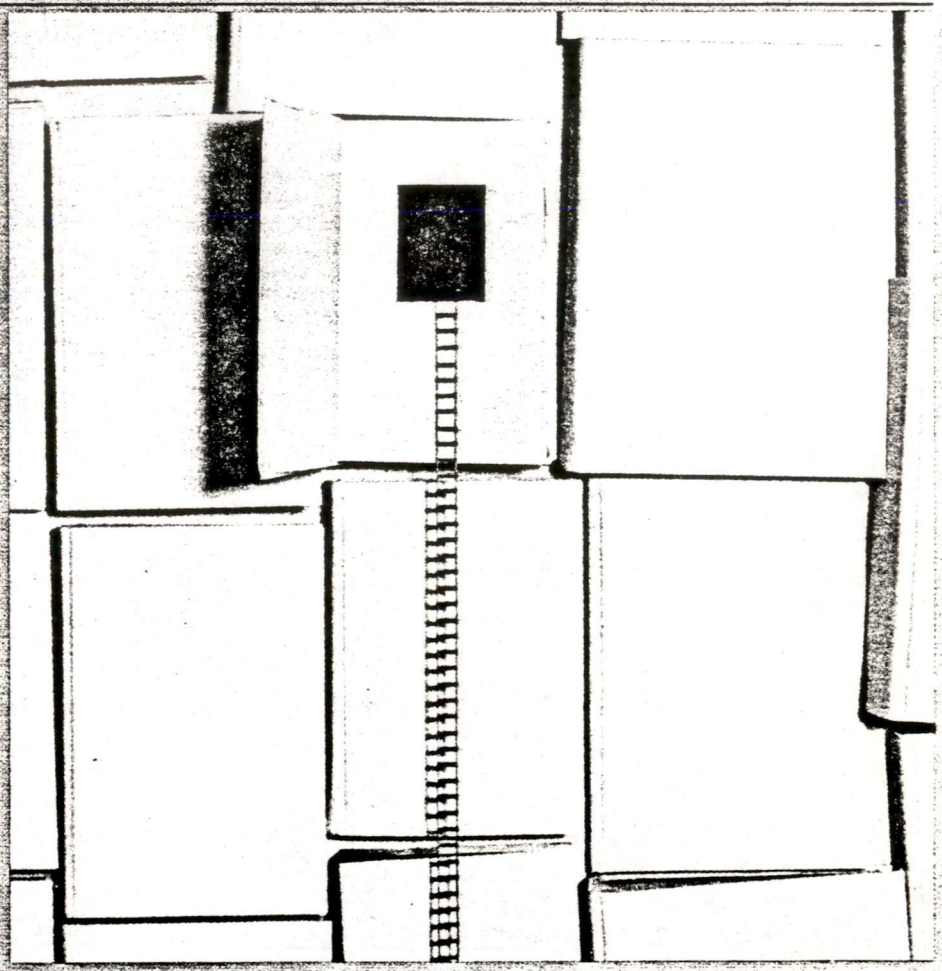
Resources and Reality: The Participation of Minorities In Science and Engineering Education

Negative trends with respect to financial resources and institutional priorities, which affect the entire student population, are particularly troublesome for minorities, Ms. Rotberg notes — and especially for those who are interested in entering science and engineering.



BY IRIS C. ROTBERG

THERE IS general agreement about the importance of increasing the participation of underrepresented minorities in undergraduate and graduate education in science and engineering. There is less agreement, however, about the commitment — public and private — to provide the resources and policy initiatives that will significantly improve the rate of minority participation. While the number of minority students in some fields of science and engineering has grown more over the past generation than most commentators have acknowledged, their underrepresentation remains a serious problem.

At first glance, there seem to be a great many programs across the country that are designed to provide academic or financial support to encourage increased minority participation in science and engineering. Some of these programs have shown impressive results. However, even the most effective "special" programs can serve only a relatively small number of students. The issue is whether these programs alone can create significant increases nationwide in the number of minority students enrolled in courses in science and engineering.

The fact is that even these highly commendable programs are in danger of being overshadowed by more general, negative trends with respect to institutional priorities and available financial resources. Moreover, these negative trends affect large numbers of potential students, and they create unintended barriers to increased participation. Although the effects of these trends are not limited to science and engineering or to minority students, they are especially troublesome in these areas.

The following are the major trends that affect minority students seeking to obtain

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Illustration by Joe LaMantia

an education in science or engineering.

• The growing financial pressures on colleges and universities have increased tuition far faster than inflation. The decline in the real value of financial aid, combined with increased reliance on loans, has exacerbated the problem. Many minority youths have chosen not to enroll in higher education at all; others have chosen lower-quality institutions. Students considering graduate school face a long-term decline in federally funded fellowships and traineeships; at the same time many have already assumed a large debt burden from their undergraduate education.

