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by
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The United States is experiencing a crisis in the training of scientific and technical personnel. A recent report from the National Science Foundation (NSF) indicates that the number of U.S. citizens earning science and engineering doctorates has decreased nearly 5% since 1980.[1] The National Research Council's study of the adequacy of research support for the mathematical sciences in the United States reveals that not only has the production of Ph.D.s in mathematics declined since 1969–70, but the percentage of U.S. citizens receiving those degrees fell during the last decade from 78% of all mathematics Ph.D.s to only 61% of all mathematics Ph.D.s.[2] Heller reports that there has been a 15% decline between 1977 and 1984 in the number of Americans studying for graduate degrees in mathematics.[3]

Despite these shortages, people of color and white women remain severely underrepresented in scientific and technical professions; this has been the case historically and continues to be true today. In recent years the relative underrepresentation of minority group members and women in the various sectors of American life has received national attention and, to some extent, national action. While a number of initiatives have been undertaken to address this problem, it still remains a serious one, particularly for blacks, Hispanics, and American Indians. Students from these groups continue to underachieve in mathematics, science, and technical subjects.[4] Furthermore, youths from these groups are less likely to take higher level high school mathematics and science courses or to major in mathematics, science, and technical fields in college.[5] The net effect of these circumstances is that members of these groups are underrepresented at the professional levels and their communities are underserved or ill-served by these fields. Perhaps what is most distressing is that these trends suggest that this situation will continue for some time into the future.

Extent of Black Underrepresentation

The selectivity index in table 1 was computed to measure the extent to which a group's representation

Table 1
Index of Underrepresentation in Science and Engineering (S/E) Professions by Race

Group	(A) Percent of 1990 U.S. Population	(B) Percent of 1988 S/E Work Force	(C) Percent of 1987 Employed S/E Doctorates	Selectivity Indexes A/B	Selectivity Indexes A/C
American Indians	0.8	0.8	0.1	0.95	6.71
Asians	3	5	8.7	0.60	0.34
Blacks	12	2.6	1.5	4.62	8.00
Hispanics	9	1.8	1.7	5.00	5.29
Whites*	75.2	89.8	88	0.84	0.85

Sources: 1990 population data reported by Felicity Barringer, "Census Shows Profound Change in Racial Makeup of the Nation," New York Times, Monday, 3/11/91, A1. Science and engineering work force data reported in NSF, Women and Minorities in Science and Engineering, 1990.

*White females had selectivity indexes of 3.0 and 3.58, using 1980 census data and 1986 occupational data.

in the science and engineering (S/E) work force and among employed doctoral scientists and engineers differs from their relative presence in the larger U.S. population. The larger the magnitude of the selectivity index, the greater the disparity between the proportional representation in the population and in the S/E work force and among employed S/E doctorate holders. A value of one means that there is no difference in the relative representation of a group in the general population and in the S/E work force. A value less than one indicates that a group is overrepresented in the S/E work force relative to its proportional presence in the U.S. population.[6]

