DOCUMENT RESUME

ED 460 861 SE 065 680

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TITLE	Class, Ethnicity, Culture and Mathematical Problem Solving (One U.S. Perspective).
PUB DATE	2001-04-00
NOTE	22p.; Paper presented at the Annual Meeting of the American Educational Research Association (Seattle, WA, April 10-14, 2001).
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Concept Formation; Intermediate Grades; Junior High Schools; *Mathematics Education; *Problem Solving; *Sociocultural Patterns; *Socioeconomic Influences; *Socioeconomic Status

ABSTRACT

This paper summarizes and extends a study of SES (socioeconomic status) related differences in a mathematics classroom aligned with current U.S. reforms. Qualitative analyses compared the lower- and higher-SES students' experiences with whole-class discussion and contextualized, open-ended mathematics problems. The higher-SES students tended to have confidence in their abilities to make sense of the mathematical discussions and problems, whereas the lower-SES students desired more specific direction from the teacher and text. Additionally, while the higher-SES students seemed to approach the real world problems with an eye toward the larger, abstract, mathematical ideas, the lower-SES students often missed the intended mathematical point. An examination of sociological literature revealed ways in which these patterns in the data could be related to more than individual differences in temperament or achievement among the children. The results suggest that reform-oriented instruction could assume and reward middle-class students' preferred ways of thinking and knowing in some unanticipated ways. After a short summary of the study is given, several questions and dilemmas related to the findings of the study are considered. Integrated into this discussion are a variety of current issues, such as the latest NCTM (National Council of Teachers of Mathematics) Standards document, class- and race-based gaps in U.S. student achievement since 1990, and the current emphasis on strictly positive aspects of diversity. Links with research on ethnicity and implications for teachers and researchers are also discussed. (Contains 59 references.) (Author)

Class, Ethnicity, Culture and Mathematical Problem Solving
(One U.S. Perspective)

Paper presented at the annual meeting of the
American Educational Research Association
April 2001, Seattle

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Abstract

This paper summarizes and extends a study of SES-related differences in a mathematics classroom aligned with current, U.S. reforms. Qualitative analyses compared the lower- and higher-SES students' experiences with whole-class discussion and contextualized, open-ended mathematics problems. The higher-SES students tended to have confidence in their abilities to make sense of the mathematical discussions and problems, whereas the lower-SES students desired more specific direction from the teacher and text. Additionally, while the higher-SES students seemed to approach the real world problems with an eye toward the larger, abstract, mathematical ideas, the lower-SES students more often missed the intended mathematical point.

An examination of sociological literature revealed ways in which these patterns in the data could be related to more than individual differences in temperament or achievement among the children. The results suggest that reform-oriented instruction could assume and reward middle-class students' preferred ways of thinking and knowing in some unanticipated ways.

After a short summary of the study is given, several questions and dilemmas related to the findings of the study are considered. Integrated into this discussion are a variety of current issues, such as the latest NCTM *Standards* document, class- and race-based gaps in U.S. student achievement since 1990, and the current emphasis on strictly positive aspects of diversity. Links with research on ethnicity and implications for teachers and researchers are also discussed.

Introduction

In this paper, I clarify and extend my interpretations of a study conducted a few years ago. The main focus of the study was SES[1]-related differences in students' experiences in a U.S. mathematics classroom aligned with the National Council of Teachers of Mathematics *Standards* (NCTM, 1989; 1991). In this qualitative study, I found ways in which the lower-SES students seemed to face particular struggles when learning mathematics through problem solving and whole-class discussions.

When I originally published this study, it was in the form of a dissertation well over 300 pages long. That format provided the luxury of space to include in-depth discussion of the complex issues the findings raised. The final chapter consisted of questions that I anticipated some readers might pose, as well as my answers through which I clarified and defended my position.

More recently, I published this study in the form of two articles. Given the constraints of space, I was not able to include the bulk of the data and interpretive remarks made in the original dissertation. One article, with a focus on students' experiences with open, contextualized problems, was published in the Journal for Research in Mathematics Education (Lubienski, 2000a). The second article, focusing more on students' experiences with whole class discussion (and emphasizing gender differences more than the first article) was published in the Elementary School Journal (Lubienski, 2000b).

The JRME article evoked the most responses from fellow mathematics educators and scholars. A few teachers of lower-SES students contacted me to report that the results ring true to the struggles they have encountered in their classrooms. A few colleagues have interpreted my stance as portraying a deficit perspective, or have at least cautioned that some teachers could see this study as an excuse to lower their expectations for lower-SES students. To the NCTM's credit, I have also been contacted by editors of two NCTM publications and asked to write about my findings for practitioner audiences in order to offer a perspective that differs from those currently being offered.

In this paper, I would like to take the time and space to re-state some of the clarifications I made in the original publication of my study, focusing primarily on the aspects that relate to the use of open, contextualized mathematics problems. Additionally, since conducting the original study, I have read more, learned more, and begun some other related studies. Hence, I intend to not only clarify my original position, but to use what I have learned to extend my analysis of the implications of this study. Part of this extension will bring in ethnicity-related issues that I did not discuss in any detail in the original publications of the study.

[1] I use the term SES when referring to particular students, but use class when discussing larger, societal structures and groups. SES can be thought of as an approximation for one's class, which connotes more permanence, shared group values and beliefs about roles in society and relation to power (Secada, 1992). I make a similar distinction between race and ethnicity.

I begin by describing the original study. I then shift into a question and answer format as I discuss what the study might mean regarding the use of open, contextualized problems in mathematics instruction.

The Study

For three years, I participated in the development of an NSF-funded, middle-school mathematics curriculum designed to implement the NCTM *Standards*. During my first two years with the project, I helped write and pilot test drafts of the materials in various sixth-grade classrooms. Although I was enthusiastic about the curriculum's goals and its impact on many students, I became concerned about disparities between the reform rhetoric and some students' reactions to the curriculum and my pedagogy. Having come from a working class background, I was particularly concerned about issues of socioeconomic equity in mathematics education.

