DOCUMENT RESUME

ED 475 059 RC 023 787

AUTHOR	Silver, Edward A.; Castro, Alison M.
TITLE	Mathematics Learning and Teaching in Rural Communities: Some Research Issues. Working Paper.
INSTITUTION	Ohio Univ., Athens. Appalachian Collaborative Center for Learning, Assessment, and Instruction in Mathematics.
SPONS AGENCY	National Science Foundation, Arlington, VA.
REPORT NO	WP-14
PUB DATE	2003-03-00
NOTE	29p.; Paper presented at the ACCLAIM Research Symposium (McArthur, OH, November 3-6, 2002).
CONTRACT	NSF-0119679
AVAILABLE FROM	For full text: http://kant.citl.ohiou.edu/ACCLAIM/ rc/rc_sub/pub/3_wp/Silver14.pdf.
PUB TYPE	Information Analyses (070) -- Speeches/Meeting Papers (150)
EDRS PRICE	EDRS Price MF01/PC02 Plus Postage.
DESCRIPTORS	Disadvantaged; Educational Attitudes; *Educational Research; Elementary Secondary Education; Mathematics Achievement; *Mathematics Education; Poverty; Professional Development; *Research Needs; *Rural Education; Rural Urban Differences

ABSTRACT

In 1998 the National Council of Teachers of Mathematics held a working conference on issues pertaining to effective mathematics education in schools serving poor communities. This paper reprises some themes of that conference and highlights potentially important issues to consider in a research agenda with an intentional focus on rural mathematics teaching and learning. A section on student learning of mathematics in rural schools discusses the decline in rural students' mathematics achievement in grade 12, relative to other locales, and considers possible contributory factors: low parent and student aspirations and expectations toward education, perceptions that mathematics is not relevant, or lower access to advanced mathematics courses. A section on mathematics teaching points out that some efforts to improve mathematics teaching have been characterized by intensive professional development involving the whole school. Such sustained professional support and mentoring may not be available in small rural schools, and distance education alone may not be sufficient to overcome professional isolation. Examination of two data sets supports the notion that lack of local support impedes rural teachers' pursuit of innovation in mathematics teaching. Research on mathematics education in rural areas is scarce. There is an acute need to identify good sources of information on these issues, develop syntheses of what is known and what is needed, and raise awareness of the issues in the larger mathematics education community. (Contains 43 references.) (SV)

Appalachian Collaborative Center for Learning, Assessment and Instruction in Mathematics

Working Paper Series

Mathematics Learning and Teaching in Rural Communities: Some Research Issues

Working Paper No. 14

Edward A. Silver and Alison M. Castro
University of Michigan
March 2003

ACCLAIM's mission is the cultivation of *indigenous leadership capacity* for the improvement of school mathematics in rural places. The project aims to (1) understand the rural context as it pertains to learning and teaching mathematics, (2) articulate in scholarly works, including empirical research, the meaning and utility of that learning and teaching among, for, and by rural people, and (3) improve the professional development of mathematics teachers and leaders in and for rural communities.

OHIO UNIVERSITY

ACCLAIM Research Initiative
All rights reserved

Address: 210A McCracken Hall
Ohio University
Athens, OH 45701-2979

Office: 740-593-9869
Fax: 740-593-0477

E-mail: howleyc@ohio.edu
Web: http://acclaim.coe.ohiou.edu/

Funded by the National Science Foundation as a Center for Learning and Teaching, ACCLAIM is a partnership of the University of Tennessee (Knoxville), University of Kentucky (Lexington), Kentucky Science and Technology Corporation (Lexington). Marshall University (Huntington, WV), University of Louisville, and Ohio University (Athens, OH).

ACCLAIM

This material is based upon the work supported by the National Science Foundation Under Grant No. 0119679. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Mathematics Learning and Teaching in Rural Communities: Some Research Issues

Edward A. Silver and Alison M. Castro
University of Michigan

Paper presented at the
ACCLAIM Research Symposium
Ravenwood Castle, McArthur, Ohio

November 3-6, 2002

Mathematics Learning and Teaching in Rural Communities: Some Research Issues

Edward A. Silver and Alison M. Castro
University of Michigan

About four and one-half years ago (on June 7–10, 1998, to be precise) the National Council of Teachers of Mathematics (NCTM) sponsored a Working Conference on Mathematics Teaching and Learning in Poor Communities in Chicago. The conference provided a forum for participants -- a diverse group of about 30 education professionals from school districts, universities, and education agencies -- to discuss issues pertaining to effective mathematics education in schools serving poor communities – whether in urban or rural settings -- and to identify fruitful approaches for addressing the challenges these schools faced.

The conference was organized around three major themes: (1) student learning of mathematics; (2) mathematics teachers and teaching; and (3) school, district, and community contexts. Within the theme of student learning of mathematics in poor communities, conference participants addressed expectations and support of students, evidence and assessment of students' learning, and mathematics content relevant to students' experiences and needs. The discussion of mathematics teachers and teaching in poor communities encompassed teaching methods and materials, teacher preparation and qualifications, and teachers' professional development and support. Participants addressed school, district, and community contexts for mathematics teaching and learning in poor communities through a discussion of school, district and community leadership, curricular policy, and parent and community involvement.

One aspect of the work of the conference was the identification of evidence of effective mathematics education in schools serving poor communities and the specification of the processes and outcomes of mathematics instructional improvement efforts in schools and districts that face the challenges and constraints of poverty and related societal pressures. Participants were encouraged to probe the circumstances under which interventions were or were not effective, the aspects of interventions that appeared to be critical to their success or failure, and the nature of evidence of success. Finally, participants were urged to compile ideas not only about what is known but also about what needs to be known about this cluster of issues. The processes and outcomes associated with the conference have been compiled in a report, *Teaching and Learning Mathematics in Poor Communities*, available from NCTM (Campbell & Silver, 1999).

