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ABSTRACT

This information bulletin reviews the research literature on blacks and mathematics. The amount of research that focuses specifically on race differences in mathematics in an attempt to explain and lessen those differences is small. Research of the past ten years indicates that black students, when compared to white students, take fewer mathematics courses and achieve at a significantly lower level, although the differences are growing smaller. Some factors which may explain why these differences exist are presented, with the focus on race, gender, and social class. A model relating these factors is presented and described. The review of the literature concerns societal influences, teacher attitudes, school mathematics curricula, student attitudes and student achievement-related behaviors, classroom processes, and student achievement. Following the concluding summary, in which directions for future research are also noted, an extensive list of references is included. (MNS)

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A Review of The Literature on Blacks and Mathematics

EDITOR'S COMMENTS

The first ERIC/SMEAC information bulletin for 1985 has been produced by Laurie Hart Reyes and George M. A. Stanic from the University of Georgia. It deals with a topic which should be of interest to ERIC users not only in mathematics education but all educators who work with racially and culturally diverse student populations. This information bulletin is a shortened version of a paper originally presented at the annual meeting of the American Educational Research Association in Chicago in April, 1985. The AERA paper is available in the ERIC system as document number SE 045 579. It will have an ED number when the abstract appears in the September issue of Resources in Education (RIE).

Introduction

The amount of research literature on blacks and mathematics is not large. This is not to say that the amount of research related to black students is small; race has certainly been included as an independent variable in a multitude of studies. However, the amount of research that focuses specifically on race differences and mathematics in an attempt to explain and lessen those differences is small. Research of the last 10 years points to a widely accepted conclusion: Although the differences are growing smaller, black students, when compared to white students, take fewer mathematics courses and achieve at a significantly lower level. This conclusion, however, tells us little about why these differences exist and what we as educators can do to improve the course taking and achievement of black students.

We believe, as do other researchers (e.g., Grant & Sleeter, 1984; Najmi, Marrett, & Kickbusch, 1985), that race-related differences in mathematics achievement cannot be viewed separately from differences associated with gender and social class. It is only when the factors of race, gender and social class are considered simultaneously that reasonable explanations of differences begin to appear.

Consider, for example, the importance of the social class backgrounds of students. Though there is no universally accepted definition, White (1982) lists occupation of head of household, educational attainment of parents, and level of family income as traditional indicators of student socioeconomic status (SES). Much research documents that SES and academic achievement are positively correlated. A meta-analysis of almost 200 studies on the SES/academic achievement relationship (White, 1982) indicated that when student was the unit of analysis, the correlation between SES and academic achievement was about .22; when school or community was the unit of analysis, the correlation between SES and academic achievement was .73.

SES is important in understanding race-related issues in academic achievement because of the disproportionate number of minority group members who are low in SES and the disproportionate number of majority group members who are high in SES. When race-related differences are studied without any attention to SES, it is likely that race and SES are confounded. As Yando, Seitz, and Zigler (1979) claimed, too often the academic achievement of black students who are economically disadvantaged has been compared to the academic achievement of white students who are economically advantaged, without considering SES as an important factor. Studies which allow one to distinguish between the effects of race and SES are more helpful. For example, Kirk, Hunt, and Volkmar (1975) studied the number recognition skills of four-year-olds with race, gender, and SES as independent variables. They found no differences by race or gender but did find differences by SES of students, with the high SES students scoring higher than the low SES students on number recognition tasks. SES, rather than race or gender, proved to be the most important explanatory factor. The necessity of studying race and SES simultaneously cannot be overemphasized.

A second factor which seems to be important for a clear understanding of race-related differences in mathematics is gender. There is evidence of gender-related differences in the mathematics achievement of students in some contexts at the secondary level and beyond, with male students achieving at a higher level than female students (e.g., Chipman, Brush, & Wilson, 1985; Fennema, 1984; Steinkamp & Maehr, 1984). Most of this research has either focused on white students or has not examined carefully the possibility of different patterns of mathematics achievement among black students and white students.

The point is that the factors of race, gender, and social class should not be viewed in isolation from each other. We believe strongly that while some differences among individuals are indeed normal and natural, the group differences that exist are largely due to factors other than native capacity. Research which considers race, gender, and social class simultaneously may provide some support for this claim.

