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Standards-Based Reform of Mathematics Education in Rural High Schools

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Researchers interviewed rural high school principals in order to learn about reform of mathematics education in their schools. Twenty principals from three rural regions of Ohio participated. A member of the research team conducted a semi-structured interview with each principal. Analysis of interview data suggested that schools were undertaking reform of mathematics education in response to state accountability standards and tests. Principals understood the reforms in a cursory way, recognizing that the reform agenda focused in a general sense on math for understanding, technology, and real world applications of mathematics. Their responses indicated that the reforms adopted at their schools neither fully embraced the reform agenda nor completely ignored it. Instead, the reforms tended to entail incremental changes involving curriculum alignment, minor modifications of curriculum content, and provision of individualized instruction.

Historically, efforts to reform rural schools have responded to cosmopolitan interests and aims (e.g., Kliebard, 2002). In fact, an accumulating body of evidence seems to show that, under pressure to reform, educators from locales of all types across the nation tend to select strategies that respond closely to state-promulgated standards and accountability tests (e.g., Jester, 2002; Posner, 2004).

Nevertheless, there are also countervailing pressures. Rural educators and community members tend to value traditional approaches to curriculum and instruction (Howley, 2003). Moreover, some research suggests that, in certain contexts, the sorts of traditional practices that rural communities favor may indeed be more effective than reform practices (Mussoline & Shouse, 2001). At the same time, progressive educators who write about rural schools often advocate "place-based education," an approach that attends in explicit ways to features of the natural or social environments of rural places (e.g., Jennings, 2000; Jennings, Swidler, & Koliba, 2005; Smith, 2002).

Despite conjectures about what might represent reasonable curriculum reforms in rural high schools, little empirical evidence documents the dynamics or consequences of such reforms. A few relevant studies demonstrate the implementation of structural reforms such as detracking (Rudnitski, 1994), curriculum alignment (Jester, 2002), and community engagement (Kushman & Barnhardt, 2001). And a few others explore reforms in the content of instruction, including studies focusing on integrated language arts (Shanks, Alvin, & Schmidt-Lyga, 1995), standards-based science education (Veal & Elliott, 1996), and the adoption of comprehensive school reform models (Carlson, 2000). Among these studies, however, little attention has been devoted either to reform of mathematics education or to principals' perceptions of and participation in reform.

Adding to the limited body of knowledge about reform of curriculum in rural high schools, this study analyzed and interpreted information from principals regarding changes in mathematics education at their schools. Two research questions provided a focus for the study: (a) How do principals of rural high schools think about reform of mathematics education? (b) What approaches to reform of mathematics education do rural principals report are being adopted at their high schools?

Related Literature

Two bodies of literature seem particularly relevant to this study. Literature about what constitutes reform of mathematics education offers a normative framework for understanding the expectations that national and state standards for mathematics education place on local schools. And literature about recent reforms of rural high schools provides a basis for situating the practices used in the high schools investigated in this study in relation to practices reported in

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other rural places. Although one might hope that this research would distinguish between reforms that primarily implicate structural changes and those that implicate changes in curriculum content, actual reform initiatives tend to conflate the two. Moreover, as a number of leadership theorists and researchers continue to maintain, significant structural reforms may be needed in order to support curricular reforms with sufficient depth to respond meaningfully to national and state content standards (e.g., Lunenburg, 2002).

Reform of Mathematics Education

The standards released by the National Council of Teachers of Mathematics (1989, 2000) redefined the purposes and methods of mathematics education. These standards, moreover, served as the model for content standards in mathematics designed by state departments of education (Joyner & Bright, 2001). In general, the standards support curricula that emphasize concepts and meaning rather than rote learning, they promote integrated rather than piecemeal treatment of mathematical ideas, and they encourage all students' engagement with high-level mathematics. The standards also emphasize an approach to pedagogy that fits with constructivist theories of learning. This approach positions mathematical knowledge as an active and socially mediated process by which children construct mathematical ideas from their experiences of the world (Ross, 2005).

