The primary feature of successful programs for women and minorities seem to be that they involve the students in the "doing" of science and mathematics.

A Review of Factors Related to Gender and Ethnic Differences in Math/Science Achievement Levels of Students K-12

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Since publication of **A Nation at Risk** (1982), a considerable amount of national attention has been focused on the state of American education, especially as it relates to the preparation of students in math, science and technological areas. While the performance of students in general has been considered below the expected standards of achievement, some groups appear to be both disproportionately underrepresented and are cited as being low or underachievers.

Such is the case with Black females. This article discusses possible explanations for underachievement by Black females in math and science. Based upon these explanations, potential avenues for reform will also be presented.

Participation

There is some direct evidence to indicate that Black females do not prepare for math and science careers in proportion to their numbers in school populations. In a rare investigation in which relevant data about Black females was collected, Marrett (1982) found that "Black females comprised a smaller proportion of the enrollees than one might have predicted, based on their representation in the sample schools" (p. 33). Marrett also reported, "Of the Black females who were taking mathematics, fewer were in the most selective courses than was true for White students of both sexes (p. 35). In science as in mathematics, minority female representation in the school population outdistanced the advanced course sums. Furthermore, the means were very similar: for both science and mathematics, the number of minority females in advanced courses was about three-quarters of the expected count" (p. 39).

Are Black females more endangered in the areas of math and science than either White females or Black males? In reference to participation in math and science classes, Marrett reported, "Although Black female rates lagged behind those for White males and females, they exceeded the rates for Black males" (p. 35). Nevertheless, despite their greater level of participation in math and science classes compared to Black males, it appears that Black males (and White females) still manage a greater level of participation in hard sciences and math careers than do Black females.

Marrett (1982) reported that Black females make up 3 percent of all social and behavioral scientists, but less than 1 percent of those in physical and biological sciences and in engineering. Approximately 72 percent of the Black females in science and engineering are in social and behavioral sciences, whereas, only 28 percent of White females in science and engineering are in social and behavioral sciences. For Black males, the figure is 17 percent.

Marrett's study is unique because it examined the participation and achievements of Black females in particular. Very little research specifically addresses the dilemmas of Black females (Adams, 1983; Scott-Jones, 1986). Instead, most researchers tend to investigate either a population of Blacks or of females, but not Black and female. This information gap limits the conclusions that can be drawn about the participation of Black females in math and science. For example, Malcolm (1984), in her work for the American Association for the Advancement of Science, was faced with this limitation as she addressed the problems of both females and minorities in mathematics and science. She reported that both minorities and women are greatly underrepresented among the populations of scientists and engineers in the United States" (p. 1). Malcolm also reported that in 1978, women were 51 percent of the work force.

For women in general, there have been some signs of improvement in their recent levels of achievement. There has been an increase in the proportion of female doctorates earned in science and engineering from 8.1 percent of the total in 1960 to 30 percent of the total in 1984. Nevertheless, Vetter (1986) reported that women's career opportunities still have lagged substantially behind those of men. Also, some fields appear to remain especially impervious to entry by women or minorities. Marrett (1982) reported that combined figures for Blacks, Hispanics and American Indians represent only 2 percent of doctorates in chemistry. In engineering, Black females received only .03 percent and Black males .09 percent of all doctoral degrees in 1980-81 (Scott-Jones, 1986).

Though not all of these figures provide direct evidence that Black females are victims of the underachievement measures in minorities and/or females, one might logically assume that, because they are members of both groups, they might actually suffer "double jeopardy." Consequently, because they would experience any deprivation to which either Blacks or females are subjected, they might be more at risk than either White females or Black males.

Taken as a whole, the figures suggest that equitable outcomes do not result for Black females in math and sci-

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ence. Black females are rare in these well-paid highly respected fields. Nevertheless, some Black females do seek and successfully obtain careers in these areas. To determine what enabled these women to succeed, one might look for events in common among a sample of those who have been successful. Johnson (1986) surveyed graduates of a program designed to meet the needs of minority gifted students. Based upon the responses of 813 graduates, Johnson found the following to be some of the key factors related to the choice of a career in science or mathematics:

1. self-perception of one's ability,
2. enrollment in advanced mathematics courses in high school,
3. the choice of a math or science teacher as most influential teacher.