A Model to Explain Differences in Mathematics Achievement Based on the Race, Gender, and Social Class of Students

The basic assumptions underlying the model are that differences in average aptitude (native capacity) among groups are not significant and that the range of individual differences in aptitude within each group is similar. A single arrow in the model represents a one-way causal connection; a double arrow represents reciprocal causation (Duncan, 1975).

The model is based on the fact that student achievement indeed differs based on the race, gender, and social class of students. In a comprehensive review of research literature on minorities and mathematics, Matthews (1984) stated that minority students consistently score below the national average on standardized tests of mathematics achievement. Anick, Carpenter, and Smith (1981) reported analyses of the second mathematics assessment of the National Assessment of Educational Progress (NAEP II) by ethnic group for students at ages 9, 13, and 17. The mean percentage of exercises correct for black students was well below the national average at each age level. Black students were about 11 percentage points below the national average at age 9, 15 percentage points below the national average at age 13, and 17 percentage points below the national average at age 17.

It is clear, then, that the mathematics achievement scores of black students have been consistently lower than those of white students. However, results from the NAEP data indicate some changes in the relative level of mathematics achievement for black students and white students during the last 10 years. Anick et al. (1981) compared the differences between the black average and the national average from the 1973 mathematics assessment of the National Assessment of Educational Progress (NAEP I) with the differences found in NAEP II. From NAEP I to NAEP II the discrepancy between blacks and the national average decreased slightly at all three age levels. Matthews, Carpenter, Lindquist, and Silver (1984) reported results from the third mathematics assessment (NAEP III). In 1982, once again, black students were achieving at a level well below the national average, but the differences between the performance of black students and white students had decreased even more from 1978 to 1982 than from 1973 to 1978. The changes in differential achievement were mainly the result of an increase in test scores for black students rather than a decline in scores for white students (Burton & Jones, 1982). This increase in mathematics achievement for black students was larger in schools composed of less than 60% white students than in schools which were composed of at least 60% white students (Matthews et al., 1984).

Gender differences in mathematics achievement also persist. Though Armstrong (1985) concluded that nationwide differences in mathematics course enrollment between male and female students have decreased, at the high school level male students, as a group, achieve at a higher level in mathematics than do female students as a group. This differential achievement is largest for application and problem solving tasks. Extensive reviews of the research on gender-related differences in mathematics are available (e.g., Chipman, Brush & Wilson, 1985, Eccles (Parsons), 1984, Fennema, 1984, Fennema & Peterson, 1984).

There has been no definitive study of SES as it relates to mathematics achievement. White (1982) examined the correlations between SES and scores on standardized tests of mathematics achievement from 143 studies. He found an average correlation of .25 for all the studies, while an average cor-