At the high school level standards-based curriculum includes a core that integrates concepts traditionally presented in courses in algebra, geometry, and statistics and probability, and it also includes elective courses that extend beyond the core (NCTM, 2000). The expectation is that all students will complete the core, and that electives will be made available for those students interested in engaging in more advanced study (NCTM, 2000). The standards also implicate the use of inquiry-based approaches to pedagogy, such as those focusing on mathematical argumentation, modeling of quantitative relationships, solution of open-ended problems, and generation of multiple solutions.

According to many writers, standards-based mathematics education constitutes a major departure from the traditional approach to curriculum and pedagogy. As a consequence, much of the literature about reform of mathematics education concerns itself with the education of new teachers and the re-education of practicing teachers (e.g., Lachance, & Confrey, 2003). Despite the constructivist premises incorporated into new mathematics standards as well as notable efforts to prepare teachers to use methods consistent with these premises, the changes that many schools make in response to new mathematics standards sometimes draw on traditional (and perhaps counterproductive) approaches, such as ability grouping, direct instruction, and increased emphasis on classroom testing (e.g., Mussoline & Shouse, 2001; Rowan, Harrison, & Hayes, 2004; Sztajn, 2003).

Recent Curriculum Reforms in Rural High Schools

The small body of empirical literature from 1990-2006 that discusses curriculum modifications in rural high schools reveals two prevalent approaches. One focuses on generic reform strategies, resembling those often used in suburban and urban high schools. The other approach has a more localized focus, responding to the circumstances confronting particular rural communities. A third approach, which entails the incremental improvement of traditional pedagogy, is rarely presented as a reform even though the rural educators who use it may do so with the explicit aim of improving curriculum and instruction.

Reforms responsive to state and national standards. Perhaps the clearest examples of the adoption of generic reforms in rural high schools can be seen in studies of schools that have implemented Comprehensive School Reform Demonstration Projects. These projects, which are sponsored by the US Department of Education, incorporate research-based approaches intended to help schools meet state and national standards.

Carlson (2000) conducted case studies of five rural districts that adopted CSRD projects; and in two of the districts, high schools were implementing the reforms. He reported that, at Crossover High School, staff had adopted the Accelerated Schools model, which addressed "curriculum alignment and promoting teamwork and cooperation among staff members" (p. 31). Data from Crossover suggested that some efforts had been made to prepare teachers for the change but that many teachers did not see a need for the reform. Teacher resistance seemed to be less of a problem at Liberty High School, which had adopted the Effective School Model. The aims of this project were similar to those of the Accelerated Schools project adopted at Crossover. Both projects focused on curriculum alignment and improved teamwork; in addition the project at Liberty involved the creation of "two advanced placement courses and five or six honors courses" (p. 41). At the end of the first year of the project, consultants reported to Carlson that teamwork had been improved and that curriculum alignment was underway. Other parts of the reform project had yet to be implemented.

Other studies also indicated that improved collegiality and increased curricular coherence resulted from efforts at rural high schools to adopt reforms that responded to state and national standards. In an evaluation of reforms of mathematics and science at Cocke County High School in Tennessee, researchers found evidence suggesting that participation in the Appalachian Rural Systemic Initiative (ARSI) had increased educators' attentiveness to state standards (Horn, Oliver, & Stufflebeam, 2000). The high school staff had, for example, conducted an audit to investigate the extent to which the curriculum was aligned with state standards, and teachers had also participated in ARSI-sponsored professional development that emphasized inquiry as a peda-

gogical approach with particular relevance to the teaching of mathematics and science. Case studies of four rural high schools in Ohio also identified curriculum alignment as a central focus of reform efforts (Howley & Howley, 2006). Moreover, involvement with alignment initiatives provided the occasion for closer collaboration among teachers.

