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Regular Lecture

Theory meets practice: What happens when a mathematics education researcher gets involved in professional development?

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Abstract

For nearly 30 years I have been involved in the study of mathematical thinking, teaching, and problem solving. Much of that research has taken place in classrooms. More recently, I was involved in the writing of Principles and Standards for School Mathematics *(NCTM, 2000), an attempt to describe appropriate mathematical curricular experiences for students in the U.S. I have also engaged in very detailed studies of mathematics teaching. One would think that, with this background, I would be well positioned to work with schools on the professional development of their mathematics teachers. But one would be wrong.*

This paper describes my recent immersion in professional development. The context is that of a racially and socioeconomically diverse urban school district, which has three middle schools (grades 6-8) that have been the focus of our efforts. In what follows I shall describe: the importance of diversity in the American educational con text; a set of conditions that I believe have the potential to ameliorate racial performance gaps, and to promote sustainable instructional improvement; the motivation for and goals of the Diversity in Mathematics Education (DiME) Center; the local context within which DiME works in Berkeley; and my experiences, which may be of some interest in the light of those conditions.

Introduction

Participants in the International Congresses on Mathematical Education presumably share at least one common purpose. Whether they are mathematicians, educational researchers, curriculum designers or teachers, they have views of what makes mathematics rich, interesting, and rewarding – and, one assumes, the goal that students will come to experience mathematics in ways that will reveal the rich, interesting nature of mathematics to them.

Each of us also has an idea of what it takes to make a difference along these lines. Those whose daily work lies at some remove from the elementary and secondary classroom (in broad-brush strokes, mathematicians and educational researchers) tend to have various ideas about what it takes to move from having a good idea to having that idea become implemented in practice. My purpose in writing this paper is to suggest, as Douglas Hofstadter (1979) does in *Gödel, Escher, Bach*, that "no matter how complicated you think it is, it's more complicated than you think." It is important to understand aspects of this reality if our knowledge is to make a difference in the world of practice. This paper describes some of my experiences in working with local schools, and (mindful of the fact that the U.S. stands apart from the rest of the world in many ways with regard to schooling, and that any one individual's experience provides scarce grounds for extrapolation) tries to extract some lessons from them.

Let me start with some personal background. My Ph.D., which I obtained in 1973, is in pure mathematics. I began my research career in education in 1975. After a year of conducting problem solving studies in the laboratory, I developed and began conducting research on a problem-solving course at the university level. The issues raised in that course led me into local secondary schools in the early 1980s. To better understand student thinking and the origins of some student understandings about mathematics, I then spent a full year observing a geometry course – and much of my time, in general, in secondary schools. By the late 1980s my research group was working with local schools in the San Francisco Bay Area, designing and testing a curricular unit on linear functions. This, too, meant working and spending much of our time in classrooms. I have, since, conducted a series of detailed studies of teaching – the goal being to understand, at a theoretical level, how and why teachers make the decisions they do while engaged in the act of teaching. I have served as a volunteer in classrooms for more than a decade. At some level, then, I have been well schooled in the realities of the American classroom. In addition, I have spent time thinking about issues of research-and-practice (Burkhardt AND Schoenfeld, 2003; Schoenfeld, 2002). Yet, I was in for some surprises when I began to work closely with local schools.

The (U.S.) national context for the work discussed here.

One of the enduring problems in American education has been the existence of racial, gender, socio-economic, and other performance gaps in school performance. In a truly equitable society, all students would have comparably rich opportunities to learn. In such a society, one might expect the distribution of achievement (in school or elsewhere) to be comparable for all sub-populations – for various ethnic and racial minorities, for males and females, across various levels of wealth, etc. Such is not the case, anywhere in the world. In the United States, as in the rest of the world, gender-related issues have been in flux. Over the course of the 20th century, women have increasingly gained access to mathematical resources: in some industrialized nations they have achieved parity (or beyond) with males with regard to enrollments and achievement at the elementary, secondary, and college levels (see, e.g., Hanna, 2004). The same has not been the case, in the U.S., with regard to racial and ethnic and socio-economic status. Whether one reads "rich, thick" popular descriptions of inequities in society and schooling (e.g., Kozol, 1992) or studies rich with statistics (e.g., Lee, 2002), the story is clear: under-represented minorities (African Americans, Latinos, and Native Americans) and poor children are provided far less by way of educational opportunity than other citizens. Statistically speaking, their graduation rates and performance on standardized tests are far worse than the norm. Indeed, noted American civil rights leader Robert Moses has declared access to high quality mathematics education to be a central civil rights issue:

> "Today … the most urgent social issue affecting poor people and people of color is economic access. In today's world, economic access and full citizenship depend crucially on math and science literacy. I believe that the absence of math literacy in urban and rural communities throughout this country is an issue as urgent as the lack of Black voters in Mississippi was in 1961. (Moses, 2001, p. 5)."