• Financial considerations have contributed to an increasing polarization of the college population in different types of institutions. Few students can afford expensive colleges, and many elite institutions are under substantial financial pressure to select increasing proportions of high-income students. As a result, many of the colleges that have the strongest undergraduate programs – indeed, those with the environment that the special programs noted above attempt to replicate – are growing less accessible to low-income students. This polarization is compounded by the fact that low-income and minority students are increasingly attending community colleges, at least in part because of costs. Only a small proportion of low-income and minority students who attend community colleges go on to receive bachelor's degrees.

• There has been a long-term trend for colleges and universities to give lower priority to undergraduate teaching and greater attention to research and a range of other priorities. At the same time, research evidence suggests that the institutional environment, especially the time that faculty members spend with students, can make a major difference in minority students' achievement and retention in science and engineering programs.

These trends affect both the access of minority students to science and engineering education and their decisions about majoring in science and engineering and attending graduate school. Indeed, any changes in access and retention can make a noticeable difference in a relatively short period of time. A recent report from the Office of Technology Assessment put it this way:

> If the nation wants more scientists and engineers relatively quickly, then retaining college and graduate students in science and engineering is the most useful policy strategy. Many able students leave science during college, after earning baccalaureate degrees, and during graduate school. Only about 30% of baccalaureate science and engineering graduates enter full-time graduate study, and nearly half of science and engineering doctoral candidates never earn Ph.D.s. Some loss is inevitable and, indeed, beneficial to other fields, but those who leave unwillingly and prematurely are a rich resource that could be tapped. Because attrition rates are so high and the population of research scientists and engineers is relatively small (only 4% of American workers), slight improvements in retention could increase significantly the number of scientists and engineers in the work force.[1]

This article considers, first, the recent trends in minority enrollment in science and engineering education and presents some examples of programs that have shown gains. And second, it analyzes the policies and priorities that appear to hinder continued progress in increasing the enrollment of minorities in science and engineering programs.

TRENDS IN MINORITY ENROLLMENT

Societal and economic changes in recent decades have led to significant gains in the participation rates of minorities in some fields of science and engineering education. Many of these gains have occurred in less than a single generation. While the number of minorities in science and engineering fields remains small and while some trends are disturbing (e.g., the declining college attendance rates among minorities), most indicators suggest that the potential exists for significant future increases in minority participation. However, the environment is fragile, and public and private policies with respect to institutional priorities and financial aid can play an important role in encouraging – or blocking – future gains.

UNDERGRADUATE EDUCATION

Between 1977 and 1987, even though overall college participation rates lagged, the number of minorities who received bachelor's degrees in several key science and engineering fields increased, both in absolute numbers and as a percentage of the total degrees awarded in these fields (see Table 1).[2] The largest gains were in

TABLE 1.
Recipients of Bachelor's Degrees in Science and Engineering By Field and Racial/Ethnic Group: 1977 and 1987

Field	Total, U.S. Citizens And Permanent Residents		White		Black		Asian		Native American		Hispanic	
	1977	1987	1977	1987	1977	1987	1977	1987	1977	1987	1977	1987
Physical sciences	22,038	19,027	20,417	16,653	692	823	377	894	68	72	484	585
Mathematical sciences	13,977	15,506	12,602	13,265	712	834	316	1,034	26	52	321	321
Computer sciences	6,161	35,943	5,508	29,181	361	2,820	163	2,455	15	112	114	1,375
Life sciences	131,430	101,085	119,442	86,858	5,860	5,251	2,578	4,107	424	420	3,126	4,449
Psychology	47,297	41,248	41,494	35,761	3,221	2,451	807	1,154	167	180	1,608	1,702
Social sciences	116,622	91,347	100,191	78,940	10,360	5,746	1,664	2,853	474	449	3,933	3,359
Engineering	46,093	85,134	42,072	71,866	1,385	3,420	1,211	6,378	135	283	1,290	3,187

Source: *Women and Minorities in Science and Engineering* (Washington, D.C.: National Science Foundation, January 1990), pp. 136-37.

TABLE 2.

Recipients of Master's Degrees in Science and Engineering By Field and Racial/Ethnic Group: 1977 and 1987

Field	Total, U.S. Citizens And Permanent Residents		White		Black		Asian		Native American		Hispanic	
	1977	1987	1977	1987	1977	1987	1977	1987	1977	1987	1977	1987
Physical sciences	4,689	4,271	4,363	3,834	94	79	142	227	21	9	69	122
Mathematical sciences	3,328	2,331	3,048	2,012	133	73	90	183	12	3	45	60
Computer sciences	2,432	5,848	2,208	4,717	67	207	108	779	3	22	46	123
Life sciences	22,327	20,961	20,262	18,687	914	888	595	663	72	68	484	655
Psychology	8,149	7,493	7,201	6,698	506	376	95	113	26	35	321	271
Social sciences	14,013	7,867	12,364	6,979	969	390	275	234	36	22	369	242
Engineering	12,695	15,947	11,444	13,239	240	433	737	1,692	23	63	251	520

Source: *Women and Minorities in Science and Engineering* (Washington, D.C.: National Science Foundation, January 1990), pp. 144-45.

engineering and computer science, but small gains also occurred in the physical and mathematical sciences. Degree patterns for minorities generally follow those of the student body as a whole. Thus there has been a trend toward engineering and computer science and away from life sciences, psychology, and the social sciences, which is consistent with overall patterns for the entire population.