If the above factors are truly related to the choice of a career in math or science, the question for Black females becomes—What can be done to enhance the acquisition of these skills by this target group?

Self-Perception of One's Ability

In reference to ability, there is little or no evidence to suggest that Black females' ommission in planning careers is due to a lack of aptitude or ability. In fact—at least in studies of early career preference—ability has little to do with aspirations to prepare for math and science careers. Jacobowitz (1983) reported "Mathematics achievement did not account for a significant proportion of the variance in science career (gender) preferences" (p. 626).

It appeared that students were not yet aware that a career in science presupposes achievement in mathematics and science and, consequently, they did not consider or realistically assess these factors when indicating preferences for science careers. These results occurred even though the Black females in the study had science and math achievement scores similar to those of the males.

In an analysis of performance by Black students in math and science on the National Assessment of Educational Progress, Holmes (1980) found that Blacks were disadvantaged at all examined levels (ages 9, 13, and 17) with the achievement gap getting most severe at age 17. Science achievement differences between Whites and Blacks were also less severe at the younger ages. Perhaps it is the lack of awareness on the part of young Black females that, in part, leads to this widening gap in achievement. Since these students do not realize the importance of both participation and achievement in math and science courses, there results a lack of achievement in these areas which prevents Black females from attaining the occupations to which they had earlier aspired.

In reference to self perception of ability, however, early adolescent science career preferences were related to interests that are consonant with sex role considerations. Jacobowitz (1983) found that sex accounted for the major proportion of the variance in science career preference of Black inner city junior high school students. These sex role related expectations may affect Black females' self-perceptions of their ability to succeed in math and science. Turner (1983) cited low levels of self-confidence and/or low expectations of success as factors that keep Black females from pursuing a career in the science or health professions. Sex role stereotypes (which generally exclude women from math and science related roles) may be very detrimental to early planning for math and science careers.

Enrollment in Advanced Mathematics Courses

In their report on equity and excellence, the American Association for the Advancement of Science (1984) reported that the quality and quantity of pre-college education was very closely related to later success in technical fields. Turner (1983) also cited poor mathematics preparation as a factor that excludes Black females from technical careers. By the time Black females arrive at college where they might make a decision to pursue a career in math or science, the chances for success have already been minimized because of poor high school preparation.

As already noted, this poor preparation may be due in part to Black females being unaware of the importance of class enrollment and achievement to entrance into math and science fields. This information gap has been blamed in part on a deficiency in the academic advisement and counseling received by Black females (Epstein, 1973). Simply stated, Black females may not enroll in classes that would prepare them for advanced study in math and science because they were not advised to do so.

When Black females are counseled into math or science courses, they usually find themselves in a lower level or general curriculum. Such decisions as which course is appropriate for an individual student are often made early in the educational career and dictate what courses will follow (Sells, 1982). As Kahle (1982) reported, both tracking and grouping practices often result in students receiving long-term assignments to groups with different objectives and expectations from their own. This is "classroom" segregation rather than "school" segregation. It still "results in fewer opportunities open to minority students, and . . . is especially damaging in science and mathematics, where each course builds upon earlier content" (p. 54).

Teacher Influences

There is little doubt that teachers play a key role in determining career goals. The problem with expecting Black females to identify with and, consequently to be influenced by a math or a science teacher is that there are very few Black female math or science teachers to be role models. This is not to say that male instructors cannot have a positive influence, but concrete role models might make it easier for adolescents to imagine themselves performing successfully in these careers. Thomas and Shields (1987) found that Black female and Black male adolescents both tended to cite a same-sex and race individual as their key influencer.

Strategies

If self-perception of one's abilities, enrollment in advanced mathematics courses, and teacher influence all offer probable explanations for the under-representation of Black females in math and science careers, what could be done to resolve the obvious inequity? Since early planning for a career in math and science and the selection of a math or science teacher as a key role model might both be dependent upon an initial self-perception of one's self as a successful scientist or mathematician, it seems appropriate that most recommendations for dealing with this problem revolve around improving self-perceptions.

Matyas (1984) placed a heavy burden on instructors, "Undoubtedly, a key factor in changing girls' opinions and achievement will be science teachers and their attitude" (p. 198). Sells (1982) advocated the same self-attitude examination by math teachers because teaching toward communication and delivery of skills is much different than teaching geared to differentiation of students. It is important for educators to hold high expectations for Black females and communicate those expectations to the students. Burlew (1977) stated that educators should provide contact with "significant others" who can communicate high expectations and

share the belief that it is appropriate for females to have career and educational ambitions similar to those of males. She advised teachers to reassure young Black females that they have the ability to complete higher levels of education and to be successful in a variety of careers.