A few studies provided contrasting results. In a study of the adoption of block-scheduling at a high school in rural Georgia, Jordan and Padilla (1999) found that this structural innovation helped teachers make significant changes in their practice. With longer blocks of time for instruction as well as support from administrators, teachers were finding it possible to move from traditional lecture and discussion methods to inquiry-based forms of pedagogy. Far less favorable results were reported in two other studies. Shanks, Alvin, and Schmidt-Lyga (1995) described how an initiative to reform K-12 curriculum in a rural Wisconsin district was scuttled by the lack of support from administrators and school board members, and Orrill and Anthony (2003) detailed the negative reactions of six high school teachers to a rural district's adoption of mathematics textbooks that were based on national (i.e., NCTM) standards.

Place-based education. Some initiatives to reform rural schools are more attentive to the concerns and needs of local communities than to national and state standards. Many of these "place-based" initiatives seem to be underway in elementary and middle schools, with only a few such programs in secondary schools. In fact, at the present time, the high-school programs of this sort that are documented in the education literature appear primarily to be taking place in K-12 schools serving Indian and Alaskan Native students (Kushman & Barnhardt, 2001; Russon, Horn, & Oliver, 2000). Internet searches using the term "place-based," however, identify a variety of programs claiming to use this approach. These sources suggest that the adoption of "place-based education" is more extensive than the literature indexed in the ERIC system might lead one to conclude (Gibbs & Howley, 2000).

Other rural improvement efforts. Locally responsive reform need not depart from traditional practices to the extent that "place-based pedagogy" does. As Mussoline and Shouse (2001, p. 55) concluded on the basis of their analyses of NELS:88 data "there are multiple avenues to school effectiveness and 'tradition' and 'restructuring' are not signposts at opposite ends of the road." A case study of an initiative to restructure a rural high school (Rudnitski, 1994) demonstrated how educators involved in a change process were able to respond to the concerns of different local constituencies. Whereas their responsiveness served to moderate the reform agenda, it also kept a powerful minority from derailing the effort. By paying attention to conflicting local values, the educators were able to design school structures that fit with community expectations while at the same time improving instruction.

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 strategies used by rural high schools to reform mathematics curriculum and instruction; the objects of participants' interpretation included mathematics content standards, the Ohio Graduation Test, and school-specific improvements.

Data Sources

The research team selected 21 participants from among rural high school principals in Ohio.[1] 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).[2]

Data Collection

One of the 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 schools were doing in order to undertake and sustain standards-based reform in mathematics and what the principals thought about the changes that were taking place. (See Appendix A 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).

Using the semi-structured approach, the interviewers were able to insert follow-up questions beyond those on the interview schedule. These probes elicited richer explana-

[1] One principal dropped out of the study along the way, so the final data set included interviews from 20 principals.

tions of the points the principals raised in response to the questions on the interview schedule. Interviews with the principals lasted for approximately 60 minutes each, resulting in verbatim transcripts ranging in length from six to 13 single-spaced pages.

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:"

> 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 (pp. 153-154).

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 (e.g., Weiss, 1994). In this study, two researchers coded data independently of one another using inductive coding processes, and then they worked together to refine the codes and identify categories and eventually broader themes. One researcher coded all transcripts using Atlas-TI software, and another researcher coded data "by hand." The initial coding using the two approaches yielded similar results, although the researchers used slightly different nomenclature to refer to various concepts. Once the researchers agreed on a set of codes that represented the key concepts in the data, they developed a chart showing the relationship among these concept, thereby identifying categories under which the most closely related codes could appropriately be subsumed. 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: leadership, reform strategies, math talk, curriculum, teachers, and impediments. Subsequent analysis involving a review of all coded and categorized quotes enabled the researchers to identify two broad conceptual domains evident in the data—the "how to" domain and the "what constitutes reform" domain. Concepts relating to leadership, teachers, and impediments all fit into the "how to" domain because they focused on the processes of reform. Most concepts relating to strategies, math talk, and curriculum fell within the "what constitutes reform" domain because they described the new state of affairs at the schools after reform processes had been put into place. Some concepts in the strategies category, however, fit into both domains. The clearest example was the strategy, curriculum alignment, which represented both a reform process and an outcome of the process.