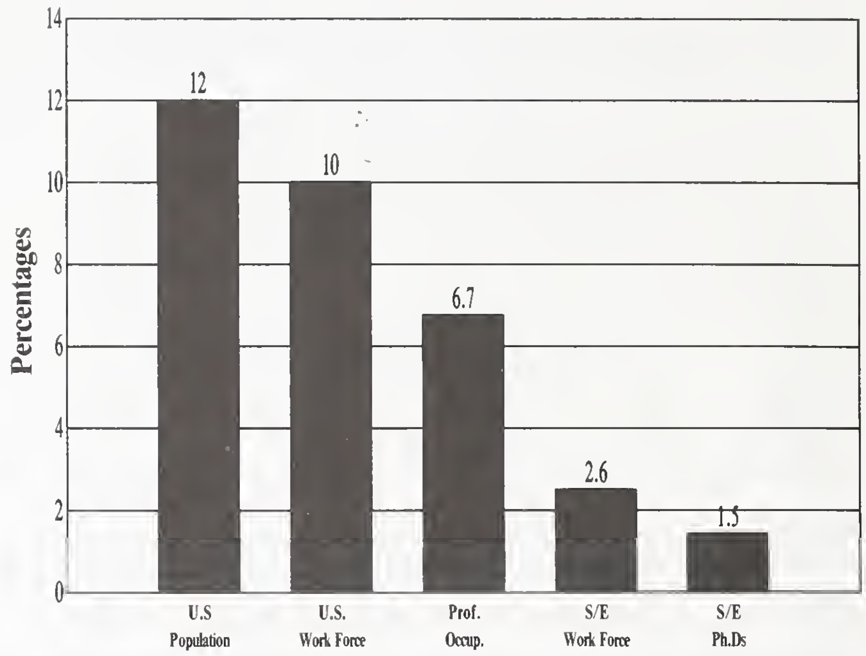
Table 1 shows the underrepresentation in the S/E work force by race. These data reveal that blacks are underrepresented by a magnitude of approximately five in the S/E work force and by a magnitude of eight among employed S/E doctorate holders. Another way of stating this situation is that black representation in the S/E work force is roughly one-fifth of the black presence in the U.S. population. The share of employed S/E doctorates held by blacks is only one-eighth of their proportional size in the larger society. In contrast, white males are twice as likely to be represented in the S/E work force and among employed S/E doctorate holders as they are in the U.S. population.

With the exception of people of Asian origin, all groups trail white males in their relative presence in the S/E work force and among employed S/E doctorate holders. Persons of Asian descent are almost two times as likely to be in the S/E work force relative to their population proportion, and almost three times overrepresented among employed S/E doctorate holders.

People of color and white women remain severely underrepresented in scientific and technical professions; this has been the case historically and continues to be true today.

Relative to black participation in the U.S. labor force and in other professional and related occupations, black representation in science and technical fields is still low. This is depicted in graph 1. This graph shows the relative representation of blacks in: the U.S. population, the U.S. work force, the professional occupations in the United States, the science and engineering work force in the United States, and the pool of science and engineering doctorate holders in the United States. While American Indians, Hispanics, and white females are also underrepresented, the magnitude of underrepresentation is generally greatest for black Americans (see table 1).

