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Learning From Teaching: Exploring the Relationship Between Reform Curriculum and Equity

Jo Boaler, *Stanford University*

Some researchers have expressed doubts about the potential of reform-oriented curricula to promote equity. This article considers this important issue and argues that investigations into equitable teaching must pay attention to the *particular* practices of teaching and learning that are enacted in classrooms. Data are presented from two studies in which middle school and high school teachers using reform-oriented mathematics curricula achieved a reduction in linguistic, ethnic, and class inequalities in their schools. The teaching and learning practices that these teachers employed were central to the attainment of equality, suggesting that it is critical that relational analyses of equity go beyond the curriculum to include the teacher and their teaching.

Key Words: Curriculum; Equity/Diversity; Learning; Problem-solving; Teaching effectiveness

The relationship between different teaching methods and students' understanding of mathematics is one that has fascinated teachers and researchers for decades (Benezet, 1935). When the mathematics reform movements of the 1980s were developed in different countries, they were based on the idea that open-ended problems that encourage students to choose different methods, combine them, and discuss them with their peers would provide productive learning experiences. There was considerable support for such ideas, and the last 20 years have witnessed the development of a plethora of curriculum materials that center on open-ended and contextualized mathematics problems. However, such materials and their associated teaching methods have not been well received by all parties (Battista, 1999; Becker & Jacob, 2000). Some of the objections to reform-oriented approaches have come from mathematicians and others who gained extensive understandings through more traditional routes (see, for example, Klein, 2001; Wu, 1999). Other objections have come from those who prefer to maintain the traditions of the past and who view changes to school presentations of mathematics as a challenge to the social order (Ball, 1995; Rosen, 2000). Recently, objections have come from a more unexpected source: Within the education community, some whose focus is on equity have expressed concerns that reform-oriented approaches to mathematics may not enhance the achievement of *all* students, as reformers originally hoped and claimed (Lubienski, 2000).

Lubienski (2000) monitored her own teaching of a reform-oriented classroom and noted that working-class students were less confident and successful than middle-class students. Some of the students attributed their lack of success to the

open-ended nature of the work, a claim that prompted Lubienski to question the prevailing notion that reform curricular materials are advantageous for all children. Delpit (1988) has also raised questions about progressive reform movements, particularly challenging notions that they can distribute achievement more equitably. She contends that schools reproduce a “culture of power” (p. 285) and that “if you are not already a participant in the culture of power, being told explicitly the rules of that culture makes acquiring power easier” (p. 283). Delpit uses a number of examples to argue that approaches founded on principles of reform exacerbate inequalities because cultural and linguistic minority students expect and want teaching to be more direct, with explicit communication of the rules to which society attends. Delpit talks particularly about progressive approaches to reading, asserting that skills-oriented approaches may be more equitable because they teach concepts and skills directly rather than providing experiences through which students may learn them. Both Delpit and Lubienski express concerns about the limited access that some students have to new curricular approaches, raising extremely important questions for the future. In giving examples of reform-oriented approaches that, in their experience, did not reduce inequality, they also point to an urgent need for a greater understanding of the ways in which mathematics reform approaches, developed to enhance conceptual understanding, may do so more equitably.

The idea that some students may be disadvantaged by some of the reform-oriented curricula and teaching approaches that are used in schools is extremely important to consider and may reflect a certain naïveté in our assumptions that open teaching methods would be accessible to all. However, although it is very important to realize that some students may be less prepared than others to engage in the different roles that are required by open curricula, analyses that go from this idea to the claim that traditional curricula are more suitable may be very misleading. Such claims are problematic, partly because they reduce the complexity of teaching and learning to a question of curriculum, leaving the teaching of the curriculum relatively unexamined. Research has found that some reform approaches do promote equity and high achievement (e.g., Boaler, 1997a; Silver, Smith, & Nelson, 1995), and it is important to understand the conditions that supported such achievements and to examine the ways in which these reform approaches differed from others (Greeno & MMAP, 1998). This knowledge could advance our understanding of teacher practices that are productive in open environments and the teacher learning that may support them. The field of mathematics education does not currently have a nuanced or well-differentiated knowledge base about equitable teaching practices. The first wave of research into the impact of reform has tended, necessarily, to report on the relationships between students’ understanding and broad teaching approaches, such as teaching through group work or whole-class discussions (Boaler, 1998; Hiebert & Wearne, 1993). In this article, I open these and other teaching practices for closer examination and contend that the differences between equitable and inequitable teaching approaches lie *within* the different methods commonly discussed by researchers. I suggest that greater insights into

equity will result from an understanding of the ways in which teachers work to enact different approaches.

The idea that traditional curricula may be more appropriate for some students than for others is problematic because of its exclusive focus on curriculum. Moreover, the claim that open-ended materials and methods are less suitable for working-class or ethnic minority students is dangerous when considered within an educational system in which many already subscribe to the view that working class students cannot cope with more demanding work (Boaler, 1997a; Gutiérrez, 1996). In such a context, researchers need to be particularly careful and responsible in their reporting, making sure that they carefully examine all possible sources of equality and inequality. Haberman (1991) and Ladson-Billings (1997) have referred to the procedural teaching that is frequently offered in urban schools as a *pedagogy of poverty*, and Anyon (1980, 1981) has noted the prevalence of closed and procedural approaches in working-class schools. If observations that reform curricula do not always eradicate inequalities are not counterbalanced by investigations into the ways they may do so, reservations about reform ideas could perpetuate these deficit patterns of opportunity.