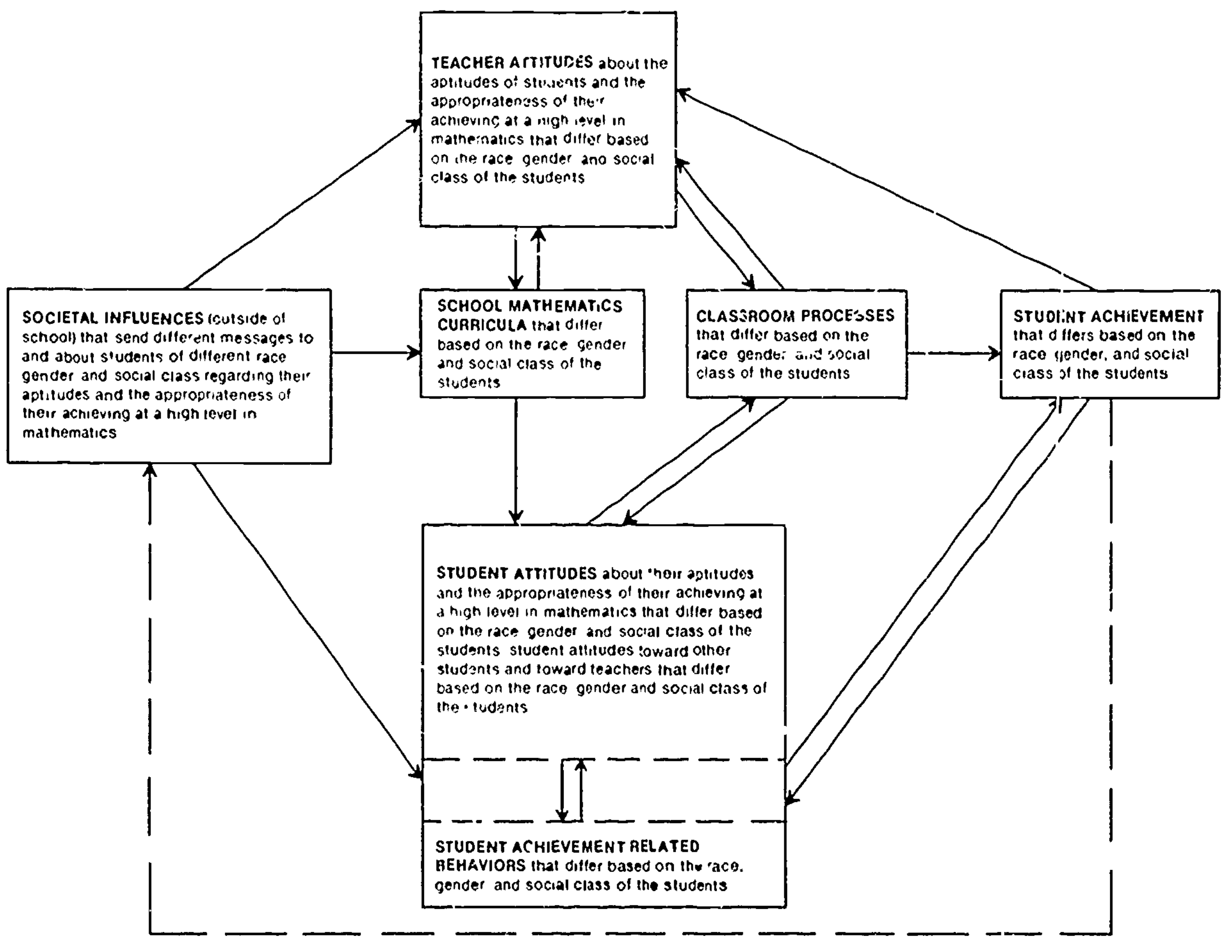

FIGURE 1.
A MODEL TO EXPLAIN DIFFERENCES IN MATHEMATICS ACHIEVEMENT BASED ON THE RACE, GENDER, AND SOCIAL CLASS OF STUDENTS

relation of .73 was found for studies where school or community was the unit of analysis and an average correlation of .22 was found for studies where the student was the unit of analysis. Yando, Seitz, and Zigler (1979) computed a correlation between SES and arithmetic achievement for 304 8-year-olds using student as the unit of analysis and obtained a positive correlation of .29. Thus, SES appears to account for less than 10% of the variance in mathematics achievement when student is the unit of analysis and considerably more when the school or community is the unit of analysis Welch, Anderson, and Harris (1982) reported an analysis of NAEP II data and found that home and community background accounted for 24% of the variation (multiple R of 49) in mathematics achievement of 17-year-olds However, there may have been a problem with the unit of analysis in this study.

In their analysis of NAEP II data, Anick, Carpenter, and Smith (1981) reported selected results based on two factors whi[illegible] would seem to be related to student SES level. The first factor was type of community, with High Metro and Low Metro as the two categories A school was classified as being in a High Metro community if the school principal judged that a high percentage of students' parents were employed in professional or managerial positions. A Low Metro classification meant that a high percentage of students' parents were judged to be unemployed, on welfare, or employed in factory or farm positions. The average performance of students attending Low Metro schools was 9-13 percentage points below the national average, while students from High Metro schools scored 8-10 percentage points above the national average The second factor was level of parent education, with classifications based on information gathered from individual students There was a clear positive relationship between parent education and student mathematics achievement

It is clear that there are significant differences in achievement related to the race, gender, and social class of students. The model represents a first attempt to posit causes for these differences.

