Questioning Assumptions: A Critical Pedagogical Perspective on Mathematics Teaching and Learning in Rural Places

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In this paper, we address mathematics education in rural contexts from a critical pedagogical perspective. We imagine our audience to be mathematics educators and rural educators who may not have background knowledge of critical pedagogy. We also confess that we are mathematics educators first, with interests in critical pedagogy and rural education. Thus we do not position ourselves as experts and do not intend to proclaim what rural mathematics educators "should" do. To set up our discussion, in this section we characterize (in broad strokes) critical pedagogy, current reform in mathematics education, and issues in rural education.

Overview of Overlapping Contexts

Critical Pedagogy

Critical pedagogy "…challenges us to recognize, engage, and critique (so as to transform) any existing undemocratic social practices and institutional structures that produce and sustain inequalities and oppressive social identities and relations" (Leistyna & Woodrum, 1999, p. 2). Thus critical pedagogists are concerned with the politics of education, which includes the structures of schools; the curricula chosen; the treatment and preparation of students and teachers; the relationship of school learning to community, national, and global events; and the purposes of public education (Leistyna, Woodrum, & Sherblom, 1999). All of these political aspects involve issues of power, culture, and ideology. Critical pedagogy seeks to heighten awareness of these issues so that people will be empowered to make changes toward more equitable and more democratic practices, relationships, and institutions.

Critical pedagogy is hardly univocal (cf. Leistyna et al., 1999). It is derived largely from critical theory, a diverse theoretical movement that emerged after World War II in response to the atrocities of the Holocaust as well as a belief that Marxism had not adequately addressed the influence of media and culture on human lives (Burbules & Berk, 1999). A major focus of critical theory was to emancipate human thought and action based on communication or discourse, rather than on "instrumental reason" (Crotty, 1998, p. 146).

Another root of critical pedagogy comes from Paolo Freire's (1970/2000) work with literacy among peasants in Brazil. Freire used the term *conscientização* to indicate critical consciousness, or "learning to perceive social, political and economic contradictions, and to take action against the oppressive elements of reality" (p. 35). He believed conscientização developed in people as they learned to "read the world" through reading words—or as they came to know and use the power inherent in words (both spoken and written) to critique and act upon the world in which they were situated. In this way Freire referred to those who are oppressed—those who are embedded in societal structures that severely and regularly constrict learning and living opportunities—and their potential liberation through critical reflection and transformative action, or *praxis* (Crotty, 1998). This orientation informed Freire's views on the relationships between teachers and students. Instead of operating on a "banking model" in which teachers "fill up" learners with knowledge, Freire believed in a dialogical relationship in which teachers and learners were equal partners in the project of learning—i.e., learners also teach and teachers also learn.

Current critical pedagogy calls existing educational norms into question to promote more socially just arrangements in schooling and society (Crotty, 1998). Its main goals are social justice, equity, and freedom. While most critical pedagogues would acknowledge the impossibility of ever fully achieving these goals, they believe it is possible to make progress toward them. Thus examining and questioning ideologies, culture, and relationships of power becomes an *ongoing* project. Such work requires disrupting what is often taken for granted: questioning the organization of schools for learning, the capacity of learners, the nature of what is to be learned, and the expectations and values of schools and communities. Thus inherent in adopting a critical pedagogical perspective is a willingness to enter into discomfort in order to rethink beliefs that may be deeply rooted. Accompanying that language of critique, however, is also a language of possibility (Giroux as cited in Burbules & Berk, 1999). Though critical pedagogy can be an uncomfortable and unsettling way to view the world, it can also invigorate by opening up new opportunities to improve practices, relationships, institutions, and the self-actualization of people within them.

Reform in Mathematics Education

The current reform movement in K-12 mathematics education is nearly two decades old and has been marked by documents such as *An Agenda for Action* (NCTM, 1987), *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989), *Professional Standards for Teaching Mathematics* (NCTM, 1991), *Assessment Standards for School Mathematics* (NCTM, 1995), and, most recently, *Principles and Standards for School Mathematics* (NCTM, 2000). This movement has been characterized by an emphasis on mathematical processes, such as problem solving, reasoning, communication, and connections, and a move away from strictly computational proficiency toward a goal of *understanding* the mathematics that one does. At elementary levels, there has been an emphasis on expanding the content of mathematics beyond arithmetic to include geometry, measurement, algebra, data analysis, probability, and links between these topics. Similar expansion of content has occurred at middle and high school levels, where reform curricula have also been based on integrating mathematical topics through contextual problems (e.g., Fendel, Resek, Alper, & Fraser, 1997); changing the approach to standard topics like algebra via technological explorations (e.g., Heid, Choate, Sheets, & Zbiek, 1995); and creating courses that focus explicitly on discrete mathematics, statistical analysis, and probability (e.g., Senk, et al., 1998; Peressini, et al., 1998).