A recent report by the National Action Council of Minorities in Engineering shows that the rate of increase of minority enrollments in undergraduate engineering programs continues to outstrip the rate of increase for the student population as a whole. In 1988, 11,754 black, Hispanic, and Native American students enrolled in undergraduate engineering programs, up from 10,325 students in 1987 for an increase of 13.8%. The corresponding increase for the total freshman population in engineering was only 2.7%.[3]

GRADUATE EDUCATION

The trends for minority students in graduate schools are consistent with those for the student population as a whole: minority students generally earned more graduate degrees in engineering and computer science in the late 1980s than they did 10 years earlier, and they earned fewer graduate degrees in several other scientific fields (see Tables 2 and 3).[4]

In the case of minorities, however, the numbers were so small to begin with that percentage increases do little to alleviate the basic problem. For example, the increase in engineering doctorates between 1978 and 1988 meant that blacks went from 13 engineering doctorates in 1978 to 31 in 1988; Native Americans, from two to four; and Hispanics, from 32 to 63. For other fields, such as mathematics, the extremely small number of doctorates awarded to minorities in previous years has now been reduced even further. However, recent reports about increased graduate enrollments in these fields are encouraging. For instance, about 600 more black U.S. citizens enrolled in science and engineering programs in doctorate-granting institutions in 1988 than in 1987.[5] The gains were spread over all fields except mathematics, which continued to exhibit a decline. Nonetheless, the societal trends that have discouraged U.S. students from pursuing doctoral degrees – cost, length of time to earn a doctorate, competing job opportunities – will be especially damaging to minorities and to the society as a whole, if there continue to be only very small numbers of minority professionals in science and engineering to serve as mentors or role models.

INDICATORS OF FUTURE GROWTH

However, there are indications that the student pool from which many science and engineering majors are drawn will grow. Given the high correlations between such indicators as parental education, family income, and achievement, the continued growth in the number of middle-class minority families could be expected to exert strong intergenerational effects on the educational attainment of minority children as a group. Indeed, as a result of the major increases in college attendance for minority groups during the 1970s, the children of these college students could be an important source of enrollments in science and engineering programs during the next two decades. While the number of potential science and engineering students will certainly increase, the reality is that institutional priorities and public policies with respect to financial aid will influence how many of these students actually choose to enter and remain in science and engineering.

One indicator of the gains that have already been made is the significant improvement in the test scores of minority students on a range of tests, including the National Assessment of Educational Progress (NAEP), the Scholastic Aptitude Test (SAT), the American College Testing (ACT) Program, and the Graduate Record Examination (GRE).[6] Increased scores have occurred at all age levels, both in absolute terms and relative to the test scores of whites. Despite the continuing gap, the overall trend for minorities is clearly upward. It must be noted that the comparisons do not control for family income and level of parental education – two variables that are highly correlated with test scores and that are substantially lower for minority groups than for the population as a whole. For instance, in 1985, 68% of blacks who took the SAT came from families with annual incomes of less than $24,000, while only 27% of whites came from families with annual incomes at that level. Thirty-four percent of the black students came from families with annual incomes of less than $12,000.[7]

It is likely that a number of factors have contributed to these achievement gains – including the emphasis over the past 20

years on supplemental academic programs for disadvantaged children. Nonetheless, the increasing proportion of minority children growing up in middle-income families has clearly played a role, even though this proportion remains small compared to the middle-class population as a whole.

SOME SUCCESSFUL PROGRAMS

Some programs that provide academic support to encourage minorities to enter or to continue in science and engineering have shown positive results. These programs are sponsored at precollege, undergraduate, and graduate levels by government and by the private sector. Virtually none have been formally evaluated. Nonetheless, the statistics from a few of the programs, along with anecdotal evidence from a number of others, suggest that the programs can serve an important purpose. However, they are not likely, by themselves, to result in major shifts in the rates of participation by minorities in science and engineering. They provide on-site support and cannot be expected to compensate for broader policies that affect much larger numbers of students.

A full description of the wide range of these programs is beyond the scope of this article. However, as examples of the potential benefits, I note two programs that have achieved especially dramatic results.