In the current paper, we reprise some of the themes touched upon at that conference and highlight some potentially important issues to consider in a research agenda that has an intentional focus on mathematics teaching and learning in rural schools. Such an endeavor seems worthwhile because so much of what we think we know about teaching and learning mathematics in poor communities is not differentiated with respect to setting – rural or urban.[1] As we shall see, some commonly held understandings about the circumstances of teaching and learning mathematics in high-poverty settings may not apply equally well to urban and rural communities.

1 We recognize that not all rural communities are high-poverty locales. Nevertheless, because of ACCLAIM's geographical focus on Appalachia, which is both rural and highly affected by poverty, the potential relevance of what is known in general about mathematics teaching and learning in poor communities seems clear. Moreover, many issues affecting mathematics teaching and learning are not strictly urban issues or rural issues; instead, they cut across settings. Individuals seeking to develop a research agenda on mathematics teaching and learning in rural regions such as Appalachia should be able to profit from research on cross-cutting issues (such as questions of access and equity, useful ways to assess student achievement gains on worthwhile outcomes, or teacher professional development as a catalyst and support for innovative pedagogical practice in high-poverty schools), even when the research has been conducted in urban settings (e.g., Campbell, 1996; Oakes, 1990; Silver & Lane, 1995; Silver & Stein, 1996; Stein, Smith, & Silver, 1999).

At this time in the field of education, much of what passes for wisdom about the problems and solutions associated with mathematics teaching and learning in poor communities is derived from an examination of schools, students, and teachers in urban settings. Yet the particular features of rural poverty, as opposed to urban poverty, may argue for somewhat different problem definitions and solution specifications.[2] Consider, for example, the current move to make U. S. public high schools smaller. Suggestions for accomplishing this goal have been around for four decades or longer (e.g., Barker & Gump, 1964), and considerable attention has been given to this kind of structural reform in recent policy discussions. In recent times, equity concerns have been prominent in the argument for this change (Lee, 2001). Yet, although this reform may be sorely needed in urban settings, rural high schools are typically quite small, smaller than any reform is likely to induce in urban settings.[3] This is just one example of a possible disconnection between urban and rural concerns, and it illustrates how critical are issues of setting and place in framing conversations about the improvement of teaching and learning in schools. In this paper we identify a few other examples. Nevertheless, there is also much that rural schools share with urban schools in regard to improving mathematics teaching and learning, so it is wise to examine the accumulated body of knowledge available across settings as one creates an agenda for new knowledge generation.

Although one of us (Castro) grew up in a rural community and the other (Silver) now lives in a rural locale, we wish to acknowledge at the outset that we do not consider ourselves to be

2 In referring to the constructs, rural poverty and urban poverty, we do not wish to convey a monolithic impression of poverty in these communities. There is considerable variation in patterns of mathematics achievement and related factors across rural communities (see, for example, Lee & McIntire, 2000). Nevertheless, the commonalities among rural communities are quite pronounced when contrasted with many key characteristics-of urban settings.
3 Ironically, in recent years, rural school districts, especially in the eastern and southern regions of the U.S., have experienced considerable economic pressure to consolidate smaller districts. In many cases this has produced larger schools that may be more efficient from an economic standpoint but that may reduce the educational benefit of smallness that may be viewed as a strength of rural schools.

experts on rural education. It is quite possible that we have misinterpreted what we have read about rural education or misunderstood some essential features of mathematics education in rural schools. If so, we are confident that readers of this paper will help us correct our mistakes. For this reason, however, the tone of our paper is intended to be tentative and illustrative rather than definitive and comprehensive. Nevertheless, we hope the issues we raise and the data we provide will be useful to readers wishing to pursue a research agenda on the learning and teaching of mathematics in rural communities.

Student Learning of Mathematics in Rural Schools

In the United States, a confluence of historical, economic, and social factors have created a situation in which poverty, minority racial status, and urbanicity are closely intertwined. Thus, it is not surprising that one can find many research studies and national reports that treat these characteristics as essentially interchangeable.

Although some analysts have tried to disentangle race and ethnicity from poverty when studying factors associated with low achievement in mathematics, numerous data sources indicate that the relationship between achievement and poverty is roughly parallel to that observed for achievement and race/ethnicity. In fact, variations in students' mathematics achievement on NAEP and other measures have long been associated with both demographic categories -- socioeconomic status and race/ethnicity (Abt Associates, 1993; Mullis et el., 1994). On standardized assessments, there is a consistent, persistent pattern of differential mathematics achievement favoring affluent and white students over poor students and (non-Asian) children of racial and language minority backgrounds. Although racial minority students and students in high-poverty communities have narrowed the achievement gap in standardized test performance and on the NAEP, a substantial difference still remains when compared with their counterparts (Congressional Budget Office, 1987; Mullis et al., 1994). Moreover, reductions in group performance differences have generally come from improvements on those sections of tests related to factual knowledge and calculation skills. Little change has been found for portions of tests measuring higher-level mathematical outcomes (Secada, 1992). That is, although the differential performance gaps between white and (non-Asian) non-white students and between students in affluent and poor communities have been closing over time on tasks that assess basic procedural knowledge and skills, substantial performance differences remain on tasks that assess conceptual understanding, mathematical reasoning, and problem solving. And these are precisely the kinds of mathematical attainments expected of students, according to recently published standards for mathematics proficiency (NCTM, 2000).