Compounding the issue of social and educational inequities is the increasing phenomenon, in the United States, of high stakes accountability testing. In much of the world, there have long been standardized tests that have major consequences for students. Typically a student's score will, in early exams, determine whether he or she will go to vocational school or pursue an academic track; later on, scores may determine college admissions and placement. The system has been much more decentralized in the United States. Each of the country's 15,000 or so school districts has had a fair amount of autonomy in curriculum coverage, in assigning grades, and in policies regarding graduation. Commercial examinations such as the SAT (Scholastic Aptitude Tests) have played a role in college admissions, but not in certifying knowledge of the curriculum. Recently, however, there has been much greater standardization of curriculum and assessment, at the state (not the national) level. Many of the 50 states now have curriculum frameworks and standards, and examinations that are used to determine whether a student knows enough material to be given a diploma. In California, for example, secondary school students have to take the California High School Exit Exam (CAHSEE). If they fail the exam they will not receive a diploma, but will receive instead a certificate of attendance.

The mathematics portion of the California High School Exit Exam, and many other such exams around the U.S., focuses in significant measure on the contents of a first algebra course. Hence learning algebra becomes a "make or break" situation for students. Indeed, if students see themselves as having little chance of passing the exam, they have little incentive to stay in school. Hence the high stakes testing environment runs the risk of exacerbating inequities, unless significant steps are taken to improve the situation of those students who are currently getting the short end of the mathematics education stick.

Conditions for improvement

Can school districts in the US make progress on seemingly intractable issues such as the racial performance gaps described above? I believe the answer is yes, if the right conditions are in place. Justification for this belief comes from the story of Pittsburgh, Pennsylvania. In what follows, I summarize some of the main lessons from the "Pittsburgh story" in brief. More detail can be found in Briars, 2000, 2001; Briars and Resnick, 2000; and Schoenfeld, 2002.

Pittsburgh provides evidence of what can happen when the conditions are right for consistent improvement. Those conditions are highlighted in Table 1.

1. A well designed, mathematically rich set of standards for instruction
2. A well designed curriculum aligned with the standards
3. Well designed assessments aligned with the standards
4. Well designed professional development aligned with the standards
5. Enough time and stability in the system for all of the above to take hold

Table 1. Systemic conditions that support improved student performance and a reduction of racial performance gaps.

By the mid-1990s, Pittsburgh had had stable professional development and assessments in line with the NCTM *Standards* (National Council of Teachers of Mathematics, 1989) for some time. (The *Standards* were the catalyst for "reform" in American mathematics education.) What was lacking was a robust curriculum; no such curricula were available, nationwide. But such curricula became available in the mid-1990s, and when they were implemented the final pieces of the puzzle fell into place. Test scores rose for Pittsburgh students at all points on the performance spectrum. The number of students who scored in the lowest quartile of a nationwide sample dropped substantially. Average scores rose quite a bit, and the number of students in the top quartile rose substantially. Students did much better on skills than they had previously. And not surprisingly, they did much better than before on measures of concepts and problem solving, since these aspects of mathematical thinking had not been foci of the earlier, traditional curricula.

Even more interesting are the results of a natural experiment comparing schools in which the new curricular materials were wholeheartedly adopted with schools in which the opposite was the case. In every large district, some teachers (and schools) will adopt a new curriculum, while others will (perhaps) go through the motions, while keeping to their old curriculum and assuming that "this too shall pass." In Pittsburgh, such schools were identified by site and classroom visits. Data on skills, concepts, and problem solving were analyzed for the "weak implementation" and "strong implementation" schools during the first year of curriculum adoption, 1998. A sample of schools was matched for demographics, both on race and socioeconomic status. Here are the data for fourth grade.

In the weak implementation schools, about 48% of the White students and 30% of the African American students met the skills standard. In the strong implementation schools, 71% of the White students and 74% of the African American students met the skills standard. *Both African American and White students did much better in the strong implementation schools, and racial performance gaps were eliminated.*

In the weak implementation schools, about 18% of the White students and 4% of the African American students met the problem solving standard. In the strong implementation schools, 50% of the White students and 30% of the African American students met the problem solving standard. *Both African American and White students did much better in the strong implementation schools. In terms of proportions, racial performance gaps were reduced substantially.*