Philip Treisman's program at the University of California, Berkeley, which has been replicated at a number of other institutions nationwide, has received widespread publicity.[8] The program uses a cooperative-learning workshop model to teach calculus, a course that has traditionally presented a major barrier to the retention of students in science and engineering programs. The workshop participants earn an average grade that is essentially the same as that earned by all students enrolled in calculus. In some years the workshop participants exceeded the course average. Furthermore, they typically earn between three-quarters of a grade and a full grade higher than other minority students in comparison groups who have similar SAT math scores. Indeed, the average grade (2.2) of workshop participants with the *lowest* SAT scores (200-460) is higher than the average grade (2.0) of nonparticipating minority students with the *highest* SAT scores (550-800). Retention rates are also considerably higher for the workshop participants than for comparison groups. For example, 44% of the black students who took part in the workshops graduated from Berkeley in math-based majors, compared to 10% of the black students who did not participate in the workshops.

Raymond Landis of California State University, Los Angeles, has developed a similar program for engineering students.[9] The program emphasizes cooperative learning and community building and has also produced dramatic gains in student learning and retention in engineering. Not only are the retention rates for minority freshmen who participated in the Minority Engineering Program (MEP) higher than those of minority students who were not in the MEP, but they are also higher than those of the student body as a whole.

FINANCIAL RESOURCES AND INSTITUTIONAL PRIORITIES

The priorities set by government and by institutions of higher education have important effects on the access of minorities to science and engineering education. While these decisions affect the student population as a whole, minorities are particularly vulnerable to changes in public policies or institutional priorities. Indeed, three interrelated factors affect student participation and retention in science and engineering education: 1) the costs of attending college and graduate school, 2) the polarization of higher education, and 3) the choices that colleges and universities make with respect to allocation of their own resources, both financial and human.

COSTS: UNDERGRADUATE

Financial considerations play a crucial role in the size of minority enrollments in undergraduate education, and they can in turn be expected to affect rates of entrance to and retention in science and engineering programs. Indeed, there has been a recent decline in total college participation rates among minority young people.[10] Between 1976 and 1988, the participation rate for low-income black high school graduates dropped from 39.8% to 30.3%, while the rate for middle-income black students declined from

TABLE 3.
Recipients of Doctorates in Science and Engineering By Field and Racial/Ethnic Group: 1978 and 1988

Field	Total, U.S. Citizens And Permanent Residents		White		Black		Asian		Native American		Hispanic	
	1978	1988	1978	1988	1978	1988	1978	1988	1978	1988	1978	1988
Physical sciences	2,161	2,231	1,750	1,922	37	33	179	137	4	6	20	62
Mathematical sciences	666	384	563	331	13	3	43	33	1	2	5	4
Computer sciences	90	326	77	265	0	2	4	44	0	1	0	2
Earth, atmospheric, and marine sciences	540	537	466	495	4	3	25	15	0	2	5	8
Life sciences	3,707	3,920	3,188	3,472	66	68	188	200	7	12	39	97
Psychology	2,858	2,700	2,524	2,421	100	100	28	47	3	7	51	93
Social sciences	2,448	1,700	2,076	1,436	76	66	87	90	4	9	47	57
Engineering	1,586	2,144	1,169	1,651	13	31	272	332	2	4	32	63

Source: *Women and Minorities in Science and Engineering* (Washington, D.C.: National Science Foundation, January 1990), pp. 151-54.

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52.7% to 36.2%. The corresponding declines for low-income Hispanic students were from 50.4% to 35.3% – and for middle-income Hispanic students, from 53.4% to 46.4%.

Although the number of minority students receiving bachelor's degrees in engineering and computer science has increased, the overall trends in college participation rates could have serious implications for any future gains in science and engineering fields. It is counterintuitive to expect that the declining participation of minorities in undergraduate education will be "compensated for" by increased rates of enrollment in science and engineering. It is more likely that the overall trend will soon be reflected in declining undergraduate and graduate enrollments of minorities in science and engineering.

There are a number of reasons for the low undergraduate participation rates of minorities. Clearly, many minority youths come from low-income families, grew up in high-crime areas, and attended poor schools.[11] Nonetheless, a major factor contributing to the overall decline is the increasing cost of higher education, which threatens minority representation in all fields, but especially in science and engineering.

Tuition costs have outpaced inflation. There have been decreases in the real value of student financial aid as government grants have declined as a percentage of the total cost of education.[12] These trends, which affect educational choices for low- and middle-income students, have had unintended consequences for minority enrollment in higher education. These are the very groups whose real after-tax income has declined or failed to keep pace with the gains posted by those in higher-income groups. Moreover, colleges increasingly set their tuition rates based on the applications of upper-middle and high-income students, whose families have had recent and substantial after-tax benefits. Under these circumstances, many minority youths cannot attend college at all. Others may choose lower-cost colleges or two-year rather than four-year colleges. And many minority youths do not have an opportunity to attend many of the institutions that specialize in science and engineering education.