A close examination of recent student achievement data at grades 4, 8, and 12 from the National Assessment of Educational Progress (NAEP) indicates a persistent performance disparity among subgroups defined by socioeconomic status, with the percent of students eligible for free or reduced lunch often taken as a proxy for the socioeconomic status of the community from which the students are drawn (NCES, 2002). In particular, the mean academic achievement of students registered in schools that enroll a high percentage of students who live in poverty is significantly lower than the mean academic achievement of students from schools in more affluent communities. A recent examination of average district-level mathematics achievement revealed that level of school funding and child poverty had "substantial and statistically significant net effects on average student achievement among the school districts of America and that these effects stand up even when juxtaposed with those of two crucial, district-level control variables: level of curricular instruction, and race" (Payne & Biddle, 1999, p. 11).

The confounding of race/ethnicity and poverty in American society explains these parallel trends, yet it complicates the task of specifying an agenda for rural schools and communities. Poverty is often viewed as an urban problem. Yet rural communities, like their urban counterparts, also tend to have high rates of poverty. About 40 percent of the poor live in urban inner cities, but poverty is not restricted to urban centers. More than one of every five persons living in poverty in the United States resides in rural or small town settings (Dalaker, 1999). However, unlike urban communities, rural settings often tend to be homogeneous with respect to race/ethnicity.

So what can be said about students' mathematics achievement in rural schools? One excellent source of information is the National Assessment of Educational Progress. In the most recent assessment (Braswell et al., 2001), NAEP used the Census Bureau definitions of metropolitan statistical areas to classify locales into three mutually exclusive categories; central city, urban fringe/large town, and rural/small town.[4] At grades 4, 8, and 12 (the grades at which NAEP assesses mathematics achievement), students in the urban fringe/large town category performed significantly better (i.e., they obtained significantly higher mean scale scores) than students in central city locations. Their performance was also better at all three grade levels than that of students in rural/small town settings, but the difference was not statistically significant. At grades 4 and 8, though not grade 12, it is interesting to note that students in rural/small town locations performed significantly better than students in central city locations.[5]

Lee and McIntire (2000) reanalyzed NAEP's 1992 and 1996 mathematics achievement data for grade 8 students using the Census Bureau classifications of metropolitan location. They

---

4 Because this classification scheme is different from the one used in prior NAEP assessments, trends are not readily available.

5 A similar trend can be seen if one examines the percent of students at each level of proficiency using NAEP's

compared the performance of grade 8 students in rural/small town settings with that of their counterparts in non-rural locations (combining central city and urban fringe/large town) and found that the two groups had comparable mathematics achievement scores in 1992. In 1996, however, the rural/small town students in the NAEP sample outperformed the non-rural students on the mathematics assessment at grade 8. Nevertheless, Lee and McIntire also found that student achievement varied widely across different rural settings. In particular, students in some rural states (e.g., Iowa, Maine) performed quite well and students in other rural states (e.g., Arkansas, Mississippi) did not. Furthermore, rural students in some states (e.g., Connecticut, Michigan, New York) outperformed non-rural students, but the trend was reversed in some states (e.g., Georgia, Kentucky, West Virginia).

The analysis by Lee and McIntire (2000) points to the possibility that the national NAEP 2000 findings may also mask variations that exist across states in the patterns of the mathematics achievement of students attending rural and non-rural schools. As the participants at the NCTM Working Conference (Campbell & Silver, 1999) noted repeatedly, *context matters* – general, national trends are often not replicated in local settings.

One finding of these NAEP-based data reports and analyses strikes us as potentially important to consider in shaping an agenda for research on mathematics learning in rural communities -- the relatively poor performance of rural students on NAEP at grade 12. [6] Is this uniform or variable across rural settings? What factors might explain this finding?

---

achievement levels.

6 It is also interesting to note in this regard that the 2001 SAT mathematics scores for college-bound seniors from rural schools were also low in comparison to students in other demographic categories of locales used by the College Board, including small cities or towns, medium cities, suburban, and large cities. The scores of suburban students were significantly higher than those of students in each of the other categories, but large city students had higher mathematics (though lower verbal) scores than rural students.

One potential explanation for generally poor performance might lie in a lack of motivation by grade 12 students on a low-stakes assessment such as NAEP. But we know of no plausible basis on which to assert that rural students in grade 12 would be even less motivated than their central city counterparts.

Another potential explanation is that rural students perform less well because of a big gain by central city students by grade 12. But neither NAEP nor other sources of data on student performance indicate stunning performance gains for inner city students in high school. In fact, the usual trend is that performance gaps widen between urban and non-urban students by the end of high school.