Another shortcoming of claims that traditional approaches may be better for some students is that such assertions tend to locate the problem within the students themselves. Educators must understand the needs of different groups of students not to develop negative ideas about the students' mathematical potential (Varenne & Mcdermott, 1999) but to become aware of the ways in which schools can serve all students. This will require a shift in focus away from what *students cannot do*—for example, cope well with open-ended problems—to what *schools can do* to make the educational experience more equitable. The aim of this article is to begin such an investigation, drawing on different studies that give insights into the ways that equity may be achieved. First I offer a theoretical grounding for questions of teaching and equity before moving to two examples of teaching that was organized to promote equity. I focus on the particular teaching practices that teachers used, and I argue that the field is in need of additional examples of *particular* teaching practices that reduce inequalities.

THEORIES OF CULTURAL REPRODUCTION

Investigations into sources of inequality have led researchers to propose that certain cultural elements mediate the relationship between people's lives and the economic structures of society (Mehan, Hubbard, & Villanueva, 1994). In this process, children learn cultural knowledge from their families—for example, ways of dressing, speaking, interacting and so on. Research suggests that children from working-class homes acquire a form of cultural capital (Bourdieu, 1986) that is different from that of children in middle- or upper-class homes and that schools recognize the cultural capital of middle-class learners. Thus, middle-class children are more likely to be perceived as effective learners merely because of their “congruency with the formal context of schooling” (Zevenbergen, 1996, p. 105).

Theories of cultural reproduction (e.g., Bourdieu & Passeron, 1977; Bowles & Gintis, 1976), which draw from both sociology and anthropology, do not deal with overt intentions or claim that teachers deliberately support students of their own gender, race, or class above others. These theories deal instead with more subtle demonstrations of power that “relate to linguistic forms, communicative strategies, and presentation of self; that is, ways of talking, ways of writing, ways of dressing, and ways of interacting” (Delpit, 1988, p. 283). Such theories are persuasive because they provide explanations for the fact that schools not only reflect but also reinforce social class disparities, despite the best intentions of educators.

Cultural reproduction theories are important to mathematics education reforms since researchers have argued that the norms of reform-oriented classrooms are consonant with the norms of White, middle-class homes. Delpit draws from Heath’s data (1983) to argue that White, middle-class students are generally more accustomed to interpreting indirect statements from parents, whereas some Black and working-class students are more likely to expect facts and rules to be communicated directly. Thus, teaching approaches that expect students to discuss ideas and discover mathematical relationships through exploration may be less accessible to children who are used to receiving information more directly. There have been objections to theories of cultural reproduction on the ground that they are overly deterministic, emphasizing social and structural constraints at the expense of individual actions (Mehan, 1992; Varenne & McDermott, 1998). It is clear that students do not just assume or uncritically accept the norms of the home or school but instead play an important part in forming, accepting and, in some instances, resisting such norms (Apple & Christian-Smith, 1991). But sociologists and anthropologists seem to agree on at least one issue: Learning to be successful in school involves understanding and following the rules of the school “game”—what Pope (1999) has defined as *doing school*—with middle-class learners frequently at an advantage. It is extremely important that movements to “reform” mathematics teaching—for example, by making it more open and contextualized—do not serve to enhance current disparities in achievement that result from subtle forms of cultural congruency. Relationships between students’ expectations and predispositions and the demands of new teaching approaches are very important to consider.

Theories of cultural reproduction suggest that there are certain practices that students need to learn in school in order to be successful and that these are related to, but go beyond, an understanding of subject content (Jackson, 1989). This suggestion fits with an emerging body of research that highlights the importance of students’ understanding their role in reform-oriented classrooms. Corbett and Wilson (1995) argue that those who are promoting educational reforms have generally overlooked the fact that students in reform-oriented classrooms need to develop not only new ways of working but an understanding of and a commitment to the changes in their roles: “Students must change during reform, not just as a consequence of it” (p. 12). This is a simple but important point that has been given surprisingly little attention. Thus, researchers have written extensively about the ways in which students may benefit from reforms but have paid relatively little

attention to the implications of such reforms for students' roles. Cohen and Ball (2000) have termed the different practices that students need to employ and understand in school *learning practices*. One important learning practice that Corbett and Wilson (1995) draw attention to is explaining work. In traditional mathematics classrooms, students are required to produce correct answers, but in reform-oriented classrooms, they often need to go beyond correct answers and explain their methods, justifying the approaches they have used. Lubienski (2000) reported that middle-class students in her classroom were more likely than working-class students to justify their answers in keeping with the expectations of the reform curriculum that she followed. Although she used this finding as an illustration of the possible inappropriateness of open-ended curricula, it could equally be given as an example of a teaching opportunity. To be successful in the classroom, students need to master not only mathematics but also particular schooling and learning practices. Researchers need to address the important task of considering the ways in which students might learn the different practices that support successful participation in reform mathematics classrooms.

