leadership as the ability to keep attention focused on reform. Such efforts were reportedly those required to mobilize support and limit distractions (e.g., Austin, 1999; Burns, 1999; Foley, 1993; Glascock, 2003). This theme appears prominently in the generic literature on instructional leadership as well as in specific recommendations for math education reform leadership (e.g., McEwan, 2000; St. John et al., 1999).

### *Methods*

This study used qualitative interviewing, a form of what Merriam (2001) calls “basic or generic” qualitative research (p. 11). The approach provides understanding of “how events occur” and “how event[s] are] interpreted by participants and onlookers” (Weiss, 1994, pp. 9-10). The events of interest in this study were the processes used by schools to reform mathematics curriculum and instruction; the objects of interpretation included mathematics content standards, the Ohio Graduation Test (OGT), and school-specific improvement processes.

Seven principals were selected from *remote Appalachian schools*, seven from *remote non-Appalachian schools*, and seven from *less remote rural schools*—for a total of 21 selected principals. (During the course of the research, one principal repeatedly cancelled scheduled interviews, so the analysis is based on 20 interviews.) The three-part locale categorization reflected significant differences in schools and the communities they serve. Rural Appalachian Ohio, for example, is quite distinct from the agrarian regions found in the northwestern part of the state. In addition, cosmopolitan (or “suburbanizing”) rural schools (and communities) differ from both of these other types of rural places in

terms of their changing demographics, their local politics, and their cultural orientation (Howley et al., 2005).

One of the four interviewers on the research team conducted a semi-structured interview with each principal, using a protocol that included eight open-ended questions. (See Appendix A for a copy of the interview schedule.) By using the semi-structured approach, which allowed for follow-up questions beyond those on the interview schedule, the interviewers were able to evoke detailed and precise responses. At the same time, the eight-question interview schedule structured conversations that were brief enough (usually less than 60 minutes) to enable busy principals to participate in the study.

Data analysis sought to identify processes (and interpretations of processes) bearing on the research questions. One researcher coded all transcripts using Atlas-TI software. Inductive coding processes were used, whereby each new idea was given a separate code—344 in all. The researcher then developed a concept map showing the relationship among codes, and created categories linking the most closely related codes. Ultimately, six categories were derived in this way. Findings consider each of the six themes and results of a systematic analysis across locales to identify similarities and differences.

### *Findings*

Data analysis of the principals' responses revealed six relevant categories: (1) leadership for mathematics reform, (2) strategies to support mathematics reform, (3) math talk—expressions reflecting attentiveness to current issues in mathematics education, (4) curricular issues, (5) teachers' role in mathematics reform, and (6) impediments to reform.

In addition, analysis of responses in relationship to three different rural locales supported some speculative comparisons.

*Leadership.* Data about the principals' approaches to leadership suggested that these administrators did not embark on reform of mathematics education as if it were a personal mission. Rather, the mandatory character of the reform agenda encouraged them to display the behaviors, attitudes, and overall detachment associated with their legitimate authority. As far as leadership was concerned, the principals seemed to stay true to their own personal styles, which incorporated transactional, transformational, or a combination of the two approaches. None of the respondents put forward the idea that innovation warranted a new approach to mobilizing the participation of teachers.

*Strategies.* Fueled by a concern to see their students perform well on the Ohio Graduation Test, principals assisted their faculties in identifying and making use of various strategies. Two strategies were used by most schools: curriculum alignment and individualization. In more than half of the schools, two other strategies were used: changes in pedagogy and collaboration among teachers, within and across schools. In some schools in which collaboration was not deployed explicitly as a reform strategy, it took place informally. Other strategies such as "double-dosing" and a "core curriculum" approach were used in a few schools.

*Math talk.* Principals did not engage in much talk about the nature of mathematics learning or about new approaches to mathematics pedagogy. They exhibited little familiarity with the specifics of the Ohio mathematics content standards and even less familiarity with the specifics of the NCTM standards. Rather, they connected reform in mathematics education with specific changes in the accountability test administered in

Ohio. These changes did, however, encourage many principals to provide support for mathematics instruction that was focused more on problem-solving and understanding than on rote recall of facts and algorithms.

*Curriculum.* The data revealed that principals primarily thought about curriculum in relationship to standard-based reform. Some of them accepted the outside pressure associated with such reform as an acceptable price to pay for improvements in the teaching and learning of mathematics. Others adopted the mandatory reform agenda somewhat unwillingly because of their reservations about its impact on average or less than average students.

Nonetheless, there was a consensus on the point that the implementation of curriculum change was ultimately the preserve of school-level agents, that is, faculty and the principal. The statements of the respondents also revealed that a number of them or their staff members tried to get away with making cosmetic changes only. By contrast, other schools went for drastic innovations in regard to textbook choices, course content and sequences, or structures that support learning.

In sum, the principals interpreted and implemented state requirements for reform in ways that reflected their personal beliefs about math instruction and the particular cultures of their schools.

*Teachers' role in mathematics reform.* Although most of the principals expressed a commitment to math education reform, most saw reform as the responsibility of the math teachers at their schools. Principals attributed successful math reform to strong teacher leadership, willingness of the staff to take on challenges associated with reform, and the

math departments' effective use of common planning time and professional development opportunities.

*Impediments and excuses.* The principals described mathematics reform as a contested terrain fraught with challenges. Their complaints centered on the fact that instructional change was a complex job that was added on top of their already heavy and complicated workloads. Existing obstacles to effective school management and leadership were thereby exacerbated by the pressing nature of state mandates. Regarding curriculum change, some principals pictured themselves as isolated figures bearing the weight of aligning official requirements with school realities. According to some, these realities included resistant teachers who did not want to change instructional practice. For others, parent and community values interfered with reform. And some principals saw the reforms themselves as politically motivated, transitory, and difficult to address in substantive ways.

*Cross-locale summary.* As mentioned previously, differences across locales might be coincidental, simply reflecting the non-randomness of the processes used to select principals to participate in the study. But they might point to consequential differences. Of particular interest are two perspectives distinguishing the principals in non-Appalachian remote schools from the other principals, namely their view that raising expectations is an important part of curriculum reform and their tendency to downplay impediments to reform. These perspectives are especially interesting given that achievement in the non-Appalachian remote schools is as high as that in the cosmopolitan rural schools, despite the fact that its economic base is almost as weak as that of the Appalachian schools. Overall, findings from this study did connect in significant ways to findings in the related empirical literature and recommendations in the relevant prescriptive literature. But the

current study also offered new insights about how principals construe the reform of mathematics education and what they do in response to mandates for such reform. Notable among these findings were: (1) principals made extensive use of curriculum alignment as a reform strategy, (2) they regarded tracking and remedial math classes as viable reform strategies, (3) they tended to read the reform of mathematics education primarily in terms of state-mandated accountability provisions, and (4) principals in different types of rural locales seemed to view reform of mathematics education differently and to respond to mandates for such reform in different ways.

Based only on a small non-random sample of principals in one state, these insights primarily represent provocations to further research. Researchers in mathematics education, for example, might use insights from this study to inform more extensive investigations of the use of curriculum alignment and various strategies for individualizing instruction. Those interested in curriculum policy might focus increased attention to the relationship between principals' support for curriculum mandates and their leadership of the reforms specified in those mandates. And scholars with an interest in rural education might add to the knowledge of schooling in rural places by conducting systematic comparisons of curriculum, instruction, and school leadership across different types of rural communities. Our research team certainly looks with anticipation for work that tests or illuminates the claims about the leadership of reform in mathematics education that our study can offer only tentatively.

### *Implications*

Based only on a small non-random sample of principals in one state, these insights primarily represent provocations to further research. Researchers in mathematics education, for example, might use insights from this study to inform more extensive investigations of the use of curriculum alignment and various strategies for individualizing instruction. Those interested in curriculum policy might focus increased attention to the relationship between principals' support for curriculum mandates and their leadership of the reforms specified in those mandates. And scholars with an interest in rural education might add to the knowledge of schooling in rural places by conducting systematic comparisons of curriculum, instruction, and school leadership across different types of rural communities.

## Leadership of Mathematics Reform: The Role of High School Principals in Rural Schools

### Introduction

From the mid-1980s forward, literature in educational administration has exhorted principals to take on the role of “instructional leader.” The functions characterizing the role have been identified often and variously, but mostly in relationship to general school reform. Characterizations of the instructional leadership associated with reform in particular disciplines are much less common. With regard to leadership of mathematics reform, the literature is indeed limited. Of the more than 2,000 entries listed under the ERIC descriptor “Instructional Leadership,” only 89 have anything to do with mathematics reform. Of those, only 31 are classified as research reports. Among those, not even one relates to schools in rural areas, and only eight of the non-research documents (e.g., program descriptions, opinion papers) concern rural schools.

Clearly, the field is open for empirical studies of principals’ role in leading reform of mathematics curriculum and instruction. Efforts to contextualize such studies (e.g., in relationship to locale or other community characteristics) and to limit them to particular organizational patterns (e.g. high schools rather than middle or elementary schools) encourage rich descriptions of actual leadership practices rather than vague generalizations about what all instructional leaders ought to do.

Moreover, narrowing the focus to schools’ understanding and deployment of standards-based reform enables such studies to contribute not only to the dialog about instructional leadership but also to the dialog about mathematics education. Whereas

professional societies and state education agencies seek a particular set of reforms linked to state accountability provisions (e.g., National Council of Teachers of Mathematics, 2000; Ohio Department of Education, 2001), local educators, parents, and community leaders often conceptualize mathematics reform differently. A political reality shaped by accountability mandates and published test results clearly pressures principals to be attentive to standards, but their location within particular schools and communities also exerts an influence.

Gathering data from the principals' perspective, this study considered such dynamics in rural high schools in Ohio. It sought answers to the following research questions:

- How do principals of rural high schools think about standards-based mathematics?
- How do principals of rural high schools construct their role with regard to the deployment of standards-based mathematics reform in Ohio?
- What actions do principals of rural high schools take in order to address state requirements (e.g., the Ohio Graduation Test) linked to standards-based reform in mathematics?

### Related Literature

Although a review of the extensive literature on principals' instructional leadership is not appropriate here, summarizing its major findings sets the stage for a discussion of the far less extensive literature on leadership of mathematics reform. Three findings seem particularly relevant. First, many studies show that strong instructional leadership influences student achievement (e.g., Waters, Marzano, & McNulty, 2003). Second, the evidence suggests that instructional leadership influences student achievement indirectly,

by influencing school culture and climate (e.g., Weber, 1987). Finally, the consensus is that strong instructional leadership influences school culture and climate through certain practices, but the set of practices that is most effective has not been agreed upon.

Early studies of school effectiveness provided various lists of practices characterizing strong instructional leadership (Howley, 1989), but later studies suggested that other practices were more salient or that instructional leadership was an ascribed trait rather than a discrete set of practices. According to Leithwood and Duke (1998, p. 32), “lack of explicit descriptions of instructional leadership makes it difficult to assess the extent to which such leadership means the same thing to all those writing about it.” One recent meta-analysis, however, claimed to identify 20 constellations of practices characterizing effective instructional leadership (e.g., Waters et al., 2003).

Despite the lack of consensus about what constitutes instructional leadership or how it might relate specifically to reform of mathematics curriculum and instruction, several writers have published documents telling principals how to perform this role. Below is a review of this prescriptive literature, followed by an examination of the small body of empirical literature describing what principals actually do to support mathematics reform.

### *Prescriptive Literature*

Recognizing principals as key change agents, Cauley and Seyfarth (1995) recommended ways for principals to promote standards-based reform of mathematics education. They explained that first principals need to understand and communicate reasons for improving mathematics curriculum and instruction. Then they need to (1) support the development of a high-level and technologically sophisticated core curriculum,

(2) encourage changes in teaching practice that enable students to focus on problem solving and reasoning, and (3) seek improvements in assessment practices. The authors concluded with a brief discussion of the kinds of supports principals can provide, such as arranging common planning time for math teachers and offering opportunities for relevant professional development.

Based on their work with NSF-sponsored systemic initiatives for reform in mathematics and science education, evaluators from Inverness Research Associates (St. John, Century, Eggers-Pierola, Houghton, Jennings, & Tibbitts, 1999) developed a guide to help principals support reform of mathematics and science education in their schools. The recommendations included in the guide ostensibly represent commonalities in the practices observed by principals of schools in which reform has been effective. As the authors explain,

Principals' roles can vary widely depending on individual style, the organization of the school and the decision-making structures of the district. You might be working in a more "traditional" principal's role, or you might be part of a site-based or shared-decision making team. Still, successful principals share some common characteristics. They always have their "finger on the pulse" of progress, and are just as aware of what is happening inside the classrooms as they are about what is happening in the school as a whole, and in the district. They easily identify and refer to specific instances of exemplary practice and recognize and praise the work of individuals who are helping the school move ahead. In sum,

they actively participate in the effort at a variety of levels and have *firsthand knowledge* of what is happening. (p. 16)

The guide provides recommendations corresponding to four stages of the reform process: “setting the foundation, building critical programmatic supports, building critical relationships, and sustaining the process” (p. 19). Not surprisingly, these recommendations parallel the general literature on principals’ role in supporting reform. Further, the guide draws on national standards (e.g., the National Research Council’s National Science Standards) to identify specific avenues that principals should pursue in order to reform curriculum and instruction. These standards represent the conventional professional wisdom about mathematics and science education; they tend to overlook the possibility that other approaches to curriculum and instruction might also foster meaningful learning or fit in better with the expectations of particular communities.

Another discussion of what principals should do focuses specifically on reform of mathematics education (McEwan, 2000). According to McEwan, her recommendations are “primarily intended for school principals at every level to help them develop a plan for raising mathematics achievement in their schools” (p. xii). With this goal in mind, McEwan explains what reform of mathematics education entails: its intent, justification, and pedagogical premises. Her attentiveness to the controversies surrounding mathematics reform and the complexity of the relevant research findings leads her to offer a balanced approach. She does not, for example, repudiate direct instruction or drill-and-practice, instead examining the research that supports these approaches.