In the weak implementation schools, about 18% of the White students and 4% of the African American students met the conceptual understanding standard. In the strong implementation schools, 62% of the White students and 38% of the African American students met the conceptual understanding standard. *Once again, African American and White students did much better in the strong implementation schools. And once again, In terms of proportions, racial performance gaps were reduced substantially.*

Those results indicate that when the conditions in Table 1 are in place, one can expect significant improvement in student performance, and a possible narrowing of racial performance gaps. Pittsburgh is an existence proof – but it is also a rare example. My experiences with NSD, described below, indicate how difficult it is to achieve those conditions. They also point to some of the difficulties in getting such conditions established – problems of systemic instability, challenges in building a climate of trust conducive to open exchange, and issues of teacher knowledge in relation to building internal capacity for sustained change within a school district. I note that these are not new issues – merely that they became particularly salient for me as I tried to be helpful.

Our grant proposal

In the context described a consortium of three U.S. Universities – The University of Wisconsin at Madison, the University of California at Berkeley, and the University of California at Los Angeles – applied to the U. S. National Science Foundation (NSF) for funding for an NSF Center for Learning and Teaching (CLT) entitled Diversity in Mathematics Education (DiME). The primary goals of the project were as follows:

- To help *all* students be successful in the mathematics that leads to and includes the study of algebra;
- To build university-school district partnerships for teacher preparation and professional development;
- To prepare a new generation of researchers to work on issues of diversity and mathematics education;
- To create professional development materials.

Berkeley did not have a history of professional development efforts; our attention had gone into the creation of a small but highly effective teacher preparation program. We proposed to redesign our teacher preparation program so that it would have attention to issues of diversity as a core component. We also arranged a partnership with the interim superintendent of a nearby school district (henceforth referred to as NSD) as follows. Each year NSD would identify a teacher whose time the grant would buy out, and who would serve as a teacher-in-residence on the U.C. Berkeley campus. That teacher would make sure that we were connected with the realities of the schools. He or she would return to NSD the following year, able to serve the district as more of an expert on diversity-related issues; another teacher would take his or her place. The interim superintendent signed a letter of support, and our proposal went in to the National Science Foundation. Then we waited to hear about the funding decision.

The local context

Our Nearby School District, NSD, has eleven elementary schools (grades K-5) with a total enrollment of nearly 4000 students[1]. The elementary schools feed into three middle schools (grades 6-8), which have a total enrollment of slightly less than 2000 students. The middle schools, in turn, feed into one high school, which serves more than 3000 students. The district serves a highly diverse population – roughly 40% White, 40% African American, 10% Asian and 10% Latino. Fifteen percent of the students enrolled are English learners. The population is also diverse economically: while some parts of the district are reasonably affluent, 38% of the students are eligible for free or reduced price meals. The district is unusual in that its voters consistently support bond measures that provide supplementary funding for the schools, thus ameliorating some of the difficulties caused by the State's very lean fiscal allocations to schools. In contrast to poor urban districts, more than 93% of the NSD teaching staff have full teaching credentials.

Despite many years of very well-intentioned efforts, NSD still struggles with issues of equity – specifically with racial performance gaps – on test scores, in course grades, and in dropout rates. As noted above, the High School Exit Exam (CAHSEE) is a high stakes exam, with serious consequences for the students who fail it. Students have multiple opportunities to take the exam, and one expects success rates to rise

[1] The data given here are drawn from the State of California web site, http://www.ed-data.k12.ca.us/welcome.asp

once the exam has been in existence for a few years and students and teachers become familiar with it. Thus the scores reported in Table 2 below are most likely more dramatic than they will be in the future. However, they paint a clear portrait of racial performance gaps in NSD, as of the 2002-2003 school year.

	All Students	African American	Latino	White
Fail Math Exam:	36%	55%	60%	6%
Fail English Exam:	23%	32%	48%	3%

Table 2. Failure Rrtes, California High School Exit Exam, NSD High School, 2002-2003

Narrative, Part 1: A new beginning

In March 2002 the DiME team was notified that its grant proposal had been funded. By that time, NSD had a new superintendent. We contacted her with the good news. The superintendent, who is smart, tough, "hands on" and detail-oriented, asked for a copy of the proposal that we had submitted. We sent it to her.

Simply put, she didn't like the proposal. Among other things, she noted that there was a shortage of qualified mathematics teachers; she could not spare one to spend a year at the university.

We regrouped, and sent the superintendent an alternative proposal. Instead of bringing one NSD teacher up to the Berkeley campus, we would "release" two teachers at each of NSD's three middle schools from teaching for one period a day. Those teachers would work with their colleagues at their school sites, focusing on issues of diversity. We would create a new seminar, which would provide professional development on issues related to middle school mathematics and diversity. DiME graduate student fellows would work in NSD classrooms. And more.