These reform efforts both play into and depart from a general standardization movement in mathematics education: At district, state, and national levels, policy-makers have created lists of objectives (largely computational skills) that students must know and have increased standardized testing to measure whether students know them (cf. Wilson, 2003). Recent federal legislation takes this standardization movement to an extreme with mandates that children not be promoted to the next grade if they do not pass the test. These test results are also being used to grade schools according to whether or not they make “adequate yearly progress,” with parents given the option to remove their children from schools that do not meet this standard (U.S. Department of Education, no date). This movement posits that all students of the same age need to know the same thing at the same time regardless of context, interest, language-proficiency, or mathematical development. Some scholars and community activists have argued that because the reform movement spearheaded by NCTM devalues computation skill, which is the currency by which one gains credibility in the real world (e.g., Apple, 1992); it does not prepare students to succeed in today’s accountability-driven society.

It is somewhat ironic that in the midst of this standardization movement, mathematics itself is more acceptably seen as uncertain knowledge (e.g., Brown & Walter, 1990; Henrion, 1997). Partly this view stems from the “crisis” in securing the foundations of the discipline of mathematics that was first brought about by the development of non-Euclidean geometry in the 1800's (Henrion, 1997): Changed premises led to changed conclusions and an accompanying rejection of the premise that mathematics is unshakeable, context-free, or an accurate reflection of the physical world. The view of mathematics as uncertain knowledge is due partly to the now commonly accepted notion, supported by the work of NCTM (1989, 1991, 1995, 2000), that learners actively build up knowledge and ideas through interaction and communication, rather than passively receive them. Thus, there is greater recognition that there are multiple ways to arrive at a mathematical solution; that learners may not conceive of mathematical ideas similarly; and that the social, cultural, historical, economic, and political histories of students can influence their mathematical reasoning (cf. Boaler, 2000).

Issues in Rural Education

At practical levels, rural educators are concerned about funding, consolidation, technology, special education, teacher recruitment and retention, and the economic viability of rural places (Kannapel & DeYoung, 1999). At a more philosophical (or at least broader) level, rural educators are concerned about linking schools and communities through an emphasis on place (DeYoung, 1987; Kannapel & DeYoung, 1999). They are highly suspect of urban models of education and well-meaning attempts of urban and suburban educators to "fix" or "reform" rural education. There is a fear that the influence of "outsiders" will damage rural ways of life. Yet, many young rural dwellers do not see viable options for their futures in their communities. Thus, rural educators face a dilemma: Rural places must change in order to maintain themselves as communities, but they must also preserve and nurture what is essential (values, orientations, practices) to their communities. We refer to this tension as "dynamic maintenance" of community, and question—in the spirit of critical pedagogy—whether the seeming opposites of changing and staying the same must be opposed. In order for rural places to remain viable as communities, we argue that these opposites must be held together and the resulting tension must be embraced.

Ah, but embraced by whom? Usually those outside rural places have controlled reform efforts and change in education. Usually those inside rural places have tried to preserve values, orientations, and practices of their schooling and communities. Rather than polarize these positions, we suggest that both outsiders and insiders can work for dynamic maintenance of rural places. For example, current national trends toward federal regulation of education may be in opposition to community goals. Yet sensitive outsiders *can* provide a perspective that insiders cannot see (Fry, 1996) and may protect against insularity. Furthermore, the recommendations of outsiders may prompt insiders to question and resist the ways in which rural communities sometimes support the very policies that lead to their destruction (McLaren & Giroux, 1990). Though a view of a community in perpetual harmony and control may appeal to insiders, it is possible that unless one can embrace community as a place of disjuncture or contradiction, the community may disappear.

In addition, rural educators question the purposes of schooling: Is it to educate citizens who can sustain rural communities, or to produce people who can succeed outside the rural setting? How do rural schools educate young people to view their communities—as vital places to remain as adults, or as places they must (perhaps for economic reasons alone) leave? While there are no pat answers to such questions, a critical pedagogical approach begs rethinking the dichotomies inherent in the questions; examining norms and assumptions upon which they are based; and working toward practices, policies, and institutions that promote more socially just arrangements.

Why Learn and Teach Mathematics?

One's view of the nature of mathematics influences greatly one's views about reasons to learn and teach it (Davis, 2001). We believe that mathematics is a fundamental human activity with both culturally-embedded and universal aspects, rather than a utilitarian tool necessary for economic survival. We acknowledge, however, that *school mathematics* is a social and political institution (e.g., Kaput, 1997) in which success is a gateway for full economic, political, and cultural participation in U.S. society (Moses & Cobb, 2001; Moses, Kamii, Swap, & Howard, 1989). Through presentation and critique of our perspective on mathematics and school mathematics, we distill reasons to learn (and teach) mathematics in a rural context.