Nevertheless, her commitments are in clear evidence in her major recommendations, which draw on constructivist views of teaching and learning. She talks about three school essentials: “maintain[ing] a complete focus on student achievement,” “develop[ing] a total commitment to meaningful curriculum,” and “concentrat[ing] on collaborative lesson planning and peer observation” (pp. 62-64 passim). Ironically, however, McEwan’s discussion of what principals ought to do in order to promote change reiterates ideas about instructional leadership that come from “effective schools” research from the 1980s and early 1990s—a far more directive and less organic version of school leadership than what emerged later on (e.g., cultural leadership, distributed leadership). For example, her list of useful leadership practices includes the following directive practices: “establish clear instructional goals,” “communicate the vision and mission of your school,” and “set high expectations for your staff” (p. 91).

Whereas McEwan makes an effort to situate recommendations within the complex, sometimes contradictory research base on mathematics reform, Leinwand (2000) simply packages the NCTM gospel for school leaders. For example, he provides a list of fifteen statements about what a “high-quality mathematics program” entails, beginning with the following:

A high-quality mathematics program is defined, guided, and supported by a comprehensive, developmentally appropriate written curriculum that is consistent with the vision of the NCTM standards and incorporates expectations of all valued assessment systems used to assess program effectiveness. (p. 82)

Although he provides detailed explanations of standards-based mathematics reform, Leinwand is much less specific about the leadership practices that foster such reform. He notes, for example, that leaders ought to be qualified and that they ought to set high standards and provide appropriate support. In the absence of empirical evidence linking specific leadership practices with reform of mathematics education, the presentation of vague but generally accepted nostrums about effective leadership practice is certainly understandable. It does, however, suggest the need for empirical investigations of what principals actually do to support improvements in mathematics teaching and learning.

Focusing on rural schools only and grounding recommendations in the literature on instructional leadership from the 1980s as well as the literature on community-based education, Glascock (2003) challenges principals to consider various approaches to standards-based reform of mathematics education. Her discussion considers the benefits of inquiry-based instruction, integrated instruction, experiential learning, and community engagement.

Overall, the prescriptive literature helps to prepare principals for issues they will encounter as they work to improve mathematics education in their schools. But the value of the specific recommendations included in this literature is uncertain because so little empirical work has been done to demonstrate the association of particular leadership practices with reform of mathematics curriculum and instruction. The small body of empirical literature is examined next.

### *Empirical Literature*

The studies providing information about how principals think about and support improvement in mathematics education do not constitute a systematic body of literature. Rather, they represent more or less idiosyncratic efforts of a few researchers and research teams to explore particular issues relating to school-level leadership of mathematics reform. This research includes surveys of principals' attitudes, beliefs, and practices; evaluations of initiatives in particular schools and districts; and descriptive case studies.

*Studies of principals' attitudes and practices.* In a 1977 survey, Post, Ward, and Wilson compared the perspectives of mathematics and mathematics instruction held by principals, teachers, and higher education faculty members. Whereas there was considerable agreement in the responses of the K-12 educators—both teachers and principals—there were notable differences between the responses of K-12 educators and those of college faculty. More faculty than K-12 principals and teachers viewed mathematics and mathematics instruction from the vantage of “cognitive science” (i.e., constructivism), and more K-12 educators viewed them from the vantage of behaviorist principles. This mismatch suggested to the authors that structural conditions in schools might be keeping teachers and principals from understanding and embracing the more productive views of mathematics and mathematics instruction made possible through the lens of cognitive science.

Using an open-ended questionnaire and collecting data from 40 schools in which principals and teachers had been collaborating on reform of mathematics instruction, Foley (1993) identified eight leadership practices that contributed positively to the change process. These were (1) support, (2) planning and participating in the process, (3)

providing appropriate training, (4) supplying teaching resources, (5) supplying relevant information, (6) communicating with parents and community members, (7) empowering teachers, and (8) exercising leadership by sharing a vision and shepherding the change process (pp. 5-6). Foley conducted site visits at two of the schools to provide greater elaboration of the processes identified via the questionnaire. Conclusions from the study were summarized using a model of the change process that incorporated principals' roles, teachers' roles, events in the process, and contextual supports.

Somewhat deeper understandings of principals' views of mathematics learning and teaching came from participant observation of administrators involved in a three-year professional development project (Nelson, 1998, 1999). Of the 40 administrators involved in the project, 32 were elementary school principals. Because the project's aim was to influence principals' thinking about mathematics education reform, it inevitably focused on their beliefs. For example, Nelson found that, prior to project activities, the administrators thought of instruction primarily as the transmission of information, and they considered supervision primarily as a top-down effort to change teachers' behaviors. As Nelson explained, "Often administrators' practice was built upon transmission ideas about learning and teaching and entailed assumptions about the standardization of student learning and the proceduralization of teaching practice." She reported, however, that by the end of the project, the administrators had learned to listen more attentively to others and to reflect on their own practice. They also seemed more open to the idea that teachers of mathematics construct knowledge that informs their practice, including knowledge about mathematics, about how children learn, and about how instructional practices work.

*Program evaluations and case studies.* Based on a case study of three elementary schools in one urban district, several researchers (Price, Ball & Luks, 1995) examined data relating to principals' allocation of resources on behalf of reform of mathematics curriculum and instruction. Their findings suggested that the six principals who were interviewed had little knowledge of mathematics or mathematics instruction, and they understood math reform initiatives in extremely superficial ways. Furthermore, they reported having little time or incentive to find out more about how to assist teachers in improving mathematics curriculum and instruction. In fact, although all of the principals had agendas focusing on some type of school improvement, none included math education on that agenda. By contrast, several of the principals devoted energy and resources to instructional improvement in reading.

A system-wide initiative in Austin, Texas also provided information about principals' role in reform of mathematics education. A 1999 report prepared by the district's division of program evaluation summarized the work involved in implementing standards-based mathematics in the elementary and middle schools of this urban district. According to the report, principals' engagement with the effort was critical. Whereas some principals provided high levels of support by working with reluctant teachers, giving positive feedback to teachers who adopted standards-based practices, and facilitating peer coaching arrangements, others communicated mixed messages. The less enthusiastic principals allowed reluctant teachers to continue to use traditional practices and failed to endorse the changes made by early adopters of the mathematics education reforms. The report identified a variety of practices that teachers attributed to supportive principals: providing kits to help them implement the standards-based approach,

increasing copy budgets, and facilitating participation in professional development activities. The evaluators also identified leadership characteristics that were associated with successful implementation of the standards-based reforms. These included: (1) knowledge about the character of standards-based reform, (2) explicit expressions of commitment to the reform, (3) understanding and communication of a systemic vision, (4) clear goal-setting embedding high expectations for teachers' engagement, (5) facilitation of team meetings and other forms of teacher collaboration, and (6) identification and support of teacher leaders. Certain practices of principals detracted from the reform, however. For example, some principals saw other goals as more important than math reforms; others gave mixed messages about the value of the reform or about the teaching materials or methods that teachers might use.

The need for leadership was also mentioned in the report of another system-wide initiative—this one sponsored by the National Science Foundation and focusing on math and science instruction in elementary, middle, and high schools in Milwaukee (Huinker, Coan, & Posnanski, 1999). According to the teachers interviewed by the project evaluators, much of the leadership of instructional reform in this system came from teacher leaders rather than from principals. Leadership involved organization of and support for the development of learning communities in which teachers could discuss learning processes, curriculum content, and instructional methods. Despite teachers' claims about the major source of leadership, principals reported that they were enthusiastic about the reform and were taking steps to support the development of professional learning communities.

Self-reports from principals engaged in reform of mathematics education were included in an edited collection (Burns, 1999). Among the successful practices that

principals described were: (1) providing opportunities for teachers to discuss curriculum and instruction, (2) arranging for relevant professional development, (3) observing teachers and offering feedback, and (4) encouraging teachers to observe demonstration lessons showcasing exemplary teaching methods.

### *Major Themes in the Related Literature*

The prescriptive and empirical literature presented some common themes associated with principals' support for standards-based reform of mathematics education. Three themes were notable.

The first concerned principals' knowledge. Increasing their knowledge about reform of mathematics education was the focus of most of the prescriptive literature. In addition, findings from several empirical studies (e.g., Austin Collaborative for Mathematics Education, 1999; Price et al., 1995) implied that principals with greater understanding of standards-based reform were more likely to support it.

A second theme focused on principals' efforts to encourage meaningful collaborations among teachers. Reports of reform initiatives (e.g., Austin, 1999; Burns, 1999; Huinker et al., 1999) provided evidence that a team effort was needed in order to stimulate and then sustain reform. Teacher collaboration was also a prominent recommendation in the prescriptive literature.

Finally, principals' leadership of standards-based improvement seemed to depend on their efforts to keep attention focused on the reform initiative. Whether these efforts entailed "visioning" (e.g., Burns, 1999; Glascock, 2003), communication with constituents (e.g., Foley, 1993), or framing of a coherent message (e.g., Austin, 1999), they succeeded

in mobilizing support and limiting distractions. The idea that principals need to develop, communicate, and garner support for a worthy vision of improvement also features prominently in general literature on instructional leadership (from the 1980s forward) as well as in specific recommendations for their leadership of standards-based reform of mathematics education (e.g., McEwan, 2000; St. John et al., 1999).

### Methodology

The methodology of this study is what Merriam (2001) refers to as “basic or generic” qualitative research (p. 11). This approach enables researchers to “discover and understand a phenomenon, a process, or the perspectives and worldviews” of a particular group of people (p. 11). The research discussed in this report focused attention on the perspectives of principals of rural high schools.

Specifically, the study used the method of qualitative interviewing. According to Weiss (1994, pp. 9-10), this approach provides a basis for understanding “how events occur” and “how event[s are] interpreted by participants and onlookers.” The events of interest in this study were the processes used by schools to reform mathematics curriculum and instruction; the objects of interpretation included mathematics content standards, the Ohio Graduation Test (OGT), and school-specific improvement processes.

### *Data Sources*

The research team selected 21 participants from among rural high school principals in Ohio. Seven were selected from remote Appalachian schools, seven from remote non-Appalachian schools, and seven from less remote rural schools. This categorization

reflected significant differences in schools (and the communities they serve). Rural Appalachian Ohio, for example, is quite distinct from the agrarian regions found in the northwestern part of the state. Economic, political, and cultural differences between these regions of the state are quite marked. In addition, cosmopolitan (or “suburbanizing”) rural schools (and communities) differ from both of these other types of rural places in terms of their changing demographics, their local politics, and their cultural orientation (Howley et al., 2005). See Appendix A for tables with data on each school in the study.

The team used the following procedures for categorizing and selecting schools. First, the team generated a list of “cosmopolitan rural” schools in Ohio including all those with (a) a CCD code of 6, 7, or 8 and (b) location in a county in which in-commuting rates moderately exceeded out-commuting rates in both the 1990 and the 2000 census (Ohio Department of Jobs and Family Services, 2002; Ohio Department of Jobs and Family Services, 2003).<sup>1</sup> From that list, they identified schools in different regions of the state. Finally, they called principals of schools on the list to determine their willingness to participate. For “remote rural” schools, a similar procedure was used, but criteria for selection were a CCD code of 7 or 8 and (b) location in a county in which out-commuting rates equal or moderately exceed in-commuting rates. Schools that met these criteria were identified by their county location as Appalachian or non-Appalachian, and the researchers developed a list of the qualifying high schools in each of the two locations. Within each

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<sup>1</sup> This definition provides a way to identify rural communities that exist within relatively stable county economies that draw workers to them. Because of the influx of workers from outside of their borders, residents of such communities are likely to be exposed to more varied influences than residents of counties that neither “import” nor “export” workers or those that primarily “export” workers. The operational definition identifies five counties: Allen, Hancock, Shelby, Union, and Summit. Counties containing large cities (e.g., Franklin, Hamilton) were excluded in order to avoid identifying communities making the transition from rural to suburban demographics.

location (i.e., Appalachian, non-Appalachian), the researchers sought schools located in geographically diverse counties.

### *Data Collection*

One of the four interviewers on the research team conducted a semi-structured interview with each principal, using a protocol that included eight open-ended questions. These questions elicited information about what principals did in order to undertake and sustain standards-based reform in mathematics. (See Appendix B for a copy of the interview schedule.) The team used open-ended questions in order to enable participants to define the issues in their own ways (Merriam, 2001).

By using the semi-structured approach, which allowed for follow-up questions beyond those on the interview schedule, the interviewers were able to evoke detailed and precise responses. At the same time, the eight-question interview schedule structured conversations that were brief enough (usually less than 60 minutes) to enable busy principals to participate in the study. This strategy proved successful: only one principal whom we contacted showed reluctance to participate. Even though he hesitantly agreed to be interviewed, his repeated changing of interview dates and times made it impossible for the team to arrange an interview. As a result, only 20 of the 21 principals selected actually provided interviews. Interviews were audio-taped and transcribed verbatim.

### *Data Analysis*

The goal of data analysis was to identify processes (and interpretations of processes) that were salient to the principals. Weiss (1994) calls this approach to data analysis “issue-focused,” explaining:

An analysis whose aim is issue focused would concern itself with what could be learned about specific issues—or events or processes—from any and all respondents. Some respondents might contribute more to the analysis, others less.

The procedures used in this type of analysis typically include coding of data, sorting and categorizing of data, and integration of the resulting categories within a coherent structure (see e.g., Weiss, 1994).

In this study, one researcher coded all transcripts using Atlas-TI software. Inductive coding processes were used, whereby each new idea was given a separate code—344 in all. The researcher then developed a concept map showing the relationship among codes, and created categories linking the most closely related codes. Salient categories were distinguished from less salient ones based on the number of coded quotes associated with each, and data identified by codes that did not fall into any of the salient categories were reviewed to determine whether or not they represented important sources of counterfactual information. Ultimately, six categories were derived in this way: (1) leadership, (2) reform strategies, (3) math talk, (4) curriculum, (5) teachers, and (6) impediments and excuses. Interpretation of the major ideas presented in each category resulted in the identification of dominant themes as well as counterfactual positions.

Once data were categorized and within-category themes derived, one of the researchers conducted a systematic analysis across locales to identify similarities and

differences. This analysis involved the comparison of tallies indicating the extensiveness of the practices associated with particular themes.