The letter got our foot in the door, and the superintendent agreed to see us. Our conversation went well. The superintendent is passionately committed to a strong vision of equity, and when we got down to substance – and the Pittsburgh data discussed above – the tenor of the conversation changed and possibilities opened. Even so, we still faced one major hurdle, trust. School districts have often been "burned" by academics who have been given access to the district, and then write harsh critiques. Why should they trust me? Interestingly, my academic credentials were of little value with regard to that issue. What did count was that as a parent I had volunteered in district classrooms every week for a decade. *That* was taken as a sign of good faith.

Narrative, Part 2: The district bites the equity bullet.

In late May 2002 we met with the superintendent to make plans for the following year, DiME's first year in the schools. Up to that point, NSD had begun tracking mathematics classes in 7th grade (see Figure 1). The Superintendent indicated that she did not believe in tracking. Moreover, the California Mathematics Standards indicated that all eighth grade students should study algebra. This, said the superintendent, should be the case as of the coming fall[2]. Whereas students in seventh grade had previously been tracked into either “pre-algebra” or “middle school mathematics” (a course designed to help low-performing students get ready for pre-algebra), all seventh graders would now go into pre-algebra, and all eighth graders would be enrolled in algebra. Figures 1 and 2 represent the current and goal states as of May 2002.

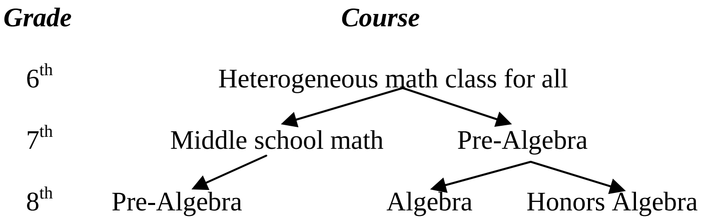


Figure 1. Course offerings in NSD Middle Schools, May 2002

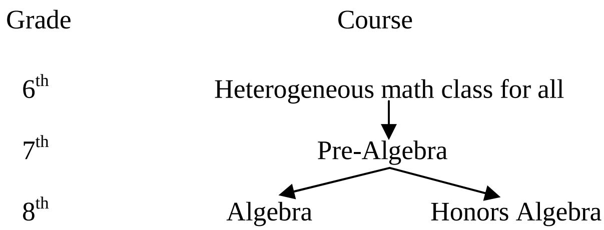


Figure 2. Goal State for NSD Middle Schools

The difficulty was that if this plan was implemented in Fall 2002, the students who had been enrolled in middle school mathematics in Spring 2002 – the ones at the low end of the performance spectrum – would have to skip pre-algebra to enroll directly in algebra. This plan was judged to be untenable. Thus NSD created what it hoped was a 1-year transitional plan. In 2002-2003, the students who had been enrolled in pre-algebra would take a special course, Algebra 1A. There they would spend a year covering the content of the first semester of the regular algebra course, “filling in” the pre-algebra skills they needed along the way. Having done so, they would leave middle school a semester behind the ideal sequence instead of a year behind it. The next year’s cohort would take the sequence outlined in Figure 2. This represented a bold attempt to move to the goal state, but (in hindsight) a destabilizing one. And stability is essential for making deliberate progress.

Narrative, Part 3: Destabilizing factors

As noted above, schools close down over the summer in NSD. This had two consequences. First, it meant that there was neither piloting nor systematic planning for the new course, Algebra 1A. Since the textbook was a known entity, it was

[2] Note that the school year ends in mid-June, three weeks after our conversation. Teachers without other district-related responsibilities would be “off” until school began again.

assumed that teaching the standard course at half the usual pace should not be a problem. This turned out to be incorrect, because the student population (homogeneously at the lower end of the performance spectrum) and their background (they were missing the preparation that would have been afforded by a year of pre-algebra) raised significant instructional challenges, requiring more support than the text itself provided. Second, the summer shutdown plus an unusual level of administrative turnover made planning for teacher support and professional development near-impossible. Two of NSD's three middle schools were assigned new principals during the summer; in once case, the principal did not meet her staff until shortly before the school year began. The principal in the third school was about to enter her second year in office. As the school year was getting under way and principals were getting to know their staffs, we needed to get DiME set up – identifying Teacher Liaisons (the six teachers who would be released one period a day to work with us, requiring ad hoc schedule changes), placing DiME graduate students in classrooms, etc. One incident sums things up. The first week of classes I had my first meeting with one of the principals. As we walked past the copying room on the way out, she looked in, saw a teacher, and brought him out. "This is Alan, who's doing DiME. How'd you like to work with him?" A "just-in-time" supply chain may work in industrial production, but it hardly provides the support for planning that is necessary for consistent systemic change.

