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ABSTRACT

An exploration of sources of gang activity in an urban area used ethnographic research with researchers posing as mathematics tutors for 1 year in a school comprising seventh and eighth grades. The "tutors" attended six eighth grade mathematics classes and acted as assistants to the teacher. The classes of 25 to 30 students lasted 40 minutes and were held at a majority black, neighborhood school. The researchers took field notes recording what happened in class focusing primarily on students' interactions with one another and with the teacher and other school employees. An analysis of these observations found that the educational goals of providing knowledge and assessing its transmission were undermined by the following factors: (1) the lack of predictability of schedule and class work from one day to the next; (2) the failure to monitor students' progress; (3) the failure of students to master material taught in previous grades; (4) the rate of student absenteeism from class; and (5) the amount of class time devoted to administrative activities. Observations also indicate that correcting these problems requires three steps: accurate assessment of each student at the beginning of the year, individualized instruction, and careful monitoring of each student's progress in order to provide feedback. (Contains 21 references.) (JB)

Research Report #8

Mathematics Instruction in Inner-City Intermediate Schools: An Inductive Approach to Identifying Problems and Crafting Solutions

by

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Mathematics Instruction in Inner-City Intermediate Schools: An Inductive Approach to Identifying Problems and Crafting Solutions

Abstract

This paper is grounded in ethnographic data collected in mathematics classes in an inner-city intermediate school. It describes classroom interaction and shows that the educational goals of providing knowledge and assessing its transmission were undermined by (1) the lack of predictability of schedule and class work from one day to the next; (2) the failure to monitor students' progress; (3) the failure of students to master material taught in previous grades; (4) the rate of student absenteeism from class; and (5) the amount of class time devoted to administrative activities. Elements of a mathematics program are identified that would meet the needs of these students. Although a program tailored to the realities of classroom life rather than to an idealized version of it is unlikely to be popular with teachers, it nevertheless has a better chance of meeting the current needs of these students.

There is general agreement among researchers, educators, parents, and media reporters that the American public school system is in disarray (McLaren, 1989; Welsh, 1987). There is now a considerable amount of comparative information suggesting that American students of all ages are outperformed across the curriculum by students from many countries (McKnight et al., 1987). Nowhere is the discrepancy more apparent than in inner-city schools (Kozol, 1991). William Julius Wilson (1987) documents the extent of these problems in Chicago:

> Of the 39,500 students who enrolled in ninth grade in Chicago's public schools in 1980, and who would have normally graduated from high school four years later in the spring of 1984, only 18,500 (or 47%) graduated; of these 6,000 were capable of reading at or above the national twelfth-grade level (p. 57).

These figures are grim and indicative not only of Chicago's educational problems but of those of all large American cities. These problems are especially noticeable in the teaching of mathematics (Stevenson, Chen & Lee, 1993). In the inner-city school system in which this research was conducted, for example, in 1992, 46 percent of the ninth graders failed the reading proficiency test, but 81 percent failed the mathematics proficiency test.

The findings reported in this paper are a product of what Allwright and Baily (1991) call "classroom centered research" which "simply tries to document what actually happens inside the classroom" (p. 2). The goal of this research project is to describe classroom interaction in order to tailor solutions that are appropriate for the setting. In so doing we are following the lead of Glaser and Strauss (1967) in grounding our proposed solution in empirical data so that "relevant predictions, explanations, interpretations and applications" can be made (p. 1). In this paper we draw on observations made over the course of a school year in mathematics classes where we participated (to the degree possible) as if we were students.

Unlike many subjects taught in school, math is cumulative. A student must be able, for example, to add, subtract, and multiply before he or she can learn to divide. By its nature, mathematics requires its students to understand one principle before proceeding to the next. Furthermore, unlike some subjects, access to an understanding of mathematics is almost exclusively via the school room:

> After third grade, math skills seem to be more affected by extra instruction in school than are reading skills, probably because reading...relies more on general knowledge acquired outside the classroom than does math, which is more formal and more [sic] uniquely learned in school. (Schorr, 1989, p. 223).

If students are to learn math, then, they must do so in the classroom. Furthermore, this is perceived as a more serious problem in the 1990s than it was in earlier times:

> Historically, mathematics and science courses were used to screen or filter out the average students and identify the best and brightest students. Now it is clear that mathematics and science education is needed by all students in order to achieve a basic scientific and mathematical literacy that will adequately prepare them for their entrance into college and the workforce (Project Discovery, 1992, p. 1-2).