But there are some factors that might bear closer examination in relation to the NAEP performance data at grade 12. Certainly, one should consider the possible influence of parental and community expectations. In most analyses academic performance is highly correlated with parents' aspirations for their children and family attitudes toward education. In many communities, and quite often in economically disadvantaged urban settings, K-12 schooling is perceived as an initial step in the process of earning a college diploma and obtaining the economic and social benefits associated with higher education. In rural communities, however, adolescents frequently experience conflict between career aspirations and their preferences for a future residential location.[7] This is because both adolescents and adults in rural communities recognize that the economic benefits associated with a college diploma may only be accessible at

7 Other conflicts can also arise. A student's social traditions or culture may either coincide or conflict with classroom norms for student activity, student conduct, and student-teacher interactions. This so-called two-culture problem may arise in urban settings and in isolated rural locations. Culture-schooling conflicts have been noted in schools serving the children of recent immigrants from other nations, schools enrolling Native American students, and schools enrolling African American students, especially (though not always) when there is a racial/ethnic mismatch between teacher and students (e.g., Delpit, 1988; Malloy & Malloy, 1998). But other versions of the two-culture problem have been noted in racially homogeneous rural settings (e.g., Heath, 1983).

locations far removed from family and community.[8] Indeed, one study indicated that, by age 25, half of all rural college attendees had not returned to their home community (Gibbs, 1995). On the other hand, it is not unusual for rural adolescents, particularly male adolescents, to decide there are substantial risks associated with "too much education," which leads them to reduce educational aspirations, to hesitate in pursuing or to delay college entry, and to decrease motivation for secondary schooling (Hektner, 1995). Thus, there is a complex confluence of factors – related to social capital, risk management, desired destinies, and hopes for intergenerational cohesion – that influence students' aspirations in rural communities.

Mathematics, often perceived by many as the school subject with the least relevance to everyday life of a community, may be especially susceptible to avoidance behavior for this reason. Contemporary approaches to mathematics topics through applied problem solving and modeling seem especially fruitful to explore to combat this factor. And studies of the efficacy of such approaches in rural schools appear to warrant inclusion in a research agenda focused on the improvement of mathematics teaching and learning in rural schools.

Another factor to consider is the academic program available in rural high schools. As we noted earlier, rural high schools tend to be smaller than those found in other locales. This undoubtedly has some positive benefits for students, but it may also impose some limitations as well. Rural students tend to have limited access to advanced courses in mathematics and other subjects because high schools in rural settings have too few students to make it feasible to offer such courses. One recent study (Ballou & Podgursky, 1998) reported that high school students in rural schools, as well as in inner city schools, are less likely than students in suburban schools to

8 A focus on future economic success promotes in schooling an almost exclusive emphasis on individual achievement. Yet this emphasis may conflict in at least some cases with the importance of a sense of place and the kinship bonds of rural families. This may be an especially critical issue for schools serving Native Americans.

enroll in advanced mathematics courses (advanced algebra, analytic geometry, trigonometry, or calculus), even after statistically controlling for school size.

One indicator often used as a proxy for a high quality academic program in high school is the extent of student participation in the College Board's Advanced Placement Program, through which students can take courses in high school that are designed to be roughly equivalent to introductory college courses and for which college credit can be earned by examination. At a College Board conference held in 2001 – the Midwestern Small Schools Summit – it was reported that over 60 percent of the all U.S. high schools participated in the Advanced Placement (AP) program in 1998-99, but only about 20 percent of small schools in the Midwest participated. Because many small schools are located in rural communities, this suggests lower access to AP courses in rural locales.[9] Other information from the College Board reinforces this suggestion. In 2000, 57 percent of high schools nationally participated in the AP program. But in states dubbed by the College Board as "rural states," the participation rate was generally much lower. North Dakota had fewer than 10 percent participation. Wisconsin – with 65 percent participation – was was the only rural state to exceed the national average, although Illinois and West Virginia were close, with about 55 percent of the high schools in those states participating in AP. Non-rural states, such as California, Connecticut, New Jersey, and Massachusetts, generally had much higher rates of participation. For example, more than 85 percent of the schools in Massachusetts and Connecticut participating in the AP program. Although the grade 12 NAEP assessment does not include questions that test knowledge of advanced high school

---

communities.

9 Some have suggested that students attending schools in rural areas might be able to gain access to a wider array of advanced mathematics courses through distance learning approaches and the Internet. The efficacy of these approaches suggests itself as a critical research topic for investigation.

mathematics, the quality and availability of mathematics courses in high school could be a contributing factor. Beyond the academic program, it is also important to consider the mathematics teachers and teaching one finds in rural schools.

Mathematics Teaching in Rural Schools

One of the most salient themes of the NCTM Working Conference on Teaching and Learning Mathematics in Poor Communities (Campbell & Silver, 1999) was the observation that the barriers limiting students in poor communities from learning mathematics include not only a relatively impoverished academic program but also limitations inherent in classroom instruction. In high-poverty classrooms instruction is frequently based on the "conventional wisdom" that students are deficient and that instruction should emphasize practice on basics before moving to more challenging material involving problem solving or reasoning. In this approach, what is taught in mathematics is differentiated by a prior evaluation of student proficiency so that remedial instruction can be provided to supplement the "known" skill deficiencies of the students (Knapp, 1995). Such an approach to instruction can further limit student learning.

Based on extensive observations in urban schools in high-poverty communities, Haberman (1991) has characterized what he calls the *pedagogy of poverty*. He identifies a set of core teaching behaviors that generally focus on low-level cognitive activity and that call for students to respond within a very limited range. In this pedagogical approach, considerable time is spent giving information and directions, assigning tasks to be done individually, reviewing homework and tests, monitoring academic and nonacademic behavior, and punishing noncompliance. Although any of these teaching behaviors can be used to foster student learning, when these actions are used in combination and reiterated incessantly to the exclusion of other approaches –

without variation to provide greater student autonomy or stimulate students' intellects and imaginations – the impact on student learning is generally predictable. If students learn anything, they learn basic skills within a narrow performance band, and they learn that school is not very interesting. Haberman contends that in schools of economic need, the pedagogy of poverty often defines what teachers do, what students come to expect, and what both parents and the public of that community presume.