Narrative, Part 4: The seminar begins and we confront the realities of Algebra 1A.

My plan for the first year of DiME was to engage the middle school teachers in a variant of lesson study, adapted (a) for the America context, and (b) to focus specifically on issues of diversity. (For detail on lesson study see Stigler and Hiebert, 1999; Fernandez and Yoshida, 2004.) That is: we would establish lesson goals, look for parts of lessons we might borrow, design lessons focusing on core mathematical ideas in light of our best understanding of student understanding, have a volunteer teach the lesson(s) while we observed closely, examine where things seemed to be working or not, and make adjustments; and iterate the process until we had a nicely effective lesson. I hoped this plan would have multiple benefits. The idea was that it would explore different approaches to key topics for different groups of students, make sure we included all students in our examination of curriculum (a key aspect of diversity), and provide a meaningful look at student thinking for the teachers.

Well, that was the plan. When we got together in the seminar, it was clear that the teachers had much more urgent matters on their minds. Algebra 1A was, in at least two ways, the legacy of the tracking system. The course was critical from an equity perspective: due to past tracking, it was almost uniformly populated by minority students. Students in the course had homogeneously low grades in mathematics, either for reasons of mathematical performance or for disciplinary reasons. As noted above, the students who had been placed in Algebra 1A had not yet studied "pre-algebra." Also as noted, the Algebra 1A teachers had had little opportunity to prepare for the course. Some of the most experienced teachers in the district had volunteered to teach Algebra 1A but, they were experiencing major difficulties with it.

NSD schools are arranged like most schools in the U.S. With some exceptions, its teachers tended to be professionally isolated – each alone in his or her own classroom, struggling to make things work, separated from others engaged in the same difficult task (Lortie, 1975). Each of the Algebra 1A teachers in each of the three schools was struggling in his or her own way – and there were few opportunities for teachers from different schools to collaborate. Thus the DiME seminar became, de facto, the place where the teachers could trade notes. "Where are you in the curriculum? Have you managed to use small groups effectively, as the curriculum suggests? What kinds of skills do your students have? How did they do on this or that problem? Do you have any suggestions for dealing with discipline problems, or…" Such exchanges dominated our early seminar time, for good reason. So I waited before embarking on my intended agenda. Later in the year, as things settled down, I inched toward my goal.

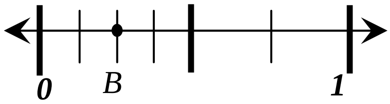
For me, mathematics professional development, PD, is about a combination of things: thinking deeply about the mathematics in question, thinking about how students come to grips with that mathematics, seeing what their engagement with the mathematics reveals about their understandings, and (once one knows "where they are" and where one would like them to go), thinking about how to help move the students from where they are in profitable directions. No matter what form of PD I would engage in, then, looking at student work would be a core component. To set the stage for lesson study, then, I proposed a straightforward activity. In NSD as in all of the U.S., the curricular topic of rational numbers (fractions) is acknowledged to be a sticking point in upper elementary and middle school. Many students have difficulties when they first encounter fractions, and many continue to do so all the way through middle school. The DiME staff was in a position to put together a collection of tasks ranging from simple algorithmic computations to complex conceptual questions. NSD teachers could use these tasks to examine in depth what their students really know. This effort could be useful across all of middle school; we could see what students picked up over time, what remained problematic, and so on. Thus, after informal consultation with some of the teachers, I proposed that we give students such tasks, bring the student work to the seminar, and explore what that work revealed about their understandings.

The first, and rather strong, reaction I got came as a bit of a surprise: "We haven't taught it yet, so we can't test it." At that point it was not clear to me why some of the teachers resisted doing these assessments; surely their students had encountered fractions in earlier grades! But, we persevered, and the results were interesting.

Problems 1 and 2 below, which provide the opportunity to look at students' understandings of the conceptual underpinning of fractions and their abilities to work with different representations of fractions, were provided to DiME by Geoffrey Saxe.

Problem 1. Write a fraction for the shaded part of the region to the right.

Problem 2. Write a fraction for point B.



As one might expect, students who were procedurally fluent still made mistakes on problem 1, saying that the shaded area was 1/4 of the given region; and a fair percentage of those students, comfortable with the "part/whole" representation of fractions, had trouble with the analogous problem in Problem 2. These and other problems revealed interesting issues related to student understanding, and (once the initial resistance to using the tasks was overcome) provoked a profitable conversation. With this behind us, I thought the group was ready to embark on lesson study. I proposed that we begin lesson study, with fractions a possible topic for instruction.