Findings

This article examines themes within the "what constitutes reform" domain, drawing on principals' perceptions to create a snapshot of what reform of mathematics education seemed to be like at the 20 rural schools. First, however, information about the schools is displayed in Table 1 and some relevant comparisons drawn.

Context

As the table reveals, the remote high schools in the Appalachian region served the least affluent families and performed least well academically, but their enrollments were in the middle of the range. Not surprisingly, the cosmopolitan rural schools had the largest enrollments, served the most affluent families, and had the highest levels of achievement. Their achievement, however, was not much higher than that of the remote non-Appalachian schools despite the clear difference in the family incomes of the students served by the two groups of schools.

Themes

The reform initiatives undertaken at the 20 high schools resulted in changes in curriculum content as well as revisions in the approaches used by the schools to help students improve performance in mathematics. These changes were, at least in part, responsive to what principals and math teachers saw as the major features of standards-based reform. To understand the changes, then, it is useful first to look at how

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[2]The team used the following procedures for categorizing and selecting schools. First, we 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). From that list, we identified schools in different regions of the state. Finally, we 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 location (i.e., Appalachian, non-Appalachian), we sought schools in geographically diverse counties.

Table 1
School Context

School[3]	Location Type	Enrollment	Median Household Income ($)	Performance on Ohio Graduation Test, Mathematics (% proficient)
Farm Valley	Remote Appalachian	581	25,736	85.2
Martin	Remote Appalachian	654	23,537	83.6
Agate	Remote Appalachian	379	28,446	78.3
Open Field	Remote Appalachian	690	24,088	74.7
Hearthstone	Remote Appalachian	432	25,790	70.9
Vineyard	Remote Appalachian	754	24,843	69.1
Pine Grove	Remote Appalachian	411	26,625	58.1
Creek Run	Remote Non-Appalachian	512	30,430	95.9
Tannersville	Remote Non-Appalachian	372	32,338	94.6
Hilltop	Remote Non-Appalachian	471	29,070	90.6
Apple River	Remote Non-Appalachian	337	31,767	88.0
Valley	Remote Non-Appalachian	693	27,050	83.0
Rome	Remote Non-Appalachian	366	28,551	75.0
Arrow Woods	Cosmopolitan Rural	684	32,922	96.8
Firestone	Cosmopolitan Rural	355	37,695	94.8
Ellensville	Cosmopolitan Rural	816	28,875	90.2
Ammons West	Cosmopolitan Rural	320	30,028	88.9
Village	Cosmopolitan Rural	290	37,850	88.7
Bell Terrace	Cosmopolitan Rural	602	29,744	87.3
Marshland	Cosmopolitan Rural	1,347	37,938	77.6

principals viewed the character of the reform they were asked to address.

What Principals Thought about the Mathematics Education Reforms

Nineteen of the 20 principals provided comments that showed some awareness of current perspectives about the reform of mathematics education. Best represented in their comments were concepts relating to: (a) math for understanding, (b) technology, (c) real world applications of mathematics, (d) inquiry-based (or active) instruction, and (e) writing as a part of mathematics learning. Far less frequently did principals mention the social justice implications of recent mandates for reform of mathematics education (e.g., NCTM, 2000).

Twelve principals characterized standards-based mathematics in terms of its focus on understanding, problem-solving, logical thinking, and higher-order processes. These interviewees often contrasted the standards-based approach with "old-fashioned" mathematics instruction, which involved memorization of facts and perfunctory application of algorithms. In doing so, they talked about the focus on meaningful explanations, which they saw as the foundation of standards-based mathematics. One principal's comment epitomized this perspective:

> 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.

In discussing the benefits of reform math three principals drew on Bloom's taxonomy to explain differences between "old-fashioned" and standards-based mathematics. For example, one principal shared a question that he asked himself and his staff in order to gauge the extent of the

[3]Pseudonyms are used in place of the schools' actual names.