Current and past student achievement data verify the ineffectiveness of this approach to instruction. Nevertheless, it persists in both public and professional conceptions and actions regarding mathematics teaching and learning. This view of teaching stands in stark contrast to the vision provided by the NCTM *Professional Standards for Teaching Mathematics*. According to this view, teachers should support student learning by ensuring that students engage in worthwhile mathematical tasks, by engaging students in mathematical discourse, and by creating a learning environment that fosters the development of students' mathematical power (NCTM, 1991). To the extent that the goal of mathematics instruction in schools of poverty is to foster mathematical understanding, with a focus on problem solving, reasoning, and making sense, then the pedagogy of poverty described by Haberman is unlikely to succeed.

Some educational research has examined mathematics instruction in in schools attended by large numbers of students from high-poverty communities. One large-scale study found that instruction emphasizing conceptual understanding of mathematical ideas and procedures within a broader range of content offers considerable promise in schools of poverty (Knapp, Marder, Zucker, Adelman, & Needels, 1995).[10] Other research and scholarship also points to productive

10 Support for students may also occur outside the classroom. There are many models of supplemental support systems that can meet students' needs and help them focus their attention on academic success. But rural communities face the added challenge of geographic isolation that limits access to community resources and support

features of instruction in high-poverty schools. For example, some research has suggested that effective teachers in these schools organize their instruction to build on students' prior knowledge as they promote and maintain solid classroom interactions with their students (Ladson-Billings, 1992). Others have shown that classroom discourse can be a mechanism to promote mathematical analysis, reflection, verification, and justification (Silver & Smith, 1996, 1997). These findings drawn from research conducted in urban schools should help those interested in rural schools, though it certainly seems prudent to make the analysis of effective mathematics instructional practices in rural schools part of the ACCLAIM center's research agenda.

Characterizing effective instructional practice is one critical element in improving teaching and learning. But this knowledge will only improve student learning if it is transformed in ways that lead to improved teaching in classrooms. Some school-based efforts to enhance mathematics teaching in urban schools serving low-income students have fostered instructional change consistent with the NCTM Professional Teaching Standards, with a corresponding increase in student achievement (Campbell, 1996; Silver & Stein, 1996). In general, these successful reform efforts have been characterized by intensive and extensive professional development that actively engages the entire mathematics teaching staff in a school. Such professional development programs have focused on increasing the teachers' own mathematical content knowledge, improving their understanding of students' learning of selected mathematical topics, and enhancing their pedagogical repertoire. They have also employed facilitators who provide sustained instructional support and mentoring during the school year to help teachers implement new ideas in their classrooms. Successful professional development programs have

---

systems that enhance student and teacher performance (DeYoung, 1994).

fostered opportunities for collaborative teacher planning and evaluation of instructional improvement efforts, and have been characterized by local administrative support of the reform effort. Other studies not focused on high-poverty schools have noted many of these some qualities in good professional development for mathematics teachers in general (e.g., Garet et al, 2001).

Although lessons can be drawn from these successes in urban locales, mathematics instructional reform and improvement in rural school settings faces some special challenges. Many of the challenges are issues tied to considerations of scale. Mathematics teaching colleagues are often in short supply in rural high schools, where it is not uncommon for one teacher to constitute the entire department. Moreover, the availability of local facilitators and mentors is similarly scarce. Some observers express great optimism that the Internet and web-based technologies can be used successfully to support collaboration among colleagues and with facilitator or mentors at a distance (Rogan, 1995; Yap, 1997). Nevertheless, these efforts need much more study before we can characterize them as effective and sustainable interventions that for teachers of mathematics in schools serving rural communities.

Even if distance education can effectively support the professional development of rural teachers of mathematics, there is another reason for concern about the isolation of teachers in rural schools from colleagues and "outside experts" to whom they might turn for advice or from whom they might receive inspiration to change. Those who have studied reform in urban districts have often pointed to the importance of a catalyst in the environment to initiate the change process. Sometimes the catalytic energy comes from a teacher, but often it comes from a person outside the classroom – such as a mathematics curriculum supervisor or a university collaborator. It seems likely that rural schools would typically have less access to these kinds of intellectual and professional resources. Without such support in the local environment, we hypothesize that rural teachers may be reluctant to try new approaches to mathematics teaching or to investigate new materials to use with students.

Support for this hypothesis comes from at least two sources. First, we examined the data reported by Winn and Olsen (1998), who surveyed a total of 270 elementary school (grades K-6) teachers in rural schools in Illinois regarding the use of manipulative materials in their mathematics teaching. To make reasonable comparisons with data available from national samples, we restricted our attention to the 220 teachers in the Winn and Olsen sample who taught in grades K-4. Of these teachers, 62 percent reporting using manipulative materials at least once per week. Then we compared these findings with data found in the Report of the 2000 National Survey of Science and Mathematics Teachers (Weiss, et al., 2001). The Weiss et al. report is based on self-reports from a nationally representative sample of about 6,000 teachers of mathematics in grades 1-12 in about 1,200 schools. Weiss et al. report their findings for teachers in three grade-level clusters, one of which is grades K-4. In this national sample, 85 percent of the teachers in grades K-4 reported using manipulative materials in their mathematics teaching at least once each week. These national data are compatible with earlier findings reported by NAEP for teachers of a nationally representative sample of students in grade 4. In 1992, the teachers of 90 percent of the students in this sample reported using manipulative materials at least once each week (Lindquist, 1997). Although one would not want to draw broad conclusions from this look at the rural Illinois data, the results of our examination suggest that rural teachers may be engaging less frequently in one aspect of so-called reform mathematics teaching. We were unable to locate good sources of documentation about a broader range of mathematics teaching practices in rural schools, so this tiny morsel is all we were able to offer from the smorgasbord of pedagogical strategies. Clearly, this is an area in which much more work is needed.