Graph 1
Black Representation in Science Fields



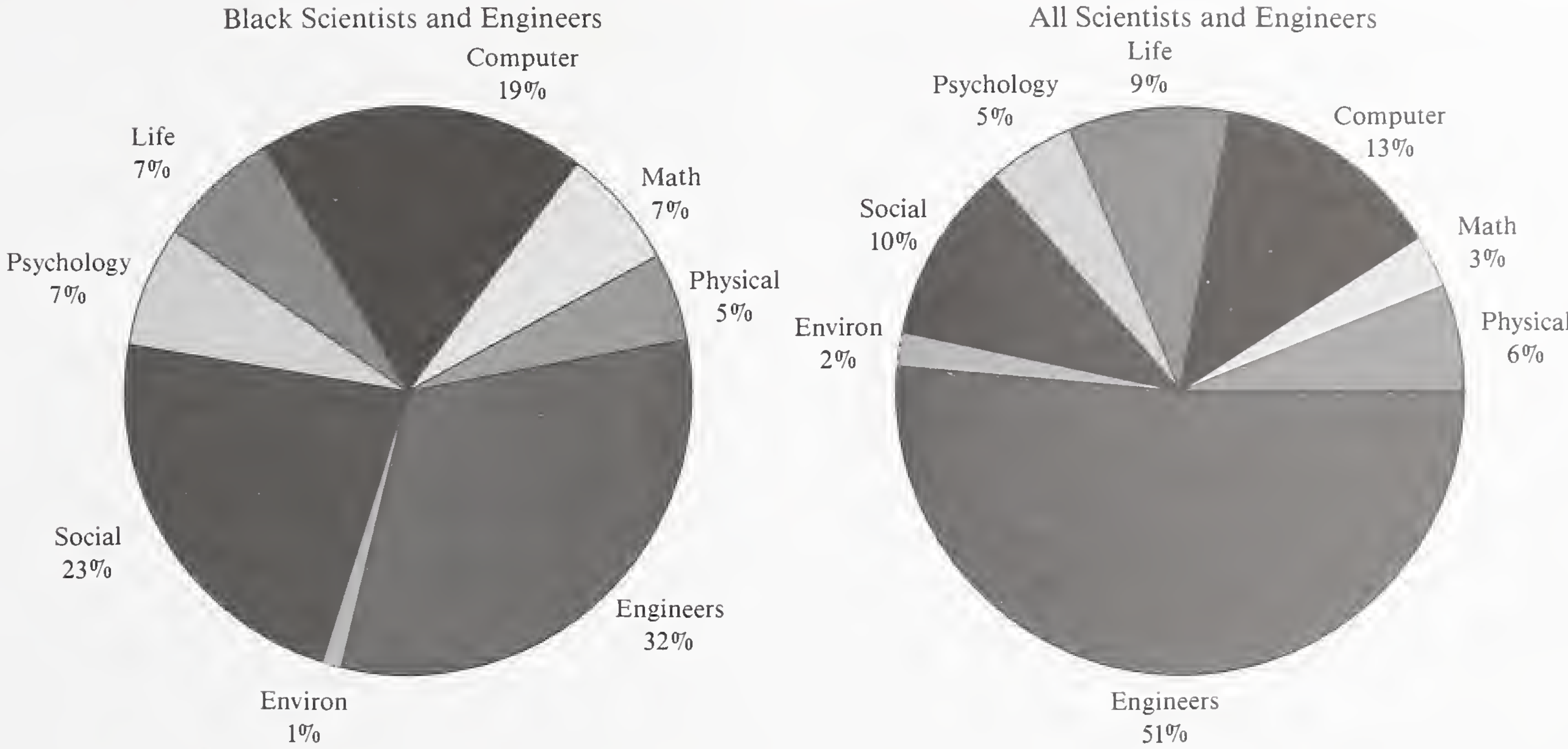
Source: National Science Foundation. (1990). *Women and Minorities in Science and Engineering.* Washington, DC: Author.

In addition to the severe underrepresentation of blacks in S/E fields, their representation varies greatly in the different science and engineering fields.[7] For example, blacks are more likely to be mathematicians, social scientists, and psychologists than are S/E professionals in general, and less likely to be environmental scientists (see graph 2). The percentage of blacks who are engineers is less than that for the total pool of scientists and engineers, 32% compared to 51%.

Black Achievement in Mathematics and Science

A number of quantitative measures are available to indicate that the achievement of black students in mathematics and science is continuing to lag behind that of other groups. To increase the black presence in the S/E fields, higher levels of black achievement in these areas are required. In considering the issue of the achievement of blacks in mathematics and science, data on course-taking patterns, test performance, and enrollment patterns in science and mathematics are consulted to determine the current level of black underachievement. Given the biased nature of standardized tests, they are useful if considered only as indicators of past experience and partial measures of achievement and not as measures of aptitude or ability. They can be used to suggest the disparities that exist between black students and those from the larger population in the areas of mathematics and science. Along with other types of data, they indicate the failings of the social and educational systems in providing opportunities and resources to many black, Hispanic, and American Indian children.

Graph 2
Employed Scientists and Engineers by Field and Race



Source: National Science Foundation. (1990). *Women and Minorities in Science and Engineering.* Washington, DC: Author, Appendix Table 1

Data from the 1986 National Assessment of Educational Progress report indicate that the gap between black and white students in science and mathematics achievement is closing, due in part to improved performance by black students. However, these results also indicate that black students fare less well on measures of mathematics and science knowledge than do their white counterparts at all age levels (9, 13, and 17 years).[8] Similar results are reported for performance on the mathematics section of the Scholastic Aptitude Test (SAT) for the period between 1976 and 1988,[9] and the quantitative portion of the Graduate Record Examination for 1979 and 1987.[10]

Closely related to performance on standardized tests is the number and type of courses taken in mathematics and science. Black students, as well as American Indian students, as a rule, take fewer advanced level courses in these areas than do Asian and white students, even though blacks, like Asians, take more years of mathematics courses than do their white, Hispanic, and American Indian counterparts. Black students received lower grades in mathematics than students from other ethnic backgrounds (grade point average: 1.98, blacks; 2.60, Asians; 2.34, whites; and 2.19, American Indians).[11]