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?"

Half of the principals mentioned technology in connection with reform of mathematics education, and all but one saw the connection as positive. Nevertheless, with the exception of reports about software that gave students practice with mathematics problems such as those that are included on state accountability tests, however, the comments tended to be vague. In fact, the principals who discussed technology seemed to see it as a generic resource rather than as a method of providing specific types of standards-based instruction. The following statement was typical of their comments: "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."

Three 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." One principal reported 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 computer algebra systems or dynamic geometry software, and only one mentioned the use of graphing calculators. Another principal, who had previously been a math teacher, explained that when he was a teacher he refused to let students use any kind of calculators because he thought they encouraged laziness.

Fewer than one-third of the principals talked about connections between school mathematics and applications in the real world. One principal, whose background had been in vocational education, however, spoke eloquently about such connections, and a few others echoed her perspective:

> 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.

Three 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. The principals who did discuss this approach were strong supporters of it, however.

Changes in Curriculum

The principals clearly saw changes in curriculum as a major part of the reform agenda, but they expressed different views about the wisdom of such changes. Despite these attitudinal differences, the principals all discussed reform in term of higher expectations for student performance, revised course content and sequences, and the selection of appropriate textbooks.

According to eleven of the 20 principals, the main purpose of standard-based reform is to "raise the bar." 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?

Only three principals expressed the view that "raising the bar" might not achieve the desired result. These principals thought that changes in expectations and curriculum at elementary and middle schools might improve achievement, but reforms at the high school were "too little, too late." By contrast, other principals claimed that they had already seen a measure of success as a result of their reform efforts.

Raising the bar for college preparatory students seemed to be the priority for the interviewees, who talked about these students more often than they talked about general or vocational students. 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 to take engineering upper level, chemistry upper level, science classes." Two respondents in fact praised their schools for putting a special emphasis on Advanced Placement.

Regarding low-to-average students, opinions were divided between giving them equal access to higher-level math knowledge and simply meeting their immediate academic needs. The first perspective was defended by two principals who expressed the opinion that many occupations now require the mastery of complex problem-solving skills. Three interviewees, however, offered a contrasting perspective, pointing out that the expectation that all students should perform at high levels in math was unrealistic. One principal even suggested that standard-based reform and the OGT were setting the average student up for failure.

Despite some disagreement about the relationship between reform of math curriculum and desired results, the majority of respondents (i.e., 11 out of 20) expressed the belief that improving math education at the high school level involved increasing access to introductory Algebra

courses. Three even suggested that the best way to improve their students' rate of success on the OGT was to make Algebra compulsory, or, as one said, "Just force it down from the top."

Other interviewees were less decisive. 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 of taking Algebra in the ninth grade. 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 reported that they had made additions to their curricula in order to address content covered by the OGT. The most common concern was that the pre-reform curriculum did not pay sufficient attention to concepts in geometry, statistics, and probability. Seven principals referred to the need to teach more geometry. And four interviewees said that they had asked teachers to reinforce concepts relating to probability and statistics in their eighth grade math or Algebra classes. One principal also talked about the need to add trigonometry content to the core math curriculum.

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 only: 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. And half of the principals spoke about efforts to upgrade general math courses, renaming them "Integrated Mathematics," and organizing them into sequences that provided success to less capable students of mathematics.

Ten of the principals expressed the view that, whatever the standards or course sequence, textbooks represented the true curriculum. For these principals, finding texts that addressed the standards was an important issue. One principal, for example, complained that some materials encouraged teachers to bypass the standards:

> Although we'd like to believe that we're different, our teachers are going to use the materials they have … they're going to use the materials that they've ordered, purchased, and handled …

These respondents also tended to equate instructional materials with textbooks rather than treating textbooks as one of many instructional materials that teachers might use. Nevertheless, interview data revealed three different views regarding the role that textbooks should play in the planning and delivery of mathematics instruction. The first and most popular perspective was 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." 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 One. 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.

