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ABSTRACT

Poor, minority, and low ability students suffer most from the general lack of sustained opportunity to study mathematics in American public schools. Studies indicate that preschool and kindergarten students show only minor social class or racial differences in mathematical thinking and that differences in mathematical performance among older students directly relate to the amount of math studied. A 1978 National Assessment of Educational Progress study of selected 9-, 13-, and 17-year-olds indicates that while the majority of American 17-year-olds have had 2 years of high school mathematics, black students have had only one year. While the National Assessment found no racial differences in cognitive level performance in mathematics, blacks had increasing difficulty with mathematical content as they became older. At age 9, blacks showed problems with variables and relationships; by age 17, they showed problems in all mathematical content areas. Although black students showed more positive attitudes towards math learning than their white counterparts at all age levels tested, this motivation alone was not sufficient to insure successful math performance. The National Diffusion Network offers a catalog of successful public school mathematics education programs. Most effective programs have included the following elements: individualized and small group instruction, calculator usage, laboratory work, cross-age tutoring, remedial pull out, and team games. (LP)

Improving the Mathematical Skills of Low Achievers

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IMPROVING THE MATHEMATICAL SKILLS OF LOW ACHIEVERS

For some years educators have known that American students perform more poorly in mathematics than do students in other major industrial nations, such as England, France, Sweden and Japan (9). Concern has also grown about the increased mathematical skills needed in an electronic age. Not surprisingly, poor, minority, and low-ability students suffer most from what, in this country, is a general lack of sustained opportunity to study mathematics throughout the school years. Whatever the term used for these disadvantaged students, and whatever the complex sources of their problems in mathematics, these low-income, inner-city, minorities or low achievers tend to be placed together early in their schooling and to be taught by the same instructional methods, by the same teachers, in the same classes, and their problems in mathematics rapidly become similar both diagnostically and in their treatment.

According to a 1978 National Assessment of Educational Progress (1), a study of 9-, 13-, and 17-year-olds in a carefully selected sample of 70,000 showed blacks about 11 percentage points below the national average in mathematics at age 9; 15 percentage points below at age 13; and 17 percentage points below the national average at age 17. It should be pointed out, however, that although the national average of mathematics scores for all students declined between 1973 and 1978, black students reduced their comparative lag by 1 or 2 points during these years.

Clearly, one source of the low mathematics scores in general is lack of contact with mathematics curriculum. According to the National Assessment (1), performance both nationally and for black students directly relates to the amount of mathematics studied, and the low scores of the black students are connected to their low enrollment in mathematics after grade 10. At present, the majority of the nation's 17-year-olds have taken two years of high school mathematics, while black students average a mere year. Seeking to remedy the deficiency for both groups, the National Council of Teachers of Mathematics (13) proposed a requirement of three years of mathematics in grades 9 through 12.

Specific Mathematical Aptitudes and Skills of Low Achievers

Studies of the mathematical aptitude and skill of black and other low-income students approach the issue from a variety of perspectives. Some merely seek to describe those areas or capacities where there is weakness and strength; others relate aptitudes and skills to motivation; and others attempt to develop instructional methods to match student learning styles.

A study of the mathematical thinking of inner-city preschool and kindergarten children indicates that only minor social class or race differences exist in these early years, and that all racial and social class groups improve in their performance between preschool and kindergarten (15). A few studies report that disadvantaged females perform better than their male peers in the mastery of numerical operations and concepts in grades 1-3, with boys slowly gaining on the girls—by way of comparison with the general population, no sex differences exist during the early grades, but boys soon take the lead (7, 12).

The National Assessment, which tested 9-, 13-, and 17-year-olds, evaluated several mathematics content areas over four cognitive levels: knowledge, skill, understanding, and application. According to the survey, the pattern of strengths and weaknesses over these four cognitive levels was the same for blacks and all other students at all age levels, and no cognitive level was disproportionately more difficult for blacks than it was for the nation's students as a whole (1). For both groups at all ages, problems in understanding and application were more serious than those in knowledge and skills. Not surprisingly, the National Council of Teachers of Mathematics (13) recommends as a focus for the 1980s the teaching of problem solving, including the ability to probe, explore, and apply mathematical concepts in relation to real world problems, and to select and match strategies to the situation at hand.

While cognitive-level performance appears to be the same for black and white students, specific content areas emerge as particular problems for black students, at least at some age levels. According to the National Assessment, variables and relationships are sources of special content problems among black students at age 9; at age 13 and 17, variables and relationships as well as measurement cause particular problems; and at age 17, problems are suggested in all the content areas, including numbers and numeration, variables and relationships, geometry, and measurement (8). An analysis of the scores of 8th graders on the Illinois Inventory of Educational Progress (10) indicates that black students have particular problems with questions about the metric system, those involving definitions, and those based on graphs and figures; at the same time, these students are particulary successful with story problems involving money and symbol substitution.