In my third year with this project, I worked as a teacher-researcher, piloting draft materials of the curriculum throughout the school year in one socioeconomically diverse (yet primarily Caucasian) seventh-grade classroom. In this qualitative study, I set out to compare lower- and higher-SES students' experiences with the many different aspects of instruction. I assumed that I might find important SES differences in parental support or familiarity with the contexts used in the problems. But I didn't.

Instead, I found SES differences in students' experiences with whole-class discussions and open-ended mathematics problems, both of which were central to the pedagogy and curriculum being utilized. While the higher-SES students tended to have confidence in their abilities to make sense of the mathematical discussions and problems, the lower-SES students often said they were "confused" by conflicting ideas in the discussions and the open nature of the problems — they desired more specific direction from the teacher and texts. In our discussions, whereas the lower-SES students focused on finding a solution to the immediate problem at hand, the higher-SES students seemed to view our discussions as a forum for sharing and analyzing mathematical ideas. More lower-SES students said they were unsure of what they were supposed to be learning, and they wished the teacher would just tell them "the rules" so they could have more time to practice them. These students seemed to become overwhelmed by the lack of specific direction in the problems and were confused by conflicting ideas in discussions. They became frustrated as they felt these aspects of the curriculum and pedagogy were roadblocks to learning what really mattered — the right rules and the right answers. This frustration was particularly pronounced in the lower-SES females, who talked of their past feelings of success in more rule-oriented contexts. (However, for the purposes of maintaining the focus of this symposium, I do not discuss the gender differences in depth here.)

The contextualized problems in the curriculum often engaged the lower-SES students, who tended to delve into the contexts and consider a complex variety of real-world variables in solving the problems. Yet, in doing so, these students sometimes approached the problems in ways that allowed them to miss the generalized mathematical point intended by the teacher and text. The higher-SES students were more likely to approach the problems and discussions with an eye toward the intended, over-arching, mathematical ideas. They seemed more familiar with what Cooper and Dunne (2000) describe as "the peculiar ways boundaries are drawn between school and everyday knowledge" (p. 3).

As one example, in a pizza sharing problem designed to help students learn about fractions, the lower-SES students became concerned about who might arrive late to the restaurant, and they talked about sharing pizza in terms getting "firsts" and "seconds." These students were very sophisticated in their consideration of multiple, real world variables, but they did not encounter the intended ideas about fractions on their solution paths. As another example, a very bright lower-SES student missed the intended mathematical ideas when solving a "find the best buy" problem involving volumes and prices of three popcorn containers sold at a movie theater. She had no trouble finding the volumes from the given dimensions, and then she sensibly argued that, since the prices went roughly in order of size, the choice should be determined by need: "It depends on how much popcorn you want." Although she had intelligently used the context to determine the degree of accuracy needed, in using this approach she did not have the intended experience of working with volumes and comparing unit prices.

In general, the higher-SES students seemed to enter my classroom with more of the beliefs and skills necessary to succeed in the classroom culture. The lower-SES students seemed more confused by many elements of their expected roles. While some disparities were attributable to prior mathematics achievement, this was not a complete explanation. The higher-SES students seemed to possess more of the culture-based beliefs and discursive skills that were assumed and rewarded by the curriculum and my pedagogy. At this point, my knowledge of class cultural differences was limited. So I went to sociological and other literatures to try and make sense of the data.

I found some literature that shed light on my findings, suggesting that a classroom emphasizing discussion and abstraction of mathematical ideas embedded in challenging problems might be more aligned with key aspects of middle-class cultural norms. Some studies suggest that differences in the nature of work and societal position play a part in creating differences in class cultures. Although working-class jobs often require obedience to authority and conformity to rigid routines, middle-class occupations tend to allow more creativity, autonomy and intellectual work (Kohn, 1963, 1983). These fundamental differences are believed to impact the ways in which adults interact with their children. Researchers have found that in child-rearing, working-class parents tend to be more overtly authoritative, whereas middle-class parents are more likely to emphasize discussion and playfulness in helping their children learn, often blurring the lines among work, learning and play (Donovan, 1990; Duberman, 1976; Walkerdine, 1998). Middle-class parents tend to guide their children's problem-solving efforts by asking questions that help children focus on the structure of the problem, whereas working-class parents have been found to be more overtly directive, focusing on solving immediate problems as they arise in specific contexts (Bruner, 1975; Duberman, 1976; Heath, 1983; Hess & Shipman, 1965). As a specific example, Heath (1983) found that middle-class parents emphasized questioning and discussing, while white, working-class parents tended to tell or show their children what to do. The white, working-class children learned to be passive knowledge receivers and had difficulty shifting their knowledge to other contexts. Other scholars have connected lower-class cultures with more contextualized ways of knowing[2] (Bernstein, 1975; Holland, 1981) and more of an external locus of control that can hinder problem-solving efforts (Banks, 1988; Bruner, 1975).

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[2] It is important to note that Bernstein and Holland do not imply that children could not speak or think differently, but that they had been raised with a particular orientation.

Although most work on the interplay between class cultures and learning has occurred outside of mathematics education, a few British researchers have used a class cultural lens when analyzing children's mathematical thinking. Two such studies offer further evidence of a relationship between social class and students' interpretations of "real world" mathematics problems. Cooper and Dunne (2000) found that class disparities (and gender disparities, to a lesser extent) were larger on "realistic" items than "esoteric" items on England's national assessment. They note that their findings correspond with Bernstein and Bourdieu's conclusions about the existence of class cultural differences in orientation to the boundary between everyday and esoteric knowledge. Walkerdine (1990) also suggests ways in which class could affect children's orientation toward contextualized, "real world" mathematics problems. She argues that the wealthy have the luxury of performing calculations as a theoretical exercise (e.g., considering how much money would be left if a particular item was purchased), whereas such calculation problems are more real for the poor. Similar to what I found in my study, she observed working class children becoming engrossed in mathematical contexts used in school (such as shopping) but not gaining the intended mathematical knowledge.[3]

NCTM (1989; 1991; 2000) suggests that opening up the pedagogy and curriculum to allow all students to approach mathematics in ways that are sensible to them is a means of promoting equity. Theoretically, this sounds sensible. But In light of the literature reviewed above, the results of my study suggest ways in which instruction centered around students discussing various perspectives and abstracting mathematical ideas from contextualized problems, could value and reward middle-class students' preferred ways of thinking and knowing in some unanticipated ways.

