Maintaining a Strong Engineering Workforce

ACT Policy Report

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INFORMATION FOR LIFE'S TRANSITIONS

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Preface

The stated mission of the ACT Office of Policy Research is to inform policy makers and the general public on important issues in education by providing timely information that can directly enhance knowledge, dialogue, and decision making. The current ACT Policy Research Agenda focuses on four specific areas:

- Developing the Applicant Pool
- Increasing Diversity in College
- Remedial Education in College
- Retention in College

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This study, *Maintaining a Strong Engineering Workforce*, was initiated as part of the second author's summer internship at ACT. What began as a look into the demographics of those planning to major in engineering has resulted in a comprehensive policy report examining twelve-year trends and including over 750,000 ACT test takers.

This study and resulting policy report have greatly benefited from the contributions of many individuals. Several external-to-ACT educators provided considerable help in shaping the study and reviewing draft manuscripts. These individuals include: Marion Blalock (Purdue University), Monica Bruning (Iowa State University), and Christine Brus (The University of Iowa). The ACT Policy Research Advisory Panel provided recommendations about the formulation of the study and reviews of draft manuscripts.

Numerous ACT staff members were involved in various stages of the study. The following ACT staff provided help on the structure of the study and/or manuscript review: Patricia Farrant, Richard Ferguson, Julie Noble, Nancy Petersen, Rose Rennekamp, and Richard Sawyer. Braden Rood, Jacqueline Snider, and Andrew Welch provided assistance in manuscript preparation and bibliographic review. Gregory Carrier provided the graphic design, and Ken Kekke was the editorial manager for the report.

We are grateful for the assistance and support of the aforementioned individuals but accept sole responsibility for any errors of omission or commission.

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Executive Summary

As the twenty-first century begins, the demand for an abundant, diverse, and talented engineering workforce remains strong. Continued growth in national productivity requires a continuous supply of engineers who are highly competent in mathematics and science, and who are adaptable to the needs of a rapidly changing profession. While overall employment in engineering is expected to increase during the 2000–2010 period, engineering degrees over this same time period are expected to remain stable.

Despite the projected high demand for engineers in many engineering fields, leaders in the engineering community have expressed concern about the supply of well-prepared engineers over the next few decades. The number of 18–24 year olds will grow by three million by 2010; and African Americans, American Indians, and Hispanics will make up almost 60% of the population increase over that time period. The consensus among leaders in the engineering community is that the necessary increase in the engineering labor supply will come about only through the development of a more diverse workforce.

The issues addressed by this policy report focus on the national need to continually attract and develop a well-prepared and diverse engineering workforce. Demographic changes overlaid with future workforce demands demonstrate the necessity to substantially increase the number of well-prepared female and minority students entering and completing engineering programs. The primary question in examining these twelve years of ACT Assessment® data for nearly 750,000 college-bound students planning to major in engineering is whether America's future engineering workforce will reflect the necessary levels of diversity and preparedness to continue the nation's competitive edge in the global marketplace. The answer, based upon the information presented in this report, appears uncertain.

The number of students who plan to major in engineering upon college entrance has continued to decrease. More than 1.1 million students from the graduating high school class of 2002 completed the ACT Assessment. Of those who selected a four-year college major, 52,112 planned to major in engineering (well below the high of 67,764 students in 1993). Similarly, the representation of potential engineering majors among ACT test takers has steadily decreased. The corresponding percentage also reached a low of 5.5%in 2002—compared to a high of 8.6% in 1992. Moreover, these students have become less certain of their choice of major, and each year consistently more than 40% indicate they need help deciding their educational and occupational plans.

Over the past twelve years, the percentages of potential engineering majors in college preparatory programs and in the top quarter of their high school graduating class have also decreased. However, a greater percentage of today's potential engineering majors are completing core course requirements and their overall high school GPA has increased.

Potential engineering majors are somewhat better prepared in mathematics than in the past. The percentage taking high school calculus and accelerated mathematics coursework has increased. The average GPA across mathematics coursework has increased, but scores on the ACT Mathematics Test have remained relatively stable.

Despite these indicators of improvement, more progress can be made. Almost 11% of all potential engineering majors completed only algebra 1, geometry, and algebra 2, only 56% have taken calculus, and almost a quarter have indicated they need help with their mathematical skills.