Societal Influences

The model begins with societal influences outside of school that may send different messages to and about students of different race, gender, and social class regarding their aptitudes and the appropriateness of their achieving at a high level in mathematics. Examples of societal influences are the family, the community in which the child lives, religious institutions, the mass media, and the implicit messages which result from the pattern of prevailing occupational and other societal roles held by members of particular groups. Societal influences can and do change; however, those that exist at any particular moment in history are powerful and persistent influences on human beings (Apple, 1979). In the model, these societal influences have a direct effect on teacher attitudes, school mathematics curricula, student attitudes, and student achievement related behaviors and an indirect effect, through these factors, on classroom processes and student achievement.

Teacher Attitudes

Teacher attitudes about the aptitudes of students and the appropriateness of their achieving at a high level in mathematics may differ based on the race, gender, and social class of the students. There is a large body of literature on teacher expectations (e.g., Brophy & Good, 1974, Cooper & Good. 1983) which indicates that teacher attitudes toward students can affect student achievement. In this model, as in the teacher-expectation model of Brophy and Good (1974), classroom processes serve as the mechanism through which teacher attitudes affect student achievement. Though it would seem that the race, gender, and social class background of the teacher may be important here, the limited research does not substantiate this claim (Brophy, in press, Brophy & Good, 1974).

School Mathematics Curricula

In the model, teacher a[illegible]es affect and are affected by sc[illegible] mathematics curricula that di[illegible] based on the race, gender, and social class of students, but research focusing on this claim is needed. School mathematics curricula consist of the courses available to students, the topics covered in those courses, and the activities used to teach those topics. Teacher attitudes may affect school mathematics curricula in that teachers may decide that certain courses, topics, and activities are appropriate only for certain groups of students. School mathematics curricula may also affect teacher attitudes in that the kinds of mathematics courses offered in a particular school may affect a teacher s beliefs about the general ability of the students in the school. Consider the following situation. As the proportion of black students in the school population increases, the likelihood of the mathematics curriculum containing lower level courses increases, as the proportion of white students in the school population increases, the likelihood of higher level mathematics courses increases (Matthews, 1984) That this situation exists may result in part from the attitudes held by teachers and may, in turn, affect teacher attitudes.

Student Attitudes and Student Achievement-Related Behaviors

Just as school mathematics curricula may affect the attitudes of teachers, they may also affect student attitudes and student achievement-related behaviors. Attitudes and achievement-related behaviors are closely related (e.g., Fennema & Sherman, 1977). Examples of student attitudes are confidence in learning mathematics, perceived usefulness of mathematics, beliefs about the appropriateness of mathematics as an area of study, and attributions of success and failure in mathematics (Fennema & Sherman, 1978; Meece et al., 1982; Reyes, 1984). Other examples of student attitudes are attitudes toward other students (Grant, in press) and toward teachers (Grant, in press, Grieb & Easley, 1984). Some examples of achievement-related behaviors are persistence, independence, and deciding to enroll in optional mathematics courses (Fennema & Peterson, 1983, Meece et al., 1982).

Confidence in learning mathematics has to do with how sure a student is of her or his ability to learn and perform well in mathematics. Confidence is an important factor because it has a significant, positive correlation with mathematics achievement; because it is one of the strongest attitudinal predictors of mathematics course taking, and because gender differences in confidence are usually associated with gender differences in mathematics (Reyes, 1984). According to Matthews (1984), confidence appears not to be as important in understanding race-related differences. However, this finding needs further clarification.

Students also vary in how useful they view mathematics to be, both for their current needs and for the future. Perceived usefulness of mathematics has been identified as one of the most important variables in understanding gender-related differences in mathematics achievement (e.g., Fennema & Sherman, 1977. 1978; Meece et al., 1982; Perl, 1979). There is a significant positive correlation between perceived usefulness and mathematics achievement, and perceived usefulness is very important as a predictor of student election of optional mathematics courses (e.g., Meece et al., 1982; Sherman & Fennema, 1977). Matthews (1984) identified perceived usefulness of mathematics as a particularly im portant variable for future research on race-related differences.