Discussion of the Study

This study's implications for teaching, curriculum and reform are neither simple nor self-evident. Therefore, instead of a straightforward presentation of implications, the remainder of this paper is organized as a series of questions relating to the study. I begin by discussing two frequently raised questions about the study itself. Then, I discuss a variety of questions relating to the study's implications for mathematics education reform and research in the United States and elsewhere.

In this study, you interpret differences among students as class cultural differences, but the sample was small and you did not follow the students home to study their families' cultures. We don't know if these students were typical of lower- and higher-SES students in the United States. How can you generalize about how key aspects of the reforms might or might not be aligned with various class cultures from such a small sample of students?

If my conclusions were based solely on the data from my classroom, I would worry about how representative my students were or how small the sample was. I would then say that what the study showed is one way that reforms can play out for individual students. Yet, while I used my data to look carefully at students' reactions to one version of a

[3] Although beyond the scope of this paper, Walkerdine (1998) makes a more general, historical argument about "progressive pedagogies" (in which teachers are expected to nurture children's "natural" development of mathematical reasoning) being rooted in gender and class oppression.

reformed curriculum and pedagogy, I drew from the class cultures literature to help me make sense of the patterns I saw, and to argue that these patterns are likely related to class differences and are not limited to my students alone.

For the students in your study, this was the first year they experienced your pedagogy, and only the second year they had a problem-centered curriculum. Of course the students struggled with the implementation of these new ideas. How could you expect these methods to prove their empowering potential in such a short time? What would happen if we started teaching this way in kindergarten?

NCTM (1991) acknowledges that establishing classroom norms consistent with the Standards takes "hard work, especially with older students who have become accustomed to a different set of standards for school thinking and talking" (p. 45). But if the struggles I saw in my classroom were just a matter of initial implementation obstacles, then these problems should have impacted my students equally. But the issue I am raising is that it might be more difficult for some children — exactly those children who have so many hurdles already — to adapt to these norms.

Even if we have a school-wide effort to use a more open curriculum beginning in kindergarten, if the lower-SES students struggle more with learning through such methods, the ultimate result could be the growth of the already existing disparity between higher- and lower-SES students in their academic achievement, particularly if teachers are not aware of and able to address the struggles their lower-SES students face.

McDowell (1990) notes that when popular educational methods do not work well with certain race, class, or gender groups, we tend to assume there was an implementation problem instead of a problem with the theoretical research base. We rarely acknowledge "the possibility that the theories that underlie the practice may not have considered relevant population characteristics" (p. 285).

You seem to indicate that lower- and working-class cultures are more aligned with typical mathematics teaching, with the teacher telling students exactly what to do, and students practicing rote computation. If this is the case, then why have there been class-related mathematics achievement gaps in the past? Shouldn't lower-SES students have had an advantage in typical mathematics classes?

There are aspects of traditional mathematics instruction that appear to be more aligned with some aspects of lower- and working-class cultures, as described in the literature reviewed above. One example is the role of the teacher as rule-giver and the role of students in receiving explicit direction from the teacher. Still, there are a variety of factors, both inside and outside the classroom, that can affect the correlation that has existed between SES and mathematics achievement. For example, Berliner (1993, p. 6) points out that "higher social-class standing allows parents to buy high quality day care, preschool, and k-12 schooling; permits the purchase of instructional toys, encyclopedias and computers; and ensures first-rate health care." Hence, higher-SES students have many advantages over lower-SES students upon entry to school.

Still, the particular instructional approach used to teach mathematics can be a help or a hindrance for lower-SES students. Despite reformers' good intentions, my study suggests that inequities are not necessarily lessened when more open approaches to teaching mathematics are implemented. Instead, new obstacles can arise for lower-SES students.

Are you concluding that rote learning is better for lower-SES students than problem-centered instruction? Are you suggesting the NCTM Standards should be abandoned?

No. I do not believe that we should revert to drill-oriented practices for lower-SES students while giving other students access to higher-level mathematical skills as has occurred in the past (Anyon, 1981; Means & Knapp, 1991). In fact, if the assertions about class cultural differences outlined above are true, one could argue that lower-SES students have the most to gain from mathematics classrooms that explicitly include problem solving and mathematical communication as part of the curriculum.

My study was not a quantitative comparison of traditional and reform-minded practices. I examined how some particular reform-minded practices — the use of open-ended, contextualized problems and whole-class discussion — played out with a small group of students. The data I collected does not allow me to make claims about the overall narrowing or widening of gaps between lower- and higher-SES students' achievement. From my study of one classroom one cannot conclude that lower SES students are incapable of functioning in a "reformed" classroom, and one cannot conclude that lower SES students will learn less from problem-centered teaching than from more typical teaching.

Certainly, current reformers' goal of high expectations and critical mathematical literacy skills for all students is a marked improvement over past initiatives geared toward developing talent in only some students or toward promoting only very basic computational skills. Learning to take initiative in problem solving, to believe in one's abilities to work through difficult problems, to reason mathematically and to communicate clearly about ideas, are important skills. Yet, this study suggests that making these elements more central to our methods of instruction can create cultural incongruencies for lower-SES students.

Noddings (1996) writes about the dilemmas of drawing conclusions from a study of this type, particularly when the pervasive attitude among education reformers seems to be, "You are either for us or against us."