Mathematics as Human Activity

The view of mathematics as a fundamental human activity is based in creating numerical, quantitative, symbolic, and spatial patterns and relationships, not reading them from some external source,[1] and posits interaction as essential for the development of mathematical knowledge. That is, with differing degrees of awareness and at differing levels of abstraction, people regularly create out of their experiences patterns and relationships that involve interactions with other humans and non-humans and interactions within their own minds. In this activity people are motivated largely by curiosity and a drive to organize their experiential worlds (Davis, 1995). For example, a child who determines that the result of counting a bunch of

[1] In fact, it could be said that people read mathematical relationships *into* their experiential worlds, rather than extract mathematical relationships from them (Piaget, 1970; von Glasersfeld, 1995).

rocks (the number of rocks) is invariant to the order or particular configuration in which the rocks were counted has created a relationship *in her mind* that we would recognize as mathematical, but the interaction with the rocks (the child's activity) was essential in the child creating this relationship (Piaget, 1970).

This view disrupts often taken-for-granted assumptions about the nature of mathematics as a fixed body of certain, mind-independent facts and provides a basic reason to learn and teach mathematics: Mathematics is a fundamental human activity across many cultures and environments, though it manifests differently in different cultures and environments. If part of the purpose of K-12 education is to explore, examine, understand, and critique what humans do and how humans think (indeed, who humans are), then K-12 education should include the study of mathematics.

Basing reasons to teach math solely on this view is not terribly convincing (or may seem beside the point), however, when considering components of conventional K-12 *school mathematics* classes like long worksheets of fraction computation, elaborate details of simplifying radical expressions, or contrived word problems that force the use of equation-solving with unknowns. That is, the view of mathematics as a fundamental human activity does not necessarily take practices of mathematics schooling into account—practices that do not often support and enact this ideal. As a result, this view tends to ignore relationships of power that underlie and enable schooling practices. Mathematics *is* a fundamental human activity from the point of view of those with well-developed (usually conventional) mathematical knowledge (such as ourselves); it is not always so from the point of view of those without. Those with well-developed mathematical knowledge hold more cultural capital (Bourdieu, 1984). They include those in the population who determine (through publications and policy documents, for example) what “counts” as human, as well as what mathematics gets taught and to whom it is taught in schools. By endeavoring to step out of this privileged group (though we can never escape it), we wish to make this rather audacious point: There is no necessity to learn school mathematics.[2] We believe that people can live quite full, healthy, vibrant lives without knowing conventional school mathematics (cf. Purcell-Gates, 2002).

A major caveat of this contention is that mathematics is highly valued in schools and on standardized tests, and knowledge of mathematics that conforms to the standards of school mathematics classes and the questions on these tests does open and close learning and career opportunities for K-12 students. We believe that this valuation of school mathematics in U.S. society is unjustified—that mathematics is overvalued as something students need to lead successful lives economically or otherwise (Ernest, 2000). Of course, mathematical knowledge is useful in reading the world—pick up a newspaper and inevitably there are graphs, tables, and other quantitative information to interpret. But uses of mathematics in the world are largely hidden: Many aspects of society are built from it, but only a few people know—or need to know—the details about how to do it (Skovsmose, 2000). For example, at a large distribution center that is part of a national chain located in a small southern U.S. city, the spatial problem of packing different sizes of totes and then packing delivery trucks is clearly a mathematical problem. But the packing problems are tackled by engineers at one location in the country—to do their job well, packers at the center do not have to know the mathematical aspects of packing.

[2] We do not mean to imply that the K-12 mathematics curriculum is solely computational or procedural, though those qualities often dominate K-12 mathematics classrooms. Even in classrooms where conceptual, “reform-oriented” ways of operating are prevalent, we believe learning school mathematics is not a necessity.

Mathematics as Ethnomathematics

Yet these packers are doing what some (mathematics educators, e.g.) would recognize as mathematical activity. In fact we believe that most people (in rural *or* non-rural settings) would be regularly engaged in what we (and other mathematics educators) would recognize as mathematical activity, though they very well would not describe aspects of their thinking and activity as mathematical. This outlook has been conceptualized as *ethnomathematics*, (e.g., (D'Ambrosio, 1994), a term that describes the mathematics embedded in cultural activities whose primary purpose is not to do mathematics, and which has been used to study the sophisticated mathematics used by carpenters (Millroy, 1992), house painters (Gerdes, 1995), and candy sellers (Saxe, 1988). Would such people be happier or more successful or "better" in some way for developing their mathematical activity in particular ways? For becoming aware of the mathematics we see in their activity? Definitive answers are hard to claim for these questions.

Having others (both within and outside the community) see their activity as mathematical might be of value, however. Uncovering the mathematics inherent in activities that take place in a rural setting means this mathematics can be incorporated into the curriculum for rural learners. Learning to see the mathematics embedded in deciding where to locate a mineshaft, for example, may motivate children who have grown up surrounded by the mining industry. They may take pride in understanding the formal mathematical ideas present in the work that their families do and thus be stimulated to learn more mathematics. This can benefit them in two ways: by advancing their understanding of what humans do (the fundamental activity view of mathematics), and by facilitating their cultural, economic, and political participation in society (the institutional aspect of school mathematics). Furthermore, incorporating the mathematical concepts involved in rural activities into the school curriculum may better prepare students to contribute to sustaining and critiquing these activities, so they can help dynamically maintain rural communities.