Several reports indicate that black and low-income students are less likely to have access to computers, either in their schools or homes, and are likely to have different types of learning experiences with computers than their white and/or more affluent colleagues. Fullilove, analyzing data from studies conducted by the National Center for Educational Statistics and the Center for Social Organization of Schools at Johns Hopkins University, reports that a smaller percentage of urban schools (33%) have computers than do suburban (37%) and rural schools (37%).[12] However, those urban schools with computers had, on the average, more computers than the other types of schools (6.8 per urban school; 3.9, suburban; 3.0, rural).

Data from the Hopkins study indicate that "computers were far less accessible in predominantly minority elementary schools than in predominantly white schools, irrespective of the socioeconomic status of its students."[13] Computers in urban schools are also more likely to be used for remediation and drill-and-practice, and less likely to be used for instruction in programming/computer science. This finding caused Fullilove to observe that computer resources at white schools, particularly working class schools, were being used more frequently to create skilled computer users than was the case in minority schools.

In terms of home computing, Anderson reports substantial differences in access related to family income.[14] A national study in 1983 found that 30% of those families with incomes above $50,000 had home computers compared to 4% of those with incomes under $15,000. Research conducted in Minnesota in 1985 reveals that families with low incomes are not only less likely to own computer equipment, but if they own one, it is more likely to be less expensive and game-oriented, with fewer peripherals and software. Also, low-income owners of computers spend less time using their computers, on the average, than their higher-income counterparts (12 hours weekly versus 18 hours).[15]

Black Community Development and Science and Technology

The importance of black underrepresentation in scientific and technical fields is not limited solely to the crisis in developing human resources for national needs (i.e., defense, industry, research, etc.); the underrepresentation bears directly upon issues facing the black community. Community development requires civil engineers, architects, urban planners, doctors, environmental scientists, and many other professionals with technical skills as well as an understanding of, an appreciation for, and a sensitivity to the needs, aspirations, and culture of the members of that community. Technical approaches to human problems require social perspectives and sensitivity. These professionals will have to represent the views of the community and not those of outside parties whose interests may not be in harmony with the community's goals.

Black representation in the scientific and engineering work force is roughly one-fifth of the black presence in the U.S. population.

A distrust of and hostility toward science and technology on the part of many blacks may be one factor contributing to the lack of representation and achievement by black Americans in these areas. Historically, blacks have been victimized by technological innovations. New technological developments also pose threats and challenges to the black community.[16] In a related vein, blacks have historically used educational, social, political, economic, and judicial means to seek relief from their oppression. As a consequence, many talented blacks have sought careers in areas where they can be of service to their people (law, education, social work, medicine, etc.). Since science and technology have not been viewed traditionally as means of obtaining social justice, they are not careers that large numbers of blacks have considered. The application of scientific and technical remedies is a relatively recent advent in the fight against racism and its effects.

Johnson has conducted several studies in which he has asked black respondents to identify their reason for selecting a professional occupation or college major.[17] A significant number of those in nonquantitative fields gave reasons that reflected a people or community focus, a "helping orientation." One implication of this finding is the need to show the relevance of science and technology to the interests and aspirations of black Americans.

Policy and Program Implications

A long-term solution to the problem of black underrepresentation in scientific and technical fields requires a comprehensive effort involving schools, community groups and agencies, families, businesses, universities, and governmental units. Projects designed to address this issue should consider working with elementary and junior high school teachers, administrators, students and their parents, community groups, and mathematics and science educators. Private and public funding sources need to recognize the complex nature of the problem and the multidimensional approach required to address it.