> Careful advocates of equity are often caught in a real dilemma. On the one hand, they properly wish to raise questions at the level of philosophy and culture; almost always, the questions are new to the discussion underway in math education. On the other hand, they do not want to be seen as advocating total abandonment of the program under discussion . . . . Consideration of the philosophical and cultural aspects of equity need not lead to paralysis or cynicism in mathematics reform. Things may indeed move more slowly, but more reflective movement may avoid debilitating swings of the pendulum and link mathematics education more securely to the larger social problems of the education. (p. 614)

But since you agree that current reforms are promoting valuable goals for all students, then everyone wins, right? Even if some students might reach these goals sooner than others, as long as we finally have everyone on the right mathematical path, we are serving all students better, aren't we?

This argument would be compelling if students only learned mathematics for its intrinsic usefulness and schools were not sorting mechanisms for positions in society. The problem with the argument is that it ignores the larger social context. Achievement in school mathematics can make a powerful impact on a student's future, because educational attainment is used to "sort" students into careers. Hence, we need to consider the possibility that methods of teaching mathematics can both raise mathematics achievement for all students while also exacerbating inequalities.

Still, it is worth considering the argument that if we bring middle-class, cultural elements into our classrooms and make them part of the curriculum and pedagogy, then we are helping lower-status students gain what is needed to succeed in main-stream society. That is, perhaps the reforms can allow lower- and working-class students access to the "culture of power" (Delpit, 1986). Yet, if this is to occur, we cannot assume that students enter our classrooms with equal access to the norms of this culture. We need to give lower-SES students extra support in learning the norms. Still, this would not counter the preceding argument that if middle-class students already have more access to the culture assumed in our classrooms, then they would seem to have an advantage in learning mathematical content that is likely to be a part of later gatekeeping.

It is also critical to note the existence of evidence that teaching with an emphasis on critical thinking, discussion, and problem solving, can, indeed, be implemented in lower SES classrooms (e.g., Silver, Smith, & Nelson, 1995) and that teaching for meaning can increase poor students' problem-solving and computational abilities when compared with teaching via rote memorization (Knapp, Shields, & Turnbull, 1995; Moses, Kamii, Swap & Howard, 1989; Newmann & Wehlage, 1995). Moreover, Boaler (under review) found that the use of open mathematics problems actually corresponded with a decrease in class-related achievement gaps.

How do you account for these other studies that have shown that problem-centered instructional approaches work for lower-SES students?

In examining such "counter-examples", two issues must be given attention. First, we must look carefully at the instructional approach being used. Upon closer examination of most programs considered to be successful with lower-SES students, one finds ways in which teachers are adapting methods advocated in the NCTM *Standards* to meet students' needs.

For example, The Algebra Project is known to be successful with helping under-served middle-school students learn algebra (Moses, Kamii, Swap & Howard, 1989). Project director Bob Moses found that the students felt vulnerable being put "on the spot" and having to expose their uncertainty publicly. Hence, the pedagogy used does not emphasize whole-class discussion. Instead, the teacher is a coach who answers students' questions privately, as they work through problems in their book alone and with peers. Moses also found that the main difficulty the students had in moving from arithmetic to algebra was "failure to make the generalization" from asking the concrete question, "how many" to more abstract, algebraic questions (p. 422). Moses developed a five-step plan to help students avert frustration when moving "from physical events to a symbolic representation of those events" (p. 433). Moses advocates explicitly teaching students' problem-solving skills and helping them learn, in non-threatening ways, how to be more self-reliant learners of mathematics, including how to generalize from concrete situations.

Another interesting adaptation is used by Project SEED (Phillips & Ebrahimi, 1993). This program uses group discovery to help low-income and minority elementary and middle-school students learn abstract mathematics in order to promote the study of more advanced mathematics later. The students are actively involved in mathematical thinking and problem exploration, but there are several differences between SEED's methods and those advocated by NCTM. First, students do not explore open problems independently, but instead the teacher leads the entire class through the exploration, using focusing questions. Second, the students do not discuss ideas with each other, but instead offer guesses to the teacher who tells the class if the guess is right or wrong. The teacher requires students to constantly use hand signals indicating their agreement or disagreement with proposed ideas, which allows the teacher to motivate and continually assess students' participation. Finally, the problems being explored are not contextualized — abstract ideas are taught in the abstract. Project SEED 's methods have been found to be successful in improving students' computational skills, attitude about mathematics, and conceptual understanding.

In addition to considering what adaptations a successful program makes, we must consider what is meant by claims that an approach "works" for lower-SES students. Again, it is possible for lower-SES students to both learn more mathematics while also falling further behind their more advantaged peers. Few of the "success stories" in the literature have given attention to the gap between lower- and higher-SES students. Boaler's study (under review) is one exception. Her study provides encouraging existence proof that teachers can implement more open, problem-centered instructional approaches and also narrow the SES-related achievement gaps. It is worth noting that her study was conducted in England, and examined the outcomes of students who learned mathematics through open-ended problem solving over a 3-year period. In contrast, my study was conducted in the U.S. and followed students for just one year. There might also be subtle differences in the instructional methods used between Boaler's study and my study, such as the extent to which the problems were "open", the "real world" nature of the contexts surrounding the problems, the guidance provided by the teacher to help students interpret and solve the problems, and the emphasis placed on whole-class discussion of the problems.

I see my study as providing a lens with which to view data from Boaler's study, as well as QUASAR (Silver, Smith, & Nelson, 1995) and other projects considered successful at implementing problem-centered approaches with lower-SES students. My study identifies struggles that lower-SES students *can* have with problem-centered approaches, and I raise questions about whether and how such approaches can be used to decrease, instead of increase SES disparities. These questions then provide a lens with which to view classroom data from other studies to see how exemplary teachers are able to make some of these more open-ended methods work for lower-SES students. As a specific example, the concerns my study raises about lower-SES students focussing on real world constraints and missing the intended mathematical point of problems can help us look more carefully at how exemplary teachers adapt either the type of problems they use or the ways in which they guide students' abstractions from the problems.

Clearly, you are saying that more research is needed. But you must have some opinion about what is to be done in the mean time, don't you? What would you do if you were going to teach seventh grade next year?

There are a couple of options I would explore. The first entails a more careful implementation of a problem-centered pedagogy, and the second involves adaptations to problem-centered instruction.