Principals who subscribed to the second perspective saw standards and textbooks as a major part of the curriculum—but not equivalent to it. These administrators 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 stressed that the staff knew all along that the textbook included a number of gaps that called for supplementary materials.

Finally, the third perspective was expressed by principals who were ambivalent about textbooks or about the teachers who relied on them too heavily. One school administrator connected reliance on textbooks with her 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.

Another interviewee implied that teachers' reverence for books harkened back to the time when such materials were the only available 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.

Finally, two principals voiced their mistrust of math textbooks because they were 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."

Strategies Associated with Reform of Mathematics Education

Attentive to the standards guiding recent calls for reform, all of the principals talked about strategic changes that had been made at their schools. The strategies used most often in the schools were: (a) curriculum alignment and mapping; (b), individualization; and (c) collaboration among teachers. The data also showed that in some of the schools' teachers were making changes in classroom pedagogy, rituals, and routines.

The schools were generally committed to the practice of aligning the mathematics curriculum to state standards. Although it represented the most popular strategy among the schools, there was not much variability in what principals meant by "curriculum alignment." All of the 16 who discussed curriculum alignment described it as a process of matching courses of study with the sequence of standards issued by the Ohio Department of Education, and they explained that the goal of the process was to expose students to the content on which they would be tested. Nevertheless, each school's faculty varied slightly in terms of the specific methods it chose to use, and the alignment process had not yet been completed in some of the schools. At the 16 schools where principals reported that there had been work on curriculum alignment, teachers had already matched the curriculum at each grade level to standards for that level. Variation across schools primarily related to the extent to which they had completed the process of grade-to-grade articulation (i.e., what's often referred to as "vertical alignment"). Comments from eight of the principals suggested that both horizontal and vertical alignment processes had already been completed.

Individualization was the second most popular strategy. Although not all of the principals saw individualization as valuable in its own right (and some seemed almost to oppose it on principle), most (n = 18) acknowledged that it was necessary in order to help less capable students pass the Ohio Graduation Test. Comments from one principal illustrated 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.

Irrespective of principals' views about individualization, the practice was used in 18 of the 20 schools. 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, explaining that (a) it made sense, and (b) it was an organizational arrangement already in place. Many schools 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" mathematics sequence, which interspersed concepts relating to arithmetic, algebra, statistics, and geometry. 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 three schools there was also an honors (or Advanced Placement) track.

Tracking was less rigid in some of the schools. Four of the principals, for example, talked about giving students the option of signing up for whatever math courses they could handle, irrespective of their plans to attend (or not attend) college. According to the principals of these schools, such efforts to promote flexible tracking depended on students' decisions about their own courses of study and, mostly their decisions kept them in the tracks to which they were originally assigned. Crossing from one track to another, while permitted and even encouraged, did not seem to take place all that often.

Other approaches to individualization were used, but they were much less prevalent. Four schools, for example had tutoring programs for students who were having difficulties in math. Other schools offered special classes to groups of students who seemed to need general or test-specific remediation. In three schools, these classes were designed for students who had failed to pass the mathematics portion of the OGT. But in one school, the class was offered to all ninth graders who had struggled in middle school math.

In their efforts to stimulate and support the changes at their schools, the principals all saw professional development as important. They reporting using whatever resources were available—workshops provided by the intermediate unit and the state department of education, sessions organized as part of grant-funded projects, and various district-wide initiatives. In four schools professional development was something that teachers created for themselves through study groups and professional learning communities.

Even in schools where teachers did not collaborate in formally established professional learning communities, other sorts of collaboration were being used. Examples included: focus on instructional planning at faculty meetings, regularly scheduled math department meetings, comparison of teaching strategies among colleagues from different schools or across subject areas within the same school, and

establishment of partnerships with community businesses and colleges. Four principals claimed that increased focus on instructional planning at faculty meetings contributed to math reform at their schools.