Yackel and Cobb (1996) draw attention to the norms of mathematics classrooms, distinguishing between norms that they describe as social and those that are sociomathematical. Their depiction and naming of the repeated classroom practices in which teachers and students engage and that develop gradually over time, has been extremely generative. This is partly because classroom norms, such as "what counts as an acceptable mathematical explanation and justification" (Yackel & Cobb, 1996, p. 461), pay attention to a level of detail in the enactment of teaching that has been lacking from many analyses (Lampert, 1985). Sociomathematical norms offer a lens through which to examine and describe the colors and contours of mathematics classrooms, giving names to some of the important choices to which teachers and students attend in the activity of mathematics teaching and learning. The notion of learning practices operates at a similar level of detail, drawing attention to the specific actions and practices in which students need to engage in different classrooms. Knowing when and how to take notes as a teacher talks is an example of a learning practice in which students may need to engage but that is rarely given specific attention or taught. There are many different learning practices that may give students access to the norms that are in place in their classrooms and, concurrently, to mathematical understanding and success. These range from general practices, such as asking questions or taking notes, to specific practices, such as knowing to sketch a diagram of a mathematics problem. Pólya (1971) and others have considered what successful solvers of mathematics problems do, producing lists of possible strategies. Learning practices could include such strategies as well as the other actions in which students need to engage to be successful in their mathematics classrooms. Reform classrooms require different learning practices from those called for in more traditional classrooms. If access to these practices is inequitably distributed at the present time, as Lubienski and Delpit have suggested, then it seems important to consider ways in which successful practices may be learned by all students.

The field of mathematics education does not currently have an extensive or well-developed knowledge base of the particular ways in which teachers mediate curriculum approaches to make them equitable, including, for example, the learning practices to which they may need to pay explicit attention. The development of such a knowledge base seems to have been severely hampered by the pervasive public focus on curriculum approaches. Teachers, researchers, mathematicians, and policymakers have all argued about what curricula should be used in classrooms. Although opponents and proponents of different curricula have disagreed about the importance of open-ended work or structured questions, they have rarely considered the ways in which teachers can or do manage such approaches. Yet, to be successful, the new approaches call for different kinds of teacher knowledge (Ball & Bass, 2000a, 2000b) and changes in student roles (Corbett & Wilson, 1995). The “math wars,” as they have been termed in the United States, have comprised bitter battles fought in schools, districts, and the popular press as opponents and proponents of reform-oriented teaching argue their cases. Such battles are unfortunate for many reasons, not the least of which is that the broad focus on curricula necessitated by such arguments has served to reduce the learning experience to an interaction between students and curriculum. This has drawn attention away from the teaching practices that mediate student success and that require considerable understanding and support.

Cohen, Raudenbush, and Ball (2002) propose that teaching and learning be understood as a set of practices that come into play at the intersections among teachers, students, and content in environments, and they represent mathematics teaching and learning by an instructional triangle (shown in Figure 1), the vertices of which are teachers, students, and content. Cohen and his colleagues suggest that learning opportunities arise at the intersections among these different variables and that few learning occasions can be understood without consideration of the contribution made by the teacher, the students, the discipline of mathematics, and the ways in which they interact within environments. They propose moreover that environments, traditionally regarded as outside influences, “become active inside instruction” (2002, p. 98).

This focus on practice is consistent with the perspective of situated theory (Greeno & MMAP, 1998; Lave, 1996; Lave & Wenger 1991), and it has profound implications for research, curriculum, and professional development. Lampert (1985) has cautioned that “efforts to build generalized theories of instruction, curriculum, or classroom management based on careful empirical research have much to contribute to the improvement of teaching, but they do not sufficiently describe the work of teaching” (p. 179). A focus on general methods of instruction, at the expense of an examination of particular teacher moves, is pervasive within and outside the education community. Broad teaching and curriculum approaches are extremely important to consider, but Ball, Cohen, Lampert and others have argued lucidly that understanding the difference between effective and ineffective teaching requires a focus on the *practices* of teaching and learning.

In the next sections of this article, I describe and examine interactions that constitute teaching and learning, as well as particular teacher moves that promote

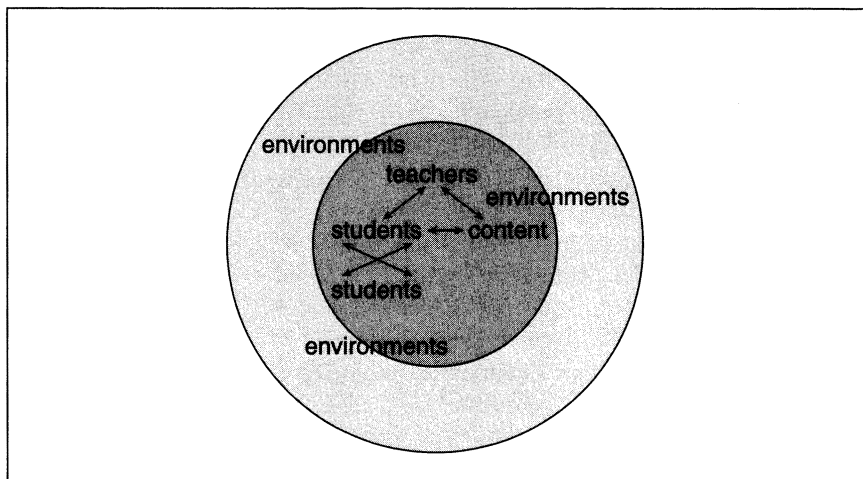


Figure 1. Instruction as interaction of teachers, students, and content in environments.