A second source we examined to test our hypothesis that a lack of local support might impede rural teachers' pursuit of innovation in mathematics teaching was evidence regarding the use of new mathematics curriculum materials. In particular, we looked at the use of materials that emerged from the NSF-sponsored curriculum reform initiative of the 1990s. For this analysis we focused on grades 6-8. We obtained data from the Show-Me Center (a project intended to support nationally the implementation of NSF-funded curriculum programs in grades 6-8) regarding the purchase of these materials by school districts in the state of Ohio.[11] Show-Me had obtained from publishers of four of these innovative curricula a list of schools and districts in each state that purchased at least $1,000 worth of the NSF-supported curriculum materials. This listing did not differentiate among settings using the materials as core curriculum and those using it as a supplement, nor do we know if the purchase related to the exploration of curricular options by a small number of teachers or a full-scale adoption across many schools and teachers. Nevertheless, we take this list to be a crude indicator of interest in these innovative curricula and commitment to investigate them and at least consider their implementation. Because the list contained some individual schools and some school districts, we decided to use districts as the unit of analysis. For an individual school on the list, we found its associated school district. We restricted our attention to public schools because we could then use a national NCES database to determine the demographic classification of each school and school district. Using this database, we determined which districts on the list were rural or small town districts (which we call rural for simplicity) and which were nonrural (i.e., urban, urban fringe, or large town). According to

11 We wish to thank Barbara Reys, Director of the Show-Me Center, for her willingness to provide these data to us.

the NCES database, there are 662 school districts in Ohio, of which 377 are rural and 285 are nonrural. On the list obtained from the Show-Me Center 64 entries involved rural districts (though in several cases the schools were classified as "urban fringe" even though they were located within school districts classified as rural) and 78 entries involved nonrural districts. Thus, approximately 17 percent of the rural school districts and about 25 percent of the nonrural districts in Ohio recently purchased (or had at least one school within the district recently purchase) at least $1,000 of innovative mathematics curriculum materials for grades 6-8.[12] Thus, nonrural districts in Ohio were almost 50% more likely to have spent money to purchase innovative middle school mathematics curriculum materials than were rural districts.

Although there are many ways to interpret these findings – economic explanations suggest themselves,[13] as do arguments based on the relative sizes of the units being compared – this examination of purchases of innovative curriculum materials is consistent with our hypothesis that the lack of local source of information and inspiration about mathematics education in rural settings may be at play here. To be sure, the examination of this hypothesis issue needs much more careful scrutiny than we were able to undertake in the time available, but we hope our initial foray into this issue suggests some fruitful avenues for others to pursue. If our hypothesis is correct, then regional capacity-building initiatives like ACCLAIM appear to be precisely what is needed to increase the pool of available expertise in rural locales.

12 We encountered some anomalies in working with the list of schools. For example, in some cases we were unable to find a school in the NCES database.

13 The Children's Defense Fund (1992) has noted that it is more costly to provide equal educational opportunities in rural locations as compared to urban districts, given the economics of scale and the meager tax base available for local funding of education in rural districts. Rural districts have to pay higher costs per course because funds are typically determined on a per-student basis. Rural states typically have inadequate cost equalization formulas based on population density, so local taxes are critical for funding education. The resulting lack of funds may negatively affect opportunities to explore innovations and alternatives.

Within such efforts there are numerous research questions. The experience of mathematics education reformers in urban schools suggests that nurturing leaders in the school and in the community helps maintain local buy-in of the reform and sustain long-term efforts. High-poverty urban districts also need access to information and expertise that are readily available in more affluent districts. Research evidence and experience suggests that district personnel benefit from access to models or exemplars of success, models for staff development, high quality learning resources for mathematics (including instructional materials), ongoing technical assistance, and follow-up support. How can similar supports be provided in rural settings? Some have argued that the rapidly growing capabilities of high-speed networks and telecommunication systems give rural regions their first real potential to overcome the persistent isolation and lack of opportunity resulting from geography and poverty (Harmon & Blanton, 1997).

It seems clear that information technologies can help teachers, students, and community members, regardless of their geographic location and socioeconomic status, gain access to resources, information, experts, mentors, and colleagues. But many questions remain to be examined about if and how these technologies can function in ways that provide the kinds of assistive features identified in urban school settings. Alternatively, perhaps one should posit a rural version of instructional innovation – one less dependent on collegiality and outside expertise and more derivative of individual reflection. If so, then we will need to understand much more about how to stimulate individual reflection using tools, such as video or narrative episodes of mathematics teaching (e.g., Stein et al. 2000) or records of student work, that can be made widely available through new technologies to foster in individuals a proclivity to examine the work of mathematics teaching in order to improve teaching (Smith, 2000). Interesting and important research questions abound!

A Research Domain in Need of Attention

We close this paper with some thoughts about the timeliness of this conference and this effort by the ACCLAIM center to focus attention on research issues relevant to mathematics education in rural locations. Our brief foray into this realm has taught us that there is an acute need to identify good sources of information about these issues, to develop syntheses of what is known and what remains to be known, and to raise the awareness of the issues within the larger mathematics education community.