In the late twentieth century, failure to learn mathematics while earning a high school diploma effectively excludes students not only from many middle- and high-status occupations but from secure employment altogether.

Following a description of the research design, we describe everyday life in the school and in the math classroom in which the research was conducted. We then discuss why the problem cannot be resolved solely by improving teacher quality. Last, we outline the specific elements of the problem as presented in this classroom and the elements of a program that would address each of them.

Research Design

This paper is based on participant observation in an inner-city school comprising seventh and eighth grades. The director of a local agency interested in crime prevention had become alarmed at the rising number of gang-related incidents in local high schools.

He was convinced that gang membership was decided prior to high school and approached us to ask if we would be willing to study four intermediate schools in an effort to find out more about gang behavior. We responded with a research design that centered on ethnographic data collection. For practical reasons, the decision was made to study the school with the worst official suspension rate. The principal of this school also was concerned about gangs and agreed to our being in the school as observers if we were willing to assume the role of math tutors for the year. This role "explained" our presence in the school but carried with it the consequence of shifting the central focus of the research. We were introduced to the head of the math department in June, 1991 and began to spend time in the school on the first day of classes in August, 1991.

We spent the first week getting some idea of the layout of the school and classrooms, the rhythm of activities, and the make-up of staff. After this period of orientation, one of us was in attendance almost every day for the first four months and for approximately half of the school days thereafter. When not in class, we spent our time in the halls, cafeteria, occasionally in other classrooms, and in a room staffed by someone who dealt with problem students. Most of our time, however, was spent in the six eighth-grade math classes, each of which had 25-30 students, although one of us did some observations in the seventh-grade math classes.

We took field notes independently (see Lofland & Lofland, 1984) in which we recorded what occurred in the classes, focusing primarily on students' interactions with one another and with the teacher and other school employees. Initially we were concerned about the problem of recording information accurately after seven hours in the setting. It soon became apparent that neither students nor teachers paid very much attention to what we were doing in the classroom, and so we began to take notes in open view which we elaborated into field notes as soon as possible afterwards. We also discussed our observations with one another.

Although within the school there is a clear distinction between "adults" and "students" (Waller, 1967 [1932]) and we are obviously (to everyone but ourselves) the former, we took great pains to avoid behaving like adults by not reacting to "misbehavior," except on rare occasions when bodily harm to someone appeared imminent (Fine & Sandstrom, 1988). Although "misbehaving" students often glanced at us to see whether we were watching and might react, and others reported "infractions" to us, as time passed they were less concerned about our apparent authority. Furthermore, although officially we were math tutors, the teacher made very little use of us. She did not expect either of us to act in her stead when she was out of the room. Occasionally, a few students were sent with us to the room next door for tutoring, but more typically we sat through the classes as much at the mercy of the teacher's agenda as were the students. When students did math problems in class, we acted as tutors by providing assistance to those who requested it and occasionally attempted to cajole students into doing assignments.

The School

This school is located in an inner city. Unlike some schools in the district, it has no distinctive programs other than those for "special" students—mentally and/or physically challenged and those with behavioral problems. It is not a magnet school and has no honors classes. Children are not selected to attend nor do parents choose to send their children to this school. Rather it is the default school for students in the predominantly black neighborhood in which the school is located and for a similar neighborhood approximately a mile away, and for students, all of whom are white or Hispanic, from across the city. The students were assigned to the school as part of the overall plan to bring the district into compliance with court-ordered desegregation. Approximately 7 out of 10 students in the school are black. Students in the eighth grade are 13, 14, and 15 years of age. The variety of shapes and sizes of these adolescents who presumably are at the same developmental stage is incredible. Of the 400 or so students officially assigned to the school, approximately half are eignth graders. All are in one of the math classes. On any day, between 80 and 85 percent of the students are in attendance according to the official tally.

The doors to the main hall, the only doors through which students are allowed to enter the building, are unlocked at 7:30 a.m. Between 7:30 a.m. and 7:45 a.m. students are expected to go to their lockers to deposit coats and other "contraband" articles. Some students are eligible for a free breakfast served in the cafeteria. At 7:40 a.m., a warning bell rings. The official school day begins at 7:45 a.m. and ends at 2:15 p.m.. From 7:45 a.m. to 8:00 a.m., students presumably are in homerooms where attendance is taken and announcements made. At 8:03 a.m. classes begin.