Note. From “Resources, Instruction, and Research,” by D. K. Cohen, S. Raudenbush, and D. L. Ball, 2002, in *Evidence Matters: Randomized Trials in Education Research*, edited by R. Boruch and F. Mosteller (p. 88), Washington, DC: Brookings Institution Press. Copyright 2002 by the Brookings Institution Press. Reprinted with permission.

equity, by analyzing two examples of equitable teaching and learning practices—one from England and another from the United States. Both approaches were reform oriented and contributed to a reduction of linguistic, ethnic, and class inequalities. The fact that these approaches promoted equity is important, since it casts doubt on claims that reform-oriented approaches are inequitable. In the final section, I consider a more important question—what methods did the teachers use to promote equity in their mediation of the reform curriculum? I consider only a small proportion of the teachers’ practices, but these will show that any reduction of the learning experience to an interaction between students and curriculum is essentially flawed, because teachers and their teaching of different curricula are central to the promotion of equity.

EVIDENCE OF EQUITABLE TEACHING

In previous issues of *JRME* (Boaler, 1998, 2000), I summarized the results of a 3-year investigation of the experiences and achievements of approximately 300 students attending secondary schools with vastly different mathematics teaching approaches in England. Both schools were situated in low-income areas and the majority of the students at both schools were White and working class. One of the schools (Phoenix Park) used an open-ended approach to mathematics; the other (Amber Hill) used a procedural, skill-based approach. I mentioned but did not

expand on the fact that the students in the open-ended approach attained not only a higher level of achievement but also more equal achievement. In an earlier article (Boaler, 1997b), I investigated the relationship between mathematics achievement and social class for the 300 students from age 13, when they first encountered a different approach to mathematics, until age 16, when they reached the end of their compulsory schooling. When the 110 students in the year cohort at Phoenix Park started at the school, significant class disparities were already evident in their achievement levels. The correlation between social class¹ and mathematics attainment at that time was .43. I had not monitored the students' experiences prior to their time at Phoenix Park, but I knew that the middle schools they attended employed ability grouping and a traditional curriculum. In England, social class often correlates significantly with achievement as well as with placement in ability groups—a process presumed to contribute to social inequalities (Abraham, 1995; Ball, 1981; Tomlinson, 1987). When the students left Phoenix Park 3 years later, having worked in mixed ability groups on an open, project-based mathematics curriculum, the partial correlation between achievement and social class, after controlling for initial attainment, was only .15. At Amber Hill, where the teachers used a procedural approach to mathematics, the initial correlation between the students' attainment at age 13 and their social class was .19. It was not possible to know why the initial correlations were so different at the two schools, but the Amber Hill students had worked for the previous 2 years in mixed ability groups, whereas the Phoenix Park students had worked in groups that were tracked on the basis of ability. After 3 years of working with a procedural mathematics curriculum in ability groups, the partial correlation between achievement and social class for the 196 Amber Hill students, after controlling for initial attainment, was .30. In addition, a comparison of the Amber Hill students' initial attainment at age 13 and their ultimate attainment at age 16 revealed that 80% of those attaining above their projected potential were middle class, whereas 80% of those achieving below their projected potential were working class. At Phoenix Park, overachievers and underachievers were equally distributed among working-class and middle-class students (Boaler, 1997a, 1997b).

At the beginning of that study, the cohorts of students at the two schools were matched by gender, race, and social class, and there were no significant differences in their levels of mathematics attainment at that time. Three years later, the students at the project-based school (Phoenix Park) attained significantly higher grades on a range of assessments, including the national examination ($\chi^2(1, N = 290) = 12.5, p < .001$). They outperformed the Amber Hill students despite the comparability of the mathematics attainment of the students in the two schools at age 13 and the extra time spent on task by students at Amber Hill, the traditional school (Boaler, 1997a). In addition, although the boys at Amber Hill earned significantly higher grades than the girls did, no gender disparities were manifest in achievement at Phoenix Park.

¹ Social class was determined using the information from the Office of Population Censuses and Surveys (1980).

Thus, the school that used an open-ended approach not only achieved significant academic results for its students—whose examination results were higher than the national average, despite their school's location in one of the poorest areas of the country—but also reduced the inequalities that typically correlate with gender or social class. These results, particularly the increase in class polarization at Amber Hill, stand in direct contrast to the idea that “the algorithmic mode of instruction might provide a relatively level playing field” (Lubienski, 2000, p. 478).

The QUASAR project (Brown, Stein, & Forman, 1996; Lane & Silver, 1999; Silver, Smith, & Nelson, 1995) began with the assumption that mathematical proficiency could be attained by all students and that it would increase in poor and minority communities if teachers placed a greater emphasis on problem solving, communication, and conceptual understanding. Teachers in six urban middle schools serving socially and culturally diverse populations of students in the United States spent 5 years developing and implementing a more open and discursive mathematics curriculum. Students learned about facts and algorithms, but they also learned when, how, and why to apply procedures, which they used to solve high-level problems. There were a number of similarities between the QUASAR and Phoenix Park approaches, including mixed-ability classes, a focus on problem solving, high expectations for all students, attention to a broad array of mathematical topics, and the encouragement of discussion and justification. As measured over time, the QUASAR students' achievement revealed extremely positive results. The students made significant gains in achievement, and they performed at significantly higher levels than comparable groups of students on a range of different assessments. Furthermore, the gains were distributed equally among the different racial, ethnic, and linguistic groups of students.