A recent study by the National Academy of Sciences concluded that the reduction in the real value of financial aid was the major factor contributing to the decline in college enrollments for blacks after the large upswing in enrollments in the 1970s, which was fueled in part by increases in financial aid. The enrollment decline has occurred even though high school graduation rates and average test scores for minority students have risen.[13] This study also noted that increases in military enlistments might have contributed to an enrollment decline (which has been especially severe for black men), but it concluded that possible interactions between military enlistment and college enrollment decisions are not clear.

Under the circumstances, the enrollment decline among minorities is not surprising. It is estimated that almost one-third of low-income students of all racial and ethnic groups would drop out of school if grants were eliminated.[14] Indeed, a recent study found that students were taking longer to complete their undergraduate degrees – or were dropping out – in part because they could not afford to meet their college expenses.[15] While minorities had the lowest college completion rates, the study found lower dropout rates for students who received grants. Ninety-three percent of both whites and blacks who received grants to attend private colleges were still enrolled after their first year, compared with 77% of white students and 66% of black students who received no grants.

Along with decreases in the real value of student grants, there has been a shift in emphasis from grants to loans. In 1985 almost half of all federal student aid was in the form of loans, up from only 17% in 1975. As one analyst put it, "In a single decade, loan programs intended originally for the convenience of the middle class have become the major funding mechanism helping needy students gain access to college. Recent estimates show that half of all undergraduates will finish their college careers with some debt."[16]

The increased reliance on loans has been especially troublesome for minorities. Understandably, debt burdens have been found to have a greater impact on the college attendance rates of minorities than on those of whites because of the continued discrepancies between minorities and whites in expected earnings and because of the large differences in the income and wealth of their families.[17]

COSTS: GRADUATE

It is not surprising that graduate school enrollments for U.S. citizens in some fields of science and engineering have been relatively low. For instance, there is little financial incentive for young engineers, who are paid well by industry, to enroll in costly doctoral programs and to accept lower-paid positions in universities.[18] Graduate programs in science and engineering have also felt increased competition in recent years from such fields as business and law.

The relatively long time required to obtain a doctorate in some fields of science and engineering results in unnecessary costs and delays the entrance of students into the science and engineering workforce.[19] The time needed to earn a doctorate serves as a disincentive to students who might otherwise choose science and engineering, attend graduate school, and complete a doctorate. The average time for completing a doctorate in all fields is about 6.9 years, up from 5.5 years in the 1960s. Engineering doctorates at 5.8 years and doctorates in the physical sciences at 6.0 years, while below the average for all doctorates, clearly entail an investment of time and money that many potential graduate students do not find productive.

In addition, reductions in federal support for graduate fellowships and traineeships during the past 20 years have contributed to lower enrollments in science and engineering among U.S. students.[20] However, the reductions in fellowships and traineeships have been partially offset by increases in federally supported research assistantships and by federal fellowship programs for minority students, e.g., the National Science Foundation's

Minority Graduate Fellowships Program.

The lower average family income and lower expected earnings of minorities make it especially difficult for them to consider graduate school. Under the circumstances, the size of the debt incurred during undergraduate school is more likely to deter minority students from attending graduate school than to deter the general student population.[21]

Minority students are also less likely to receive research assistantships, which – in addition to the financial implications – means that they are less likely to gain the experience of being part of a research group that might encourage them to continue in science and engineering fields and to serve as faculty role models and mentors for the next generation of students.[22] Table 4 shows the serious underrepresentation of minority doctoral faculty members in four-year colleges and universities.

THE POLARIZATION OF HIGHER EDUCATION

Along with financial pressures for students to choose less expensive institutions, colleges and universities also have pressures to choose students who can afford to pay. Many institutions actively recruit minority students who are "superstars," but well-qualified students from families just entering the middle class may be eligible neither for recruitment nor for financial aid. Indeed, changes in eligibility requirements mean that large numbers of middle-income families are no longer eligible for federal grants.[23] For instance, in 1980 families with incomes under $32,500 in 1980 dollars were eligible for Pell grants. In 1986 that $32,500 income would have been worth just over $41,000 in 1986 dollars, yet the ceiling for eligibility for Pell grants was reduced to $28,500. The irony is that, as more minorities enter the middle class, they are being squeezed from two directions, as financial aid packages disappear and as colleges and universities seek increasing numbers of students from quite affluent families.

A study by Lionel Lewis and Paul Kingston documents the fact that the increasing cost of higher education in the 1980s has increased the homogeneity of the student body in highly selective private institutions.[24] Although the student body remains more diverse than it was 20 years ago, these institutions are enrolling an increasing proportion of high-income students. Between 1980 and 1986 the proportion of students with family incomes above $100,000 increased from 10% to 25% – a large increase in a few years that is only partially explained by inflation or real growth in family income.

The proportion of middle-income students (defined as students from families with annual incomes between $35,000 and $49,999) enrolled in highly selective institutions is small; that proportion fell from 4.5% in 1980 to 2.5% in 1986, again a reduction only partially accounted for by inflation. As that trend continues, minority students from low- and middle-income families will find it increasingly difficult to afford to attend many of the institutions that have been especially effective in encouraging students' interest in science and engineering.