In addition, explicating such rural mathematics can help those who live in other settings learn to value the work of rural dwellers. Having non-rural dwellers see mathematics as inherent in rural activities opens the possibility of reconceptualizing social change in rural contexts. As we have previously commented, the goal of social change is often to “modernize” or “urbanize” rural people, places, and activities—to show rural dwellers how to live their lives “better” as defined by non-rural dwellers. An ethnomathematical perspective means that rather than positing mathematics education in non-rural contexts as the standard against which mathematics education in rural contexts are judged, rural contexts themselves can be seen as independent and vital communities for mathematical learning and teaching. This perspective does not imply that outsiders cannot contribute useful suggestions for mathematics education reform and social change, but it gives an independent and valid mathematical life to insiders.

Nevertheless, ethnomathematics can easily degenerate into a “mathematics is everywhere” scenario in which even trivial tasks are seen as mathematical, which leads to a devaluation of the work (Millroy, 1992) and the people who do it. In addition, the approach suffers from the fact that one can only see what one knows: Those who have been schooled in conventional mathematics are likely to miss some of the mathematics embedded in the work of rural people. Even if they are able to recognize mathematical aspects of the work, they may have no formal vocabulary or symbols to describe it (Millroy). In this way the premises of ethnomathematics may subvert its most central goal: to value the mathematical thoughts and activities of those who may not be conversant in conventional school mathematics. Thus while we include an ethnomathematical view in our perspective on mathematics as a fundamental human activity and school mathematics as an institution, we acknowledge its potential limitations in actually reinforcing norms it aims to disrupt.

Reasons to Learn and Teach Mathematics

To conclude this section, we focus on three intertwined reasons for learning and teaching mathematics in a rural context. First, mathematics learning and mathematics education can disrupt norms regarding what is to be learned, what is taken as learning, and the connection between what is learned and context. This reason opens up the growth and development of mathematical knowledge as a link between school and community. Second, mathematics learning and mathematics education can facilitate work for social justice in rural settings. Viewing mathematics as embedded in the activity of rural dwellers means that rural communities can be vital places of mathematical learning where issues of the nature of mathematical knowledge and whose knowledge gets valued as mathematical (not to mention who decides on this valuation) are explored. Third, mathematics learning and mathematics education can involve the dynamic maintenance of community. The ways in which mathematics learning is enacted can both bring out characteristics of rural life that are important to maintain and simultaneously challenge rural dwellers to consider alternatives and changes.

Organization of Mathematical Learning

Issues of Social Justice

Issues of social justice in mathematics education often revolve around knowledge production and valuation. Some mathematics educators look upon which students are engaged in which levels or topics of mathematics and find the scene inherently disconcerting: Why are advanced classes populated largely by white students (albeit now almost evenly split by gender—in some cases the girls even outnumber the boys), perhaps with a smattering of Asian or Indian students? Why are the remedial classes populated largely by black or Latino students (or both)? Asking these questions using solely race as an identifier is simplistic because socioeconomic status, race, gender, and other identifiers are intricately intertwined in this kind of inquiry. Responses to such inquiry are still even more complex and well beyond our scope in this paper. The issue of whose mathematical knowledge gets valued and in what ways students' mathematical needs are met in classrooms bump up against a salient issue in rural education: small school size.

School Size

Small school size means that typical models of organization found in urban and suburban settings are often untenable: There are not enough students (or teachers) for multiple tracks of courses (e.g., three different levels of introductory algebra) or even for separate mathematics courses across ages or topics (e.g., distinct algebra and geometry courses, or distinct mathematics courses for 9^{th} versus 12^{th} graders.) Rural schools have thus often used both multigrade and multiage groupings of students, thereby breaking down traditional single-grade organization. In multigrade organization, students from at least two grades are grouped together in the same classroom with the same teacher for most of their time in school. In multiage organization, students of a range of ages are similarly grouped together, but the practice of assigning students to grade levels based on their ages is deemphasized or unused.

Potential Advantages of Multigrade and Multiage Grouping

What do these other structures make possible from the point of view of critical pedagogy and our reasons to learn and teach mathematics? First, they allow teachers, administrators, and parents to manage students of a particular age in more flexible ways. Students of a particular age typically are grouped together for instruction. While there may be some attempt to sort them into fixed groups based on some measure of ability or achievement, they often do not demonstrate identical levels of sophistication in their mathematical thinking. For example, in a multiage or multigrade classroom, a 7-year-old and a 10-year-old may be good mathematics partners because they think similarly or on relatively the same level—they are on the "same wavelength," and provide a good match for each other much as good tennis partners do. In time, that 10-year-old may progress rapidly in some way and become better matched with a same-age peer, while the 7-year-old may be assigned to work with an 8-year-old and a 9-year-old because they demonstrate relatively heterogeneous ways of operating mathematically, and there are social and intellectual benefits from that way of grouping students as well. Thus, small rural schools may actually make it easier for teachers to flexibly group students homogenously *and* heterogeneously according to some (not necessarily formal) measure of students' mathematical ways of operating. This flexibility may benefit students' personal mathematical development by not rigidly confining them to a particular group, as often happens in single-age and tracked mathematics courses.