Each class is 40 minutes long. Between the bells, marking the end of one class and the beginning of the next, there are either 3 or 4 minutes during which students pass from one classroom to another. Students are enrolled in eight courses and assigned to one of three 20-minute lunch periods. The bells, except at the beginning of the day and again at the end, never ring on the hour, half hour, or even quarter hour, but at such times as 18 or 41 or 38 minutes after the hour. With few exceptions, the clocks in the school are either not running or inaccurate. Students occasionally asked one of us or a student known to wear a watch, "What time is it?" and then, after a pause, "What time does the bell ring?" Since it is difficult to gauge the passing of time in each class, students' days are not marked by the clock but by the number of completed classes.

Inside The Math Class

Thirty student desks were scattered throughout the classroom and arranged facing one another in groups of four to facilitate "cooperative learning." The room was large enough to accommodate the desks easily with space left to walk among them. Students were expected to work together, so a certain amount of talking was allowed. Initially they chose their seats. After the first four weeks of school, students were assigned to seats alphabetically. As time passed, friendship groups reconvened, albeit in different locations within the classroom, and new ones formed and reformed throughout the year. Each student, for several months, had an "official" seat which could be invoked by the teacher: "Where are you supposed to sit?" An unintended consequence of arranging the desks for cooperative learning was to make it easy for the students to gather in congenial groups during math classes.

Ostensibly, the teacher had 40 minutes with each group of students each day to teach them math. Over time it became clear that her ideal use of the time was to correct the homework assignment, introduce new material by reading aloud from the textbook, solve exemplary problems, and then begin the new homework assignment. Although this would be a model day, the class rarely was structured in this way. The dual goals of imparting knowledge and assessing whether students were accumulating it were hindered by the unpredictability of the use of classroom time from one day to the next, and the methods of instruction and assessment. Each is described in detail below.

Unpredictablity of the Daily Schedule

Robert Everhart (1983) makes the point that "students in school spend a large portion of time in a role of 'spectator' wherein they watch and wait for something to happen" (p. 12) (see also Jackson, 1968; Cusick, 1972). In the junior high school he studied, Everhart found that approximately one-third of the day was consumed officially by "maintenance" activities—for example, taking roll, passing between classes, passing out and collecting papers, and having lunch. If maintenance activities within the classrooms themselves were taken into account, he estimated conservatively that the amount of time spent in such activities during the day was closer to 45 percent including approximately 20 percent of class time. In the math classroom of the intermediate school, the percentage of time consumed by non-instructional activities was even greater.

The teacher was often not in the classroom when the bell rang. Even when she was, the business of education did not necessarily begin on time:

> The teacher arrived at 8:22 a.m. (class begins at 8:18 a.m.). Beginning near the door, she proceeded around the room quietly asking individual students if they had their homework. Most did not. She gave some students passes to go get their books. She did this until 8:36 a.m. At 8:42 a.m. a paraprofessional came in, interrupted the teacher who by then was explaining the lesson at the blackboard, and talked briefly with her.

In addition, the teacher often did not stay in the room, but left to go to the classroom next door where there was a computer, a test-scoring machine, and a telephone, or to some other location in the building. Even when the teacher was in the room, she typically sat with two or three students and focused her attention exclusively on them, often with her back to half the students in the class.

Furthermore, throughout the school year the teacher announced plans for many things that did not occur, some of which, such as a calendar with daily assignments and "bell work" at the beginning of each class, would have made the class more predictable for the students. The relationship between one day's class and the next was largely unpredictable. Students were often left to their own devices to write notes, play "pencil break" or "table football," or simply to socialize. There was no rhythm to the 40-minute period on which students could depend. The only continuity was the textbook, the pages of which were assigned in numerical order.

Imparting Knowledge and Assessing Students

As noted above, mathematics, unlike some subjects taught in school, is learned in sequence *and* in school. The old adage that children learn to read and then read to learn does not apply to mathematics. Students must continue to absorb information at school in order to become competent in math. Whether information is being passed on in the classroom, then, is critical to students' future academic success.