A comprehensive approach would include increased scholarship aid for black students (as well as other underrepresented groups); support for presecondary school programs; increased emphasis on the contributions and achievements of blacks and other underrepresented groups in the fields of science and technology; support for out-of-school programs; the development of centers that provide computing and science opportunities for interested parties (both younger and older people); and more intensive recruiting efforts to attract black youth to mathematics and science courses, majors, and careers. Holman has put forth proposals incorporating these elements and identified programs currently operating under this model.[18]

The responsibility for producing scientific talent lies with the schools. However, a number of studies and reports indicate that our schools are falling short of fulfilling this responsibility. The National Commission on Excellence in Education stated in *A Nation at Risk*[19] that the nation's security is imperiled by poor educational quality. The National Science Board recognizes the importance of and urges improving mathematics, science, and technology education in elementary and secondary schools.[20] Among its recommendations is the call for retraining teachers.

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Calls abound for educational reform from the mathematics and science education communities. For example, the National Science Teachers Association in a report on science education for the 1980s called for more resources to be devoted to science education to combat the deterioration of mathematics and science instruction in the schools.[21] Beyond the calls from science and technological communities, most of the reports on educational reform have indicated a need for more quantitative, scientific and technological instruction for the youth of America.

Teachers are very important in the production of scientific personnel. For students of color, role models are considered important in encouraging participation in scientific fields. However, the proportion of teachers who are minorities is declining.[22] Thus, it is very likely that, unless significant actions are taken, many, if not most, minority students will be taught by whites. This situation raises the question: To what extent are these teachers prepared to teach mathematics and science in a multiethnic environment to culturally different students? It is clear that most teachers are lacking on both dimensions—the technical and the cultural.

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Consequently, teachers are generally not viewed as partners in the production of black scientific personnel. Research by Johnson on factors related to black participation in mathematics and science shows that teachers and other school personnel generally are not influential persons.[23] For example, persons without a quantitative background tend to identify themselves or their parents as the most influential persons in the selection of mathematics courses, college majors, and occupations. Johnson also found this to be the case among college students majoring in science and technical fields. On the other hand, some black professionals in scientific and technical professions indicated that school personnel did play a role in their election of high school mathematics courses.[24]

A key aspect to addressing this problem must be sensitizing elementary and junior high school personnel, as well as those who create school policy and curriculum, to the problem of underrepresentation of blacks and other minorities in mathematics and science and its ramifications. This qualitative factor is very important in minority student achievement according to sociological and educational research.[25]

In order to reverse the current situation of minority underrepresentation, it is important that teachers play a greater role in teaching and orienting students toward quantitative areas. While teachers are not deemed very influential at this point in time, they can be an important source of influence in black youths' enrollment in such critical courses as mathematics and science.

Not only are the teachers of minority students not preparing them for a technological future, but the schools that these students attend are not equipped with the computer equipment and expertise to prepare them in computer literacy.[26] Greater access to technological training is a must for large numbers of black students, as well as more creative use of existing technological resources in the schools. Giving the teachers of underserved students better training in the use of modern technology as an instructional tool will enhance the utilization of available technological resources in their schools and increase the level of teacher expertise.

Another key aspect of addressing this problem involves parents. Since there is research indicating that parents are identified by students and professionals as the most influential people in their career choice, a related goal would be to give parents information about scientific and technical professions so as to enable them to better advise their children about course selection and other pertinent matters. Similarly, programs such as the Family Math Project at Berkeley, which aims to help parents become mathematics educators at home, should be expanded and extended to more black families.

The final key aspect of addressing this problem involves the community. Community resources, both public and private, will have to be identified and utilized to implement comprehensive and ongoing programs of the type suggested above to address the problem of minority underrepresentation in quantitative fields at an early and basic level and to effect both immediate and long-term redress to this problem. Use of community resources to complement school facilities will give black youths additional opportunities to be exposed to technical materials and expertise. Programs and equipment housed in churches, civic centers, schools, businesses, and other community-based institutions can provide increased access to underserved populations. Support for such programs can come from community organizations and governmental sources.

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Additional research is needed in the area of black underrepresentation to identify the early determinants and correlates of this problem. Ethnographic and quantitative research on family, community, and early school experiences is called for. In addition, there is a need to assess the programs that have been initiated over the past ten to fifteen years to address this problem in order to identify the factors that make for successful and effective responses. Finally, it would be helpful to catalogue the different intervention programs according to purpose, design, content, target group, demographic composition, effects, and results.

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