Second, working across ages and grades may support and enhance community values. It is not uncommon for gatherings and informal (i.e., outside-of-school) learning situations to span generations in rural settings. Continuing this kind of cross-age grouping in schools may reinforce underlying notions that everyone can be a teacher and a learner, and that people of all ages (and ethnicities, and genders, and economic status) deserve respect and attention. Cross-age grouping can also contribute to drawing out the mathematics inherent in activities of people of different ages and vocations. In a more radical vein, however, it might provoke support for schooling itself as a community-building process rather than a means to promote individualistic competition in a national and global economy (Gruenewald, 2003). What would it mean for mathematics education to embrace community-building rather than emphasizing solely individual achievement? Some mathematics educators have experimented with such notions in urban and suburban settings (e.g., Chazan, 2000; Gutstein, 2003). Rural settings may provide an even better venue for experimentation because of their strong traditions of community.

Third, experimenting with school organization may also challenge traditional notions about how school is organized. Embracing cross-age and cross-grade grouping means that teachers, administrators, and community members may have to actively resist the notion that in real (read urban or suburban) schools, students are grouped into single-age grades and tracks. Questioning this notion may open the way to rethinking assumptions upon which grouping students in schools is based. For example, in rural settings the onset of organizing groups of students of the same age into a grade in schools came about in the late 1800s and made possible the emergence of a coherent curriculum that did not rely solely on recitations from individual students' textbooks (Kliebard, 2002). While such coherence may indeed have been "better" for student learning (and in particular for student socialization) than fragmented, individualized work, embedded in this shift were changes in the power structures of schools. Who would decide on and develop the curriculum for each grade level? At the time, classroom teachers were proclaimed unsuitable for such a job (Kliebard). Furthermore, who would place students in grades and on what criteria would these placements be made? How would students be promoted to the next grade or retained in their current grade? To what extent and with what ease would students be "re-graded" if initial placements proved inappropriate in some way? All of these questions can open up discussion about what is "just" in schools and society, sparking important conversations about the control over schooling and learning processes (e.g., administrators' control over teachers, teachers' control over students, etc.)

Potential Drawbacks of Multigrade and Multiage Grouping

What are the drawbacks to or the cautions about embracing a model for organizing mathematics education that differs from typical urban and suburban single-grade, tracked models? Research studies have shown that students in multigrade classrooms do no worse and may do better than their single-grade counterparts in terms of academic achievement (Vincent, 1999). Vincent reports that multigrade classrooms also seem to have a positive effect on student attitudes toward school. Furthermore, teachers might get to consider trajectories of student thinking over several ages and to work on the development of mathematics curricula across these ages. This larger perspective can help teachers become more adept at seeing and working with a variety of students. We believe such teachers are in a position to work for greater equity and freedom for students because of their greater ability to attend to students' mathematical needs and development so that each student reaches her or his potential rather than achieves a preset standard.

These structures also may require more from teachers than teaching in a single-grade classroom, however. Teaching may be more difficult with two or more tracks of curricula to manage (Vincent, 1999) and with a wide variety of activities to coordinate. Some students might not feel challenged or might be overwhelmed, because the teacher might cater to a particular group in the classroom or have difficulty meeting certain students' needs. Perhaps the most serious problem with multigrade or multiage organization is that they can revert back into the one-room schoolhouse model where everyone works independently and in isolation, and the teacher cannot possibly "teach" that many different students or address that many different topics. As a result, students end up learning via independent study because the teacher's attention is so fragmented. In turn, the teacher acts primarily as an organizer and record-keeper, copying worksheets for different students because there is so little time and energy to carefully plan and orchestrate learning for children on so many different levels. In addition, even for teachers with a great deal of skill, issues of sequencing and building on students' previous and current mathematical ways of operating are profound.

To circumvent or at least ease these difficulties, we believe the same sort of philosophy and support for the learning and education of students must be given to teachers. That is, teaching in structures that may be significantly better for the community (whether or not it is multigrade or multiage) requires support from administrators and other community members; teachers cannot go it alone. Rather than view schooling as a process located solely in the school and solely for the students, the community might respond to work in schools as an integral part of most adults' lives. What would it mean for community members to act as aides for teachers? To support teachers' time to plan and learn by fulfilling non-teaching roles? At the same time, what would it mean for teachers and schools to support community work and events with their students? Responding to these questions has the potential to address issues of social justice in terms of knowledge generation, valuation, and locus of control of education.