Another important attitude is a person's belief about the appropriateness of mathematics as an area of study. Although Travers and McKnight (1985) found that students in general do not view mathematics as a male domain Fennema (1984) suggested that gender differences in the stereotyping of mathematics as a male domain may be an important factor in the differential mathematics course taking and achievement of male and female students According to Fennema, female students, when asked, strongly disagree with the notion that mathematics is a more appropriate area of study for male students, while most male students also disagree with this notion, their level of disagreement is not as strong and differs significantly from that of female students (Fennema & Sherman, 1978). This finding, when considered in light of the fact that the instrument used was not designed to measure subtleties of sex-role stereotyping, indicates that more research in this area is needed. There may also be racial and social class differences in the perception of mathematics as an appropriate domain of study. For instance, Matthews (1984) suggested that black students may perceive mathematics as a white domain.

Mathematics education research based on attribution theory deals with perceptions of the causes of student success or failure on mathematics tasks. The main purpose of this research has been to understand gender-related differences in mathematics course taking and achievement. On the average, females and males seem to differ in their patterns of attribution of success and failure. Wolleat, Pedro, Becker, and Fennema (1980) found that males attributed their success in mathematics to ability more often than females did, and females attributed their success to effort more often than did males. Females more often than males attributed their failure in mathematics to lack of ability and to the difficulty of the task. These differences, however, are not large. More data collected using school tasks in naturalistic settings are needed not just to clarify gender-related differences in attributions but also to determine the extent to which attribution theory can explain race- and SES related differences.

In the model, it is also suggested that student attitudes toward other students and toward teachers may differ based on the race, gender, and social class of the students. Grant (in press) has suggested that students of differing race and gender hold different expectations about teachers and about other students. Furthermore, in Grieb and Easley's study (1984) of the development of independent thinking in mathematics, they suggested a relationship exists between student interest in mathematics and student attitude toward the teacher.

Achievement-related behaviors refer to the tendency for a student to act in a particular manner (e.g., to persist in completing a task, to work on a task independently, to take an optional course in mathematics). The achievement-related behavior of course taking has received the most attention. Female students and black students have traditionally enrolled in fewer optional mathematics courses than have white male students (Fennema, 1984, Marrett, 1981). Students who enroll in optional mathematics courses achieve at a higher level than those who do not (Chipman et al., 1985, Fennema, 1977, Meece et al., 1982).

Sells (1982) reported data on the high school mathematics backgrounds of a stratified. random sample of 324 freshmen entering the University of Maryland in the fall of 1977 by race and gender of student. Ninety percent of white men, 64% of black men, 54% of white women, and 44% of black women had taken at least 3 years of high school mathematics. Twenty-nine percent of black women, 21% of black men, 10% of white women, and 1% of white men had taken at most a one year course in algebra. The blacks and women in her sample were entering the university with less background in mathematics than were the white men.

Anick et al. (1981) reported nationwide mathematics course enrollment data from NAEP II for 17-year-olds. The percentage of 17-year-old black students who reported having taken at least one-half year of algebra 1, geometry, algebra 2, or trigonometry was considerably lower than the percentage of all students in the sample who reported taking these courses. The majority of all 17-year-olds reported having taken both algebra 1 and geometry, the majority of black 17-year-olds reported having taken only algebra 1. On the average, it appears that black students take about one year less of high school mathematics than the norm for the nation.

Matthews et al. (1984) compared enrollments in mathematics courses of 17-year-old black students and white students using NAEP III data. The percentage of black students who reported they had completed at least one-half year of general mathematics was larger than the percentage of white students, this was also true for prealgebra. On the other hand, the percentage of white students who reported they had completed at least one-half year of algebra 1 was considerably larger than the percentage of black students; this was also true for geometry, algebra 2, trigonometry, and precalculus/calculus. The percentage of black students who had completed at least half a year of each of these mathematics courses increased slightly from NAEP II to NAEP III, except for precalculus/calculus where the percentage remained the same.

Marrett and Gates (1981) collected enrollment data for black students and white students in 12 high schools of varying size and location, and with varying proportions of black students in the schools. In each school, they found that the proportion of black students enrolled in a high school mathematics course was about equal to the proportion of blacks attending the school. However, the black students who were enrolled in mathematics courses were much more heavily represented in the lower-level courses such as general mathematics than in the higher-level courses such as algebra 2 and geometry. In 9 of the 12 schools, the proportion of black students enrolled in higher-level mathematics courses was much lower than the proportion of black students in the school. The conclusions of Matthews (1980), who studied differential mathematics enrollments in four Oakland, California high schools, are similar to the conclusions of Marrett and Gates.