If I were to use a pedagogy and curriculum like I used previously, I would attempt to address possible cultural incongruencies through explicit, cross-cultural training. As Delpit (1988) writes, making the rules of the "culture of power" explicit can help students gain power. Hence, as a teacher, I would strive to clearly explain the rationale for the classroom culture I was intending to create and make the norms for operating within that culture explicit. I would show students videos of other classrooms to model these cultural norms. In an ironic sense, I would use direct instruction in order to establish a classroom culture that de-emphasizes direct instruction.

I would also consider ways I might adapt my pedagogy to more closely match the expectations of lower- and working-class students, without giving up the over-arching goal of students' becoming critical mathematical thinkers and problem solvers. There has been a tendency to dichotomize "traditional" teaching with "reformed" teaching (Chazan & Ball, 1995). What is often called "traditional" teaching is not the only other option. Certainly, I would not advocate returning to a pedagogy that teaches students only *how* to carry out computations, with no conceptual understanding of *why* the methods work. But we might consider other ways we can teach students to make sense of mathematics.

Current reforms (e.g., NCTM, 1991; 2000) encourage teachers to make problem solving the primary means of instruction, as opposed to a separate curricular topic. Although some compelling arguments are made for this in the *Standards*, perhaps we should consider alternative methods that could be even more beneficial for under-served students. We might consider the drawbacks and benefits of teaching students how to solve problems without teaching all of mathematics through problem solving. (See Lubienski, 1999a for a more thorough discussion of the distinction between teaching *about* problem solving and teaching *through* problem solving)

Still, I struggle with dilemmas about adapting methods, particularly when such adaptations might be made only for some groups of students, because, as NCTM (1991) states, "What students learn is fundamentally connected with how they learn it" (p. 21). The implications of this statement are troubling. For example, one adaptation that might seem promising is to provide more structure for lower-SES students. While this might be helpful in addressing some students' struggles, I have concerns about increasing teacher direction, since I would ultimately like students to move away from being directed and validated by authority figures.

In addition to pedagogical adaptations, the nature of the open problems used to teach mathematics should also be considered. One question raised by both my study, as well as the work of Cooper and Dunne (2000), is the extent to which curricular problems should be set in real-world contexts. I certainly want all students to be able to critically analyze mathematical situations in the real world. Although it sounds efficient to use real-world problems to develop students' abilities to analyze those problems, evidence from my classroom raises the possibility that lower-SES students might have more difficulty learning the abstract, mathematical principles when taught in real-world contexts.

One solution could be to use "real world problems" that are actually more real than those typically used in mathematics textbooks. Perhaps more extended, open ended projects that students and teachers co-construct in response to issues the students are currently grappling with (e.g., sexism in the school sports program) would help redraw the boundary between school and everyday knowledge that is assumed by typical textbook writers and that seemed to pose problems for the lower-SES students in my study. However, as someone who has witnessed, first hand, the challenges involved in creating a coherent, problem centered mathematics curriculum, I remain unsure of whether this approach is feasible in typical classrooms.

A solution in another direction could be to teach mathematics using abstract problems. Ball (1995) found that teaching through real-world problems posed difficulties for some children because of limited access to relevant background knowledge. She writes, "The children were distracted, or confused, or the differences among them were accentuated in ways that diminished the sense of collective purpose and joint work" (p. 672) In her third grade classroom, abstract mathematical contexts often seemed more inclusive, giving students more of a common understanding and purpose. She writes, "What seems like more abstract mathematics, unconnected to the real world, may be one step toward the reconstruction of mathematics as common property and pursuit" (p. 677).

Hence, there might be advantages to using abstract problems instead of realistic problems. However, we must also consider whether there is a cost in terms of student motivation or attitudes toward mathematics when such a replacement is made. Overall, the ways in which learning mathematics through problem solving can be a help or hindrance for particular groups of under-served students is an area in need of further research.

Overall, it sure sounds like you are returning to a deficit model. Are you saying that lower-class students are not capable of abstract, higher-order thinking or taking initiative in solving complex problems?

I am not saying that lower-class students cannot think abstractly nor solve complex problems. My primary concern is not whether lower-SES students can do such work, but whether the socioeconomic gaps in achievement will increase as new methods are implemented, because these methods draw upon and reward middle class cultural capital in ways of which reformers and educators are not aware.

This leads me to a larger point about current trends in educational research on equity. Certainly, cultural distinctions are generalizations, and one cannot assume that any particular individual will exhibit the characteristics found to be associated in the literature with a person's culture. Hence, care should be given to the ways in which cultural differences are interpreted.

Still, discussions of cultural differences in relation to the norms and roles expected at school, however uncomfortable, are important. Social class, in particular, tends to be a touchy subject, especially in the United States, where citizens cling to a belief in equal opportunity for all. Cooper and Dunne (2000) note that scholars who legitimately discuss class cultural differences in relation to schooling practices are often hastily labeled deficit theorists. They write,

> Orientations to time, linguistic resources, orientations concerning 'abstraction', willingness to tolerate ambiguity, 'cultural capital' and many other factors have been discussed in the literature.

Writers addressing these matters have often been attacked for characterizing the members of 'disadvantaged' groups in terms of a 'deficit', read off by comparing them with some other group presented as 'normal.' We would readily agree that sometimes this criticism is justified, but if carried too far it rules out a quite proper sociological concern with the consequences of the *relations* between a child's cultural resources, which are given on entry to the school, and what the school demands of the child as the conditions of his or her success." (p. 5)

With well-intended attempts to move away from deficit theory, the research community has tended to limit attention to only the positive aspects of diversity. The Swedish social scientist Gunnar Myrdal (1974) noted this trend when it began a few decades ago. He wrote that the American glorification of diversity is a product of "upper-class intellectual romanticism" and only serves conservative interests, as it "does not raise the crucial problems of power and money" (p. 28, Quoted in Havighurst, 1976, pp. 63-64).