Mathematics Content and Pedagogy of Place

Nature of a School Mathematics Curriculum

A school mathematics curriculum reveals what is valued in the schooling experience (Tanner & Tanner, 1995). If we are freed from the commonly accepted progression of topics tied to age levels as suggested by the ideas about school organization in the preceding section, what does a curriculum look like? More specifically, what kinds of curricula will meet the needs of a diverse group of learners while also addressing critical pedagogical goals of equity and social justice? McLaren and Giroux (1990) argued that a curriculum that arises from a critical perspective "must be a pedagogy of place, that is, it must address the specificities of the experiences, problems, languages, and histories that students and communities rely upon to construct a narrative of collective identity and possible transformation" (p. 163). This view contrasts starkly with curricula based on notions of standardization and accountability in the name of erasing achievement gaps, which reflect a value of "individualistic and nationalistic competition in the global economy and that an educational competition of winners and losers is in the best interest of public life in a diverse society" (Gruenewald, 2003, p. 3).

Place-based Curricula

As an alternative to discipline-driven standards, many rural educators have argued for a place-based curriculum. Although this term has been widely used in the literature, it is ill-defined. We use this term to mean educational experiences that "prepare people to live and work to sustain the cultural…integrity of the places they inhabit" (Woodhouse & Knapp, 2000, p. 1). The notion of place-based education is connected to preparation for participation in the democratic process; by learning more about how their communities function and what the citizens value, students are better prepared to take an active role in the decision-making processes in their communities. A focus on place allows educators to "address the *values* of the culture in which educators wish to enculturate students" (Heckmann & Weisglass, 1994, p. 30).

Place-based approaches to mathematics learning can enhance the sustainability of rural places because they can engender pride in place (Haas & Nachtigal, 1998). As students learn about the significant and powerful mathematics present in the everyday lives of people in a community, they may come to value both the work and the citizens who do it —work often unappreciated and even devalued by those outside the community. For example, a group of students might visit a granite quarry and the associated stone-cutting businesses and extract mathematical ideas from the situation. They might investigate how surface area is calculated, how symmetry is used in cutting stones, how the laws of physics are used to move large pieces of stone, or how probability is employed in "grading" the stone. By uncovering the mathematics inherent in quarry work, students may come to see members of their community as knowledgeable, competent individuals with mathematically powerful ways of operating. By interacting with the quarry workers, students can participate in the intergenerational exchange of knowledge, which further fosters a sense of community.

Place-based education can also take the form of students identifying a local need or concern and applying their knowledge to solve it. Through this approach, students may take pride in their surroundings and in their roles in preserving and enhancing their communities. They can envision new roles for themselves as participants in the community and can feel empowered to make needed changes in the community. This sense of empowerment may, in turn, motivate students to learn more mathematics in order to participate more fully in the community.

Potential Advantages of Place-based Curricula

From a mathematical perspective, a place-based curriculum offers some advantages. Mathematics that arises from a real world situation is more likely to involve multiple pieces of content often not connected in a standard textbook presentation. Students may encounter mathematics not typically considered “appropriate” for their grade level or age. For example, in studying stream contamination, students might have to deal with questions about accuracy of measurement, rounding of decimals, choice of an appropriate measure of central tendency, choice of an appropriate type of graph, solving a linear equation, and computing standard error in one lesson or a series of lessons. In contrast, it would be highly unusually for students to encounter this breadth of content in a sequence of lessons in a typical Algebra I class. Further, place-based experiences are likely to lead to interdisciplinary work so that students will see how mathematics is connected to other subject areas.

A place-based approach to mathematics teaching and learning can help to erase inequities in student achievement by redefining what counts as “competence” in mathematics. Competence in this situation is not necessarily reflected solely through procedural fluency (National Research Council, 2001). Rather, competency involves being able to see the mathematics in a situation, extract it, work with it using formal or informal notation, apply the results back to the situation, and evaluate the effectiveness of the solution in the real world situation.

Potential Drawbacks of Place-based Curricula

Several possible pitfalls of place-based education deserve careful consideration, however. First, there is the danger that the teacher or the students may fail to recognize the mathematics inherent in a real world situation. For example, it is possible to simply collect some stream water, make a chart, and speculate about the results without making mathematical ways of thinking explicit. If the mathematics is not extracted from the context and formalized with the vocabulary and symbols shared by the mathematical community, then students run the risk of being perceived as less mathematically competent by outsiders.

Second, if the mathematics to be learned is drawn strictly from real world experiences, it is likely that some pieces of mathematics will never be addressed. Students may develop isolated bits of mathematical knowledge that are well connected as they relate to a particular situation but not well connected within the larger discipline of mathematics. They may also develop informal and non-standard ways of operating mathematically without learning the more formal notation and language used by the wider mathematical community. One could argue that this type of understanding of mathematics is sufficient because it arises out of needs in students' everyday lives. This argument, however, presupposes that students will never encounter situations beyond those that they investigate as in their school work. This argument also assumes that students will never need *or want* to encounter the more standard and formal mathematics taught in a standards-based curriculum. And finally, this argument assumes that practical use of mathematics is the measure of what is important to engage with intellectually. A counterpoint to this argument is that all mathematics learning does not have to occur in an environment outside the classroom. If mathematics is a creation of the human mind, then the mind is a valid place in which to learn mathematics. Thus, teachers are justified in teaching some mathematics "for mathematics' sake" because it is interesting, beautiful, and satisfying, independent of an immediate local application (cf. Brenner & Moschkovich, 2002; Brown, 2001).