Jones, Burton, and Davenport (1984) found enrollment in algebra and geometry varied with the percentage of white students enrolled in a school. In schools with less than 70% white students, the average number of years

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Patricia E. Blosser
Bulletin Editor

of algebra and geometry taken was 1.3, while in schools with at least 90% white students an average of 1.8 years of these courses were taken. Seventy three percent of black students and 8% of white students attended schools which were less than 70% white, 7% of black students and 66% of white students attended schools which were at least 90% white.

It is important to look closely at course taking because of the relationship that exists between course taking and achievement. Jones et al. (1984) compared mathematics achievement with the number of mathematics courses taken for black students and white students. Not only was number of years of algebra and geometry taken related to mathematics achievement, but it was also helpful in explaining differential achievement of black and white students. Matthews et al. (1984) analyzed NAEP III mathematics achievement by number of mathematics courses taken for 17-year-old black students and white students. The achievement level for both groups increased substantially with each mathematics course taken. However, the gap in mathematics achievement between black students and white students was largest for students who had taken the greatest number of years of mathematics. In addition, the achievement differential was larger for lower cognitive level tasks than for higher level tasks.

Although course taking has been studied the most, researchers have begun to examine other achievement-related behaviors. Fennema and Peterson (1983) claimed that a student's ability to persist at a task and to work on a task independently are important factors in explaining gender-related differences in solving higher cognitive level mathematics problems. According to Grieb and Easley (1984), white male students more than female and minority students are allowed to develop independent thinking in mathematics, they believe this is a crucial factor in male students showing more creativity in their mathematics performance.

As we stated at the beginning of this section, school mathematics curricula may affect student attitudes and student-achievement-related behaviors. For example, the topics and activities made available to a student will necessarily have an impact on a student's conception of what mathematics is and of her or his ability to learn mathematics. In addition, the kinds of activities in which students participate can encourage or discourage achievement-related behaviors such as persistence and independence, students involved in any activities which require persistence and independence should develop these behaviors to a greater degree than those students who are involved in few such activities. The achievement-related behavior of course taking is also affected by school mathematics curricula, that is, courses that are not available cannot be taken.

Classroom Processes

Classroom processes serve as an essential part of the model. Classroom processes include interactions between teachers and students and between fellow students. Gender-related (Becker, 1981; Fennema & Peterson, 1983; Reyes, in press) and race-related (Matthews, 1984) differences in mathematics classroom processes have been substantiated. Research on teaching has documented that certain patterns of classroom interaction are related to student achievement in mathematics (Good & Grouws, 1979). These conclusions point to the importance of considering classroom processes as a means of explaining differential student achievement. In the model, classroom processes serve as a mechanism through which teacher attitudes, student attitudes, and student achievement-related behaviors can affect student achievement; and it is through classroom processes that teacher attitudes, student attitudes, and student achievement-related behaviors may change.

Student Achievement

Student achievement refers not only to scores on standardized achievement tests but also to measures of student performance on nonroutine mathematical problems. According to the model, student achievement is affected by classroom processes, student attitudes, and student achievement-related behaviors; and student achievement has a direct effect on student attitudes, student achievement-related behaviors, and teacher attitudes There is support in the literature for a direct effect of classroom processes on student achievement (Good & Grouws, 1979). The literature also substantiates a relationship between student achievement and student attitudes and achievement-related behaviors (e g , Jones et al., 1984; Matthews et al , 1984; Reyes, 1984) and between student achievement and teacher attitudes (Brophy & Good, 1974). The cycle of the model is complete when differential student achievement serves to perpetuate the societal influences that begin the model.

Conclusion

It is clear that we live in a society where racist, sexist, and classist orientations exist in institutions and individuals. What is not clear is how such ideas are transmitted to and through schools, how the ideas are mediated by the democratic ideals of equality and equality of opportunity, and the extent to which teachers and students accept and resist such ideas. Even more specifically, we do not yet know how these ideas affect the teaching and learning of mathematics.