Almost no lecturing took place in the class, although when it did occur, students usually respected the form to the degree that they either paid attention to the teacher or continued their activities at a reduced noise level. Formal instruction typically occurred by a student's reading (often with some difficulty, usually inaudibly) from the textbook and the teacher rereading the material, interspersing it with explanation. It was unusual for more than three or four students to be paying attention. One boy turned to one of us one day and made the astute observation: "She's talking to herself." In place of going over the book in class, students were given work sheets with examples at the top and problems with multiple-choice answers. They were instructed to use number two pencils to fill in answer sheets which could be graded by machine, or to write their answers (but not their computations) on a separate sheet of paper. Occasionally the teacher went over a problem or two on the blackboard, but typically students were expected to read the examples and to do the problems without assistance, except for the students with whom she happened to be sitting or those who approached her (or one of us).

In a class of twenty-five students, after the first five minutes, it was rare to observe more than one or two students working alone on problems. Many students ignored the assignment and got on with what interested them—activities such as drawing, talking, writing notes, and playing games. Students who did work, worked together, solving problems, comparing answers, and arguing about whose was correct; or dividing the problems and then sharing answers. Even this work was not concentrated but interspersed with other activities such as those noted above. Other students simply waited until someone in their foursome had done problems and then copied the answers.

> A boy had finished the homework almost before the teacher had finished explaining the assignment. He gave his paper to the boy on his left who proceeded to copy it. Then he gave it to the boy on his right who did likewise. Then they sat and talked to one another for the rest of the period. They also were drawing things on paper. Later in the period (I was sitting near them at a desk), because I was curious to know whether his answers were correct, I asked the boy if I could see his paper. He said, "Sure." I looked at it and he had done the assignment correctly. I gave it back to him. One of the other boys said to, "Do you want to see mine?" I said, "I don't need to. Yours is exactly like his." He laughed.

Students sometimes moved to another set of desks to find someone from whom to copy. Those who worked together sometimes came to a consensus about how to solve the problems and did all the problems wrong.

If students were working on worksheets, they were asked to turn them in when they were finished or at the end of the period. Producing evidence that they had been working became important. Some students then copied someone else's paper (with the other student's permission):

> A girl grabbed another girl's paper and said, "The bell's going to ring and I'm stuck."

Some filled in their answer sheets randomly, although they might have attempted to solve the first few problems. Others produced a reasonable facsimile from someone else's scratch paper.

These papers were never graded, with the exception of machine-graded answer sheets. Percentage correct achieved by each student was then sometimes read aloud by the teacher to the class. It was not atypical for most of the class to have failing grades:

> The teacher said that she was going to read the scores from the quiz that the students had taken on Friday but that she wouldn't read the names of those who had failed the test. She then proceeded to read everyone's score. Since almost everyone had failed, if she had been true to her word, she would have read only two or three names....I had tutored two girls on Friday and we had worked (diligently!) through 14 problems by the end of the class period. We didn't get through even half of the problems. I had looked through the students' answer sheets on Friday to see whether the students who had stayed in the classroom had gotten through more problems than we. Most had not.

Whether the scores were an accurate indication of what students knew was not clear because some students had solved, perhaps correctly, the first problems and then randomly filled in answers to the remaining ones or left them blank, as had the two girls described above. The significance of the absence of clocks and the peculiar times at which bells ring is apparent here. Students who might have worked against the clock had no way to gauge the passage of time.

The week before the school year ended, answer sheets from a test which had been machine graded were given back to the students so that they could see what problems they had missed. This was the first time either investigator had witnessed this and the fact that the students needed instructions to interpret the machine-made marks was taken as evidence that it was the first time it had occurred.

Homework was assigned almost every day, but was not always corrected or collected. Students routinely copied one another's homework:

> Juanita greeted the teacher by telling her that she had done her homework. Rudy came in and asked the teacher if he could go next door. The teacher didn't acknowledge him and, after waiting a bit, he gave his homework to Juanita with instructions to turn it in for him, and

> left. Juanita and another girl proceeded to copy Rudy's homework. All three (Rudy had returned) reported scores of 78 when their names were called.

When homework was checked in class, students exchanged papers and the answers were read by the teacher from the instructor's manual. Many students used this as an opportunity to write down the correct answers as they were read. Other students did not bother to do this and, when their names were called, reported their grade as zero:

> The teacher asked the students to exchange their homework assignments and then she read the answers to the problems. Phoebe copied the answers onto her paper as the teacher read them. Christine who was sitting next to her had done the homework assignment. John sat next to Christine and corrected hers while she looked on. John had not done the homework. When they reported their scores, Phoebe claimed to have gotten 100% (The teacher said, "Excellent!"); Christine reported 88%; and John reported zero and said, "I left it on the bus."