Third, we lack evidence of what students can learn from a place-based approach to mathematics education and how this learning compares to what students who study more traditional curricula learn. These students' mathematical competence will, for the foreseeable future, be judged by norms that do not stem from a place-based approach to education. Externally mandated, high-stakes tests are based on a set of values more in line with the standardization approach to curriculum. If students' learning does not prepare them to succeed on these external measures, inequities may be perpetuated. Students from rural places may be seen as less competent than their suburban peers and may therefore be denied access to further education, jobs, or other opportunities.

Finally, another concern about a pure place-based approach is that the curriculum must be entirely constructed by the teachers and students in a particular setting. This places a tremendous burden on the teacher to identify rich local situations, explicate the mathematics in these situations, and design classroom-based investigations to complement students' experiences in the community. Granted, some of the burden for identifying the rich local situations can be shared by the students and larger community, but the responsibility for curriculum creation rests largely with the teacher. Teachers in the United States are not typically prepared for this type of curriculum design, nor does their work day typically allow for much time to be devoted to this type of activity. There is also a need for constant updating of the curriculum because once a group of students has attacked a particular local problem and solved it (to some degree), the problem may no longer be an authentic one for a new group of students. Thus, the role of commercially produced curriculum materials in a place-based curriculum also needs to be investigated.

Professional Knowledge for Teaching

Traditional Professional Development

The previous discussions of student grouping and place-based education suggest the need for radically different preparation and support for teachers. Traditional models of professional development are not likely to meet the needs of rural teachers trying to create curriculum from circumstances in the local community in order to foster the learning experiences of academically diverse students. In fact, teachers often view professional development as a nuisance that directly opposes the important work of planning and teaching. This all-too-common experience raises questions about what it means to be a teacher and how teachers might have more control over their professional lives.

Turning the critical pedagogical lens on the lives of teachers reveals a group of people largely oppressed by institutions, ideologies, and relations that exist in education. Teachers' lives are ruled by bells that tell them when to start and stop teaching, by paperwork that impedes their time to plan for instruction, and by external assessments of their students that purport to measure teacher quality. In particular, professional development is often "done to" teachers by outsiders, and teachers usually have little say in the topic, format, or timing of the professional development. If teachers are to function in the ways described earlier in this paper, the first step may be for them to take control of their own professional lives to liberate and emancipate themselves from the traditions that create and maintain their oppression.

Reimagining Teachers' Work

If we assume that rural teachers are knowledgeable, competent, caring individuals who desire to act in ways that foster critical capacity in their students, we can reimagine their work in several ways. First, teachers know what they need to learn and how they might best learn it. Thus, they can and should be in control of their professional learning. They can mine the riches of their school and community to learn from colleagues, parents, and citizens the myriad things that will enhance their teaching, including , content, local needs and values, the work of local citizens, pedagogies that are adaptable to local situations.

Second, learning should be viewed as a regular part of teachers' work. We should not assume that teachers come to a community knowing everything they will need to know in order to effectively teach the children of the community. Teaching is a profession in which learning is continuous and often steep. Thus, part of a teacher's work week should be devoted to learning. The first and most important thing teachers need to learn are their students. If teachers are to craft place-based curricula and teach to students of varying ages and abilities, they need to know who their students are mathematically, socially, and historically. They need the time and opportunity to build second-order models (Steffe, 1990; Steffe & Wiegel, 1996) of their students' mathematical thinking—individually and collectively—so that they can craft learning experiences that appropriately challenge each student and the whole class.

Teachers also need an opportunity to learn about the community in which they teach so as to become aware of the available curriculum resources. This may mean that the teacher spends time at a local mine or agricultural center to find out more about the work done there. The teacher might even participate in doing some of the work to gain first-hand experience and to contribute to the well-being of the community. If the teacher spends part of her working time at a local business, however, there may need to be a ripple effect in the community, with citizens assuming roles in the school. Making the walls between community and school more permeable can enhance students' and teachers' connections to the community and vice versa (Gruenewald, 2003).

Third, teachers can be change agents in schools and communities. Teachers can challenge notions of age-grading, traditional curricula, formal staff development, and other practices of education and can transform them in ways that better support student learning and community building.

Caveats for Reimagining Teachers' Work

If we rethink the work of teachers as described above, we must also acknowledge that the work of rural teachers is intensified (Apple, 1992) over that of other teachers because they frequently need to teach multiple topics to learners on multiple levels in the same classroom at the same time. For example, a teacher preparing to lead a unit grounded in stream water contamination, as described in the previous section, would need to know about the local stream—its flow levels, direction, relationship to other bodies of water, and its value and uses in the community; the mathematical and scientific ideas that are likely to come up in the unit—in short, the pieces of content themselves, how they relate to each other and to earlier topics studied by the students; students' prior learning in this area: the mathematical and scientific ideas that they have already investigated, the social questions they are likely to ask, and their probable motivations for this learning; and the community: the individuals and business that use and monitor the stream, the sociopolitical history of water contamination in the area, and the people in the community who might be able to assist with the unit of study.