## Findings

The researchers' analysis of the data resulted in a mapping of similarities and differences in the approaches to reform of mathematics education taken by the 20 participating principals. Then it turned to a comparison of the approaches across rural locales. In order to understand this comparison, descriptive information about the locales is presented first, followed by a discussion of similarities and differences in practices (organized in relationship to six categories). Finally, the cross-locale comparison is presented.

### *School Context*

Information about the cosmopolitan rural schools is presented first, followed by information about remote rural schools (first, Appalachian and then non-Appalachian schools). Next, the discussion turns to a brief consideration of patterns in the data that reveal differences across the three locales. (See Appendix A for data on individual schools.)

*Cosmopolitan rural schools.* The high schools that were identified as being “cosmopolitan rural” were Allen East, Anna, Bath, Elida, Fairbanks, Marysville, and Van Buren. These seven high schools had annual student enrollments in 2004-05 ranging from 290 to 1347, with an average annual enrollment of 630.6 (SD = 374.1). The annual student

attendance rates for the schools ranged from 93.9 to 96.9%, with an average of 95.2% (SD = 1.1).<sup>2</sup>

The average median income of families in the school communities was \$55,663, revealing incomes somewhat above the Ohio average of \$50,037.<sup>3</sup> Another indicator of relative affluence was the schools' low percentages of economically disadvantaged students.<sup>4</sup> These percentages ranged from 3.6 to 14.5, with an average of 7.6% (SD = 4.6). Low student mobility rates, moreover, suggested that the schools served stable communities. During 2004-05 the annual percentage of students who were in these schools for less than a full year ranged from 3.5 to 6.9%, with an average of 5.1% (SD = 1.4). This average contrasts with an average mobility rate across Ohio schools of 12.9%,

In the cosmopolitan rural schools, performance on state accountability tests in mathematics exceeded Ohio averages. In 2004-05, the annual percentage of students from these schools who passed the math section of the OGT ranged from 77.6 to 96.8%, with an average pass rate of 89.2% (SD = 6.2). The pass rate for Ohio as a whole was 81.6%. Similar patterns emerged with regard to performance on the mathematics subtest of the Ohio Proficiency Test (OPT) in the years 1999-2000 through 2003-2004, as revealed in Table 1.

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<sup>2</sup> Unless otherwise specified this report draws on data from 2004-05.

<sup>3</sup> Source: Census 2000 *School District Demographics Project*, accessible through NCES.

<sup>4</sup> The criterion for economic disadvantage in Ohio is eligibility for subsidized meals. Across the nation, subsidized meal rates in secondary schools are considerably lower than subsidized meal rates in elementary schools. This pattern suggests that subsidized meal rates may represent an underestimation of poverty levels in secondary schools.

Table 1: Comparison of Math OPT Pass Rates for the Cosmopolitan Rural High Schools

Year	Schools' Range	Schools' Average	State Average
2003-2004	85.6% to 96.4%	91.5% (SD = 5.5)	84.5%
2002-2003	86.0% to 93.8%	89.4% (SD = 3.1)	82%
2001-2002	82.7% to 95.7%	90.1% (SD = 4.3)	85.4%
2000-2001	78.6% to 94.0%	86.1% (SD = 5.2)	83.4%
1999-2000	79.1% to 95.0%	86.5% (SD = 5.3)	81.3%

*Remote rural Appalachian schools.* The high schools that were identified as being “remote rural Appalachian” were Adena, Fort Frye, Huntington, Meadowbrook, Oak Hill, Paint Valley, and Vinton County. These seven high schools had annual student enrollments in 2004-05 ranging from 379 to 754, with an average annual enrollment of 557.3 (SD = 150.1). The annual student attendance rates for 2004-05 ranged from 92.4 to 94.5%, with an average of 93.4% (SD = 0.8).

The communities in which the schools were located had an average median income of \$39,180, placing them considerably below the Ohio average of \$50,037. Another indicator of the economic hardship facing these schools was their percentage of economically disadvantaged students. These percentages ranged from 10.3% to 40.1%, with an average of 24.3% (SD = 9.5). Despite these indicators of economic distress, the schools seemed to serve fairly stable populations of students. Whereas across Ohio the average school mobility rate for 2004-05 was 12.9%, the average mobility rate for these schools ranged from 8.2 to 14.6 percent, with an average of 10.9% (SD = 3.1).

In the remote Appalachian schools, performance on state accountability tests in mathematics fell below Ohio averages. In 2004-05, the annual percentage of students from the high schools who passed the math section of the OGT ranged from 58.1 to 85.2%, with an average pass rate of 74.3% (SD = 9.3). The pass rate for Ohio as a whole was 81.6%.

Pass rates on the mathematics subtest of the Ohio Proficiency Test (OPT) in the years 1999-2000 through 2002-2003 also failed to reach state averages, but they exceeded that state average in 2003-04. These data are presented in Table 2.

Table 2: Comparison of Math OPT Pass Rates for the Remote Appalachian Rural High Schools

Year	Schools' Range	Schools' Average	State Average
2003-2004	77.2% to 97.2%	86.9% (SD = 6.1)	84.5%
2002-2003	67.7% to 85.6%	78.4% (SD = 7.4)	82%
2001-2002	66.0% to 88.0%	77.8% (SD = 7.0)	85.4%
2000-2001	62.8% to 86.3%	75.6% (SD = 9.0)	83.4%
1999-2000	65.6% to 85.7%	75.0% (SD = 8.0)	81.3%

*Remote rural non-Appalachian schools.* The high schools that were identified as being “remote rural non-Appalachian” were Ayersville, Crestview, Hicksville, Riverside, Tinora, and Van Wert. These six high schools had annual student enrollments in 2004-05 ranging from 337 to 693, with an average annual enrollment of 458.5 (SD = 133.8). The annual student attendance rates for 2004-05 ranged from 94.3 to 96.2, with an average of 95.3% (SD = 0.7).

On average, median family income in the communities served by the remote non-Appalachian schools was \$43,777, placing them somewhat below the Ohio average of \$50,037. The percentage of economically disadvantaged students was moderate, ranging from 0.0 to 18.8%, with an average of 10.8% (SD = 7.4). The schools also seemed to serve highly stable populations of students. Whereas across Ohio the average school mobility rate for 2004-05 was 12.9%, the average mobility rate for these schools ranged from 3.3 to 7.9%, with an average of 6.4% (SD = 1.7).

In the remote non-Appalachian schools, performance on state accountability tests in mathematics exceeded Ohio averages. In 2004-05, the annual percentage of students from the high schools who passed the math section of the OGT ranged from 75.0 to 95.9%, with an average pass rate of 87.9% (SD = 7.8). Performance on the mathematics subtest of the Ohio Proficiency Test (OPT) in the years 1999-2000 through 2002-2004 also exceed state averages. Table 3 presents these data.

Table 3: Comparison of Math OPT Pass Rates for the Remote Non-Appalachian Rural High Schools

Year	Schools' Range	Schools' Average	State Average
2003-2004	83.1% to 100%	93.1% (SD = 7.8)	84.5%
2002-2003	79.7% to 94.7%	88.7% (SD = 6.1)	82%
2001-2002	79.0% to 95.2%	87.5% (SD = 6.0)	85.4%
2000-2001	71.2% to 93.6%	86.6% (SD = 8.5)	83.4%
1999-2000	78.3% to 95.9%	86.8% (SD = 6.7)	81.3%

*Patterns.* The data profiles of the three sets of schools suggested some interesting patterns. Economic indicators revealed that cosmopolitan rural schools were the most affluent, with non-Appalachian remote schools and Appalachian remote schools showing evidence of economic disadvantage. Of these schools, the economic picture among the Appalachian schools was the worst. School mobility was also comparatively high in the Appalachian schools. Furthermore, performance on accountability tests in mathematics was lowest in the Appalachian schools, where pass rates were below state averages.

Nevertheless, despite differences in economic resources in the cosmopolitan rural and remote non-Appalachian schools, their pass rates in mathematics were comparable—with both sets of schools exceeding state averages. Another interesting difference related to average size of schools across the three categories: Cosmopolitan rural schools on average

enrolled almost 200 more students than remote non-Appalachian schools. Appalachian schools were in the middle, with average enrollments that were lower than those of the cosmopolitan schools and higher than those of the non-Appalachian schools.

### *Leadership*

Data analysis revealed that the ingredients of either transformational or transactional leadership, or some combination of the two forms of leadership, were found in the responses of each of the principals (see e.g., Bass, 1985; Burns, 1978). Some of the principals appeared to have used one of the approaches primarily, while other principals seemed to have used a combination of the approaches. Specifically, the responses of two of the principals appeared to reflect that they had used primarily transformational approaches; the reactions of four of the principals seemed to suggest that they had used primarily transactional approaches, and the responses of 14 of the principals (i.e., 70%) suggested that they had used some combination of the two approaches.

*Transformational leadership.* Transformational leadership is typically thought to involve vision, passion, enthusiasm, and energy. And four primary methods of influence associated with transformational leadership—idealized, individualized, inspirational, and intellectual—have been identified empirically (see e.g., Bass, 1985, 1990; Burns, 1978; Hoy & Miskel, 2005; Yukl, 2002).

Interview data revealed that the principals in our study who used transformational leadership deployed all four methods. Individualized and intellectual influences seemed to be particularly prevalent in their answers. Among all of the responses, nine revealed individualized influence and ten revealed intellectual influence. In contrast, only limited

examples of idealized and inspirational influences could be identified. Five responses appeared to be tangentially related to inspirational influence, and three responses suggested that principals might be attempting to make use of idealized influence.

Several responses showed that principals were attempting to use individualized influence. This approach typically entails encouragement and the provision of resources to promote and sustain the objectives of each member of the organization. Illustrative comments revealed the kinds of support often associated with individualized influence, but they did not provide much evidence of individualization. For example, one principal explained, “My role is to provide my staff with professional development that will assist them in being successful as they deliver this to the students, providing them opportunities to be with people who are more knowledgeable in that area than I am.” Another principal offered, “Well I kind of feel like I’m the coach and that my job is to provide my teachers with as many resources as I can for them to do their job.”

Intellectual influence, involving efforts to identify and promote creative perspectives about and understandings of situations appeared, along with individualized influence, to be the most evident in the responses of the principals. For example, one principal commented, “My role has been sitting in on meetings ... where we’re going over data and discussing what needs to be done ... ” Another principal proposed that, “My role ... is one of ... a middle man ... feeding all of this information, all of the materials ... to the department chairs.” And a third principal offered, “I met with some of them ... the very first department meeting that we had last year, I met with them and laid out what the challenge was and what they needed to do before the end of the school year.”

Idealized influence might be described as involving an appeal to association, emotion, ideals, high standards, respect, and trust. A comment from one of the principals demonstrates this approach fairly clearly: “The approach I use is—I try to get good people in place, and then generally let them do their job.” Another principal stated explicitly, “I do trust them.” One other comment might be interpreted as evidence of idealized influence: “We have really high expectations for our teachers...”

A combination of individualized and idealized influence is evident in a respondent’s efforts to involve teachers of other subjects in the reform process and integrate the new Ohio standards across the curriculum,

Now, some of the other teachers seem to be distanced by it because well, “this doesn’t affect me. You...you test them in math. There’s no test for my...program, there’s no standard test for my industrial arts program.” I’ve tried to impress upon them that they are a big part of it, and you have to help us with these things. What you can bring ... whatever it may be, it needs to happen.

This principal thus provides one-on-one instructional support to individual teachers in order to help them find ways to address math standards within the specific context of their particular subjects.

Vision- and meaning-related influences typically characterize the inspirational approach. Few of the principals’ answers reflected their use of this approach. The statement that seemed closest was, “We have to make sure that we don’t let those students down.” A vision focused on the importance of students seemed to be imbedded in this statement.

The comparative lack of reported use of idealized and inspirational influences was not unexpected. These influences typically emerge from and are based upon visionary and emotional appeal. But the standards—the basis for the changes these principals were leading—had been mandated at the state level and developed at the national level. For this reason, they represented the vision of state and national leaders, not necessarily the vision of the principals who participated in the study.

Another way to think about transformational leadership is in terms of the taxonomy of power proposed by French and Raven (1959). According to several commentators (Hoy & Miskel, 2005; Yukl, 2002), expert and referent power are regularly associated with transformational leadership. References to both types of power were found among the responses of the principals. In fact, seven statements appeared to be at least somewhat reflective of expert power, and 21 comments seemed to be reflective of referent power.

Expert power is suggested when a leader exhibits special knowledge about the manner in which to address an issue, particularly an issue of importance. The interviews provided several explicit examples of expert power. One principal, for example, indicated, "... I coordinated a series of meetings that ended up in rearranging student schedules." According to another, "I think my role as an educational leader has to be one of being involved and being in the trenches ... staying there and working through things with the staff and with the teachers." And a third principal explained, "We showed them how to get on the Ohio Department of Education website to look at lesson plans pertaining to standards, practice tests, etc. etc."

Leaders make use of referent power when they exhibit respect, care, and regard for others, particularly when these behaviors inspire followers to engage in similar behaviors.

Comments from several of the principals reflected a caring approach, and one in particular suggested that the principal expected teachers also to assume leadership: “I also think you need to have an administrator who propels, or allows, the teacher to be a leader.”

*Transactional leadership.* The other major approach to leadership found in the responses of the principals was transactional. This approach involves actions that are quite different from—perhaps even opposite to—those constituting transformational leadership. Transactional approaches typically entail management in which the leader motivates others through negotiations involving rewards and punishments. According to various researchers (e.g., Bass, 1985, 1990; Burns, 1978; Hoy & Miskel, 2005; Yukl, 2002), three techniques are commonly used by transactional leaders: contingent reward, passive management by exception, and active management by exception.

Active management by exception seemed to be the most prevalent transactional approach used by the principals. In fact, 26 statements seemed to make reference to behaviors that are associated with this approach. By contrast, only three rather weak examples were found of passive management by exception, and only two examples of contingent reward were found in the responses of the principals.