Some students were reluctant to mark a fellow student's answers wrong— understandably, in light of the fact that students were grading one another's papers, but also because the relationship between what the teacher read and what a student had put on the paper was not always clear. When grades were reported, the distribution was often bi-modal—96s and 0s, for example—with very few scores in between. When there was a more even distribution, identical scores were likely to be reported by students who were sitting together in a foursome. Occasionally students pointed out to the teacher that "cheating" was occurring. The teacher's response was to challenge the students' motivation for making complaints.

By the end of the year, approximately two-thirds of the textbook had been covered and a series of grades had been recorded for each student. These are standard ways to gauge the amount of learning that has taken place in a class. As we have seen, neither of these was a good index to whether the students had learned math. Our assessment was that students learned very little during the year, and we expect very few will pass the state-mandated test given to ninth-grade students as the first hurdle to receiving a high school diploma. Making this prediction seems safe since fewer than 15 per cent of their immediate predecessors passed it.

Thus far this paper has described what occurred in six eighth-grade math classes during the course of a year in an inner-city school. The educational goals of imparting knowledge and assessing whether its transmission had been successful were undermined by the lack of predictability due in part to the teacher's frequent absences from the classroom as well as to the way in which the class was organized and students were assessed. What life was like in this classroom for these 150 students shows why, even when inner-city students receive high school diplomas, they frequently are not knowledgeable, the concern raised at the beginning of the paper in Wilson's description (1987, p. 57) of the fate of students in the Chicago Public Schools. In the following section of the paper, we address directly the power of the teacher to affect a different outcome.

Assigning Blame

Many readers (including teachers) will lay blame for the failure of the students to learn mathematics in this classroom at the feet of the teacher. A good teacher, they will argue, would not have let this happen. The seventh-grade teacher, however, was no more successful in his approach and was rarely out of the classroom. Even though we recognize that every classroom and every teacher is unique, we contend that being a "good" teacher of mathematics to these students would have been very difficult—first, because of the range of knowledge that students brought to the classroom and, second, because of the number of intrusions into classroom time.

Levels of Competence in Mathematics

The range of students' mathematical knowledge was such that it was impossible to introduce material that would be simultaneously understood and not boring to the entire class. This is a perennial problem of mass education with its "standardization of tasks that 'fits' so few students at any one point in time" (Everhart, 1983, p. 194). In these math classes, however, this problem was exacerbated by a very wide distribution with many students falling at the lower end.

The mathematics background of many (but not all) of the students was so inadequate that they did not have the requisite knowledge (or reading ability) to use the assigned textbook. Many students, for example, did not know the multiplication table, making a lesson on multiplying fractions pointless. It was not atypical for students confronted with a multiplication problem, such as, for example, seven times nine, to write nine sevens on a piece of paper in a column and attempt to add them together. Needless to say, this was so time consuming and prone to error that students quickly lost site of the goal and interest in completing the problem. As another example, a student asked to write an addition problem on the board did not know how to line up the numbers in order to add the right digits. At the other extreme, a few viewed what they were presented as a waste of their time because they had learned it already in previous grades. As Paulos (1988) suggests, very bright students in math classes may be disruptive because they find the material boring and begin to compete with the teacher.

Through attempting to help students learn to solve problems, we were able to see firsthand their various levels of ability. Although the range is indeed great—from a fourteen-year-old boy who could not solve "two times two" and "three times three" to a twelve-year-old boy who performed extremely well on a national proficiency test—the great majority of students was extremely weak in their grasp of elementary mathematics.

In the process of understanding their difficulties, we have found it convenient to distinguish two kinds of mathematical competence: the first concerns "substrate skills," the second, "applied skills". By substrate skills, we refer to the very basic computational ability to add, subtract, multiply and divide, the ability to recite the multiplication table, and to do simple mental arithmetic. By applied skills, we refer to the knowledge of rules that allow second order calculations to be completed, such as the division of fractions or elementary algebraic problems.