While gender and ethnic differences give richness and character to our society, there seem to be fewer positive things to say about large disparities of wealth and power, particularly for those at the bottom rungs of society.[4] This could account for the findings in a recent survey of 3,011 mathematics education research articles that were published between 1982 and 1998 (Lubienski & Bowen, 2000). Among the 3,011 articles, there were 323 articles pertaining to gender, 112 on ethnicity, and only 52 on class. The results for the subset of 999 articles published in U.S. mathematics education research journals were even more extreme. Among the 999, there were 89 articles on gender, 32 on ethnicity, and only 6 on class.

Thus, the strictly positive rhetoric surrounding current discussions of diversity could be constraining the attention given to class in educational research. Such constraints on legitimate realms of inquiry are detrimental for lower-class students, whose strengths and needs then tend to be ignored.

The idea of mathematics instruction centered around open-ended tasks has been promoted in the U.S. by the NCTM Standards, both in previous versions (1989; 1991; 1995) and the newest edition (2000). What attention have these documents given to the issues your study raises?

Since 1989, the National Council of Teachers of Mathematics has been working toward the laudable goal of "mathematical power for all students," including those students previously under-represented in mathematics-based careers. (NCTM, 1989; 1991; 1995; 2000) Despite this worthy goal, NCTM's original *Standards* documents (1989; 1991) were criticized for merely mentioning equity and giving the impression that the needs of all students would be satisfied through high expectations and a single pedagogy (Meyer, 1991; Secada, 1991; Stanic, 1991).

The newest *Standards* document (NCTM, 2000) gives greater reference to equity. For example, the current document names equity as one of its guiding principles, and states, "equity does not mean that every student should receive identical instruction; instead, it demands that reasonable and appropriate accommodations be made as needed to promote access and attainment for all

[4] This is not to say that lower-class cultures do not have strengths or that middle-class cultures do not have weaknesses. Yet, there are some difficult realities of life in the lower classes that tend to be ignored amidst recent attempts to move away from deficit views of diversity.

students" (p. 12). NCTM (2000) also specifically mentions that teachers need to understand and attend to students' cultural differences:

> Teachers need help to understand the strengths and needs of students who come from diverse linguistic and cultural backgrounds, who have specific disabilities, or who possess a special talent and interest in mathematics. To accommodate differences among students effectively and sensitively, teachers also need to understand and confront their own beliefs and biases. (p. 14)

Still, the current *Standards* offers few specifics. It contains a small section regarding accommodating student differences, but only students who are disabled, gifted, and non-native English speakers are mentioned. No specifics are given about ways in which ethnicity, class, or gender might affect students' experiences with reform-minded pedagogies and curricula.

This is not surprising. The *Standards* have been shaped by good intentions and existing research, both of which offer limited guidance in addressing the complexities of equity in today's mathematics classrooms.

NCTM is calling for a particular type of classroom environment, and any change in classroom culture could privilege those possessing white, upper-middle class "cultural capital" (Bourdieu, 1973) in unanticipated ways. It might seem reasonable to think that open discussions, in which a variety of methods and ideas are considered, and open-ended problems that can be solved in a variety of ways (including drawing from one's own experiences), would communicate to all students that their ways of thinking and communicating are valued. But my study raises the question of whether the very nature of a classroom culture that expects students to learn through puzzling over problems and debating ideas, might conflict with the cultural beliefs and norms of some students.

Mathematics education research that seriously considers these questions has been limited. Amidst the movement to embrace and implement the *Standards*, the mathematics education community has given little attention to culture-based clashes that could arise in reformed mathematics classrooms. Instead, the struggles encountered by teachers of poor and minority students who are attempting to implement the *Standards*, tend to be attributed to teachers' low expectations of their students, teachers' limited pedagogical and/or mathematical knowledge, or lack of administrative support. The complexities of social class, ethnicity and gender, as they combine to shape classroom processes, tend to be overlooked.

Since the introduction of the Standards over a decade ago, what has happened to gaps in U.S. student achievement? What do National test results show?

The National Assessment of Educational Progress (NAEP) is the only nationally representative, ongoing assessment of academic achievement in the United States. The NAEP measures student performance at 4th, 8th, and 12th grades in mathematics and other subject areas. The NAEP also provides information from student and teacher questionnaires regarding classroom practices. Since 1990, the main[5] NAEP mathematics assessment has been shaped by a framework based on

[5] There are two different NAEP mathematics assessments: the main assessment and the long-term trend assessment. The framework that determines the content of the main assessment is responsive to national trends, such as the recent emphasis on the NCTM *Standards*. The long-term trend assessment was created in 1973 and has remained

the NCTM *Curriculum and Evaluation Standards for School Mathematics* (1989). As early as 1992, changes in the NAEP mathematics scores were attributed by some to the NCTM *Standards*. For example, in an NCTM *Bulletin* article entitled, "NAEP Results Show Improvement," then Secretary of State, Lamar Alexander, credited the NCTM reforms for the "improved" scores (NCTM, 1993). But a closer look at the fine print in the article revealed that, although White students' scores increased at all three grade levels tested, African American and Hispanic students' scores were up only at the 12th grade level. Moreover, there was a significant decline in the average proficiency of eighth graders from "disadvantaged, urban areas."

I recently completed an analysis of race[6], class and gender interactions in achievement and classroom practices from the more recent 1996 National Assessment of Educational Progress (NAEP). The good news is that between 1990 and 1996, overall scores increased for both females and males in every grade tested. Additionally, both lower- and higher-SES students' scores have increased, and although SES disparities have persisted, they have actually decreased slightly (but not significantly). Although some disparities between African American and White students increased slightly (again, not significantly), this is because the gains of the White students tested were larger than the gains of the African American students tested. (Lubienski, 2001a.)

But the picture in terms of equity was not completely rosy. Equity-related disparities are still very large, with White, high-SES students scoring roughly 3 grade levels higher than low-SES and African American students. The NAEP utilizes both multiple choice items, as well as more open-ended tasks. Analyses of NAEP item types reveal that race and SES-based disparities are largest on open-ended problems. Additionally, lower-SES and African American students are much more likely to completely omit such problems (with their omit rates for some problems nearing 50%!).