The results of these and other studies (e.g., Knapp, Shields, & Turnbull, 1995) cast considerable doubt on claims that open-ended approaches are less suitable for working-class and minority children, but they also raise an important question. Why did the reform-oriented approaches of the Phoenix Park and QUASAR teachers appear to promote equality when other reform curricula have not reduced inequalities (Lubienski, 2000)? The answer to this question may be important to our field, and next I address the particular practices of teaching and learning that the Phoenix Park and QUASAR teachers employed and that appeared to have an impact on the attainment of equality.

A FOCUS ON TEACHING AND LEARNING PRACTICES

At Phoenix Park School the curriculum was designed by the teachers. They did not use any textbooks but instead brought together a collection of different open-ended projects that generally lasted for 2 to 3 weeks of mathematics lessons (for more information on Phoenix Park's approach, see Boaler, 1997a). The teachers designed the curriculum with teachers who came from five other schools and were part of a working group of teachers in the Association of Teachers of Mathematics (the British equivalent of NCTM). When I conducted my research study, the school had been using an open-ended approach for 2 years.

When the students arrived at Phoenix Park, many of them were immediately receptive to the open-ended mathematics approach that they encountered, despite having spent the previous 8 years working on more closed and traditional mathematics questions. However, some of the students—most of them boys—found the openness of the work extremely disconcerting. They, like some students in the Lubienski study (2000), said that they were uncomfortable with the lack of structure or direction in the problems and indicated that they would prefer a more traditional approach. These students, along with the majority of their peers at Phoenix Park, lived in severe poverty on a housing estate (similar to subsidized housing projects in the United States), where drug-related and other crimes were widespread and the police would not venture at night. When I interviewed the Phoenix Park students at the beginning of the study, they described their motivations clearly. The following comments from Shaun and Megan, two Year 9 students, are typical. (These names and the others that follow are all pseudonyms; JB is of course the author.)

Shaun: When I go into a maths lesson I usually sit down and I think—who am I going to throw a rubber [eraser] at today?

JB: Can you think of a maths lesson that you've enjoyed?

Megan: Messing about, that's what I enjoy doing.

JB: What would make maths better?

Megan: Working from books—you don't mess about if you've got a book there, you know what to do.

Although some students blamed their misbehavior on the openness of the work, the teachers did not give the students books or structure. Providing such materials and methods may have been the easiest option, but the Phoenix Park teachers believed that the open-ended approach that they used was valuable for *all* students and that it was their job to make the work equally accessible to all. They therefore developed a range of practices that served to increase the students' access to the problems and the methods they were expected to use. In the sections that follow, I describe three such practices in order to highlight these particular practices and to illustrate the importance of the detailed teacher *moves* that could become a greater part of the lexicography of mathematics education (Lampert, 1985). Where appropriate, I also include examples of similar practices from QUASAR classrooms.

Introducing Activities Through Discussion

One practice that was central to the Phoenix Park teachers' approach was introducing students to the activities through discussions in which the teachers themselves participated. This enabled the teachers to decide on the degree of support or structure students needed. In the 3 years that students attended Phoenix Park, they were never left to interpret text-based problems alone. The teachers always spent time with individuals, groups, or the whole class introducing ideas and making sure that all students knew how to start their explorations. Phoenix Park teachers would frequently ask students to gather around the board when new problems were being introduced and when homework was being assigned, in order to

have some discussion of the problems posed. (More detail on the actual ways in which teachers introduced activities in Phoenix Park is given in Boaler, 2002).

Likewise, teachers in the QUASAR classrooms also spent time introducing problems. Margaret Schwan Smith (personal communication, January 18, 2001) reported that she observed one urban middle school teacher who would ask her students to read problems aloud in class and then would hold a discussion about their contexts and any unfamiliar vocabulary. Afterward, she would ask students to discuss what they thought the problems were calling for them to do, and then she would have them work in groups while she circulated to check that individual students understood what they should do. Group and class discussions of the aim of activities, the meaning of contexts, the challenging points within problems, and the access points to which students might turn were employed by Phoenix Park and QUASAR teachers to make tasks equally accessible to all students. These methods stand in contrast with those employed by teachers in many classrooms where students are left to interpret the meaning of problems from their reading of reform texts, which are often extremely wordy and linguistically demanding. The way in which work is introduced to students and the access that students are given to the mathematical ideas that they are intended to explore seems to be extremely important.

Teaching Students to Explain and Justify

A second important feature of the Phoenix Park teachers' practice was that they paid attention to the ways in which students communicated their mathematical thinking as well as the students' understanding of the need for that aspect of their work. The teachers at Phoenix Park were committed to encouraging students to explain and justify their thinking. They frequently urged individual students to explain their reasoning and communicate in more detail because the students were not used to doing so when they arrived at the school. In one of the lessons that I observed, a student gave the teacher his solution to a problem on which he had been working. His paper showed some of his methods, and a correct answer. The Year 10 teacher, whom I call Rosie Thomas, studied it for a while and then said, "Brilliant work, John, but you can't just write it down, there must be some sense to why you've done it, some logic—why did you do it that way?—explain it."