We observed that the few students with good substrate skills were able to learn and apply second order rules easily and, when they made mistakes, were able to correct and learn from them. However, the students with poor substrate skills were rarely able to master any applied skills. As the weeks passed, it became apparent that they had learned almost nothing from their previous math classes. Unfortunately, this was the situation for most eighth graders.

Clearly, the lack of substrate skills made algebra and other math topics incomprehensible. Even when students knew the rule to apply to solve a given problem, their inability to do the required computation made it impossible for them to get the answer right. For students who were willing to attempt to do the problems on the worksheets—and many were—frustration soon set in. The eighth-grade math and algebra curriculum—and as a consequence the teacher—assumes knowledge of substrate skills, an assumption that for most students is unwarranted. Most of these students, then, will continue to be frustrated and frustrating to teachers unless and until they learn substrate skills.

No Time to Learn

A second factor that worked against successful teaching in the classroom was the way the school day was organized. Eight 40-minute classes, a 20-minute lunch period, and three or four minutes to pass between classes meant that the day was eaten up by "maintenance activities" (Everhart, 1983). Passing out and collecting papers for 25 students in a 50-minute class, for example, takes proportionately less time than in a 40-minute class. Five minutes to pass between classes is realistic; three minutes means that students will often arrive late, effectively delaying the beginning of class if everyone must be ready before instruction begins.

The class routinely was interrupted by announcements over a public address system. The last three minutes of the last period of each day, for example, were devoted to someone's reading over the public address system the names of students who were to report to detention after school. Students who misbehaved in class were supposed to be sent from the room with a hall pass and a written explanation to take to the vice principal's office, an infringement on time for instruction. The time frame within which teachers were expected to educate these students, then, meant much time was absorbed by maintenance activities leaving considerably less than forty minutes to devote to the actual business of education.

Furthermore, many legitimate school activities took students out of the classroom. Who was in the classroom and whether class was held at all varied from one day to the nex.. School assemblies were held during the school day. Some basketball games were held during the last two periods of the day and students were allowed to attend. Extracurricular clubs which met after school nevertheless scheduled field trips during the school day for which students were excused from regular classes. Some students were unofficial teachers' helpers and were routinely excused from classes. Weekly, during the same class period, Student Council met. Although most games were played after school, students on sports teams were often excused for the last period or two "to dress." Most students were probably in math class more often than they were not; nevertheless, the competing demands of the school for classroom time were many.

Students' absences from the school were another impediment to successful teaching. Students were suspended for several days or more—for some, once; for others, several times during the year. Assignment to in-school detention precluded a students' attending class. Others were absent due to illness, family responsibilities, missed buses, and truancy. Students transferred in and out and, in a few cases, back, during the course of the year. For a significant number of students their presence in school from one day to the next was difficult to predict. The official attendance each day indicated that 80 to 85 percent of students were in school, but because approximately 20 percent of the students were "special" and much more likely to be in school than "regular" students, the average percentage of the latter was in fact lower.

Although teachers rarely explained their absence to us or the students, it was clear that at least some absences were legitimate. Many things apparently took precedence over teaching. If a student's parent came to school, the teacher was expected to meet with him or her instead of the class. Requests from other teachers, although they were not supposed to take class time, were difficult to ignore. Teachers and teachers' aides frequently interrupted the class to borrow keys or equipment or to ask for advice.

The description of what occurred in the math classes may appear, at first reading, to be the fault of poor teaching. In fact, the teacher was faced with a difficult situation, made worse because the students were not prepared to learn what she was expected to teach. Even if the students had mastered math taught in previous grades, the 40 minutes that were ostensibly devoted to imparting knowledge were eaten up by maintenance activities, and competing activities such as assemblies, field trips, and public address announcements, or completely negated by students' absence from school.

Elements Of A Solution To Teaching Mathematics

We believe that programs to reform math instruction will only be successful if they acknowledge the different realities of classroom instruction. Rather than trying to produce a single model for math instruction, teaching must be tailored to the local problems encountered in particular schools. For classrooms in which the range of students' knowledge of mathematics is wide, and students have poor attendance records, a weak grasp of substrate skills, and very short class periods in which a disproportionate amount of time is devoted to maintenance activities, proposed solutions must be formulated within the following parameters.