Active management by exception involves the efforts of a leader to monitor a situation and then to take measures to keep problems from emerging. Numerous comments provided clear evidence of the popularity of this approach. For example, one principal explained,

I just make sure the right people are in the right places at the right time.... The math people spent all last year in departmental meetings reviewing materials and

brainstorming ideas ... I ... knew what was going on.... They will have much more success than last year.

A second principal indicated,

Knowing full well that some of the students don't have the mathematics [to be tested on the] OGT are going to go the JVS, we need to work with our students that go to the JVS to make sure that the JVS coursework—is aligned the same way—and we need to make sure of that.

A third principal suggested, “I think ... the big thing is making sure we have intervention and that teachers are actually making, you know, talking to the math teachers.” And, a fourth offered,

Periodically I look through lesson plan books to make sure. If I go up to a classroom, and sit in classroom for 20 minutes, I pretty much have a knowledge about the benchmark indicators.... So, and they know that. So, there's no opportunity to deviate anything from what the book has.

One principal was particularly proud of keeping a tight ship. The administrator's recipe for keeping teachers accountable was to make them submit detailed information on the content they had covered and the indicators and benchmarks they had addressed. His

favorite technique for keeping math teachers motivated was to make them compete for the privilege of developing the tests to be used across sections of the same math class.

When leaders use passive management by exception, they do intervene, but only after a problem has become serious. The response of one of the principals provided a clear illustration of this approach, "... I say that we've had a math department where we have one member that was not as strong in computer programs and using computers and there were some other deficiencies.... This teacher retired, and we've brought in someone new that we feel is really going to work in this program."

With contingent reward, leaders explicitly manipulate followers by describing the consequences associated with completion of a task or failure to complete a task. As indicated above, only two examples of contingent reward were found among the responses of the principals. The first provided clear evidence of this approach: "I've made part of the evaluation something about standards and then something about the OGT test." The second implied that consequences might be used, but did not say so explicitly:

We have really high expectations for our teachers to use the math standards that are in place. All of our math teachers have been told by the district and by the building administrator ... that they need to get on board with the academic content standards, and I believe that they are all on board with it.

*Legitimate power.* The data also included comments suggesting that principals thought about leadership in terms of their official role. Rather than focusing on what they did in order to lead reform, these comments focused on the authority relations entitling and

requiring them to take action. French and Raven (1959), among others, describe leadership as legitimate when it is grounded in hierarchical authority relations of this sort.

Among the principals who were interviewed, most made reference to their legitimate power. In some comments, the reference to legitimate power was explicit. For example, one principal explained, “Well, I believe that the principal ... has got to be the person who holds the bag, or the standards, or whatever.” And according to another, “I accept and understand that the push to get better is going to come from the principal’s office.” In other comments, the focus on legitimate power was implied, but not stated quite so directly. One principal summed up by saying, “Well the buck stops here.”

*Summary.* Data about the principals’ approaches to leadership suggested that these administrators did not embark on reform of mathematics education as if it were a personal mission. Rather, the mandatory character of the reform agenda encouraged them to display the behaviors, attitudes, and overall detachment associated with their legitimate authority. As far as leadership was concerned, the principals seemed to stay true to their own personal styles, which incorporated transactional, transformational, or a combination of the two approaches. None of the respondents put forward the idea that innovation warranted a new approach to mobilizing the participation of teachers.

### *Strategies*

All of the principals cited strategies they had promoted in their schools in an effort to support math education reform. The strategies used across most of the schools were: (1) curriculum alignment and mapping; (2), individualization; (3) changes in classroom

pedagogy, rituals, and routines; and (4) collaboration. Some schools also made use of other, less popular strategies, such as “double-dosing” and “Algebra for All.”

*Curriculum alignment and mapping.* The schools in the study were all committed to the practice of aligning the mathematics curriculum to state standards, but each school’s faculty varied slightly in terms of the specific methods it chose to use and its stage in the alignment process. At most schools, however, teachers had completed horizontal alignment; as a consequence, variation across schools primarily related to vertical alignment. Some faculties saw this process mainly as something that occurred within their own buildings, but some were involved in district-wide or even county-wide alignment projects. And in some schools vertical alignment was such a new initiative that principals were struggling to coordinate teachers’ efforts to create a coherent curriculum across grade levels. In addition, some principals who recognized the supposed need for vertical alignment had not yet developed concrete plans for its implementation.

Across the schools there were practices commonly used to accomplish both horizontal and vertical alignment. One such practice involved the selection of textbooks that were reportedly aligned with Ohio’s content standards. By adopting texts that matched up with the standards, teachers and administrators felt reassured that the correct content would, indeed, be presented in the correct sequence. According to one principal, “I think materials are key, because more often than not the teachers are going to be aligning their daily lesson plan, with textbooks in mind first, curriculum in mind second.” Some principals, moreover, explained that the choice of a math series responsive to Ohio’s standards helped kept the school from having “gaps” in its curriculum.

The interviews revealed, moreover, that the principals all understood “horizontal alignment” in the same way—as a strategy in which the curriculum at each grade level is matched up with the content standards for that grade level. In addition, the principals agreed that certain practices made it possible to accomplish horizontal alignment. These practices included the development of curriculum maps, the use of pacing charts, and the use of short-cycle assessments.

Whereas all principals indicated that teachers in their schools were making use of these practices, some principals also reported the use of other practices. In some schools principals held staff meetings with teachers toward the end of each grading period (i.e., nine or twelve weeks) to identify which standards had been taught and which still need to be addressed. Several principals had developed actual accounting methods whereby teachers recorded what they had taught in relationship to a list of required standards.

Another approach involved adding content to preexisting courses. With regard to courses in the general track, this process typically involved adding some content relating to algebra and geometry. Sometimes geometry concepts were also incorporated into ninth-grade *Algebra* classes. And in several schools, teachers had added units on probability and statistics to whatever math courses were offered in the ninth or tenth grades.

In some cases, horizontal alignment meant working with math departments from other schools through the auspices of Educational Service Centers. Using this approach, math teachers collaborated to design instructional sequences and teaching methods that addressed the content standards. Adopting a similar strategy, some principals organized special planning sessions in which teachers within and across departments could get together to share ideas and address other issues relating to curriculum and instruction.

Although the schools in the study were not equally far along with regard to alignment spanning grade levels (i.e., vertical alignment), most were working toward this goal. Only one school had not yet developed a plan for accomplishing cross-grade alignment, but the principal at that school explained that he wanted the faculty to develop such a plan. Furthermore, he expressed the hope that the district as a whole would create a plan for cross-grade alignment as a way to facilitate students' progress from school to school within the district.

As with horizontal alignment, faculties used curriculum maps to show how the math courses at all grade levels in their schools addressed the content standards. Moreover, they revisited these curriculum maps in light of data about how their students performed on various achievement tests. One principal explained the use of data about student performance to gauge the effectiveness of the math curriculum district-wide:

What we've also done is looked at our kids, our current 10th grade kids did not do real well in the 4th grade proficiency tests and the 6th grade tests that's given in Ohio.... And, we looked at the raw data and found out where the kids' skills were at, what their strengths were, and what their weaknesses were. For example, measurement was a huge problem in fourth grade. So we dissected: what are doing in 4th grade in measurement in math? Um, geometry was one of our strengths, so we found out, because of geometry and some of the staff members that are preparing the middle school, their current geometry.

*Individualization.* Although not all of the principals saw individualization as valuable in its own right (and some seemed almost to oppose it on principle), most acknowledged that individualization was necessary in order to help less capable students pass the Ohio Graduation Test. Comments from one principal illustrate the typical sentiment:

As educators, you know and I know that all kids don't learn the same way; they don't learn [at] the same pace. Unfortunately legislators don't know that. Our challenge is to properly prepare all the kids, not only going in, that's very difficult, because they don't all learn the same thing.

A comment from another principal reveals a rather different perspective:

If we teach our kids the right way the first time, then we won't have the need to create special classes like some schools. We do not have a special class for the OGT Math or a special class for Social Studies...We just teach regular. We teach the curriculum, and that also will make us be successful in the testing room.

Irrespective of principals' views about individualization, the practice was used in almost all of the schools. Different schools, however, chose to emphasize different approaches. The most common approaches were curriculum tracking, tutoring, and special remediation or intervention classes.

Tracking was the individualization strategy most often mentioned. Principals rationalized its use, claiming that (1) it made sense and explaining (2) that it was an

organizational arrangement already in place. Almost all seemed to endorse tracking and to take it as “a matter of course.” Most schools, in fact, were *rigidly tracked*, with separate curricula for college preparatory, general, and vocational students. Typically, the “college prep” track exposed students to a traditional sequence of courses in mathematics, including *Algebra*, *Geometry*, and *Calculus*. By contrast, the “general” track, tended to provide an “integrated” (sic) mathematics sequence, which presented concepts relating to arithmetic, algebra, statistics, and geometry in all (or most) courses. Although principals did not speak explicitly about the types of mathematics that vocational students experienced, some comments implied that they were focusing on applied mathematics in a “tech-prep” curriculum. In some schools there was also an honors (or Advanced Placement) track.

Tracking was apparently somewhat more fluid in some of the schools. Principals in these schools talked about giving students the option of signing up for whatever math courses they could handle, irrespective of their postsecondary plans. According to the principals of these schools, such efforts relied on students’ decisions about their own courses of study and, mostly their decisions kept them in the tracks to which they were initially assigned. Crossing from one track to another, while permitted and even encouraged, did not seem to take place all that often.

According to one principal, a different basis for tracking was used in his school—the career interests of students. He noted,

I think certainly we tried to develop some tracks a few years ago, trying to make it almost like, “Kids, pick yourself a major: do you want to look at engineering, if you do, here’s what you need.” You know, you need to go through this math

curriculum. Uh, if you want to be an electrician, well, here's what we got for you. If you want to do business management, you know, look at these accounting courses that we offer, and some of these things.

Other approaches to individualization were used, but they were much less prevalent. Four schools, for example had tutoring programs for students who were having difficulty in math. In one of these schools, teachers provided tutoring in two ways. First they offered an after-school program called "Pride Academy." Second, they arranged for math teachers to visit students in their homerooms in order to provide one-on-one assistance. At another school, students made appointments with teachers for math tutoring, so that individualized help could be provided in response to the students' needs.

Despite the positive view of tutoring in the schools that were using it and the investment of effort it called forth from students and educators, there was also some frustration associated with the use of this practice. According to one principal,

They give it their best effort, and they do everything we ask them to do: they come to the tutoring sessions, they come for review sessions, and they do, they'll do everything we ask them to do, and they just...can't pass it.... I think every legislator who voted for those bills and who participated in that committee ought to have to sit in here with me while I tell the kid, "Sorry, John, you're not going to graduate with your class because you didn't pass the proficiency test," whatever section it is, and math is the one that they fail the most often—when that kid has been in every

after school session we've had, and has gone to study tables and worked hard, has come in during the summer, has done everything we've asked him to do.

Another method for individualizing involved the provision of special classes to select groups of students who seemed to need general or test-specific remediation. In a few schools, these classes were designed for students who had failed to pass the mathematics portion of the OGT. But in one school, the arrangement was somewhat different: the school offered a class called "Proficiency Math" to all those ninth graders who had struggled in middle school math. The principal saw this approach as a way to bring such students "up to speed." A similar—but more test-specific—approach was used by some schools. Special "intervention classes" in these schools were added to selected students' schedules a few weeks or months before the administration of the OGT. For example, one school offered what it called "emphasis courses" in all of the core subjects, using intervention specialists to provide focused assistance to students with particular (testing) needs. By contrast, another school used intervention classes not as a form of individualization but as a method for giving *all students* a chance to review the material that was likely to be tested.

Overall, individualization seemed to be a popular strategy. In fact, 18 of the 20 principals mentioned that their schools used some form of individualization. Mostly, individualization involved curriculum tracking. Far less frequently, it involved tutoring or the scheduling of special remedial or test-preparation classes.

*Change in classroom pedagogy, rituals, and routines.* The third strategy principals used to reform mathematics education in their schools involved efforts to get teachers to make changes in pedagogy. Where such changes had actually been made, moreover, the

principals saw an impact on classroom rituals and routines. In some cases, the principals explained that they were still advocating changes in pedagogy that teachers had not yet adopted.

The changes most commonly mentioned were (1) holding higher expectations for student achievement, (2) using cooperative learning techniques, (3) using technology as a teaching and learning tool, and (4) incorporating extended response and higher order thinking questions into classroom discussions and assessments. Support for these changes typically was provided through professional development workshops.

Five principals saw changes in pedagogy in terms of the expectations teachers held for student performance. One principal explained, “Our message to students is, [that since] they’re expecting more from us as teachers, well, we’re going to expect more from you as students, and the end result will be a positive result.” Some principals also saw a connection between higher expectations and the need for increased remedial support. As one principal commented, “With higher expectations, though, you have to give extra help. All students can’t learn at the same time.”

Two principals cited the inclusion of more cooperative learning activities in the math classroom as a positive change in pedagogy. One principal explained how cooperative learning benefits both teachers and students,

I like to see, you know, Suzie over here helping Johnny do some things, because she has an understanding...I really like to see the kids helping each other, because I tell the teachers, she’s [Suzie] a very valuable resource.

A number of principals mentioned the use of instructional technology as one of the most noticeable changes in pedagogy in math classrooms. Principals cited the purchase of math software, on-line lesson plans and progress reports, computers in every classroom, and use of other equipment (e.g., Smartboards) as contributing to the reform effort. One principal commented, “I think the use of technology’s the biggest one [i.e., change] that has occurred since I’ve been here.”

Six principals cited the use of extended response and higher-order-thinking questions in classroom discussions and assessments as an important change in pedagogy. Several principals expressed the view that students need to be able to explain their answers if they are to engage in higher order thinking. One principal commented, “We see the kids work the math problem, and we ask, “how did you do that and why did you do that,” and that’s a key element. I try to stress that.” Another principal agreed, “They have to be given problem-solving situations to work on, and then they have to be made to show their work, they have to be made to show how they arrived at answers.” Two principals mentioned the importance and difficulty of teaching students to explain their thinking in a written response. One principal remarked,

I think traditionally math and science really; the kids haven’t had to explain an answer. They’ve looked at a graph, they’ve looked at a chart, they pick the answer, and they haven’t had to explain why they picked this answer or why they chose this particular method of solving the problem. And to get them to use those higher-order thinking skills, and being able to evaluate their choices, and then to synthesize

the response and be able to put it down in writing, I think has been very, very difficult, particularly in the math area.