It has been suggested that *minority* students can better solve mathematical problems that have concrete or practical implications, or that are related to their own lives and convey a positive image of themselves and their culture (6). Projects for younger students stress physical manipulation as central to the enhancement of learning for this group (17).

A number of investigations have related the cognitive styles of field-independence and field-dependence to learning ability in mathematics and other subjects. The general view is that field-independent students have greater personal autonomy and tend to be better at analyzing and imposing organization on poorly organized stimuli as well as ignoring distracting cues, while field-dependent students are less proficient at cognitive restructuring. Studies also tend to show disadvantaged students as more likely to be field-dependent than the general population. Proceeding from this line of research, one investigation found that individualized instruction with immediate reinforcements enabled field-dependent, disadvantaged students in the 5th grade to do as well as field-independent students in mathematical learning (11).

Some Affective Considerations

The attitudes of black students toward mathematics indicate that positive motivation alone does not bring success, nor does failure in a field necessarily turn one against it. The National

Assessment shows positive attitudes on the part of black students towards mathematics and toward themselves as learners of mathematics. At ages 9, 13, and 17, 69 percent, 69 percent, and 64 percent, respectively, say they like mathematics (compared to slightly lower percentages for the nation as a whole), and at every level they think it is the most important subject in school. Over 90 percent want to do well and say they are willing to work hard to do so. Although they take fewer mathematics courses than their white peers, black students actually indicate a greater desire for the courses.

The National Assessment data may simplify the issue, however, as they record expressed desires and intentions, at best, and, at worst, may even reflect what students think they ought to say. The burgeoning literature on mathematics anxiety suggests that anxiety (which presumably conflicts with simple pleasure in a subject) is strongly associated with underachievement in mathematics as well as other academic subjects. According to one recent study of mathematics achievement among 11- and 12-year-olds, measures of mathematics-specific anxiety differentiated the underachieving group from achievers and overachievers more strongly than measures of general anxiety and test anxiety (16). The study also confirms slight differences in mathematics anxiety between the sexes, with 11- and 12-year-old girls experiencing somewhat more anxiety than boys.

Instructional Programs

There are a number of studies and program evaluations of teaching mathematics to disadvantaged students at all ages. Though much of the research argues for the effectiveness of "active teaching" or "direct instruction" (3, 4, 5), "indirect" or "individualized instruction" is also shown to be effective, particularly in the preschool and elementary grades (2, 11).

The National Diffusion Network offers a catalog of *Educational Programs that Work* (14). The catalog includes programs in mathematics that have been proven successful for students of all ages. Those successful projects, disseminated by the NDN, cover the range of the public school years, and may be easily as well as inexpensively instituted. They include such programmatic elements as

- individualized instruction
- calculator usage
- diagnostic testing with prescriptive planning
- laboratory work
- remedial pull-out
- cross-age tutoring
- criterion-referenced testing
- small group instruction
- manipulative instructional materials
- student responsiveness
- team games.

Educational Programs that Work also lists programs not disseminated by the National Diffusion Network. These are largely programs that are more difficult or expensive to institute, although their success is equal to that of the NDN projects; they also tend to be for grades K-3, the early years when intervention may actually do greater good. An example of such a major program is DISTAR, a direct instructional approach. Other elements in similarly successful projects include

- careful monitoring
- highly structured instruction
- positive reinforcement
- rapid pacing
- parent involvement
- remedial pull-out
- criterion-referenced testing
- planned sequences
- a combination of structured and nonstructured instruction
- small groups
- ongoing diagnoses
- child-initiated or self-regulated instruction
- direct manipulation of the environment
- computer-assisted instruction.

Clearly, no single method has emerged as most effective; there are a variety of instructional methods that work. However, the opportunity to learn mathematics through a sufficient number of hours of weekly classroom time and years of courses is fundamental. Schools need to be flexibly organized so that all students, including low-achievers, can take a variety of individually-tailored mathematics programs that ultimatley provide access to advanced mathematical learning. As the National Council of Teachers of Mathematics (13, p.1) has stated:

> It is important that recommended programs permit lateral movement and not strictly "track" students, trapping them in a linear pattern that does not permit change to another path. Flexibility is vital, and the key is to keep options open as long as possible.
>
> Since a higher level of mathematical skill and understanding will increasingly become a significant advantage in nearly all lives, then justice demands that all groups have equal access to these advantages.

—Carol Ascher, Ph.D.

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