Lewis and Kingston conclude:

> Although the evidence that middle-income students have "traded down" because of a new inability to pay for an expensive selective college or university is still mostly anecdotal, public encouragement for increasing opportunities for the less economically privileged at these institutions appears to have waned. . . . Little suggests that as matters now stand the public interest is being served.[25]

At the same time that the highly selective institutions are enrolling a larger proportion of high-income students, the low-income and minority students are increasingly attending community colleges. While some states have developed "articulation" programs between two- and four-year colleges, the overall proportion of community college students who obtain bachelor's degrees has been decreasing.[26] It is estimated that only 10% to 15% of all community college students and only 20% to 25% of those who intend to transfer to a four-year institution actually go on to receive bachelor's degrees. Moreover, black, Hispanic, and Native American students are less likely to transfer than are white or Asian-American students.

The issue is not whether community colleges serve an important function. Clearly, many students are helped to make the transition to four-year colleges, and many others receive vocational/technical training that would otherwise not be available. The concern is for the students who attend community colleges only be-

TABLE 4.

Doctoral Scientists and Engineers on the Faculties of Four-Year Colleges and Universities, by Field and Racial/Ethnic Group: 1987

Field	Total*	White	Black	Asian	Native American	Hispanic
Physical sciences	28,700	25,700	300	2,600	100	500
Mathematical sciences	13,000	11,600	100	1,200	**	200
Computer sciences	5,400	4,900	**	500	**	100
Environmental sciences	7,400	6,900	100	400	**	100
Life sciences	64,700	58,200	1,000	5,000	100	1,000
Psychology	22,000	20,700	600	400	**	300
Social sciences	44,400	40,200	1,300	2,400	100	800
Engineering	23,600	19,600	300	3,600	**	400

Source: *Women and Minorities in Science and Engineering* (Washington, D.C.: National Science Foundation, January 1990), pp. 107-8.

*Rows do not add to total because racial/ethnic categories are not mutually exclusive and because total includes "other" and "no report."

**Too few cases to estimate.

cause of financial considerations and who therefore have significantly reduced their chances of obtaining a degree in science or engineering.

A recent study concludes that the net effect of community colleges has been to increase the separation of elite and non-elite institutions in the U.S. and of the students who attend them:

> The very real contribution that the community college has made to the expansion of opportunities for some individuals does not, however, mean that its aggregate effect has been a democratizing one. On the contrary, the two-year institution has accentuated rather than reduced existing patterns of social inequality. Indeed, in both the social origins and the occupational destinations of its students, the community college clearly constitutes the bottom tier of a class-linked tracking system in higher education. As a growing body of evidence accumulated over more than two decades demonstrates, the very fact of attending a two-year rather than a four-year institution lowers the likelihood that a student will obtain a bachelor's degree. Similarly, entering a two-year as opposed to a four-year college has a negative effect on adult occupational status, even controlling for individual differences in socioeconomic background, measured mental ability, and other variables.
>
> To be sure, the growth of community colleges has brought some individuals into higher education who would otherwise never have attended college; at the same time, however, this growth has also meant a diversion to the two-year sector of large numbers of students – disproportionately of modest social backgrounds – who would otherwise have attended four-year institutions. Finally, a fundamental (and by no means entirely unintended) effect of the rapid extension of community colleges has been to enable public four-year colleges and universities to tighten their admissions requirements and thereby to exclude on meritocratic grounds many students who, in the absence of community colleges, might have felt entitled to a place in the freshman class of what are, after all, public institutions.[27]

INSTITUTIONAL CHOICES

The decisions an institution makes about tradeoffs between such competing priorities as research, undergraduate teaching, programs abroad, and the renovation of aging facilities affect costs as well as students' educational experiences. These experiences in turn can be expected to influence academic achievement, persistence in science and engineering programs, and occupational and graduate school choices.

There is a growing body of evidence that the undergraduate environment of colleges and universities, especially the time faculty members spend teaching and advising students, plays an important role in student achievement and retention in science and engineering programs.[28] Mentoring by faculty members has been found to be an important factor in keeping minority students in science and engineering fields. Indeed, one purpose of the minority science and engineering programs described above is to create a supportive environment for students within the current structure of colleges and universities.

The financial pressures and the emphasis on research have driven many institutions away from a focus on undergraduate education. Faculty members often have little time for teaching and mentoring undergraduate students or for involving them in research. Freshman and sophomore science and engineering courses, which are most likely to influence students' decisions about continuing in these fields, are increasingly taught in large classes or by graduate assistants. As one faculty member put it, "Students are the weeds in the garden of academia."