As newcomers to this field, we may have been looking for information in the wrong places or using ineffective search strategies, but we found it surprisingly difficult to locate information we wanted about mathematics education in rural communities. For example, when we inquired at the College Board about information on the use of AP in rural communities, we found no readily available database that could provide what we sought. Our task was further complicated by the use of multiple definitions of rurality in the literature that was available. Moreover, we had considerable difficulty tracking down sources, many of which were unpublished or published in journals not easily obtained.[14] For example, two journals that emerged consistently as good sources in our ERIC searches were *The Rural Educator* and the *Journal of Rural and Small Schools*. But neither of these journals was available at the University of Michigan, nor through any of the usual inter-library loan connections the university has within Michigan and nearby states. Fortunately, we were able to obtain copies of some articles by contacting journal editors directly. It was striking to us how few articles on rural education issues appear in so-called

14 Another issue that hampered our research has been noted by others (e.g., Stern, 1994); namely, the multiple definitions of rural. In recent years, there appears to be a drift toward the use of the census Bureau definition of rural. Common definitions will be helpful as researchers track trends into the future, though shifting definitions will

mainstream research journals. One of us (Silver) is editor of the Journal for Research in Mathematics Education, arguably the leading research journal in the world in mathematics education. Yet, a recent search of the files turned up not a single article dealing explicitly with the teaching or learning of mathematics in rural settings among the 400 submissions to the journal in the past three years.[15] This circumstance has led the editor to write an editorial that will soon appear in the journal, in order to call attention to what he has dubbed an *attention deficit disorder* with respect to rural education issues and concerns. (*Editor's note: Silver's editorial is now available at the ACCLAIM website:*
http://kant.citl.ohiou.edu/acclaim/news/silver.pdf).

According to the Census Bureau, there were about 61.3 million children between the ages of 5 and 19 in the United States in 2000. Of these, about 12.1 million lived outside metropolitan areas in small towns and rural communities. Thus, about 20 percent of the school-aged population reside in rural and small town locales. This means that one of every five mathematics lessons is taught in these locales. To the extent that there are issues of specific concern to rural communities – issues not "covered" by research that addresses broader topics, including equity – it appears that these issues are grossly underrepresented in our research literature.

In the rhetoric of education these days, it is fashionable to speak of improving the academic opportunities and achievements of all children. Whether one looks at NCTM's equity principle (NCTM, 2000) or the current "No Child Left Behind" initiative of the federal government, one finds this goal in play. Even a modest understanding of percents reveals that we as a field of professional endeavor and we as a nation committed to opportunity for all are unlikely to reach

plague attempts to trace back in time.
15 There were a few manuscripts in which rural students, teachers, or schools were participants. But in each of these cases, the research questions examined in the study were not framed in a way that related in any clear way to

our lofty goals if we continue to ignore the 20 percent of our student population living in rural communities. Thus, we close with a refrain from the NCTM conference mentioned earlier in this paper:

> A duality of attention and action is essential in order to realize the larger national goal of excellence in mathematics education because there can not and will not be excellent mathematics education in the nation unless and until we have quality mathematics education in every classroom. (Campbell & Silver, 1999, p. 22)

We think these words apply to rural classrooms as well as classrooms in nonrural settings. We hope the work of ACCLAIM, CLT-West, and other initiatives specifically focused on the challenges and concerns of mathematics education in rural communities will draw much more attention to these issues, stimulate thoughtful research on them, and thereby make it possible for us to realize our lofty aspirations for *all* of the nation's students.

---

the rural setting in which the research was conducted nor were rural characteristics or issues discussed in relation to the findings.

References

Abt Associates. (1993). *Prospects: The congressionally mandated study of educational growth and opportunity*. Washington, D. C.: U. S. Department of Education.

Ballou, D., & Podgursky, M. (1998). Rural teachers and schools. In R. M. Gibbs, P. L. Swain, & R. Teixeira (Eds.), *Rural education and training in the new economy: The myth of the rural skills gap* (pp. 3-21). Ames, IA: Iowa State University Press.

Barker, R., & Gump, R. (1964). Big school, small school: High school size and student behavior. Stanford, CA: Stanford University Press.

Braswell. J. S., Lutkus, A. D., Grigg, W. S., Santaapau, S. L., Tay-Lim, B. S-H., & Johnson, MS. (2001). *The nation's report card: Mathematics 2000*. Washington, D. C.: National Center for Education Statistics.

Campbell, P. F. (1996). Empowering children and teachers in the elementary mathematics classrooms of urban schools. *Urban Education, 30*, 449-475.

Campbell, P. F., & Silver, E. A. (1999). *Teaching and learning mathematics in poor communities*. Reston, VA: National Council of Teachers of Mathematics.

Children's Defense Fund. (1992). *Falling by the wayside: Children in rural America*. Washington, D. C.: Author.

Congressional Budget Office [CBO]. (1987). *Educational achievement: Explanations and implications of recent trends*. Washington, DC: U. S. Government Printing Office.

Dalaker, J. (1999). *Poverty in the United States 1998* (Current Population Reports, Series P60-207). Washington, DC: U.S. Government Printing Office.

Delpit, L. D. (1988). The silenced dialogue: Power and pedagogy in educating other people's children. *Harvard Educational Review, 58*, 280-298.

DeYoung, A. J. (1994). Children at risk in America's rural schools: Economic and cultural development. In R. J. Rossi (Ed.), *Schools and students at risk: Context and framework for positive change* (pp. 229-251). New York: Teachers College Press.

Garet, M. S., Porter, A. C., Desimone, L.., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Analysis of a national sample of teachers. *American Educational Research Journal, 38*, 915-945.

Gibbs, R. M. (1995). Going away to college and wider urban job opportunities take highly educated youth away from rural areas. *Rural Development Perspectives, 10*(3), 35-44.