Even if principals saw different changes as consequential, most of them mentioned the importance of professional development to the process of changing pedagogy. Some principals took advantage of the professional development opportunities for math teachers that are provided by the Ohio Department of Education. Others got teachers involved in programs provided by Educational Service Centers. Some professional development was provided by projects, such as High Schools that Work, with which schools became affiliated. And in several schools professional development was something that teachers created for themselves through study groups and professional learning communities.

Of the principals interviewed, more than half cited examples of change in pedagogy as an important part of the reform of mathematics education. The majority of principals, moreover, expressed the view that changes in daily classroom rituals and routines were having a positive effect on mathematics performance in their buildings. Overall, principals expressed the belief that math teachers were willing to change classroom practices, once they were provided with relevant support, primarily in the form of professional development. In some cases, principals were promoting changes in pedagogy, but their teachers were not yet incorporating these practices.

*Collaboration within the school, among schools, and across the community.*

Another strategy used to improve math education was to increase meaningful collaboration within the school, among schools, and across the community, and 13 of the 20 principals discussed their use of this strategy. Examples of collaboration included: focus on

instructional planning at faculty meetings, regularly scheduled math department meetings throughout the school year, coordination of K-12 math teachers across the district, comparison of teaching strategies among colleagues from different schools, collaboration of teachers across subject areas, and establishment of partnerships with community businesses and colleges.

Five principals claimed that increased focus on instructional planning at faculty meetings contributed to math reform at their schools. Several principals took responsibility for this change by becoming more involved with instructional leadership and by modeling innovative instructional practices during faculty meetings and in math classrooms. One principal explained, “As instructional leader, I need to encourage them, and I need to help them by giving them some examples.” Another principal agreed, “I’m doing a tutorial on that at the teachers’ meeting, and I, as principal, made up an extended answer questions to show them.”

One principal expressed the view that regularly scheduled math department meetings throughout the school year would have a positive impact on math reform at his school, but he felt frustrated by the lack of time available for monthly meetings.

From the standpoint of departmental meetings, we don’t have enough. We need to be on a regular cycle of monthly departmental meetings, and we’re not able to do that because the master contract doesn’t allow us to do that. We’re going to ask our teachers if we can develop a plan where we extend the school day, for more collaboration.

Three principals explained the need for communication among math teachers from all grade levels as a way to promote vertical alignment of the curriculum, and one principal thought that such alignment could best be accomplished as a district-wide initiative: “It’s very important that our K-12 math is aligned vertically so that we clear up any gaps where maybe we’re not teaching something.” Another principal agreed that communication and collaboration between math teachers from all grade levels was important:

I’m okay that it [accountability] has forced our teachers to really collaborate with one another in our own high school. It’s forced our teachers to collaborate vertically with our middle school math teachers, and our elementary math teachers.

One principal suggested to his teachers that they collaborate with colleagues in neighboring schools as a way to learn more about teaching methods that have proven useful for addressing the content standards. In the interview, the principal repeated his instructions to the school’s math faculty: “Next time you people get together, find out how they’re teaching this particular set of standards. Because they’re doing something we’re not.”

To address changes on the Ohio Graduation Test requiring extended responses from students, one principal encouraged the math and English teachers to work together. “The English department worked very well with my [only] math teacher, so there’s a lot of writing going on in the math classroom.” It’s important to note that this rural high school employs just one math teacher because vertical alignment in such cases, which are not uncommon in rural areas, is the project of a single faculty member.

One principal emphasized the importance of forming partnerships with community businesses and area colleges. Describing the schools' partnership with businesses, the principal said, "We have their cooperation, where they come in and help teach, facilitate in our classroom; our kids go out and see what the business world is like." The principal also cited examples of the school's collaborations with a local college. "We have some agreements, where kids will take classes here, and they'll have instant credit if they decide to go to Ohio State."

*Less popular strategies.* Two principals referred to "double dosing" as an effective way to help less capable students learn math. Using this approach, the schools scheduled students into two periods of mathematics per day: a regular math class and a math lab where students had the benefit of individualized assistance from their teachers and from peers. (The math lab idea may have originated some years ago at an impoverished rural Appalachian district in Ohio whose work in this regard received publicity from the North Central Regional Educational Laboratory; see Dreher, 2000.)

In a few cases, a "core curriculum" approach was used in order to assure that all students had the opportunity to experience the same, high-level curriculum. One principal, for instance, gave the following report: "When a freshman comes in, his first year of math, it doesn't make any difference whether they select college prep, general, business, vocational—they're all really the same thing." Another told the interviewer that his school was so small that it was possible to group all students at one grade level in the same math class.

More often, particularly in larger schools, principals organized students in ability groups but asked teachers to cover similar content with each group. For example, two

interviewees pointed out that their version of tracking was to have each ability group cover the same content, but at a different pace. Principals referred to this approach as “Algebra for All,” because algebra was the content that all students encountered, regardless of ability-group placement. In one school, Geometry instruction was handled in the same way. According to a few principals, the slower pacing of instruction was sometimes accomplished by allowing (or requiring) less able students to repeat (e.g., with a tutor) a lesson, unit, or even an entire math course.

*Summary.* Fueled by a concern to see their students perform well on the Ohio Graduation Test, principals assisted their faculties in identifying and making use of various strategies. Two strategies were used by most schools: curriculum alignment and individualization. In more than half of the schools, two other strategies were used: changes in pedagogy and collaboration among teachers, within and across schools. In some schools in which collaboration was not deployed explicitly as a reform strategy, it took place informally. Other strategies such as “double-dosing” and a “core curriculum” approach were used in a few schools.

### *Math Talk*

Seventeen of the 20 principals who participated in the study provided comments that were attentive to current issues in mathematics education. Best represented in their comments were themes relating to: (1) math for understanding, (2) use of technology, (3) real world applications of mathematics, (4) inquiry-based (or active) instruction in mathematics, and (5) writing as a part of mathematics learning. Far less frequently did

principals mention either the NCTM standards or the social justice implications of current reform initiatives in mathematics education.

*Math for understanding.* Twelve principals characterized standards-based mathematics in terms of its focus on understanding, problem-solving, logical thinking, and higher-order processes. Some contrasted this approach with “old-fashioned” mathematics instruction, which involved memorization of facts and perfunctory application of algorithms. Several talked about the focus on meaningful explanations that they saw as the foundation of standards-based mathematics. One principal commented:

I think there has to be a connection with the kids, you know; ... they always need to know the “why.” ... Try to explain the “why” whenever possible. You have to be able to do that, because I think a lot of the times that’s the key to understanding.

Not surprisingly, the principals who explained this idea most fully were those who had themselves been math teachers. As one such principal explained,

I think the basis of mathematics is about teaching kids to think logically, and I believe that mathematics is one area in our curriculum that can help kids go that direction and to become, hopefully, a little bit more logical thinkers.

Other principals mentioned that reform mathematics cultivated higher-level thinking, some drawing on Bloom’s taxonomy (Bloom, 1956) to explain differences between “old-fashioned” and reform mathematics. For example, one principal shared a

question that he asked himself and his staff in order to gauge the extent of the changes in mathematics instruction at the school: “Have we done everything that we can do to get into the upper four levels ... rather than just assessing in the lower two levels of the taxonomy?”

*Technology.* Half of the principals mentioned technology in connection with math instruction, and most saw the connection as positive. With the exception of reports about software that gave students practice with mathematics problems such as those that are included on state accountability tests, the comments, however, were remarkably vague. The principals, in fact, seemed to treat technology as a “magic bullet” as the following statements illustrate:

Our math department [has] computers in the classroom—to use the world-wide web, to do some problem-solving, different things with mathematics on the computer.

We’re using a lot of technology. We use Smartboard technology in our math classrooms now. Those were on mobile carts, so to speak, and our math department gets kind of selfish with those—that technology. They don't want it out of their classrooms.

We are a very computer-oriented school. We have technology. I have a technology coordinator that used to be a math, physics and chemistry teacher, and is retired, and has come back as our computer coordinator, and he’s really technologically

minded, and so we—if our teachers want computers in the classrooms, we can get them.

Several principals also described software that helped students study for the Ohio Graduation Test (OGT) in mathematics:

This year we've purchased the use of a software [program] called *Study Island*, which has questions geared toward the state standards to kind of model the OGT test questions.

We have a computer program called *Compass Learning* for math. And there are other areas of *Compass Learning* in reading, language arts, and so on, but we don't utilize those. We've only purchased it for our math.

One principal explained that the school had tried some of this software but had found it ineffective: "One area ... that I don't encourage or have ... success is the computer learning. We've tried...it just doesn't do."

None of the principals talked about technology applications such as graphing calculators, computer algebra systems, or dynamic geometry software. In fact, the single mention of calculators was a negative example—the report of a math teacher who refused to let students use them because, according to the teacher, calculators encouraged "laziness."

*Real-life applications.* Less than one-third of the principals talked about connections between school mathematics and applications in the real world. One principal,

however, whose background had been in vocational education, spoke quite eloquently about such connections:

I think that kids need to see a real-world application, and be given a problem to solve, and then allowing them to solve it, and not have one right answer. Because as we know when we go out into the world of work, there may not necessarily be just one right answer, there may be several ways that you can deal with a problem.... Plumbers and pipe-fitters use those math skill sets all the time. They're constantly having to calculate: if you have to reduce the size of a pipe, if you have to expand, or where a joint's going to be, and you're going to have to manufacture something to fit in there. If you're going to have to manufacture a piece to go into a heating system or something like that, you're going to have to use those math skills.

A few other principals echoed her perspective with comments such as,

I want them to see how it [a math concept] applies. I want to them ask, "How does it apply? Where do you use these things, to get the connection?" And that's what I... [that] has been a big goal of mine.

*Inquiry-based instruction.* Some of the same principals who talked about connecting mathematics learning to real-world applications also talked about inquiry-based instruction as an effective approach. Nevertheless, with only five principals mentioning anything about inquiry or "active learning," this theme was not strongly represented in the

data. Nevertheless, the principals who did discuss this approach were strong supporters of it, as the following comments suggest:

I think she had the kids doing [math] in their head and building and constructing in the classroom ... and a lot more things for the kids to enjoy, made sense to kids. I think the teachers made sense of things. I think they kind of get more involved with them, because, you know...it makes sense!

We're finding that kids are doing more of the hands-on learning with the math—and I'm not a math teacher, so I'm not going to be able to talk specifics—but I'm seeing kids do more hands-on collaborative learning, where the teacher is showing a couple of problems, but then the kids have to do more verbal explanation of how they got to where they got, how they resolved that problem.

If they can get their hands into a project, and see the application of the higher-level math skills then they'll be much better...much more likely to be able to learn it, whereas just looking a book and doing story problems and doing just rote mathematics, that's not going to have any meaning for them.

*Writing as part of mathematics learning.* Several principals talked about the fact that their teachers were now incorporating writing into math classes. For most of them, the purpose of such activities was to prepare students for extended response formats on the mathematics subtest of the Ohio Graduation Test. As one principal explained,

No longer can a kid take a math question from the Ohio Graduation Test and get an answer. We have to show our work. We have to extend our response; we have to write. So, that's been changing, expanding questions, expanding responses to questions. No longer is "A, B, C, D" going to help: multiple choice won't get them. So, in math here, I do not want to do true and false questions; I do not want to do a lot of multiple choice questions. What I want is short answer and long answer essays: opening paragraph, a few paragraphs to support that. Even in math.

Another principal linked the use of math journals to a school-wide initiative for "writing across the curriculum." From her perspective, this approach was effective because it encouraged students to work independently as well as with peers.

*Summary.* Principals did not engage in much talk about the nature of mathematics learning or about new approaches to mathematics pedagogy. They exhibited little familiarity with the specifics of the Ohio mathematics content standards and even less familiarity with the specifics of the NCTM standards. Rather, they connected reform in mathematics education with specific changes in the accountability test administered in Ohio. These changes did, however, encourage many principals to provide support for mathematics instruction that was focused more on problem-solving and understanding than on rote recall of facts and algorithms.

### *Curriculum*

Principals talked about the fact that they were subjected to conflicting pressures from different sources in their role as local administrators of state-mandated curriculum

reform. The complexity of their task was reflected by the issues that surfaced in their interviews: “raising the bar,” personal attitudes about the reform, course content and sequences, and textbooks.

*Raising the bar.* According to the principals, the main purpose of standard-based reform was to “raise the bar” in mathematics instruction. Two of them claimed that, thanks to concerted efforts at upgrading the curriculum, they had put an end to the teaching of “bonehead math” or “watered down mathematics” in their schools. A third principal commented,

You had all this lower-level math—Math 9, Math Lab, Applied Math, you know, and all this stuff. So I look back at that and cringe, because, I mean, that’s just the worst, you know?

Two others pointed out that the pressure to learn mathematics well starts in elementary school where faculty use math textbooks that help students develop problem-solving skills. One principal said that he did not expect to see any significant change in his students’ math performance until they had all received an early exposure to standard-based instruction. By contrast, the majority of the principals claimed that they had already experienced a measure of success in their reform efforts. One principal declared,

But, so far, as you know, what we do in the math classes—everything from the graphing calculators to your advanced placement courses, um, you know...it’s ...those kids in those upper tiers, it’s pretty heavy. They get ’er done.

This passage reflects the common interpretation: Raising the bar *for college prep students* seemed to be the priority for the interviewees, who referred to these students more often than to others. For instance, a principal stressed how important it was to keep in mind the needs of, “the upper level kids that want to move on, and go onto college and [for us to] take engineering up a level, chemistry up a level, science classes.” Two respondents praised their schools for putting a special emphasis on Advance Placement.

Regarding low-to-average students, opinions were divided between giving them equal access to higher-level math knowledge and simply meeting their more pressingly apparent academic needs. The first perspective was articulated by two principals who shared the espoused view of state policy makers that many occupations now require the mastery of complex problem-solving skills. Some interviewees, however, offered a contrasting perspective, pointing out that the expectation that all students would perform at high levels in math was simply “overkill.” One principal even suggested that standards-based reform and the OGT were setting the average student up for failure, and, as this interviewee said, “for unjustified reasons.”