Stephen Joel Trachtenberg, president of George Washington University, describes the disincentives for undergraduate teaching and their impact on the costs of higher education:

> [W]hat the American public itself has done is to lay down the rule that the pacesetters in higher education are the world-class *research* universities where the rules are that the higher you rank as a faculty member the less you teach; and that the more you charge as a school the better you are. . . .
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> [T]he nationally established pecking order for the universities you'd like your son or daughter to attend has also resulted in a pecking order that prevails *within* those universities. With very occasional exceptions, the more a faculty member is exposed to students and to classroom teaching, the lower that faculty member's standing within his or her academic peer group.
>
> Among those faculty members who do, unfortunately, have to teach in order to receive their paychecks, additional hierarchical distinctions prevail. Those who teach graduate students and an undergraduate senior-level honors seminar rank higher than those who teach *only* junior- and senior-level undergraduates. The latter, in turn, rank higher than those who teach sophomore-level introductory courses in their academic specialties. And those poor souls, in turn, occupy an Olympus that towers far above the plains of drudgery where teaching assistants hand out the basics on how to write decent English and how to understand the cultural and historical foundations of our society.
>
> For faculty members who have internalized these standards, getting released time from teaching and teaching as little as one can possibly manage have taken on the value once associated with the Quest for the Holy Grail. . . .
>
> And requests like that are by no means confined to the faculties of the major research universities. They've made their way down to the four-year colleges and are probably scoring inroads at the two-year colleges as well.[29]

Given the financial pressures faced by colleges and universities, occasioned in part by their attempt to serve so many constituencies in and outside the academic community, these trends should not be unexpected. Even elite institutions have difficulty sustaining costly advanced research programs along with strong undergraduate liberal arts programs. As expenses exceed revenues, higher education institutions are under increasing pressure to raise grant money – pressure only in part related to the merits of conducting research and attracting top-flight faculty members. For many institutions, the "indirect cost" component of grants has become a necessary prop to help support overall operating expenses. Colleges and universities also face growing pressure to raise private funds; however, legal restrictions prevent the use of most endowments for operating expenses, and donors, especially corporations, are increasingly earmarking their gifts for programs other than the liberal arts.

There are a number of reasons why the costs of higher education have outpaced the rate of inflation: a growing number of "exotic" programs across a wide range of academic and nonacademic areas, technological advances that have increased the costs of undergraduate education and of research, and increased institutional contributions to student financial aid (although these contributions cannot begin to compensate for the declines in the

real value of government assistance).[30] These factors make it increasingly difficult for institutions to give high priority to undergraduate education.

The comments above are not meant to detract from the important role that research plays in U.S. higher education. It is generally acknowledged that no other nation can match the range and quality of research opportunities offered by U.S. colleges and universities. As Jean-Jacques Servan-Schreiber and Herbert Simon of Carnegie Mellon University put it, "For the first time in modern history, one country seems to serve, in the advanced sciences, as the university of the world."[31] However, there is a need for caution about the growing pressures for faculty members to conduct research and for undergraduate colleges to shift from their traditional teaching role to a greater emphasis on research. These choices have implications for the costs that society – and families – must bear and for the quality of undergraduate education. They have especially important consequences for the participation and retention of minority students in science and engineering.

The resource and policy trends addressed here play a significant role in the participation of minorities in science and engineering education. While there are a number of effective programs and while there have been recent gains in minority participation in some fields of science and engineering, the situation remains fragile. At a time when increasing numbers of minority young people might wish to seek an education in science and engineering, the negative trends with respect to financial resources and institutional priorities have created unintended barriers to the continuing progress of minorities in science and engineering, and these trends threaten to overshadow potential gains and effective programs. These trends, which affect the entire student population, are particularly troublesome for minorities – and even more so for those who are interested in entering science and engineering.

The result is a personal hardship for the students involved and a loss of technical skills to the nation as a whole at a time when U.S. competitiveness in the international marketplace increasingly depends on a highly skilled labor force. Indeed, because educational attainment is highly correlated with the level of parental education, our educational losses are not simply "one-time" misfortunes for this generation of young people – or for the society at large. They have enduring implications for future generations.[32]