Additionally, an analysis of NAEP data on student beliefs revealed that lower-SES and minority students are more likely than other students to agree with the statements, "There is only one way to solve a mathematics problem" and "Learning mathematics is mostly memorizing facts."

NAEP data on classroom instructional practices indicate that many *Standards*-based ideas are permeating classrooms, such as the use of manipulatives, group work and "real life" mathematics problems. However, further analysis reveals that middle-class and White students are experiencing more of the fundamental shifts called for by NCTM. For example, these students are more likely than others to be tested on higher level skills, to be allowed regular access to calculators (including on tests), and to receive instruction emphasizing "reasoning to solve unique problems." (For more details, see Lubienski, 2001a; 2001b).

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constant over time. The long-term trend assessment was most recently administered in 1999, whereas the main assessment was administered in 1996 and again in 2000 (the raw data from the 2000 assessment will not be available to researchers until late 2001.)

6 My analyses of race involved comparisons between White and African American students only. This relatively narrow focus is due to both recent concerns about the growth in the gap between African American and White students' achievement (e.g., Jencks & Phillips, 1998), as well as a concern about NAEP sample sizes for other minority groups becoming too small when examined in conjunction with SES.

While it might be tempting to draw conclusions about the effects of *Standards*-based, problem centered instructional practices based on the NAEP achievement data, it is difficult to do so. The NAEP is not designed for drawing cause-and-effect conclusions. The instructional practices reported for each student are only those the student is encountering at the time the NAEP assessment is administered. Hence, students' experiences in previous years with other teachers are not reflected in the NAEP classroom practice data. Although White and higher-SES students appear to have more of the beliefs and classroom experiences promoted by the NCTM Standards, we cannot conclude from NAEP data that Standards-based experiences are the *cause* of their higher achievement. For example, one alternative explanation is that teachers are more likely to implement open-ended practices with higher achieving students, or with students whose cultural backgrounds are more aligned with such practices. Additionally, while the pronounced race- and class-related gaps on open-ended tasks are generally assumed to be caused by differences in instruction the students received, my study and some of the sociological literature reviewed above (e.g., Bernstein, 1975; Heath, 1983; Holland, 1981) reveal ways in which these patterns could also be related to cultural differences at home.

Overall, the NAEP results clearly show that lower-SES and minority students need more opportunities to become skilled at complex problem solving. However, whether all mathematics should be taught through solving complex, contextualized problems remains an issue.

Do you view the concerns that your study raised about social class as transferable to ethnicity?

First, on a personal note, my explorations of NAEP data have caused me to become more concerned about ethnicity — African American students, in particular — than ever before. In examining *intersections* of SES and race, I found that the highest-SES quartile of African American students were scoring below the lowest-SES quartile of White students at each grade level. I found that African American 12th graders were graduating from high school with lower mathematical achievement than White 8th graders (Lubienski, 2001a). Although race-related gaps narrowed in the 1970s and 80s, gaps between White and African American students have been widening slightly on the NAEP and other assessments in the past decade. (It is important to note that this has been true in all subjects, not just mathematics -- e.g., see Jencks & Phillips, 1998).

Scholars concerned with African American students' mathematics achievement have tended to view the *Standards* as promising for promoting equity. Some scholars have noted that the *Standards*' goal of "mathematical power for all" is a vast improvement over current practices, in which minority children have received more than their share of rote learning and low-level exercises from teachers who expect little of them (e.g., Ladson-Billings, 1997; Means & Knapp, 1991). Others argue that African-American students tend to prefer learning in more relational, holistic ways (Gilbert & Gay, 1985); therefore, it is argued, teachers who use open instructional approaches and emphasize real world connections will better serve African American students. (Stiff, 1990)

Still, there has been little research conducted that carefully examines the classroom experiences and outcomes for minority children who are asked to learn mathematics through solving open, contextualized tasks. As Tate (1997) argues, mathematics education research has tended to be narrowly focused, restricted to the disciplines of mathematics and psychology — or as Jacob (1998) describes it, "cognition without context or culture" (p. 23).

Clearly, the issues my study has raised regarding class transfer to ethnicity in the broad sense, in terms of raising the possibility that particular ethnic groups could be advantaged or disadvantaged in *Standards* based classrooms in unanticipated ways. However, the specific aspects that particular groups are likely to struggle with remain an open question.

Class and race are often conflated in mathematics education research, with few attempts made to isolate either variable or to carefully examine them in conjunction with one another. Researchers need to give attention to both class and race, including intersections between them, as well as interactions with gender. Additionally, we need to go beyond studies of African American and White students, and consider other ethnic groups, including Native American groups and the rapidly growing Latino/Latina populations.

As the survey of 3,011 mathematics education research articles (discussed above) revealed, ethnicity was examined in only 112, or less than 4% of the articles. Most of these articles pertained to a specific ethnic group, as revealed in table 1. African-American students received more attention (47 articles) than other groups, yet still less than 2% of the total number of articles. Latina/o groups received about half as much attention as African-Americans, and immigrant/LEP and Native American groups received the least attention. It is important to note that these categories are not disjoint — for example, the 6 articles on immigrant groups overlap with the 24 articles on Latina/o groups. When one considers that 88 of the 3,011 articles pertained to gifted students, the attention given to each ethnic group seems particularly limited. (See Lubienski, 1999b for more information.)

Table 1: Articles Relating to Specific Ethnic Groups

	African American	Latina/ Latino	Native American	Immigrant /Limited English Proficient	Asian American
Percents are of the 3,011 Articles	47 1.6%	24 .8%	5 .2%	6 .2%	12 .4%

However, there is relevant work that researchers interested in sociocultural issues in mathematics learning can build upon. For example, research regarding the learning styles prevalent in some Native American groups suggests ways in which these students could struggle in reform-oriented mathematics classrooms. For example, Swisher and Deyhle (1989) argue that that Navajo and Oglala Sioux children tend to prefer learning through observation and contemplation before giving public demonstrations of what they have learned. They conclude that these students, "prefer to learn privately — competence precedes performance (p. 3). Assuming these findings are correct, might these children struggle in mathematics classrooms in which they are expected to work on and discuss complex, open-ended problems in small group or whole class settings?