Haberman, M. (1991). The pedagogy of poverty versus good teaching. *Phi Delta Kappan, 73*, 290-294.

Harmon, H., & Blanton, R. (1997, September). *Strategies for improving math and science achievement in rural Appalachia*. Paper presented at the 89th annual meeting of the National Rural Education Association, Tucson, AZ.

Heath, S. B. (1983). *Ways with words: language, life, and work in communities and classroom*. Cambridge (UK): Cambridge University Press.

Hektner, J. M. (1995). When moving up implies moving out: Rural adolescent conflict in the transition to adulthood. *Journal of Research in Rural Education, 11*, 3-14.

Knapp, M. S. (1995). The teaching challenge in high-poverty classrooms. In M. S. Knapp (Ed.), *Teaching for meaning in high-poverty classrooms* (pp. 1-10). New York: Teachers College Press.

Knapp, M. S., Marder, C., Zucker, A. A., Adelman, N. E., & Needels, M. C. (1995). The outcomes of teaching for meaning in high-poverty classrooms. In M. S. Knapp (Ed.), *Teaching for meaning in high-poverty classrooms* (pp. 124-144). New York: Teachers College Press.

Ladson-Billings, G. (1992). Liberatory consequences of literacy: A case of culturally relevant instruction for African American students. *Journal of Negro Education, 61*, 378-391.

Lee, V. E. (2001). *Restructuring high schools for equity and excellence: What works?* New York: Teachers College Press.

Lee, J., & McIntire, W. G. (2000). Interstate variation in the mathematics achievement of rural and nonrural students. *Journal of Research in Rural Education, 16* (3), 168-181.

Lindquist, M. M. (1996). NAEP findings regarding the preparation and classroom practices of mathematics teachers. In P. A. Kenney & E. A. Silver (Eds.), *Results from the Sixth Mathematics Assessment of the National Assessment of Educational Progress* (pp. 61-86). Reston, VA: National Council of Teacher of Mathematics.

Malloy, C. E., & Malloy, W. W. (1998). Issues of culture in mathematics teaching and learning. *The Urban Review, 30*, 245-257.

Mullis, I. V. S., Dossey, J. A., Campbell, J. R., Gentile, C. A., O'Sullivan, C., & Latham, A. S. (1994). *NAEP 1992 Trends in Academic Progress* (Report No. 23-TR-01). Washington, D. C.: National Center for Education Statistics.

National Center for Education Statistics. (2002). *The condition of education 2002.* Washington, D. C.: U.S. Government Printing Office.

National Council of Teachers of Mathematics. (1991). *Professional standards for teaching mathematics*. Reston, VA: Author.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: Author.

Oakes, J. (1990). *Multiplying inequalities: The effects of race, social class, and tracking on opportunities to learn mathematics and science*. Santa Monica, CA: RAND Corporation.

Payne, K. J., & Biddle, B. J. (1999). Poor school funding child poverty, and mathematics achievement. *Educational Researcher*, *28*(6), 4 -13.

Rogan, J. M. (1995, April). *The use of the Internet by math and science teachers: A report on five rural telecommunications projects*. Paper presented at the annual meeting of the American Educational Research Association, San Francisco, CA.

Secada, W. G. (1992). Race, ethnicity, social class, language, and achievement in mathematics. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 623-660). New York: Macmillan.

Silver, E. A., & Lane, S. (1995). Can instructional reform in urban middle schools help students narrow the mathematics performance gap? Some evidence from the QUASAR Project. *Research in Middle Level Education*, *18*, 49-70.

Silver, E. A., & Smith, M. S. (1996). Building discourse communities in mathematics classrooms: A challenging but worthwhile journey. In P. C. Elliott and M. J. Kenney (Eds.), *Communication in mathematics, K-12 and beyond* [1996 Yearbook of the National Council of Teachers of Mathematics] (pp. 20-29). Reston, VA: National Council of Teachers of Mathematics.

Silver, E. A., & Smith, M. S. (1997). Implementing reform in the mathematics classroom: Creating mathematical discourse communities. In *Reform in math and science education: Issues for teachers*. [CD-ROM]. Columbus, OH: Eisenhower National Clearinghouse for Mathematics and Science Education.

Silver, E. A., & Stein, M. K. (1996). The QUASAR Project: The "revolution of the possible" in mathematics instructional reform in urban middle schools. *Urban Education, 30,* 476-521.

Smith, M. S. (2001). *Practice-based professional development for teachers of mathematics*. Reston, VA: National Council of Teachers of Mathematics.

Stein, M. K., Smith, M. S., Henningsen, M. A., & Silver, E. A. (2000). *Implementing standards-based mathematics instruction: A casebook for professional development*. New York: Teachers College Press.

Stein, M. K., Smith, M. S., & Silver, E. A. (1999). The development of professional developers: Learning to assist teachers in new settings in new ways. *Harvard Educational Review, 69* (3), 237-269.

Stern, J. D. (Ed.). (1994). *The condition of education in rural schools*. Washington, D. C.: U.S. Government Printing Office.

Weiss, I., Banilower, E., McMahon, K. C., & Smith. P. S. (2001). *Report of the 2000 National Survey of Science and Mathematics Education*. Chapel Hill, NC: Horizon Research Inc.

Winn, A. & Olsen, J. (1998). The use of manipulatives for mathematics learning in rural school districts in Illinois. *Illinois Mathematics Teacher, 49(3)*, 10-16.

Yap, K. O. (1997, April). *Creating connections: The Internet and teacher isolation.* Paper presented at the annual meeting of the American Educational Research Association, Chicago, IL.