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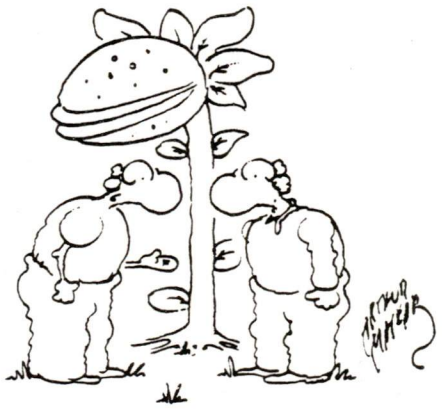
1. Congress of the United States, Office of Technology Assessment, *Educating Scientists and Engineers: Grade School to Grad School* (Washington, D.C.: U.S. Government Printing Office, June 1988), p. 2.
2. *Women and Minorities in Science and Engineering* (Washington, D.C.: National Science Foundation, January 1990), p. 136.
3. National Action Council of Minorities in Engineering, *Statistical Report 1988 Addendum* (New York: NACME, June 1989), p. 1.
4. *Women and Minorities in Science and Engineering*, pp. 144-45, 151-54.
5. *Science and Engineering Indicators – 1989* (Washington, D.C.: National Science Board, December 1989), pp. 54, 216.
6. *Women and Minorities in Science and Engineering*, pp. 122-23, 125, 131; and Deborah J. Carter and Reginald Wilson, *Eighth Annual Status Report on Minorities in Higher Education* (Washington, D.C.: American Council on Education, December 1989), p. 7.
7. The Atlanta Comprehensive Regional Center for Minorities, "Proposal to the Career Access Opportunity Program of the National Science Foundation," Atlanta, Ga., 1988, p. 18.
8. Philip Uri Treisman, "A Study of the Mathematics Performance of Black Students at the University of California, Berkeley," unpublished paper, University of California, Berkeley, 1985, pp. 63, 69; and "Dana Award Winner's Innovations in Educating Minority Students in Math and Science Attract Nationwide Interest," *Charles A. Dana Foundation Report*, Spring 1988, pp. 1-5.
9. Raymond B. Landis, "The Case for Minority Engineering Programs," *Engineering Education*, May 1988, p. 4.
10. Carter and Wilson, pp. 5-6, 39.
11. Michele N.-K. Collison, "More Young Black Men Choosing Not to Go to College," *Chronicle of Higher Education*, 9 December 1987, pp. A-1, A-26 – A-27.
12. Kathryn Mohrman, "Unintended Consequences of Federal Student Aid Policies," *Brookings Review*, Fall 1987, pp. 24-30.
13. Gerald David Jaynes and Robin M. Williams, Jr., eds., *A Common Destiny: Blacks and American Society* (Washington, D.C.: National Research Council, National Academy Press, 1989), pp. 340-45.
14. Mohrman, pp. 24-30.
15. Robin Wilson, "Only 15% of Students Graduate in 4 Years, a New Study Finds," *Chronicle of Higher Education*, 21 February 1990, pp. A-1, A-42.
16. Mohrman, pp. 24-30.
17. Congress of the United States, Office of Technology Assessment, p. 77; and Mohrman, pp. 24-30.
18. Iris C. Rotberg, "A New Perspective on Math and Science Education," *Phi Delta Kappan*, June 1984, pp. 668-73.
19. Susan L. Coyle and Delores H. Thurgood, *Summary Report 1987: Doctorate Recipients from United States Universities* (Washington, D.C.: National Research Council, National Academy Press, 1989), pp. 29-42.
20. Michael G. Finn, *Trends in Science and Engineering Education and the U.S. Labor Market* (Washington, D.C.: National Research Council, 1 June 1989), p. 5.
21. Congress of the United States, Office of Technology Assessment, pp. 68, 77; and Mohrman, pp. 24-30.
22. See, for example, *Women and Minorities in Science and Engineering*, pp. 35-53; and Sheila E. Widnall, "AAAS Presidential Lecture: Voices from the Pipeline," *Science*, September 1988, pp. 1740-45.
23. Kenneth C. Green, "The Rising Institutional Cost of Student Aid," *Educational Record*, Summer/Fall 1988, p. 57.
24. Lionel S. Lewis and Paul William Kingston, "The Best, the Brightest, and the Most Affluent: Undergraduates at Elite Instutitions," *Academe*, November/December 1989, pp. 28-33.
25. Ibid., p. 33.
26. Fred L. Pincus and Elayne Archer, *Bridges to Opportunity: Are Community Colleges Meeting the Transfer Needs of Minority Students?* (New York: Academy for Educational Development and College Entrance Examination Board, 1989), pp. 1, 13, 15.
27. Steven Brint and Jerome Karabel, *The Diverted Dream: Community Colleges and the Promise of Educational Opportunity in America, 1900-1985* (New York: Oxford University Press, 1989), p. 226.
28. See, for example, Thomas L. Hilton et al., *Persistence in Science of High-Ability Minority Students* (Princeton, N.J.: Educational Testing Service, September 1988), p. 26.
29. Stephen Joel Trachtenberg, "Money, Sex, Power," speech delivered to the Washington Higher Education Group, 15 November 1988, pp. 6-8.
30. See, for example, Lee A. Daniels, "Some Top Universities in Squeeze Between Research and Academics," *New York Times*, 10 May 1989, pp. A-1, B-8; and Green, p. 58.
31. Jean-Jacques Servan-Schreiber and Herbert Simon, "America Must Remain the World's University," *Washington Post*, 15 November 1987, pp. C-1 – C-2.
32. See, for example, Mohrman, pp. 24-30. K



"And when my son didn't get first prize at the science fair, the judge mysteriously disappeared."