In exploring these issues, mathematics education researchers will need to become more aware of important differences between and within minority groups. For example, we will need to consider Ogbu's (1992) distinction between voluntary and involuntary minorities, and the differences in their orientations toward schooling. There *is* mathematics education research that gives careful attention to particular ethnic groups, but the work that goes beyond reporting achievement results tends to be published outside of mainstream, mathematics education journals.

Conclusions -- Future Research Directions

Reformers are calling for substantial changes in classroom cultures, and in order to most effectively and equitably implement more "open" pedagogies intended to empower all students, educators need help in understanding how particular changes can privilege some students while creating difficulties for others. As Warren & Rosebery (1995) argue, learning in any classroom can be thought of as socialization into a particular discourse. And discourses are

> inherently ideological; they…are always in conflict with one another in their underlying assumptions and values, their ways of making sense, their viewpoints, the objects and concepts with which they are concerned… Therefore, appropriating any one discourse will be more or less difficult depending on the various other discourses in which students and teachers participate." (p. 309)

Holding high expectations for all students is not enough to produce equitable instructional practices. Instead of viewing the learning of mathematics through solving open, contextualized problems as equally "natural" for all students, we need to uncover the cultural assumptions of this particular discourse. Only then can we identify and seek to address the difficulties that some under-served children could face in reform-oriented classrooms.

Research from Britain, the U.S., and elsewhere has shown that some teachers have successfully implemented problem-centered mathematics approaches with lower-SES and minority boys and girls (e.g., Boaler, under review; Silver, Smith & Nelson, 1995). However, these success stories do not negate the concerns raised above about the difficulties teachers and students can face in doing so. Clearly, educators need additional help to understand how cultural issues involving social class, ethnicity, and gender relate to mathematics teaching and learning, as well as how to adapt meaning-oriented instructional approaches to best meet their students' needs.

In response to this challenge, we need more research on the enactment of reformed instructional practices in mathematics classrooms. In conducting this research, mathematics education researchers must go beyond studies of individual cognition or achievement (Lerman, 2000). Forman (in press) urges researchers to draw from sociocultural theory when investigating the effects of mathematics education reforms, thereby making social and cultural activity more focal in this research. She argues,

> At the very least, sociocultural theory makes us wonder whether students who fail to learn in reform classrooms are failing not just because of a lack of "ability" or "interest" but because of resistance to learning the discourse of mathematics, or alienation from authority figures in classrooms and mathematics communities, or a misalignment between the beliefs and values of their home communities and those of the classroom. (pp. 35-36)

Research in this vein should consider ways in which cultural and status differences play out both inside and outside of the mathematics classroom[7]. Using a sociocultural lens, researchers must

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[7] For example, in the study of lower- and higher-SES students described above, one issue that arose was the boys' treatment of a lower-SES female named Sue. When Sue was brave enough to ask questions during whole-class

give attention to ways in which teachers and students struggle when implementing particular instructional approaches, as well as ways in which exemplary teachers are able to address such struggles. Such studies can illuminate cultural differences between some students' backgrounds and the assumptions underlying particular instructional approaches.

What I am proposing moves beyond the dichotomy of "traditional" versus "reformed" instructional approaches. In identifying particular instructional practices that conflict with some students' cultures, researchers would need to disentangle various aspects of the instructional vision being promoted in the NCTM *Standards* and elsewhere. As a specific example, the study described above raised concerns about two particular aspects of instruction—the use of open, contextualized problems and whole group discussions. It found no correlation between social class and students' experiences with numerous other instructional aspects that are also aligned with current reforms (and were utilized in this classroom), such as the use of technology, "hands-on" activities, heterogeneous group work or teaching with an emphasis on the meaning of mathematical concepts.

Hence, the goal of future sociocultural studies should not be to conclude that current reforms "work" or do not "work" for under-served students. Instead, the goal is to learn more about the complexity of successfully implementing meaningful instructional methods equitably with students who differ in terms of social class, ethnicity and gender. We need to study how to build from what under-served students bring to school, to help them become critical thinkers and actors. Such studies could help identify specific practices (e.g., specific forms of collaborative group work) that appear promising for particular groups of students. Such studies could also identify ways in which other practices might be problematic for some students (such as particular uses of "pseudo real world" problems), as well as the adaptations that successful teachers make in order to address the problems that arise.

When one considers the sheer number of student groups that exist in the intersections of various ethnicity, class and gender categories, this task can feel overwhelming. However, what is learned about cultural assumptions underlying particular reformed practices in studies of one group can inform efforts to make practices more equitable for other groups. Additionally, we do not start with a blank slate, in terms of research on various cultural groups.

Consequently, the mathematics education community needs to bring relevant *existing* research on equity and culture into the conversation about mathematics education and reform. This research includes both work in mathematics education that tends to appear in places other than mainstream journals, as well as work from fields outside of mathematics education, such as sociology and literacy education.

This is an important time for mathematics educators to take stock of their knowledge of, and commitment to, equity. Strides have been made in terms of achieving equity, but much work remains in this era of pedagogical and curricular reform. This discussion highlights the need to monitor the effects of current reforms on various under-served groups. Additionally,

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discussions, several of the boys would call her a "dumb blonde" in the hallway after class. Although a teacher can attempt to create a culture of "niceness" during class, we should not be naive about ways in which sexism, racism, and classism can permeate students' experiences, particularly as educators attempt to "open up" classrooms and give students a stronger voice (Lensmire, 1993) sociocultural studies of mathematics classrooms, particularly those framed by analyses of relevant research from other fields, hold promise for informing our efforts to empower all students. This work can address some of the current shortcomings of mainstream, mathematics education research and the U.S. reform movement, both of which have given limited attention to cultural factors in mathematics learning.

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