The type of teaching we envision above also intensifies the work of teachers by giving them more control over and responsibility for their professional lives. Thus, teachers, administrators, and community members will need to address this issue of intensification in order to make the work of teachers manageable and realistic. Typically, teachers are simply given more responsibility and more challenges (mostly imposed externally), but they are not given more time, more resources, or more support. To reimagine their work, rural teachers may need to develop a critical consciousness (*conscientização*) that allows them to refuse to accept the inevitability of the status quo, achieve a sense of confidence and efficacy, and collectively work to change their circumstances (Burbules & Berk, 1999).

What's Next: Research Agendas and Questions

Based on the perspectives we've presented and issues we've discussed, in this final section we consider research agendas and research questions with regard to mathematics education in rural contexts. In particular, rural education seems to be a research venue that invites collaboration among mathematics educators, sociologists, anthropologists, and others in order to more fully understand mathematics teaching and learning in a rural context. The understanding and practice of mathematics educators (teachers and researchers) could be enriched by considering the perspectives on rural education of practitioners and researchers in other fields. But perhaps most important, rural mathematics educators, students, and community members need to be integrally involved in setting research agendas and contributing their expertise to researchers from both inside and outside rural contexts. Rural mathematics educators may want to consider the integration of research on their own practices and communities as vital contributions to understanding and rethinking mathematics education in rural contexts.

Organization for Mathematical Learning

Students, teachers, schools, parents, and communities need to know more about what multigrade or multiage organization in mathematics classrooms involves, and the appropriateness of these ways of organizing rural schools to meet student learning and community goals. Current research (e.g., Vincent, 1999) does not focus specifically on what mathematics students in multigrade or multiage classrooms learn. Because rural educators may have experiential expertise in these areas, perhaps they might contribute and deepen their insights to any research agenda about issues of school organization. In addition, critical researchers need to ask in what ways equity in schools is fostered or blocked by such changes, as well as how these changes impact the community. If a central desire is to dynamically maintain rural communities, how might organizational changes in schools contribute to that effort?

Mathematics Curriculum and Content

Place-based education seems to lack a clear and consistent definition. Examples are often vague in terms of what intellectual academic content is involved and how that content is treated once students have completed activities in the school and larger community. Future research might attempt to provide a more descriptive view of place-based mathematics education and how both teachers and students connect the in-class and out-of-class experiences. Researchers need to investigate what mathematics students are engaged in and learn through place-based education. How teachers draw out mathematics from place-based experiences—and what kinds of resources they need (including professional development experiences) to be effective doing so—are also vital areas for research.

In addition, traditionally valued mathematical knowledge is the currency of the day with national policies like No Child Left Behind. Thus, researchers might attempt to document whether or not students actually acquire traditionally valued mathematical knowledge via place-based education. Critical researchers, however, need to explore how place-based curricula can facilitate not just acquisition but also *critique* of traditionally valued mathematical knowledge. This line of investigation is linked to how place-based education may promote or limit equity in rural schools. Finally, impact on the community might be considered as a research topic in terms of how place-based experiences support or enhance dynamic maintenance of rural communities.

Teacher Professional Development

The previous subsections have included investigations about professional development in terms of what experiences teachers need to be effective in alternative classroom and curriculum organization. In addition to these researchable domains, the reinvention of the teacher's role opens further avenues for investigation. As teachers take more responsibility for their learning and for the structure of their working conditions, we need to know how their identities as teachers change and what impact this change has on their teaching and on the community. Researchers might investigate how a community changes sociologically when the work of teaching is shared among community members and when teacher learning is viewed as a community responsibility. Future research might provide descriptive examples of how a community can be an active and vital resource for student and teacher learning. Finally, if teachers are empowered to challenge and change social institutions that impede student learning, researchers might investigate what actions teachers and communities take when community values are at odds with larger societal or political agendas.

Conclusion

McLaren and Giroux note that one of the central acts of critical educators is to "reveal and unsettle the ways in which the inequities of power and privilege" (2002, p. 163) are manifested in schools. We have attempted to do so by positing some alternatives to the status quo and by troubling the alternatives we presented. In the beginning of this paper we introduced the notion of *dynamic maintenance of community* and the inherent tensions between changing in order to maintain the vitality of the rural community and preserve the values and activities of rural settings. We argued that such tensions need not be considered an irresolvable dichotomy between changing and staying the same. Thus, throughout the paper we have posed examples of ways that mathematics teaching and learning might be changed in order to prepare students to preserve, enhance, and participate fully in rural communities. In a similar vein, it seems that a goal of mathematics education in rural communities might be to empower all citizens—not just those of school age—to question structures imposed by outsiders and that threaten the livelihood of rural places, and to act in ways that create communities "steeped in a sense of justice, compassion, radical empathy, and civic courage" (McLaren & Giroux, 1992, p. 163).

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