There is, however, a strong and growing research tradition which is based on the attempt to explain why different groups of students seem to get different benefits from the school experience. Called the *new sociology of education* in the early 1970s, this tradition is now perhaps better labelled as the *critical sociology of education*. Scholars in this tradition (e.g., Apple, 1979, 1982a, 1982b; Apple & Weis, 1983; Bernstein, 1977; Bourdieu & Passeron, 1977; Bowles & Gintis, 1976; Karabel & Halsey, 1977; Whitty & Young, 1976; Willis, 1977; Young & Whitty, 1977) have asked why, despite the meritocratic ideology of schooling, for certain groups fundamental inequalities in school performance and societal position persist. To answer this question, the critical sociologists have focused on, among other things, the relationship between the overt and hidden curricula of schools.

In Schooling in Capitalist America, Bowles and Gintis (1976) described a theory of correspondence between schools and society. Schools, according to Bowles and Gintis, mirror the conditions of society and, in effect, impose the inequalities of the wider society on students. Research done by other critical sociologists has called this correspondence theory into question. Paul Willis (1977), for example, in his classic work Learning to Labour: How Working Class Kids Get Working Class Jobs, recognized that unjust societal inequalities indeed persist despite the potential benefits of the schooling process, however, he saw schools as much more than a mirror of society. Willis confirmed what at one level is a commonsense understanding but at another level is difficult to see if one does not look beyond the institution as a whole to the individual human beings who make up a school: Students often struggle with and resist the messages of the school curriculum and school officials. The point is that any theory of the role of schools in perpetuating (or not overcoming) unjust inequalities from the wider society must take into account this resistance by students.

It is in the research of Grieb and Easley (1984) that we may find a kind of bridge between the work of the critical sociologists of education and the work of mathematics educators interested in differential achievement by race, gender, and social class. Grieb and Easley spoke of how students acquiesce to, ignore, or resist a teacher's attempts to control the learning environment. This is very close to Willis's interest in the concept of resistance. There are differences, however. For example, critical sociologists like Willis would consider ignoring as a form of resistance, would look for a more complex interaction of acquiescence and resistance, and would look beyond the teacher for other sources of ideas being accepted and resisted. Indeed, ever teachers must be seen as actors in a particular historical moment who accept and resist societal influences.

This possible overlap of interests points to two necessary elements in future research. First, mathematics educators must become more concerned with providing explanations for differential group achievement which are based on situating schools within a wider context. To use the terms of our model, we need to find out more about how societal influences affect schools and the people who live and work in schools. Furthermore, recognizing that schools may not be able to build the new social order that George Counts called for in 1932, we need to consider what schools can and cannot do in dealing with the unjust inequalities.

Second, both the critical sociologists and Grieb and Easley point to the need to learn much more about classroom processes. Despite the importance of societal influences, it is clear that something important goes on in schools. Ginsburg and Russell (1981) studied the basic mathematical cognitive skills of four and five-year-old black students and white students from middle class and lower class families. They concluded that all these children enter school with the prerequisite cognitive skills for adequate performance in mathematics. In addition, Yando, Seitz, and Zigler (1979) examined the problem solving skills of eight-year-olds with race, SES, and gender as independent variables. They found that students of differing SES levels excelled at different types of problem solving tasks. The low SES children performed better than the high SES children on some of the tasks, particularly those requiring creativity, while high SES children performed better on other tasks, usually whose which were most similar to the activities children were familiar with in school. Thus, students of differing racial and social class backgrounds enter school with the potential to succeed in mathematics. And students from low SES backgrounds may have certain skills that are superior to those of students from high SES backgrounds. A close examination of classroom processes appears to be important in understanding what happens to some students after they reach school so that these abilities and skills are not fully tapped.

For example, Tobin (1984) found in ethnographic observations of mathematics classrooms that the number of teacher-boy and teacher-girl interactions did not differ except in a particular situation. When the teacher was attempting to make important connections between topics, the teacher called on only a small group of "target" students in the class. This target group consisted of seven boys and one girl. Both those students who were in the target group and students who were not were readily able to identify the target students. Instruments capable of detecting subtle differences such as this are needed.

We believe that our model provides a mechanism for joining these different research traditions that may have important things to say about differential achievement in mathematics by race, gender, and social class. There is clearly much work to be done to prove that group differences in mathematics achievement we now see do not reflect the natural order of things.

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