Rosie's comment "there must be some sense to why you've done it" typifies the sort of encouragement the students were given at Phoenix Park. The teachers strove to expand the way in which the students thought about mathematics, extending the students' value systems to incorporate more than the desire to attain correct answers. There was considerable evidence that they were successful in that regard, as illustrated in this excerpt from my interview with Ian, a Year 10 student:

- Ian:* It's an easier way to learn, because you're actually finding things out for yourself, not looking for things in the textbook.
- JB:* Was that the same in your last school, do you think?
- Ian:* No, like if we got an answer, they would say, "you got it right." Here you have to explain how you got it.

JB: What do you think about that?

Ian: I think it helps you.

In one of the lessons that I observed, the teacher asked the students to gather around the board, and then she posed the following question: “If someone new came into class and they asked you what makes a good piece of work? What does Ms. Thomas like? What would you say?” The first student offered “lots of writing”; others offered suggestions such as “have an aim,” “draw a plan,” and “write about patterns.” Each time, the teacher came back with further questions: “Is the amount of writing important?” “What does that mean?” “Why is a plan important?” “What does a good plan look like?” “Why do we record patterns?” The students struggled over many of their explanations, but they sat around the board engrossed in this discussion for some time. The students were clearly appreciative of the opportunity to learn about valued ways of working. As they talked, the teacher kept a record of the students’ suggestions on the board. After approximately 40 minutes of discussion, the teacher told the students that their task was to design a poster describing the different features of “good work.” She also gave them a page that the mathematics department had prepared called “Hints for Investigations.” The handout was divided into three columns—What to say, How to say it, and Making sense of it—that gave various suggestions for students. “Can you make the problem more general?” one entry asked. “Make the original problem more difficult,” another suggested, and “Now explain how or why your algebraic rules work,” a third prompted. The students studied the page and incorporated many of its suggestions into their posters. This lesson focused explicitly on the mathematical *learning practices* (Cohen & Ball, 2000) of explanation and justification, as well as planning, labeling, drawing diagrams, and other practices that the students would need to employ in pursuing their mathematical investigations. Many of the practices were those that are valued in other reform-oriented classrooms, but teachers do not always give them such explicit attention. Teachers may assume that students will understand the need for such practices and other new methods of working. At Phoenix Park, when the teachers found that some students were not communicating their thinking or interpreting numerical answers, they devoted more time to this aspect of their teaching, assuming that the students’ reluctance reflected a gap in their understanding of what was required in the work.

Making Real World Contexts Accessible

One of the reservations that Lubienski (2000) and others have expressed about reform-oriented teaching involves the use of real-world contexts. Many of the reform-oriented curricula that are used in different countries are replete with contexts that are intended to bring some realism into the mathematics classroom. I share Lubienski’s concerns about the potential of these curricula for increasing the gap between low and high socioeconomic students, between boys and girls (Boaler, 1994; Murphy, 1990; Murphy, Gipps, & UNESCO, 1996), and between students of different cultural groups (Ball, 1995; Silver, Smith & Nelson, 1995; Zevenbergen,

2000) if such curricula are not carefully introduced. One of the problems presented by real-world contexts is that they often require familiarity with the situation that is described, but such familiarity cannot always be assumed. In teaching mathematics to a linguistically and culturally diverse class of elementary students, Deborah Ball (1995) found that contexts could be “unevenly familiar or interesting,” a state of affairs that caused some distraction and confusion that “diminished the sense of collective purpose” in her class (p. 672). Ball led her students in explorations of theoretical, abstract, and at times esoteric mathematical concepts that fascinated the children, causing her to conclude that contexts are far from necessary for the encouragement of high-level thinking among young children.

One significant problem arises in many contexts when students are required simultaneously to engage with the contexts as though they were real and to ignore factors that would pertain to real-life versions of the tasks. As Adda (1989) puts it, we might offer students questions involving the price of sweets, but the students must remember that “it would be dangerous to answer them by referring to the price of sweets bought this morning” (p. 150). Yet, mathematics books—particularly commercially produced, reform-oriented curriculum—are full of examples of pseudo-situations that students are meant to consider. Knowing how much consideration to give to the real-world factors presented in questions has now become a form of school knowledge that students need and that appears to be inequitably distributed (Boaler, 1993, 1994; Cooper & Dunne, 1998; Zevenbergen, 2000). The QUASAR teachers addressed this issue by engaging students in conversations about the meaning of the different contexts that they encountered in questions. In one published example, the teacher introduced a question about the most economical way to buy bus tickets—as a weekly pass or as daily tickets (Silver, Smith, & Nelson, 1995). The textbook authors intended students to calculate the most cost-effective tickets, but the students, understandably, considered the variables in the question—such as how often they would use a weekly ticket and the different family members that could use it. Lubienski (2000) draws similar examples from her own classroom of students’ considering given contexts and variables that would pertain in the real world—whether people would want “seconds” (another piece) of pizza, for instance, in what was intended to be a straightforward calculation of dividing a pizza into slices. When a QUASAR teacher realized that students were situating their reasoning in the context of their lives and that there was more than one correct answer to such problems, she changed her expectations and provided students with opportunities to explain their reasoning. Silver, Smith, & Nelson (1995) conclude from similar situations that “increasing the relevance of school mathematics to the lives of children involves more than merely providing ‘real world’ contexts for mathematics problems; real-world solutions for these problems must also be considered.” (p. 41).