First, **instruction must be individualized.** Some of the clearest findings from our observations are that students vary tremendously in what they know initially when entering the seventh or eigth grade, in their ability to learn new mathematical concepts, and in their attendance rates. Only by individualizing instruction will it be possible to accommodate the variation in attendance and knowledge. Standard classroom instruction assumes both uniform knowledge of mathematics from previous years and high attendance rates. Both of these assumptions are often wrong, and the cumulative nature of mathematics then ensures widespread failure.

Second, **the progress of students must be monitored very carefully.** We believe that students should be tested at the beginning of the year to establish their actual (rather than their supposed) mathematical skills. Students must then be assigned work that is pitched at their level of competence. This will allow them to complete nearly all the problems given to them. In addition, solving problems should encourage the "overlearning" of substrate skills so that students will be able to concentrate on conceptual issues instead of puzzling through computations. By these means, math problems can be transformed from a source of frustration or indifference to a site of success. Once students master one set of problems, they can be given another that is more difficult. This, of course, requires that someone is continuously monitoring each student's progress.

Third, **a program of math education must be devised that is self-sustaining and hence independent of the enthusiasm of the teacher or the success of a homework schedule.** From our observations, it is clear that, as Wilson (1987) suggests, teachers, with good reason, become frustrated with teaching and cannot always convey a high level of enthusiasm. While it is obviously beneficial for students to be taught by someone who is passionate about the subject, it is unrealistic to base the success of a math program on the exceptional abilities of a teacher. Similarly, although homework is almost always an important supplement to classroom instruction, it it hard to enforce its completion, especially in the context of an inner-city school where even regular attendance is hard to achieve.

Our solution, then, is to assess each student's knowledge at the beginning of the school year. Students could begin at their own level of competence and be provided with feedback so that they could learn from their mistakes, assuring a cumulation of knowledge.

In the current environment, the type of program we favor has two drawbacks: it is not "innovative" and, depending on the method used to monitor students, it is either expensive or labor intensive. Currently in Ohio and across the nation, innovative programs to improve science and math education are being implemented (Jetter, 1993). For example, the Ohio Mathematics/Science Discovery Project, a program sponsored by the National Science Foundation and the State of Ohio, has as its primary objective, "To increase the quality of teaching and learning of mathematics and science *through professional development of teachers* in the overall context of systemic change" (1992, p.1, emphasis added).

> Professional development includes three elements: 1) an inquiry-based science or mathematics content curriculum for teachers; 2) instruction in inquiry-based teaching and cooperative learning; and 3) sustained professional development and continuing support. To enhance this development, experts in the fields of mathematics and science will work with teachers to improve the structure of mathematics and science education. (Project Discovery, 1992, p.1)

Comparison of Project Discovery to the type of program we propose is especially relevant because Project Discovery's target is the middle school—sixth, seventh, and eighth grade students.

Although we cannot fault the objectives of Project Discovery, based on our ethnographic research, we suggest that the teacher trained in "inquiry and problem-solving instruction" will be effective with only a minority of the students we observed. Students' lack of substrate skills will continue to interfere with their ability to learn material aimed at an eighth-grade level. Teachers who are trained in this method will still be in the position of teaching students who have widely disparate levels of competence, whose attendance is poor, and who are not regularly in the classroom for the variety of reasons delineated above. Individualized problem sets and careful monitoring are not nearly as exciting for teachers or imaginative educators as "inquiry and problem-solving instruction" but they nevertheless appear to fit these students who get further behind with each passing year and who must now play catch-up if they are to graduate from high school with adequate knowledge of mathematics.

Evidence that focusing on catch-up is important is found in the school district statistics that show that students who do not pass the proficiency test the first time rarely pass it the second time. Of the 2,593 ninth-grade students who failed the test in fall of 1991 and took it again in spring of 1992, only 177 (6.8 percent) passed. Of these 177, all but 7 initially were within 20 points of the 200 points required to pass (Cleveland City Schools, 1993). This not only indicates that many students have fundamental problems with mathematics but also that catch-up programs are essential for a significant number of students. For most of these students, repeating the same class is ineffective.