In addition to positive teacher attitude, the literature suggests many specific instructional strategies that may help boost Black females' self-perceptions in math and science. Fauth and Jacobs (1980) suggested starting early by taking advantage of and building on the early enthusiasm for mathematics before girls reach adolescence. This might be accomplished through utilization of instructional techniques that incorporate the learning styles of Black females. In fact, Malcolm (1984) found, "The primary feature of successful programs for minorities and females seems to be that they involve the students in the 'doing' of science and mathematics and convey a sense of their utility" (p. vii). Jacobowitz (1983), also, recommended that teachers and administrators work to eliminate perceptions of science as a masculine domain. They should attempt to enhance the self-concept by reinforcing specific scientific behaviors and encouraging Black girls to participate in hands on laboratory experiments.

Simply providing opportunities for hands-on activities may not be adequate, however. Educators must monitor student participation by assigning and rotating job roles in the laboratory setting. Jones (1985) has developed a system for helping science educators define and teach task group roles to students, thereby assuring more equitable hands on participation.

Role models have also been suggested as a way to enhance Black females' self perceptions in math and science. Many researchers have suggested enabling Black females to interact with female role models as well as exposing them to films and publications on the lives and actions of women scientists (Fauth and Jacobs, 1980; Jacobowitz, 1983; Scherrei and McNamara, 1981; and Smith, 1981).

In order to effect Black female enrollment in math and science courses, Jacobowitz (1983) Scherrei and McNamara (1981) recommended that Black females be advised and encouraged to enroll in mathematics and science courses in high school. Jacobowitz (1983) and Smith (1981) suggested that this goal might be attained by increasing Black students' awareness of the link between their school achievement in math and science courses and their potential for success in lucrative, well-respected careers. Fauth and Jacobs (1980) suggested developing positive attitudes toward math and its practical usefulness. They contend that this might be accomplished by identifying high ability students early and establishing support groups of same sex peers to maintain the interest and commitment to mathematics. Peer interaction might foster cooperative support groups, giving Black females who are interested and talented in math and science an appropriate reference group. Burlew (1977) described an approach that involved group discussions with Black females and males designed to restructure sex role perceptions and give increased options for both sexes. School curriculum, course requirements and school organization also might be investigated to determine changes that might foster increased enrollment of Black females in math and science courses.

In reference to students' choice of a math or science teacher as one's most influential teacher, the answer appears to be exposure to and encouragement from a dedicated teacher/counselor (Scherrei and McNamara, 1981). Good teachers have made the difference in many lives and will continue to do so, but Black females must have ample opportunity to interact with such teachers. It might also be important (according to Fauth and Jacobs, 1980) to "identify and guide the 'math anxious' teacher" (p. 489), who might actually be functioning as a "turn off" to the aspirations of Black females for math and/or science careers.

Summary

Matyas (1984) stated, "the technological society in which we live cannot afford to waste the scientific brainpower of one-half of its population through unequal education" (p. 75). When we refer to Black women exclusively, we are no longer dealing with as large a proportion of the population, but the same argument rings true. However, is it necessary to target Black females specifically rather than just women as a whole? To this point, Turner (1983) argued:

"While the future is likely to bring greater White females' participation in science, the same trend does not appear to be as likely for Black females. This observation highlights the increasing importance of NOT deciding that being female in society equally handicaps all women, regardless of ethnic origin . . . the barriers to successful careers in science must be individually examined for each ethnic group and means developed to overcome these barriers must be, perhaps, specific in design" (p. 4).

Finally, how great is the necessity of a continued, concentrated effort in order to achieve the goal of greater participation in math and science by Black females? Vetter (1986) answered this question for all females by stating:

". . . there is evidence that an increasing proportion of precollege women are taking the essential high school courses in mathematics and science that will hold open the option of choosing to pursue a science career. The gains over the last two decades have occurred in a climate of legally mandated educational opportunities, supportive changes in society's view, and favorable political backing. But a change in this climate—even to neutral—could slow women's reach toward equality" (p. 63).

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