At Phoenix Park, the teachers rarely gave the students contextualized mathematics questions from published curricula, but they did attempt to make the different mathematical explorations relevant to the students by relating them to their lives. For example, when introducing work on statistics, the teachers asked the students to collect data that was of interest to them from newspapers and magazines. When

the problems involved patterns and tessellations, they asked students to bring in patterns that they liked. In another situation, one of the teachers whom I observed suggested to a girl who was interested in babies that she investigate the admissions policy of the nursery that was attached to the school. Thus, the Phoenix Park teachers encouraged students to relate mathematics to issues and topics in their lives. They, like the QUASAR teachers, did not expect students to interpret contextualized textbook questions exactly as the textbook authors intended—that is, assuming a certain degree of reality *but not too much* (William, 1997).

Both the Phoenix Park and QUASAR teachers encouraged students to interpret mathematical and real-world variables and their relationship with one another. In doing so, these teachers were able to promote equity and help students view mathematics as a flexible means by which to interpret reality. There are important reasons for moving mathematics instruction beyond the abstract, making it extremely worthwhile to explore the ways in which teachers can accomplish this goal in a manner that treats their students equitably. The recognition that girls and boys, as well as students of different social, cultural, or linguistic groups, encounter contexts differently is relatively recent, and researchers from across the world are considering the implications of this finding (Cooper & Dunne, 1998; Zevenbergen, 2000). The recommendations that are emerging from this work center on ways in which teachers can use contexts more equitably, allowing all students to consider the constraints that real situations involve and to attend to the necessary *code switching* that may be an important and more general feature of “doing school” (Pope, 1999).

The three practices that I have highlighted were intrinsic to the Phoenix Park teachers’ success in engaging students in reform-oriented mathematics investigations even though the students had not engaged in such work before they arrived at the school. After months of careful support from the Phoenix Park teachers, the students who had struggled and been extremely reluctant to accept an open approach started to become more interested in their work and more comfortable with the freedom that they were given. The change in some of the disaffected boys became most obvious when, in the 2nd year of the school (Year 10), they were taught by a student teacher who tried to teach mathematics in a more traditional way. The following extract from my observation notes records how the boys started to complain about the *closed* nature of the work that was given to them. This was very different from the approach to which they had, by then, become accustomed:

The teacher starts the lesson by asking the class to copy what he is writing off the board. He is writing about different forms of data, qualitative and quantitative. The students are very quiet and they start to copy off the board. The teacher then stops writing for a while and tells the students about the different types of data. He then asks them to continue copying off the board. After a few minutes of silent copying Gary shouts out “Sir, when are we going to do some work” Leigh follows this up with “Yeah, are we going to do any work today, sir?” Barry then adds, “This is boring, it’s just copying.” The teacher ignores this and carries on writing and talking about data. The boys go back to copying. The teacher looks across at Lorraine, who is looking puzzled, and asks her if she “is OK”; she says, “No not really, what does all this stuff mean?” This seems to

annoy the teacher, or make him uncomfortable; he turns back to the board and continues writing. Gary persists with his questioning, this time asking, "Sir, why are we doing all this?" The teacher replies, "We are just rounding off the work you have done."

After about 20 minutes of board work, the teacher asks the students to go through all of their examples of data collection that they have done over recent weeks and write down whether they are qualitative or quantitative. Peter asks, "Sir, what's the point of this? Aren't we going to do any work today?" The teacher responds with "you need to know what these words mean." Peter replies, "But we know what they mean, you've just written it on the board so we know."

This series of interactions was particularly interesting to observe because it was the group of boys who had at first been most resistant to open-ended work who now objected to the closed nature of the work the student teacher gave them. The boys repeatedly asked "whether they were going to do any work today," indicating that they did not regard copying off the board as work, probably because it did not present them with a problem to solve. When the student teacher told them to classify data as quantitative or qualitative so that they would learn what the words meant, Peter questioned the point of this because they had already been told what they meant. Yet, the mathematics teaching offered in this example is fairly characteristic of more traditional high school mathematics pedagogy in which the teacher explains what something means to students, they copy it down from the board, and then they practice some examples of their own. The degree of resistance that the students offered seems important to consider. In a different class, the regular teacher was absent one day, and when he returned, one of the boys who had been initially resistant complained about the substitute teacher they had been given. "It was terrible," the boy said. "We had this teacher who acted like he knew all the answers and we just had to find them."

My description of practices that the Phoenix Park and QUASAR teachers used to enhance students' access to the reform approaches—helping them to understand the questions posed to them, teaching them to appreciate the need for written communication and justification, and discussing with them ways of interpreting contextualized questions—includes only a small part of the teachers' repertoires of practices. Nevertheless, these examples provide some indication of the complex support that teachers using reform-oriented approaches may need to provide to students. Ball and Bass (2000a, 2000b) have offered a careful analysis of the mathematical understandings that teachers need when they engage students in collaborative explorations. Their analysis has shown that teaching approaches based on student investigations, exploration, and discussion confer on mathematics teachers additional demands that we are only now beginning to understand. Confrey (1990) observed a teacher who employed constructivist principles and recorded the particular methods that the teachers used to promote student thinking. Some of these methods, including asking students to restate problems in their own words—are similar to methods that were used by the Phoenix Park teachers to great effect. Henningsen and Stein's (1997) analysis has also been valuable in identifying the particular aspects of the QUASAR teachers' practices that supported under-

standing: using tasks that built on students' prior understanding, giving appropriate amounts of time, and modeling high-level performance. Such detailed investigations and descriptions of the ways teachers enact reform approaches are still rare, but they may be essential to advancing our understanding of the demands of reform-oriented teaching and the development of more appropriate learning opportunities for teachers.