*Personal attitudes toward the reform.* The principals were somewhat divided on the issue of the OGT and mathematics reform. On the one hand, several principals showed strong support for a standards-based curriculum. Two respondents, for example, stressed their approval for a national curriculum. One of them commented, “for way too long it’s been different. *Algebra I* could be different from [room] 202 to [room] 204 upstairs.” In addition, a few interviewees declared that they had no doubts about the fact that promoting curriculum reform was the right thing to do.

On the other hand, a number of principals expressed some misgivings. One stated that the focus on cognitive skills development promoted by proponents of standard-based mathematics was a poor substitute for a sound knowledge of basic math facts and concepts. In the same vein, another interviewee objected to the distortions created by high stakes testing in math education. According to this interviewee,

*Algebra and Geometry* is not algebra and geometry any longer. It is toward the Ohio Graduation standards and benchmarks. Once we accomplish those standards and benchmarks as indicators, *then* we start teaching some algebra and geometry.

Two principals complained that “the feds and state people” or “the high school teachers and the college professors [who] have got together to make the OGT test” had set the bar too high for the average student. The dual statement that all students were not college material and that schools were teaching too much mathematics in fact appears in a number of interviews. A respondent (perhaps with Trelease’s 2002 article tracing connections between the Bush and McGraw families) proposed a theory casting doubt on the legitimacy of recent reforms, as follows:

But then they looked and went, “Oh, wow! ... We’re now capitalizing on a *Nation at Risk*, and all of the other reports that have duped the American public into thinking that schools are terrible. We need to take advantage of this, force an accountability system, buy all these textbook companies, buy all these research arms.” You know, you’ve got McGraw Hill that’s bought Education Testing

Service, and 'ole Mr. McGraw there worked over a deal with George W. Bush; it was no secret.

*Course content and sequences.* The majority of the respondents claimed that improving math instruction at the high school level involved teaching *Algebra* from grade nine onward. Three principals even suggested that the best way to improve their students' rate of success in the Ohio Graduation Test was to make algebra compulsory, or, as one said, "Just force it down from the top." With regard to such an approach, the second principal remarked, "That was a huge step. That was an uncomfortable step to take," but he also admitted that the results were "definitely" worth the risk. The third principal expressed similar views,

I mean, let's face it: people don't like to change unless they're forced to... You know, we used to teach general math: you know, add, subtract, multiply and divide. And the 9<sup>th</sup> grade proficiency test came along, people said, "Oh, kids, you know, kids are never going to be able to do algebra: these kids aren't *capable* of that." And now our kids at our lowest level are doing things that, you know, people thought they would never be able to do.

Other interviewees did not condone the use of pressure as a way to assure that all students would receive algebra instruction. One noted that the freshmen in his school were simply advised to take *Algebra*. A second explained that his school offered a foundation course to all grade-eight students in order to prepare them for the challenge. Two

respondents reported that their schools had structures in place that would assure incremental adoption of an “Algebra for All” curriculum. Another expressed the belief that it was crucial to continue offering *Pre-Algebra* to some incoming freshmen who were not yet ready for higher-level math.

Principals also explained that they had had to make additions to their curricula in order to address content covered by the OGT. The most common observation was that the pre-reform curriculum did not pay sufficient attention to concepts in statistics and probability. Three interviewees said that consequently they asked teachers to reinforce such concepts in eighth grade math or to add a statistics and probability component to their *Algebra* courses. A few principals also referred to the need to teach more geometry and trigonometry.

With regard to course sequencing, two interviewees admitted that their schools had maintained their traditional arrangements virtually unchanged. By contrast, three principals described what appeared to be a revised course sequence for more able math learners: *Algebra* in Grades 8 and 9, *Geometry* for sophomores; *Pre-Calculus*, with or without other higher-level math courses, in Grade 11; and *Calculus* for seniors. Finally, there was a consensus on the practice of upgrading general math courses, renaming them “Integrated Mathematics,” and organizing them into sequences that less able students were able to follow more easily. A respondent described the sequence at his school this way:

Integrated classes ... involve teaching a little bit of measurement, a little bit of basic math, a little bit of geometry, a little bit of algebra. They don't do too much

trigonometry kinds of things. They do geometry kinds of things. So ... they get a little bit of everything in that class.

There were two exceptions to the practice of assigning less able students to “Integrated Mathematics” classes. In one school, students in all tracks took integrated courses at the freshman and sophomore levels. (This appears to resemble the intentions of originators of the idea—where mathematical topics are integrated in order to enrich content rather than to dilute it.) In another school, students had the opportunity to follow paths that matched their unique ability levels by choosing between the (diluted) integrated class “at their level,” a higher-level math course, or the higher-level course that was offered in the preceding level (i.e., to younger students).

*Textbooks.* Some principals expressed the view that, whatever the standards, textbooks represented the true curriculum. For these principals, finding texts that addressed the standards was therefore an extremely important issue. One principal, for example, complained that some materials encouraged teachers to bypass the standards:

And, although we’d like to believe that we’re different, our teachers are going to use the materials they have, they’re going to teach to the class what they have, they’re going to use the materials that they’ve ordered, purchased, and handled or provided for...

Most interviewees also equated instructional materials with textbooks; they did not treat textbooks as one of various instructional materials that teachers might use. In fact,

beyond acknowledging the importance of textbooks in a general sense, the principals did not seem to know very much about the specific character of the books that the math teachers were using. Notably, only three of them provided information about the mathematics textbooks at their schools. Two of these principals referred to the Saxon series as the math books chosen by their institutions. One of these principals remarked that the practice of using other textbooks in the K-6 building in his district caused difficulties when students were introduced to the Saxon series at the high school level. Expressing the opposite opinion, the other principal condoned the use of *Everyday Mathematics* and similar materials in lower grades because, as he said, these books reflected a constructivist perspective. This may strike some readers as a non-sequitur, but this principal *also* talked about the constructivist focus of the high-school-level Saxon texts (i.e., expressing a view of the series that is not widely held).

Principals also appeared to hold three different stances on the role that textbooks should play in the planning and delivery stages of mathematics instruction. The first perspective is an *unconditional belief in the appropriateness of particular books* or book series. A principal thus stressed the importance of selecting the “right” textbook, that is, one that teachers can use freely because it is “appropriate for the age level, the grade level, and for the state standard we use.” Likewise, two interviewees declared that their choice of college prep math books provided everything their more able students needed to know. The traditional practice of “teaching to the book” is best illustrated by a respondent, who admitted that textbooks dictated the content and succession of math lessons given in his school,

What we're doing is, we're teaching four chapters—we call it *Applied Algebra I*. They learn the first four chapters semester one their freshman year, they learn the second four chapters semester two of their freshman year, and they learn the final four chapters semester one of their sophomore year. If they don't successfully complete a semester, if they fail a semester, they have to retake that section.

A sub-category in this “rightness of text” perspective saw, not the textbook, but the state tests as the sole basis for deciding what to teach. One principal, for example, claimed that state-mandated reform had caused him to shift emphasis from promoting what he saw as genuine mathematics instruction to encouraging the faculty to “teach to the test.” From his perspective, the primary duty of mathematics teachers is simply to cover the minimal content circumscribed by “these standards and benchmarks that are outlined in the curriculum.” As one might expect, this principal's idea of a good textbook was one that addressed the largest number of state-mandated requirements and included a minimum of the so-called “extraneous” material.

In the second perspective, by contrast, both the standards and textbooks constituted a major part of the curriculum—but they were not *equivalent* to it. Principals operating from this outlook rejected the rigid and indiscriminate use of published materials, and instead viewed textbooks as useful but incomplete sources of academic content and pedagogical guidance. For instance, an interviewee noted that his school had selected, “the one [book] that we felt best aligned with our test” but insisted that the staff knew all along that the textbook included a number of gaps that called for supplementary materials.

Finally, a third stance was taken by principals who were ambivalent about textbooks or about the teachers who rely on them too heavily. One school administrator suggested that the textbook issue was a factor in faculty's continued attachment to traditional teaching:

You know, there's lots of variety of ways that you can teach a lesson, and sometimes I think we follow the book, meaning the book is what's driving the curriculum rather than the standards being what's driving the curriculum, and with the OGT, you've got to cover the standards before these kids take this test.

Another interviewee implied that teachers' reverence for books goes back to the time when such materials were the principal popular repositories of human knowledge. He credited the Internet for opening easy access to larger and more up-to-date databases and thereby allowing teachers to become autonomous in their use of academic content. Another principal shared his belief that the reign of the textbook had finally come to an end. The principal who had complained about the prevalence of book-centered instruction nevertheless commented that textbooks can be used in a number of productive and responsive ways in order to meet the demands of standard-based instruction.

Finally, two principals voiced their mistrust of math textbooks that are published for a national audience. One remarked, "They are not written with Ohio content standards in mind; they're written for larger states that may or may not have the same standards that we have." The other suggested that the writers of such textbooks just wanted to get rich by

luring Ohio math teachers into spending their money on academic content that is “just gravy for us.”

*Summary.* The data revealed that principals primarily thought about curriculum in relationship to standard-based reform. Some of them accepted the outside pressure associated with such reform as an acceptable price to pay for improvements in the teaching and learning of mathematics. Others adopted the mandatory reform agenda somewhat unwillingly because of their reservations about its impact on average or less than average students.

Nonetheless, there was a consensus on the point that the implementation of curriculum change was ultimately the preserve of school-level agents, that is, faculty and the principal. The statements of the respondents also revealed that a number of them or their staff members tried to get away with making cosmetic changes only. By contrast, other schools went for drastic innovations in regard to textbook choices, course content and sequences, or structures that support learning.

In sum, the principals interpreted and implemented state requirements for reform in ways that reflected their personal beliefs about math instruction and the particular cultures of their schools.

### *Teachers' Role in Mathematics Reform*

Because they saw their own roles as complex and their knowledge of mathematics education as limited, most of the principals believed that teachers should be the ones to take primary responsibility for instituting and sustaining mathematics education reform.

Nevertheless, principals acknowledged that the attitudes of the math teachers in their

schools and the functionality of their math departments largely determined the ways in which such responsibility was interpreted and discharged.

*Faculty involvement.* Most of the principals saw teachers' attitudes as an important influence on the eventual success of math education reform. In the view of some principals, faculty's resistance constituted an obstacle to reform. The comments they made on the topic of teachers' negative attitudes are reviewed below in the section on impediments and excuses. By contrast, half of the principals reported that the math teachers at their schools were open to reform initiatives. The following comment illustrates their assessment of their teachers' supportive attitudes:

We have teachers who want to know more, gain more, and find better ways to teach...They believe math isn't stagnant, you see—it can continue to evolve in any way.

Another principal praised his faculty for limiting their textbook use and for developing their knowledge of technology in order to design original standard-based lessons. Two others focused on the active roles played by their teachers in the development of a revised curriculum. One of them remarked,

I can't say that I absolutely agree with this, but I trust my staff. I've got good educators, and they believe that our kids will be prepared if not more prepared than the rest by taking *Algebra 1* and then *Algebra 2*.

Other administrators underscored the crucial role of improved classroom practice in the reform process. They claimed that teachers gave substance to state standards in the classroom while keeping a watchful eye on their students' unique needs and abilities. One said, "I think our math teachers are fine with standards, but that they can say, 'Well, here's what the kids are...what all kids need to learn,' but at what ability level."

Another pointed to a tension between the latitude to make autonomous instructional decisions about math instruction and ensuring that teachers do not stray from the common framework of the standard-based curriculum,

At the same time I think that we're headed in the right direction to have a universal, a more universalized curriculum...not take the place of locally...I mean, you are a teacher who's skilled, who's exceedingly dynamic, and [have] other interests, but happen to be a math teacher. You can make math classes come alive through whatever this other interest is, and that takes you in a different direction. I will always defend that. I will defend that because that's great for [our] kids...

*Math department involvement.* Most principals said that they appreciated the fact that their math departments were actively involved in the reforms taking place within their schools. One principal said he was pleased to let the newly-appointed head of his mathematics department lead math reform in his school. Another said, "My math department is doing a fantastic job of keeping up to speed with the changing times of mathematics in public education." A third respondent concurred, "I give all the credit to our math department, because they do all the work."

Almost half of the principals reported that their math departments used common planning times and other professional development opportunities in order to review standards and align curriculum with the Ohio Graduation Test. One principal observed, “I’ll get the staff meetings started; and they’ve been able to take off and talk to one another, to change things that they are duplicating and they’ve been very helpful in re-aligning the curriculum.”

*Summary.* Although most of the principals expressed a commitment to math education reform, most saw reform as the responsibility of the math teachers at their schools. Principals attributed successful math reform to strong teacher leadership, willingness of the staff to take on challenges associated with reform, and the math departments’ effective use of common planning time and professional development opportunities.

### *Impediments and Excuses*

Principals tended to focus on the active roles they played in fostering improvement in mathematics performance, and most also talked about impediments to improvement. These impediments were related to (1) limited resources, (2) difficult students, (3) resistant or under-prepared teachers, and (4) unsupportive contexts. In many cases, the principals saw these impediments as interrelated. Moreover, some principals treated the political environment—with its ambiguities and vested interests—as another impediment to actual improvement in students’ learning. A few principals, however, saw the ambiguities of the political environment as a condition that enabled them to “lie low,” that is, to disregard calls for reforms and continue in the path they had been following.

*Limited resources.* Principals said that resource limitations affected their ability to provide the instructional support required for mathematics reform. Lack of time was the most serious constraint for many respondents. One principal saw the need for extra time as particularly pressing because of the multiple roles he played in a small rural school.

As an administrator in a small rural school, you have to wear so many hats; it is extremely difficult for you to move as much time as you need to each individual aspect or hat that you have.

Another principal explained that, if he had more time, he would spend it making additional classroom visits: “[I] would love to be able to be in and out of my mathematics classrooms ten times a quarter – forty times a year – to really know what's going on.”