The result: A resounding "No." At first I was mystified, and then I realized what was happening. Engaging in lesson study involves a great deal of trust. A lesson is taught, and then scrutinized in extreme detail. In general, teachers in the U.S. are not used to such things. When shown a video of teaching they tend to be highly judgmental, saying things like "She did that wrong," "That's not how I would teach it," or more strongly, "That's not how to teach it." Many of the teachers in the DiME seminar expected their peers to be highly critical of any lesson we taped, and they expected us university types to be even more critical. There was no way they would expose themselves to potentially withering commentary. Never mind our assurances that things didn't work that way – the response was just "no." Moreover, we realized in hindsight that fear of being judged was the reason that some teachers had resisted giving the fractions tasks. The teachers were concerned that we would blame them for their students' lack of understanding.

On to Plan B. While looking at videos of teaching might cause them to be judgmental, we thought that teachers might take a different tack if they were looking at videos of students working on problems. So, I asked a teacher I knew well (I had volunteered in his classroom the previous year, and was observing in one of his classes that year) if I could videotape groups of students in two of his classes (Algebra 1A and Honors algebra) working a series of problems. The compare-and-contrast might prove interesting.

He said that I could make the tapes and share them with the other teachers. So, we taped students working these two tasks:

- Jamal went to the State Fair. It cost $5 to get in to the fair. Each ride cost $2. If Jamal spent a total of $21, how many rides did he go on?

- The length of a rectangle is five inches longer than twice the width of the rectangle. The perimeter of the rectangle is 112 inches. What are the dimensions (the length and the width) of the rectangle?

The first task was barely a warm-up for the honors algebra students. A group of four students finished working it (and comparing answers) by the time I had my camera set up. The second task took them about three minutes. The group dynamics were wonderful to behold. The students stopped half-way through the problem to compare their algebraic formulations of the problem, de-bugged each others' work, and confirmed the answers. They went on to a third, much more difficult problem that the teacher had ready – he had known that these tasks would provide no challenge.

The Algebra 1A class was something else altogether. When we handed out the problem, we asked a student in each group to read the problem out loud. A few seconds after one student in a group of four finished reading problem 1, a student announced "He went on ten rides" and called me over to check her solution. I reminded her that this was a group effort, and that she should work through the problems with her groupmates. She announced her solution. Another student responded that the $5 entry fee had to come off first – and that once you took off the $5, there was enough money left for 5 rides. These two students worked at resolving their differences while a third student faded in and out (at one time counting off the costs of rides on his fingers by 2's: "2, 4, 6, 8, 10, 12, 14, 16, 18, 20, it's ten rides" and later announcing, out of the blue, "Oh, it's the total") and the fourth student, an English language learner, worked by himself. It took seven minutes for the first two students to work things through to a correct solution, including their dividing sixteen by two by counting off twos. When they finished the third student started copying their solution and got roundly chastised by them for it. The fourth student was completely ignored by the others.

We showed the tapes at the DiME seminar. They were a wonderful stimulus, for a variety of reasons. Algebra 1A teachers at the other schools looked at the 1A tape and said, "those could be my students. I face exactly the same issues." For the next few DiME seminar meetings, we explored the issues raised by the tapes. Those issues concerned teachers' perceptions of consistent differences between honors and 1A students along the following dimensions:

- the ability to model the situations described in the problem statements (reading skills, abilities to make sense of situational contexts described in words);
- the ability (and willingness) to communicate with fellow students;
- basic skills;
- the ability to remain focused on tasks for more than a few minutes; and
- issues of the students' identities, and how they affected classroom behavior.

The tapes also provided grist for serious and thoughtful conversations about teaching and tracking. Topics raised and discussed included:

- the advantages and disadvantages of homogeneous groups;
- the use and consequences of different management styles;
- finding ways to support feelings of accomplishment for 1A students;
- asking if the teachers did or should use different facilitating tools for the different classes;
- asking if they had different standards of accountability, if they asked different kinds of questions (perhaps providing different opportunities to learn);
- whether more "spoon-feeding" in the 1A meant fewer opportunities for student independence; and
- asking what diversity issues emerge (besides the obvious demographic ones) and how they might be addressed.

These conversations, along with conversations about another set of tapes, took place over a period of four meetings. They were rewarding. When we were done there was a feeling of community: this group could now discuss delicate issues openly, and without blame or recriminations. At the end of the fourth such meeting, one of the teachers who had actively resisted the idea of lesson study volunteered, "Alan, we're ready for lesson study."

Narrative, part 5: The fiscal fates intervene.