Fifteen of the schools' principals also reported that teachers had made changes in pedagogy that were influencing classroom rituals and routines. The extensiveness of the changes varied considerably from school to school, however; and in some cases, the principals reported they had been advocating changes in pedagogy that teachers were reluctant to adopt. The pedagogical changes most commonly mentioned were (a) using cooperative learning techniques, (b) using technology as a teaching and learning tool, and (c) incorporating extended response and higher order thinking questions into classroom discussions and assessments.

Several principals also saw changes in pedagogy in terms of the expectations teachers held for student performance. One principal reported, "Our message to students is, 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." According to six of the principals, one important way to increase expectations for student performance involved the change from rote memorization to problem-solving. Thirteen principals talked about the way classroom assessments could be used to accomplish this change. Notably, they talked about the connection between students' ability to explain their answers and their engagement with 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."

Interpretation

Findings from this study suggested that the 20 participating principals regarded standards-based reform of mathematics education as a necessary response to state accountability initiatives. Their responses to interview questions revealed some familiarity with differences between traditional and reform views of mathematics, but their knowledge about the reforms was often expressed in terms of simple nostrums such as "use extended response questions," "increase the focus on higher-order thinking," and "provide Algebra for all." Few of the principals were knowledgeable enough about mathematics education to discuss standards-based reforms in depth or from various perspectives.

Even though their understanding of the reforms tended to be superficial, the principals reported that they had guided their schools in initiatives designed to address the state's content standards. These initiatives included modifications in the scope and sequence of the mathematics curriculum as well as strategies for achieving improved results on the Ohio Graduation Test. The two most frequently mentioned strategies, curriculum alignment and individualization, contributed to (and were also aided by) increased collaboration among teachers. Some changes in pedagogy had also taken place at most schools, although thoroughgoing changes from traditional to adventurous teaching (Cohen, 1988) were not reported by any of the principals. Moreover, there was no mention by any of the principals of initiatives that connected mathematics curriculum to the places where students lived.

Even though the changes in curriculum and pedagogy that principals described clearly were consistent with state and national standards, they represented modest adjustments rather than radical departures from past practice. They resembled the sorts of changes reported by Carlson (2000), Horn and associates (2000), Howley and Howley (2006), and Jester (2002). In contrast to the initiatives at the schools studied by Shanks and associates (1995) and Orrill and Anthony (2003), the reforms at the 20 Ohio high schools were not met by strong enough resistance from teachers or community members to derail or substantially alter them. Instead, the mathematics education reforms adopted by these schools were becoming institutionalized in almost all cases.

Furthermore, the data suggested that the reforms did not explicitly respond to local interests or needs other than educators' concern to raise test scores. As a consequence, the curriculum changes and reform strategies did not correspond to the aims or methods of "place-based" education (e.g., Kushman & Barnhardt, 2001; Russon et al., 2000). Nor did the reforms appear to take community preferences into account. In the few cases, for example, where parents or community members had questioned the relevance of the reforms, principals were quick to discredit their perspective. Rather, the principals saw changes in mathematics education as necessary responses to the state's demand for accountability. The only response to the rural circumstance seemed to be the principals' belief that the traditional culture of rural schools and communities might stand as an impediment to rapid adoption of reforms. In fact, despite a certain amount of skepticism about the wisdom of some of the changes their schools were adopting, the principals nevertheless saw themselves as instruments of the state's reform agenda.

Whether or not the principals lived in or came from the rural communities where they worked, their perspectives on curriculum reform seemed to be shaped primarily by professional norms and wider political forces. Nevertheless, the incremental character of the reforms in these schools revealed the likelihood that the educators were being attentive to the traditional values of these rural communities. Perhaps the mathematics teachers in these schools, who typically were the ones advocating or at least enacting the changes in curriculum and pedagogy, were responsible for

modulating the reforms or the language of reform in ways that fit with community sensibilities.

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Appendix A
Interview Schedule

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