Other principals thought that increased funding would enable them to provide more extensive professional development to their math teachers. In some schools, the principals also linked limited levels of funding to their difficulties in hiring sufficient numbers of qualified math teachers. According to the principal of an Appalachian school,

I don't necessarily think that our kids should be compared to kids who attend Upper Arlington, who have the benefit of better staff, more materials, better teachers and so forth, because when Upper Arlington has a vacancy for teaching math, they'll have 150 applicants. We have a vacancy, we're lucky to have two or three.

*Difficult students.* Principals also explained that it took special efforts to get the majority of their student body ready for the high stakes OGT. A few reported that they had some students whose presence created unwelcome problems. For instance, one interviewee referred to an entire class in his school as a “dead weight.” Another principal complained that his school had a higher than average percentage of students with disabilities and said,

And, um, so that lends itself to a whole 'nother problem, a hurdle, I should say—providing the services for all special education students ... because their kind of opportunity is different from a student who may be above or an average student. Uh, so, that's a hurdle for us, and that's a hurdle that we are always working on to try to make sure those kids have all the same access to the curriculum and the standards as average students.

For a few principals, students in the general education program also seemed to present challenges. One principal, for example, remarked that reform was slowed by new freshmen who entered his high school without basic knowledge of algebra. Another principal reported that he looked forward to the day when all students would have started process-oriented math in elementary school,

Once we get those kids that've come all the way up through, I think we're going to be better off—and we started, how many years ago now? There's still a handful of years to go... But until we get kids that have come up all the way through, we've got a little gap that we're going to have to work with

*Resistant or under-prepared teachers.* About one third of the interviewees identified teacher resistance as an impediment to change. Several principals viewed veteran teachers as the ones who were most likely to resist the reforms. These principals described teachers' resistance in terms of an unwillingness to adopt the new teaching practices associated with a standard-based mathematics curriculum. And some principals noted that pressure to make unwanted changes was eroding the job satisfaction of certain veteran teachers, suggesting to them that retirement might make sense. Illustrating these perceptions are the following comments from principals:

Teachers that have been around awhile are faced with the challenge of changing an awful lot of things they do.

I also have to challenge them in getting away from doing what their favorite lessons are and what doesn't meet the Ohio Graduation Test. And that's a challenge, because people are molded in that area that they want to teach.

She told me she may take early retirement because it's really stressful for her to teach.

Frustrated by the reported resistance from some veterans, a number of principals said that they welcomed novice teachers because the latter were more open to change, especially regarding the use of technology. These principals generally agreed that new,

more youthful teachers were better informed about current thinking in mathematics education than experienced instructors.

According to these principals, newly employed teachers were also more willing to take on the challenges associated with reform. As one interviewee put it, “They are relatively young, and that’s important ... [they] stay abreast of changes in mathematics and what’s best in mathematics teaching.” Another explained, “The people we’ve brought on have the math/technology combination folks, and that’s been a real big step up for us.”

By contrast, other principals believed that resistance was an individual response that had nothing to do with teachers’ experience levels. Two principals, for example, reported that their veteran and novice teachers simply did not expect students to succeed. The teachers’ negative attitudes predictably had an adverse impact on reform efforts. As one of the principals explained,

I do have teachers—and I don't care if they're second year into it or 28 years into it—they don't necessarily believe that all kids can pass that test, and trying to work with them and convince them that if we change how we deliver and we change how we assess, and we change our expectations, then yeah...maybe not every kid, but almost every kid can pass this test. So trying to change that mindset that some people have and that, you know, we all—we tend to say that all kids can learn, but I don't know how many teachers in the trenches believe that.

For other principals, teacher resistance was not so much related to attitudes about students as it was to beliefs about what constitutes appropriate assessment or what ought to

be covered in the curriculum. One principal viewed his teachers' unwillingness to change their expectations about assessment as an impediment to helping students succeed on the state-mandated graduation test. Another reported that members of his faculty had insisted on retaining some low-level mathematics courses. According to one interviewee, the need to add statistics and probability to the *Algebra* courses frustrated faculty and caused resistance:

There was a heavy emphasis on statistics and probability, and those were not engrained in our curriculum, and so it's been a real headache, especially when some of the teachers have been around forever, they've got their process down, and changing and developing probability and statistics tacked into an *Algebra* class doesn't seem realistic to the teachers, because realistically, we understand for him to cover the material that he would need to cover would take all year-- without the classroom interruptions, I mean, and those are legitimate complaints.

Finally, some respondents suggested that teachers dragged their feet because they simply did not buy into the idea of making changes to mathematics instruction. One commented, "My assessment of my school is they [teachers] don't believe there is a need for any sort of reform." Another suggested that teachers were reluctant to change their teaching practices because they viewed the OGT as a temporary concern:

Some challenges would be staff who are...what should I say?...they think it's a thing that will come and go, so they're not really into changing their classrooms to accommodate the OGT.

*Unsupportive contexts.* Some principals blamed parents or the values of their local communities for students' difficulties with mathematics. This point of view was put forth strongly by three of the seven principals in Appalachian schools, whereas it was expressed in a veiled way by one of the principals in a non-Appalachian school. From the perspective of these respondents, parents should be responsible for supporting the school's academic agenda, and their failure to do so is evidence of inadequate or neglectful parenting. As one principal claimed, "they don't understand AYP, you know ... that doesn't concern them at all. A more educated parent would help me explain the importance of the OGT [Ohio Graduation Test]." According to another principal,

When you're not getting the support at home, the child's not coming to school, and, you know, I'm having to call the home, or try to get meetings with parents that won't come in, who do not take ownership of this child's education. It makes it very difficult.

A third principal explained,

I think our biggest problem with that is the demographics—the type of student we get. It holds us back some. You know, shoot, if you've got students that want to

learn and are willing to learn, and you've got parents willing to treat that issue, I think you're going to, you're going to be ok. But, we get so many students that...their parents don't see education as being number one.

The one non-Appalachian principal mentioned the legacy of an economy based in agriculture as a rational (if misguided) reason why parents did not support advanced mathematics classes for their children. By contrast, the Appalachian principals did not attribute parents' attitudes to rational judgments. Rather, they talked about parents' fear of authority figures and ignorance of what might serve their children best as irrational impediments to parent involvement. As one principal put it, "I don't think a lot of our Appalachian parents understand the importance of getting their child through this test."

The principals also mentioned other impediments to reform that they believed were associated with the schooling context. These related to student transience, the need to spend time on discipline and other non-academic activities, and, ironically, the disruptiveness of the assessment process itself. One principal addressed some of these perceived impediments in the following way:

I think we spend too much time testing them. Because teachers are having a hard time putting together their curriculum, just between the testing and all of the other things we pull them out of school for.... By the time you pull them out for all of those things and all of the other interruptions, and then you take them out testing 600 times a year, obviously that's an exaggeration, but, I think we need to pull back

a little bit, just for simple time. Yeah, having all that data's nice, but there's got to be a middle ground.

According to another principal,

As an educational leader, I still feel that we spend an enormous amount of time on management issues in the high school facility. I spend way too much time on the 10% and not enough on the 90% that's taking place in our building. We've got about 25 discipline problems that take up about 90% of our time. From an educational leadership standpoint, I need to do a better job of managing that.

*The political environment.* Whatever their stance toward reform of mathematics curriculum and instruction, the principals who participated in the study were aware that standards-based reform had become highly politicized. Some were frustrated because they saw the state's agenda as a "moving target" that interfered with the coherence of the reform initiatives they instituted. As one principal commented,

Well, I think our—probably the biggest frustration for all of us—I think it's probably in all education, but I know for sure in our building here, is, like I said, the moving target. You know, we stay here all the time. Give us a target, and we know how to work towards it. We know how to meet it; we really do. I mean, we're...we've been very experienced in this building. We're like bulldogs around

[here], and we know how to fix where we want to go, but I think the biggest frustration is the moving target.

Others saw state standards as more stable, but viewed the graduation test as the “moving target.” For these principals, changes in the test that reduced its difficulty level were more disruptive of reform than changes that increased its difficult level. One principal interpreted the situation in the following way:

So now the challenge is, now our teachers know that to be honest it will take a 41 or 42 percent to pass the math test— they can get less than half of this right—they may not even have to deal with answering the questions right to pass this test, so “why are we stressing out, panicking about changing and making all these changes?” So your challenge now is, “Ok, what, educationally speaking, what should we be doing as educators?” Isn't this the way we should be going—trying to get all kids to think, period, rather than the easy way out now, which is, “Oh, the pressure’s off, and...let’s not worry so much about the writing because we can work on the computational part of it and grind out the numbers to give kids to pass with, you know, less than half right.” So, that’s the new challenge that I’ve been faced with.

For a couple of principals, the specifics of standards-based reform were less important than the opportunity to foster sustained and meaningful improvement. These principals tended to view reform as a long process, aimed less at test scores than at

significant change in classroom practice. Although this view of reform might be considered both realistic and earnest, the “high stakes” associated with the graduation test led many principals to focus on short-term and superficial changes rather than on long-term and more substantive ones. Only one principal, for example, anticipated a ten-year process of reform. Others didn’t seem to think that they had the luxury to extend their reform initiatives over such a long timetable.

Even principals who opted for short-term change seemed to view the state’s emphasis on standards-based reform as an honest attempt to foster improvement. A few were dubious. As one principal put it, “This is going to go away ... You know it’s another fad, it’s another thing; it’s come like other things have come along, and it’s going to go.”

*Summary.* The principals described mathematics reform as a contested terrain fraught with challenges. Their complaints centered on the fact that instructional change was a complex job that was added on top of their already difficult workloads. Existing obstacles to effective school management and leadership were thereby, in their views, exacerbated by the pressing nature of state mandates. Regarding curriculum change, some principals pictured themselves as isolated figures bearing the weight of reconciling official requirements with school realities. According to some, these realities included resistant teachers who did not want to change instructional practice. For others, parent and community values interfered with reform. And some principals saw the reform mandates themselves as politically motivated, transitory, and difficult to address in substantive ways.

### *Patterns across Locale Types*

Comparison of the themes across locales revealed some similarities and some differences. Whereas leadership patterns and the choice of certain reform strategies (e.g., curriculum alignment, individualization) were similar, for example, engagement with the issues of technology seemed to differ. Other apparent differences by locale included: (1) the degree to which schools focused on raising expectations, (2) the extent to which changes in pedagogy were seen as an important reform strategy, and (3) the relative importance that principals accorded to various impediments to reform.

*Leadership.* The general approaches to leadership taken by principals did not seem to differ by locale. In all three locales, most principals deployed a combination of approaches, incorporating both transformational and transactional practices. Moreover, in all locales there were one or two principals who drew attention to their legitimate power, expressing the view that they were in charge of the reforms. Most principals, across rural locales, however, saw reform of mathematics education as a collaborative venture, mainly involving teachers. They viewed their role primarily as involving supportive and supervisory practices.

*Strategies.* Many of the strategies that principals and their faculties used also were the same regardless of locale. Almost all of the schools made use of curriculum alignment, although some were just beginning to think about vertical alignment. And almost all of the schools used one or more types of individualization. Only a few schools were experimenting with a core curriculum, and only two were using the strategy of offering students a “double dose” of math.

One strategy instituting changes in pedagogy did seem to differ somewhat across locales. It seemed to be used more often in the cosmopolitan rural schools than in the schools located in the remote rural locales (both Appalachian and non-Appalachian). Considering the small number of schools, of course, this difference could certainly be coincidental. But it might suggest a trend that other researchers could explore through the use of more systematic research methods.

*Math talk.* Although the “math talk” that principals engaged in was, in general, similar across locales, there was one notable difference. Whereas principals in cosmopolitan rural and non-Appalachian remote schools discussed technology as an important part of math instruction, only one principal in an Appalachian school mentioned technology. Interesting similarities also were evident. Half or more of the principals in each locale talked about math reform as an initiative whose goals are to help students understand math concepts in greater depth and use mathematics as a way to think critically. Only one principal in each locale, however, focused on the pedagogical approach—inquiry based learning—that math educators believe is needed in order to accomplish these goals. Moreover, only one or two in each locale talked about the way real-life applications of math might encourage students to see the value of this subject in general or the practical relevance of particular math concepts.

These comparisons also suggest some possible patterns that other researchers might examine using larger, more systematically drawn samples. The first concerns possible differences between Appalachian and non-Appalachian districts in the extent to which principals view technology as an important feature of reform pedagogy. The second concerns possible differences between principals’ knowledge of the aims of reforms in

mathematics education, on the one hand and recommended methods to accomplish those aims, on the other.

*Curriculum.* With regard to curriculum, there was also one notable difference across locales. Whereas every principal in the remote non-Appalachian schools talked about higher expectations for students as an important influence on the curriculum, only one Appalachian and two cosmopolitan principals mentioned this influence. Across locales, however, there was agreement that curriculum content and sequences needed to be changed. Furthermore, about two-thirds of the principals expressed the view that curriculum work at their schools needed to involve more than the selection of appropriate textbooks. Only seven principals equated textbook content with the curriculum, and only one of these principals was in an Appalachian school.

*Teachers' role in reform.* Across locales, about half of the principals expressed the belief that teachers in their schools were the primary agents of reform of mathematics education. These principals explained that they trusted the math teachers to make the changes necessary to improve curriculum and instruction. The other half of the principals seemed to think that the math teachers at their schools could not be trusted to make the reforms that were needed because they lacked either the capacity or the will to do so. Several of the principals in the cosmopolitan and Appalachian schools also thought that the department structure at their schools facilitated reform. This idea was expressed less often by principals in the non-Appalachian schools, which tended to be smaller (and therefore to have only one or two math teachers).

*Impediments and excuses.* There was an interesting difference across locales regarding the extent to which principals complained about various impediments to reform.

Principals in the cosmopolitan rural schools had the greatest number of complaints—almost double the number mentioned by those in the non-Appalachian remote schools. What this means is that the most complaints—even regarding the adequacy of resources—came from principals in schools with the most resources. In these schools, however, the principals were less likely than the principals in other locales to see families and community demographics as an impediment to reform. Nevertheless, they were more likely to see unmotivated teachers and students as impediments.