California state law mandates that local school budgets must be balanced; budget deficits are illegal. State law also mandates that if teachers are to be dismissed, they must be notified of the possibility in March.

Two things happened in 2002. First, there was a downturn in the State's economy. Second, the new superintendent's close examination of the budget led to the discovery of an illegal $6 million deficit. The deficit amounted to the salary equivalent nearly 40% of the district's teaching staff. To give itself "wiggle room" in finalizing its budget for the following year, the district distributed notices of possible dismissal to nearly 40% of the teaching staff that March. (See Zenkin, 2002.)

This meant that, just as the DiME teachers were about to engage in the very labor-intensive effort to engage in lesson study – on a volunteer basis – 40% of them were told they were about to be dismissed. You can imagine the impact on the teachers' morale and motivation. It was a hectic time of year. The state's high-stakes testing was just around the corner; teachers' work loads were high; and now this. Teacher morale was affected, and the lesson study effort lost momentum. Things eventually got sorted out, but DiME limped through the balance of the year.

Perhaps most distressing is the fact that there was no need for any of the credentialed mathematics teachers to receive pre-dismissal notices. This is for two reasons. One is simply a matter of fiscal prudence. It seems reasonable to assume that, however the budget is ultimately cut, half the savings will come from expenditures other than teaching salaries. Under this assumption, at most 20% of the teaching force in general needed to be warned of possible dismissal. The other reason is that while teachers are ordinarily dismissed by order of seniority ("last hired, first fired"), there are principled exceptions to this seniority rule. If a district can show that there will be a teacher shortage in a high priority subject area, then teachers of that subject can be exempted from dismissals. (After all, the district would just wind up hiring them back to meet teaching needs). There was a shortage of credentialed mathematics teachers, so mathematics teachers could have been exempted from the list of those receiving pre-dismissal notices. (Indeed, the district wound up re-hiring all of the credentialed mathematics teachers who had not left the area when they received dismissal notices.)

A second consequence of the NSD budget crisis was that NSD cut the number of DiME teacher liaisons (the NSD staff released to work with DiME, called TLs) in half. Recall that our grant originally provided funds for one teacher to be released from teaching to come work with the university. A one-period released is considered 20% release time, so our grant funds would be considered the rough equivalent of releasing five teachers one period a day. The district had agreed to release six teachers (two at each middle school), absorbing some of the costs itself. There was good reason for this. With two TLs at each school, one gets much more than double the impact than with one TL. As discussed below, curriculum expertise tends to be localized: sixth grade teachers do not necessarily know seventh and eighth grade curricula, and vice-versa. Two DiME TLs in a department can span the grade levels. Moreover, they can play "tag team" (taking turns in making DiME-related requests, and supporting each other when the requests are made) at department meetings and guarantee that DiME-related items get attention. Thus when the district reduced the number of TLs to one per school, the DiME presence during departmental meetings was dramatically reduced.

Narrative, part 6: Staff and structural issues undermine attempts at coherence and professional development.

DiME efforts proceeded through the 2003-2004 year. Our focus remained, as it had been from the beginning, using student work on rich mathematical tasks to delve into (a) the mathematics, (b) student understanding, and (c) pedagogy. There were ways in which we made significant progress. But we also faced some major structural difficulties that impeded progress.

Middle school in the U.S. represents a transitional phase between elementary school, which has a largely developmental focus, and high school, which has a primarily academic focus. For good reason – to provide a smooth transition from elementary to middle school – grade 6 lives apart from grades 7 and 8 to varying degrees at each of NSD's three middle schools. Sixth grade classes may follow slightly different bell schedules. They are either self-contained or "paired core" (where a math/science specialist and a humanities specialist share two classes), while students in grades 7 and 8 move from course to course, and taught by subject matter specialists. There is, in general, more communication within grade than across grades. Teachers at a school will often discuss grade-specific curricular issues, but there is not, in general, much opportunity to take the long view and see the middle school curriculum as a whole. This has some serious unintended consequences. In terms of subject matter content, the grade six-to-seven split on an NSD middle school campus can be as large as the grade five-to-six split from the elementary schools to the middle schools.

By and large, the 6th grade teachers in NSD have migrated upward from elementary school. They tend to have generalist backgrounds rather than specific subject area foci. Broadly speaking, they are excellent at developmental and "whole child" considerations. But, although there are some notable exceptions, they tend to have comparatively weak subject matter backgrounds. For the reasons described in the previous paragraph, they may have scant knowledge of the curricula at grades 7 and 8. This is a serious issue. It is difficult to make decisions about which "big ideas" (see, e.g., National Council of Teachers of Mathematics, 2000; National Research Council,

1989) to emphasize in any grade when you don't know where those big ideas are supposed to lead.