The second problem is that providing feedback to students is a very labor intensive activity even if it is turned over to a computer. Schools are based on an economy of scale: A large number of students who have the same level of knowledge can be taught in a classroom by one teacher. In a classroom in which levels of competence vary widely and are generally below that assumed in the material to be covered, economy of scale means that very little learning takes place. Some way must be found, then, to individualize instruction. This can be accomplished either through increased use of computers or through the use of "graders," volunteers who assume the responsibility of grading problem sets on a daily basis in order to provide students with timely and helpful feedback. The former is expensive because computers (60-70 in the intermediate school in which this research took place) and software would be required. The second approach requires a group of dedicated adults who would assume the daily responsibility of grading problems. These volunteers would need to be welcomed into the school by teachers who would be giving up a great deal of their autonomy in the classroom. Although this solution at first may seem diametrically opposed to Project Discovery's goal of the long-term professional development of teachers, it may be that the presence of volunteer graders may make it possible to do both things well. This latter solution also has the advantage of giving adults a reason to be in public schools, something that may be a great advantage to young students whose knowledge of the adult world is limited.

Conclusion

In this paper we have presented a proposal for a way to teach math to intermediate students in inner-city schools that is grounded in extensive observation of existing math classes rather than in idealized models of classroom instruction. The paper identifies some of the principal causes of the extremely high failure rates for these students on the state-mandated proficiency test. The first problem area is classroom management: The day-to-day teaching of eighth-grade math was unpredictable and class time was over-burdened with administrative and other "maintenance" activities. As a result, students did not know what to expect from day to day, and class time was devoured by non-teaching activities. The second problem area is the vast variation in mathematical competence among students. It is simply unrealistic for a teacher to design one program of instruction for all the students in the class. The attempt to do so did not serve the interests of any of the students. A few quickly became bored by repetition of material previously mastered while most students became frustrated with their inability to solve problems and turned their attention to other activities. None of the students' needs was met.

Our observations indicate that correcting these problems requires three steps: (1) accurate assessment of each student at the beginning of the year, (2) individualized instruction, and (3) careful monitoring of each student's progress in order to provide feedback. Accurate assessment is needed because student competence in math varies enormously. Individualized instruction serves the interests of a diverse student body in which only a few students have mastered material covered in the previous grades. It also makes students much less dependent on one another. Students who are "discipline problems" affect only themselves rather than the entire class. Those students who are absent from class for any reason can resume learning where they left off rather than at the presumed level of the class as a whole. Last, students' work is monitored so that students can be provided with adequate feedback which helps them recognize their successes and understand their mistakes. Problems that require actual computation replace multiple-choice questions that allow "bubbled-in" circles on an answer sheet to stand as evidence of students' knowledge or work completed.

Proposals to transform math instruction must consider the role of the teacher. In Project Discovery, the goal is to teach teachers a new instructional method—inquiry-based teaching and cooperative learning—and to deepen their knowledge of math and science. The assumption is that better-trained and educated teachers will improve students' knowledge and skills and, not incidentally, their scores on proficiency tests. One of the immediate problems is that not all teachers are willing or able to become "exemplary". In our interviews with the principals of the four intermediate schools, one said candidly that of the 30 or so teachers in the school, only 7 cared about teaching. Given the mathematical competence of these students, however, even if all teachers could be persuaded and trained to become exemplary, such a solution is unlikely to be effective.

Our proposal takes a different tack. Instead of being responsible for preparing lesson plans based on inquiry-based instruction or cooperative learning, teachers would essentially be managers of computers and/or volunteers. Assessment would be performed in conjunction with either computers or volunteers. It is possible, however, that computerization or the use of volunteers could facilitate substrate learning, thereby freeing time for teaching conceptual skills.

Even the most dedicated teachers in inner-city schools find their work an uphill battle at best, a losing one at worst (cf. Freedman, 1991). More training for teachers, by itself, is unlikely to solve the problems presented by students who apparently have been socially promoted throughout their years in school. Inquiry-based teaching alone may work well for students who are performing at their grade level, but most of the students we observed are in a position in the seventh and eighth grades of playing catch-up. As a result of spending more time with individual students and seeing many of them progress, math teachers may find their work more rewarding, if less prestigious. Furthermore, the presence of volunteers in the school may inadvertently improve the accountability of the institution while giving students access to more role models and positive attention from adults. The alternative, a computer available to every student during math class, would also serve the useful function of student's becoming familiar with computers.

It is important to remember that the most critical question of any policy proposal is its ability to bring about meaningful change. If the individualized instruction proposed here is capable of improving students' knowledge of mathematics and their proficiency-test scores, then it is worth implementing for the sake of children who must live, for the remainder of their lives, with the effects of having been short-changed by public school systems.

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