Notable also was the fact that so few complaints came from principals in the non-Appalachian remote schools. Of the eight complaints made by these principals, moreover, three came from a principal who had recently moved from an Appalachian school. His comments about unsupportive families were similar in character to those made by other Appalachian principals. With the exception of comments from this one principal, comments from the other principals in non-Appalachian rural schools were less negative and less definitive. For example, one principal from a non-Appalachian remote school commented:

We have a lot of parents here that—well, not a lot, but a good percentage of them—they're in a rural area, that they cannot imagine why their students have to know these things. They don't know why they should know about these...a graph or why would they have to operate at the higher-level geometry and stuff, you know, because the goal is to work the ... you know, on the farm or whatever.

His comment expressed the view that, even if rural families' values differ from those of educators, they have some rational basis. By contrast, the principals in Appalachian schools treated families as deficient, not just as different. The following comment illustrates their perspective:

I think our biggest problem with that is the demographics—the type of student we get.... We get so many students that...their parents don't see education as being number one. And we get so many students that enter that worry about where their next meal's coming from, where their...whether or not their parents are going to be fighting when they get home, so that there, you're fighting a battle there, trying to teach them math when they're just worried about whether or not they're going to have a parent at home, or whether or not they're going to have a meal on the table when they get there.

*Summary.* As mentioned previously, differences across locales might be coincidental, simply reflecting the non-randomness of the processes used to select principals to participate in the study. But they might point to consequential differences. Of particular interest are two perspectives distinguishing the principals in non-Appalachian remote schools from the other principals, namely their view that raising expectations is an important part of curriculum reform and their tendency to downplay impediments to reform. These perspectives are especially interesting given that achievement in the non-Appalachian remote schools is as high as that in the cosmopolitan rural schools, despite the fact that its economic base is almost as weak as that of the Appalachian schools.

## Interpretation

This study was focused by three research questions relating to rural high school principals' perceptions of standards-based mathematics, their responsibilities for standards-based reform of mathematics education, and their responses to applicable state mandates. Data analysis of the principals' responses revealed six relevant categories: (1) leadership for mathematics reform, (2) strategies to support mathematics reform, (3) math talk—expressions reflecting attentiveness to current issues in mathematics education, (4) curricular issues, (5) teachers' role in mathematics reform, and (6) impediments to reform. In addition, analysis of responses in relationship to three different rural locales supported some speculative comparisons.

Generally speaking, findings from this study suggested that the rural principals who participated primarily regarded standards-based mathematics education as an approach required by state accountability initiatives. Their understanding of these reforms extended to familiarity with some differences between traditional and reform views of mathematics, but few were knowledgeable enough about mathematics education to discuss the desired reforms from other perspectives. Findings also seemed to indicate that principals' leadership of reform varied, probably more in keeping with personal predispositions than with decisions regarding the deployment of a set of practices associated with instructional leadership. Irrespective of their proclivities for particular methods of leadership, however, the principals guided their schools in initiatives designed to address the state's content standards in mathematics. These initiatives made use of some combination of four popular strategies: curriculum alignment, individualization, changes in pedagogy, and professional

collaboration. The principals also regarded the reforms in relationship to conditions they viewed as impediments. In some cases, resistant teachers were seen to constrain reform; in others students, their families, and local communities were perceived as impediments.

Analysis of the data, moreover, revealed some possible patterns distinguishing principals in some locales from those in others. Notable was the finding that principals in remote agrarian districts outside of Appalachia were more likely than other principals to (1) regard high expectations for students' performance as an important condition for promoting standards-based mathematics education and (2) to downplay impediments to reform efforts.

Findings from this study fit, to a limited degree, with earlier related literature in which three themes seemed most evident. These themes were (1) standards-based improvements are dependent upon the efforts of principals to focus stakeholders' attention on reform initiatives (Austin Collaborative, 1999; Burns, 1999; Foley, 1993), (2) reform of mathematics education is more likely to occur when principals encourage meaningful teacher collaborations and resulting changes in instructional practice (Austin Collaborative, 1999; Burns, 1999; Huinker et al., 1999), and (3) principals' understanding of standards-based mathematics education promotes their engagement with reform (Austin Collaborative for Mathematics, 1999; Price et al., 1995). Roughly speaking, these themes relate most closely to three sets of findings from the present study, namely those concerning leadership preferences, strategies, and "math talk." In addition some specific findings from the current study also match up with specific findings from earlier studies.

The related literature suggested that principals' efforts to share and nurture a vision of reform contributed to its success. "Visioning" is often associated with transformational leadership, and the current study also showed that a few principals used such practices

(identified in this study as inspirational and idealized influence). At the same time, for most principals, transactional and authoritarian approaches predominated. Comments from principals, moreover, provided insufficient basis for judging whether or not the leadership practices they used were selected because of any perceived relevance to curriculum reform in general or to the reform of mathematics education in particular. In fact their approaches to leadership appeared to represent some other factor, such as familiarity with or the preference for a certain approach.

Providing support for findings from some of the related studies (Burns, 1999; Foley, 1993), this study showed that quite a few principals encouraged collaborations among teachers as a strategy for promoting reform. Some principals also guided teachers' efforts to make changes in pedagogy—a finding that fit in with recommendations offered in most of the prescriptive literature (Cauley & Seyfarth, 1995; Glascock, 2003; McEwan, 2000; St. John et al., 1999).

This study, however, revealed that principals were more likely to use strategies other than these two. In fact, two approaches that were used extensively by principals in this study were not mentioned in any of the related literature: (1) curriculum alignment and mapping and (2) individualization.

Findings from this study also showed that principals had some—albeit superficial—knowledge about the character of recommended reforms in mathematics education. Notably, 85% of the principals offered comments revealing some knowledge of current issues facing mathematics educators. The comments related to a view of mathematics as a tool for increased understanding, the use of technology in math instruction, and the value of

including real-life applications in mathematics lessons. These ideas also appeared in some of the prescriptive literature (Cauley & Seyfarth, 1995; McEwan, 2000).

A relatively small percentage of principals in this study demonstrated knowledge of other practices related to the reform of mathematics education. Of particular interest was the fact that so few mentioned constructivist principles or the related inquiry-based approaches to pedagogy. These principles and practices, however, represent a dominant focus in the literature recommending steps principals should take to support the reform of mathematics education (e.g., Glascock, 2003; McEwan, 2000; Nelson, 1998, 1999; Post et al., 1997).

Another finding from the current study also suggested that principals had limited knowledge about issues relating to the reform of mathematics education—namely that many principals delegated responsibility for the planning and implementation of standards-based reform to their teachers. Whereas such delegation is recommended in some related literature (e.g., Foley, 1993; Huinker et al., 1999; Price et al., 1995), it may be inappropriate in certain schools. About half of the principals in this study, for example, saw teachers as an impediment to reform. These principals could not possibly believe that turning the reform process over to teachers would actually accomplish very much. But their own limited knowledge about the specific nature of desired reforms left them with only a few other options (e.g., to rely on one strong math teacher or to draw on the curriculum leadership of someone outside the school or district).

As might be expected with a mandated reform, moreover, only some of the principals were enthusiastic. Others tended to exhibit a compliant attitude but to draw attention to conditions impeding the progress of reforms and limiting their effectiveness.

To the extent, however, that these principals' concerns about impediments had a basis in fact, they did point to conditions that other writers have seen as unfavorable.

For example, several principals explained that they had too few resources to support reform initiatives. Findings from several empirical studies suggested, however, that the implementation of math education reforms depended on the provision of adequate resources (Austin Collaborative, 1999; Burns, 1999; Huinker et al., 1999). Several of the prescriptive narratives also talked about the need for adequate financial support for such initiatives (Cauley & Seyfarth, 1995; Leinwand, 2000; St. John et al., 1999).

Principals' concerns about the reluctance of some teachers to institute reforms and their lack of appropriate knowledge (e.g., about technology and other new teaching methods) also resonated with ideas presented in the earlier literature. This literature often made reference to professional development as a way to change teachers' attitudes and expand their knowledge of pedagogy (Austin Collaborative, 1999; Foley, 1993, Huinker et al., 1999; McEwan, 2000). Principals in the current study also saw professional development as an important support for reform, but they did not seem to find it adequate in all cases. Those who spoke about reluctant or unprepared teachers, for instance, seemed to suggest that limiting their influence on students or waiting for them to retire might be the only workable options.

It is important, however, to acknowledge that some complaints from principals may have been a reflection of their attitudes toward reform, rather than an accurate picture of the conditions facing their schools. Analyses showing differences across rural locales support this caveat. Notably, principals in non-Appalachian remote schools had far fewer complaints than those in other schools. Nevertheless, some evidence suggests that they

faced conditions similar to those faced by principals in Appalachian remote schools.

Furthermore, the principals with the largest number of complaints were those in the cosmopolitan rural schools, which on objective terms seemed to be in the most favorable position.

Overall, findings from this study did connect in significant ways to findings in the related empirical literature and recommendations in the relevant prescriptive literature. But the current study also offered new insights about how principals construe the reform of mathematics education and what they do in response to mandates for such reform. Notable among these findings were: (1) principals made extensive use of curriculum alignment as a reform strategy, (2) they regarded tracking and remedial math classes as viable reform strategies, (3) they tended to read the reform of mathematics education primarily in terms of state-mandated accountability provisions, and (4) principals in different types of rural locales seemed to view reform of mathematics education differently and to respond to mandates for such reform in different ways.

Based only on a small non-random sample of principals in one state, these insights primarily represent provocations to further research. Researchers in mathematics education, for example, might use insights from this study to inform more extensive investigations of the use of curriculum alignment and various strategies for individualizing instruction. Those interested in curriculum policy might focus increased attention to the relationship between principals' support for curriculum mandates and their leadership of the reforms specified in those mandates. And scholars with an interest in rural education might add to the knowledge of schooling in rural places by conducting systematic comparisons of curriculum, instruction, and school leadership across different types of rural communities.

Our research team certainly looks with anticipation for work that tests or illuminates the claims about the leadership of reform in mathematics education that our study can offer only tentatively.

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## APPENDICES

Appendix A: Data on Study Schools

Non-Appalachian Rural Remote Schools

School	District	County	Student Enrollment 04/05	Mdn Fam Income 04/05	% Disadv 04/05	% Mobility < 1 yr 04/05	% OGT Pass 04/05	% OGT Pass 03/04
Ayersville High School	Ayersville LSD	Defiance	337	\$59,902	8.6	6.6	88.0	69.0
Crestview High School	Crestview LSD	Van Wert	512	\$46,792	0.0	3.3	95.9	73.7
Hicksville High School	Hicksville EVSD	Defiance	471	\$44,767	18.8	6.1	90.6	75.0
Riverside High School	Riverside LSD	Logan	366	\$45,625	17.4	6.9	75.0	63.5
Tinora High School	Northeastern LSD	Defiance	372	n/a	5.2	7.9	94.6	90.2
Van Wert High School	Van Wert City SD	Van Wert	693	\$43,777	14.7	7.7	83.0	72.9

Appalachian Rural Remote Schools

School	District	County	Student Enrollment 04/05	Mdn Fam Income 04/05	% Disadv 04/05	% Mobility < 1 yr 04/05	% OGT Pass 04/05	% OGT Pass 03/04
Adena HS	Adena LSD	Ross	379	\$45,331	10.3	9.7	78.3	69.9
Fort Frye HS	Fort Frye LSD	Washington	581	\$42,813	25.8	6.3	85.2	74.4
Huntington HS	Huntington LSD	Ross	432	\$37,378	20.4	13.5	70.9	60.0
Meadowbrook HS	Rolling Hills LSD	Guernsey	654	n/a	22.2	8.2	83.6	64.9
Oak Hill Middle/HS	Oak Hill Union LSD	Jackson	690	\$31,266	31.7	13.4	74.7	52.4
Paint Valley HS	Paint Valley LSD	Ross	411	\$43,890	19.4	14.6	58.1	65.9

Cosmopolitan Rural

<b>School</b>	<b>District</b>	<b>County</b>	<b>Student Enrollment 04/05</b>	<b>Mdn Fam Income 04/05</b>	<b>% Disadv 04/05</b>	<b>% Mobility &lt; 1 yr 04/05</b>	<b>% OGT Pass 04/05</b>	<b>% OGT Pass 03/04</b>
Allen East High School	Allen East LSD	Allen	320	\$50,740	7.8	3.5	88.9	76.9
Anna High School	Anna LSD	Shelby	684	\$60,307	4.8	3.5	96.8	78.2
Bath High School	Bath LSD	Allen	602	\$48,289	14.5	6.9	87.3	73.2
Elida High School	Elida LSD	Allen	816	\$46,980	13.4	6.4	90.2	69.7
Fairbanks High School	Fairbanks LSD	Union	355	\$65,432	4.7	4.0	94.8	75.7
Marysville High School	Marysville EVSD	Union	1347	\$58,605	3.6	6.1	77.6	68.8

Sources: all data from the Ohio Department of Education's Interactive Local Report Card (<http://ilrc.ode.state.oh.us/Default.asp>), except for median family income, which are for the relevant districts and which were obtained from the School District Demographics System, National Center for Education Statistics, U.S. Department of Education (<http://nces.ed.gov/surveys/sdds/>).

## Appendix B: Research and Interview Questions

### Research Questions

- What actions do principals of remote rural and cosmopolitan rural high schools take in order to address state requirements (e.g., the Ohio Graduation Test) linked to standards-based reform in mathematics?
- How do principals of remote rural and cosmopolitan rural high schools construct their role with regard to the deployment of standards-based mathematics reform in Ohio?
- How do principals of remote rural and cosmopolitan rural high schools think about standards-based mathematics?

### Interview Questions

1. What is your school doing to prepare for the OGT test in mathematics? [Prompt: Tell me more about ...]
2. What challenges are you facing in preparing for the OGT test in mathematics?
3. What role do you play in working toward standard-based reform in mathematics?  
What approaches are you using?
4. What expectations do you have for your teachers to use the math standards?
5. Where do you see your school in relationship to a process of reforming mathematics instruction?

6. In what ways do you see the OGT as relevant or not relevant to the students in your school?
7. Where do you think the changes in mathematics in Ohio came from?
8. In what ways do you think the changes in mathematics education are headed in the right direction and in what ways do you think they're headed in the wrong direction?