By and large, the issue for 7th and 8th grade teachers is the reverse. Typically these teachers have single-subject mathematics credentials. Hence their content knowledge tends to be their strength – but with some notable exceptions, their developmental orientation less so. In sum, each group has much to learn from the other. Yet, as noted, the teachers seem at times to inhabit different worlds, despite living in the same buildings.

The issue of teachers' content and curricular knowledge is always critical. It becomes that much more critical, however, when teachers at the site level have almost complete curricular autonomy. In the 2003-2004 school year, the three middle schools were using two very different curricula at sixth and seventh grades – one a state-sanctioned traditional text, one a reform text that had been introduced on a pilot basis. At the very end of the school year, the teachers at one of the middle schools announced their decision to buy and implement an alternative curriculum for grade 6 at their school site. (This decision was made without consultation or prior consent. It was made in contradiction to recommendations made by the NSD mathematics articulation committee, and without the knowledge of the NSD Director of Curriculum!) At the school in question, the grade 6 textbook would no longer dovetail with the grade 7 textbook being used. Equally important, this last-minute decision meant that the teachers had precious little time before the summer break to identify the main ideas in the new curriculum, line them up with the California Standards and with the 7th and 8th grade curricula, and make modifications of the curriculum to ready themselves for the next year's instruction. Not only was the timeframe unreasonable, but (see the discussion two paragraphs above) there was serious reason to question whether the teachers' content and curriculum knowledge was robust enough to support this kind of effort.

In short, autonomous curricular decision-making at the various school sites created curricular incoherence and a professional development nightmare. A district with three middle schools would now be using three different curricula at sixth grade and two at seventh, some with different philosophical bases and all with different ordering of topics. At those two grades, students in the different curricula would be at different "places" mathematically at almost every point in the school year. Imagine trying to develop a coherent district-wide plan for curriculum-related professional development under those circumstances! Indeed, the teachers at the school in question (the largest in the district) have demanded professional development that is tied to their curriculum choice, earning the resentment of their teaching colleagues.

The project continues, with attempts to find a middle ground – to find activities that are meaningful to all of the teachers, and that focus them on issues of student thinking. We have done so, with some success; but with much less success than might have been the case if there were (a) curricular coherence, (b) stable lines of communication across the school district and with the project, and (c) clear lines of authority and responsibility within the district, so that decisions could be made on at least a somewhat rational basis and then enforced. These are lessons to the author, in terms of his future work; they may be lessons for others as well.

Discussion

Although the stories I have told were all derived from my experience with one school district, the district itself serves merely as a case in point, and the stories merely a way of providing detail. When I have discussed these issues at ICME and elsewhere, friends who spend their lives in school districts (either as teachers, administrators, professional development providers or curriculum developers/implementers) have responded by saying "I assume you weren't surprised. That kind of chaos is a fact of life everywhere in the U.S."

It may be a fact of life, but it is one we need to examine and do something about. There are lessons in this story both for administrators and for researchers. Earlier in this article I noted a series of conditions necessary for the sustained development of a teaching force, and for instructional improvement:

- A well designed, mathematically rich set of standards for instruction;
- A well designed curriculum aligned with the standards;
- Well designed assessments aligned with the standards;
- Well designed professional development aligned with the standards;
- Enough time and stability in the system for all of the above to take hold;

Unless and until district and school administrations put mechanisms into place to insure conditions of this type they will, however unintentionally, be sabotaging their own well-intentioned efforts to make things better. As indicated by this narrative, some preconditions will be necessary to facilitate the above:

- Policy and curriculum coherence;
- Some balance of top-down and bottom-up curriculum control;
- Mechanisms for developing teacher knowledge. This means more than deepening an understanding of particular topics, and how to mine specific curricula for their riches. It also means developing a sense of the "big picture." Teachers need to know not only how students have experienced mathematics in their previous courses, but which ideas, in which ways, will be central in years to come. Only then can they lay a truly solid foundation for future study.

For researchers, there is a different kind of lesson. For far too long, many educational researchers have done their (our) work under the assumption that the knowledge we uncover will eventually make its way into practice. At some level, there is truth to that assumption: the revolutionary work on mathematical thinking and problem solving conducted in the 1970s and 80s has indeed made its way onto *Standards* and into curricula, and we are better off for it. However, to call research-and-practice a "loosely coupled" system is an understatement. If we researchers are to make good on our wish to improve things in classrooms, we need to devote much more time and effort to understanding what can happen to nice ideas when they enter the "real world," and work in partnership with teachers and administrators to nurture the ideas in practice. Good intentions and good ideas are not enough.

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