DISCUSSION AND CONCLUSION

My brief description of the work of the Phoenix Park and QUASAR teachers is intended to serve as an illustration both of the particular teaching practices that need to be considered in mathematics classrooms and of the effectiveness of teachers who are committed to equity and the goals of open-ended work. Gutiérrez (1996, 1999, 2000, 2002) has provided more detailed and careful analyses of teachers who achieved equitable outcomes using reform curricula in low-income and culturally and linguistic diverse communities. She concluded from her work that our greatest hope for providing equitable teaching environments is to focus on teachers' *practices* (Gutiérrez, 2002), investing our time and resources in the teachers who enact reform curricula. The Phoenix Park mathematics department was relatively unusual. In England, schools rather than districts choose new teachers, and the Phoenix Park department had carefully selected new teachers who wanted to teach through open-ended projects and were dedicated to equity. In addition, the mathematics activities at the school had been chosen and designed by the teachers; these teachers shared a commitment to and knowledge of the activities they used. This is different from the scenario that often plays out in American schools in which the district chooses both the curriculum and the teachers. Reform-oriented curricula are often used by teachers who have received no training in their use and have no commitment to the materials. Although the Phoenix Park mathematics department may be unusual, the results that it achieved are nonetheless an important illustration of what can be done. The role of the teacher in securing high-level equitable teaching environments has been minimized in debates surrounding curriculum (Becker & Jacob, 2000). Yet, it seems that the teachers' mediation of different curricular approaches is central to the attainment of equity. Furthermore, advancing awareness of the particular learning practices that are required to make reform-oriented approaches accessible to all students appears to be an important stage in the process.

Sociologists propose that open approaches to learning not only give access to a depth of subject understanding but also encourage a personal and intellectual freedom that should be the right of all people in society (Ball, 1993; Willis, 1977). Moreover, they suggest that opportunities for higher-level thinking are inequitably distributed in schools, a situation that serves to maintain the structural class inequalities that exist in many societies. Willis (1977) characterizes this state of affairs as a process by which "working-class kids" are prepared for "working-class jobs." Anyon (1981) has supplied some insight into this relationship, finding that schools in poor and working-class areas "discouraged personal assertiveness and intellec-

tual inquisitiveness in students and assigned work that most often involved substantial amounts of rote activity” (p. 203). The situation at Amber Hill school conformed to this finding in that the mathematics teachers offered a structured, procedural approach and explained to me in interviews that they needed to do so because the students were from poor backgrounds and would not have been able to cope with open-ended work. This was not a malicious belief—the teachers simply believed that students did not receive the support at home that they needed to cope with work that was linguistically and conceptually demanding, so they provided them with more structure to help them. The Phoenix Park teachers did not hold these beliefs; they thought that all students could benefit from open-ended work and that the students’ home lives should not be a barrier to their pursuit of mathematical explorations.

Anyon and others suggest that teachers tend to offer working-class students more structure, presenting mathematics as a closed domain with clear rules to follow. Other researchers have noted a relationship between the level of the mathematics and the degree of structure provided. Thus, some teachers believe that students who experience more difficulty should be given more structure (Confrey, 1990; Orton & Frobisher, 1996). This view is easy to understand, particularly by those of us who have been in teaching situations when a student has expressed frustration at trying to understand a concept and the provision of a structured procedure would have encouraged immediate success. But my observations of teaching and learning within high and low attainment groups of students and my interviews with students in these groups (Boaler, William, & Brown, 2000) have demonstrated the importance of questioning the relationship between level of achievement and structure. In addition, the Phoenix Park teachers demonstrated that students of all levels and from all backgrounds could be assisted to develop a conceptual understanding of the mathematics with which they were engaged. These teachers did not succumb to the temptation to spoon-feed students who sought such help, and the rewards of their hard work were the students’ achievements. This is not to suggest that teachers should never make decisions to provide students with additional structure, only that such decisions should not correlate with mathematics level or social class. As long as we set conceptual understanding as a goal for students, it is imperative that it be a goal for *all* students. Teachers who are aware that students of low SES or low achievement levels encounter difficulties in interpreting open work must accompany this knowledge by a drive to understand the students’ experiences and provide action to make the teaching of open-ended approaches equitable.

The different teachers whose work I have reviewed in this article all spent time sharing understanding of the learning practices that students needed for their work on open-ended mathematics problems. The advances that they made in giving equitable access to these approaches demonstrate two important points. First, an understanding of the ways in which open-ended approaches promote equity will involve a consideration of the *detailed* practices of teaching and learning that occur in classrooms (Chazan & Ball, 1999). Researchers and others will need to delve inside the general teaching approaches that have been the subject of discussion of recent years. Second, such work may contribute to helping mathematics teachers replace the

“pedagogies of poverty” (Haberman, 1991, p. 290), which often predominate in low income and minority communities, with pedagogies of power.

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