Potential engineering majors have only modestly increased their science preparation. A majority have completed physics (76.7%), but that percentage has remained relatively stable over the past twelve years. Between 1991 and 2002, the percentage of all students enrolled in accelerated science courses has increased slightly and the average GPA across high school science coursework has increased as well. However, scores on the ACT Science Reasoning Test have dropped slightly.

Despite some indications of progress, further improvement is possible. Although the majority (64.2%) of potential engineering students took the entire high school science course sequence, 7.5% of the 2002 cohort completed only general science and biology, and another 19% completed only general science, biology, and chemistry.

Females

Concurrent with a decrease in the overall number of students who planned to major in engineering was a decrease in the number of females. In 2002, 9,345 females planned to major in engineering (representing a twelve-year low of 18.0%). Although females represented a smaller percentage of all potential engineering majors, they were among the better-prepared students. A greater percentage of females were certain of their choice of major, had higher GPAs and ACT scores, and took more advanced mathematics and science coursework.

Females are an untapped source of talent to lead the high-tech economy and culture, but they must receive early encouragement. This encouragement can include exploration of engineering in middle school, affirmation of the value of mathematics and science coursework in high school, and support for female engineering students in college.

Minorities

Between 1991 and 2002, the representation of African American and Hispanic students increased; the representation of American Indian students remained fairly stable. Together, these groups represented 22.2% of all potential engineering majors from the high school class of 2002 (African Americans, Hispanics, and American Indians represented 14.1%, 6.9%, and 1.2%, respectively).

The percentage of potential engineering majors among various minority groups improved over the past twelve years, but the increase was due in large part to a decrease in the number of Caucasians who planned to major in engineering. In fact, the number of minority students planning to major in engineering has dropped. The actual number of African American and American Indian engineering majors was lower in 2002 than in 1991 (African Americans reached a low of 6,993 in 2002).

For minority students there is a substantial misalignment between aspirations and preparation. Although many were very sure of their choice to enter an engineering major, many did not complete core coursework requirements and had taken only basic mathematics and science course sequences. This included lower levels of course taking in calculus and physics.

Minority potential engineering majors had significantly lower overall grade point averages, as well as lower mathematics and science GPAs in high school. Far fewer minority students ranked in the top quarter of their graduating classes, despite the fact that many did not take a rigorous core curriculum, and they had significantly lower average ACT scores than those of all college-bound test takers and of potential Caucasian engineering majors. Finally, minority students indicated high levels of perceived academic need, most frequently requesting help with study skills. Overall, it appears that many minority students may not have been prepared academically to enter an undergraduate engineering program.

The data presented in this report raise serious questions about the future of America's engineering workforce. On one hand, the nation needs more well-prepared engineers; and, given demographic trends, many future engineers will need to be female and minority. On the other hand, there has been little change in representation, and a decreasing trend in actual numbers, for potential female engineering majors—most of whom are well prepared to succeed in engineering studies. Further, the percentage of potential minority engineering majors has improved over time, but actual numbers have dropped; and many of these students appear poorly prepared to meet the challenges of rigorous engineering curricula.

This report can hold a range of implications for K–12 educators, college and university engineering programs, engineering organizations and agencies, and policy makers at local, regional, and national levels. This report urges a coordinated national agenda and concludes with a series of integrated policy and program recommendations which include:

- ***To help more students consider, plan, and pursue engineering professions, school districts should:***
  - *provide challenging science and mathematics curricula and courses that align with postsecondary requirements, and engage qualified individuals to teach these courses, beginning no later than middle school, for all students.*
  - *specifically target the educational and career explorations of female and minority students to ensure that they have encouragement and support to consider and plan for a broad range of careers–especially those in science and engineering.*
- ***To nurture a broader interest in engineering, colleges and universities should:***
  - *work with school districts to strengthen middle school and high school mathematics and science courses and instruction, and to better align content with college course content prerequisites.*
  - *include parents, teachers, and counselors in outreach programs that help them learn about engineering as a profession so that they can encourage and support the young people who rely on their knowledge and influence.*
- ***To ensure a well-prepared and diverse engineering workforce, professional engineering organizations should:***
  - *use a variety of mediums to provide students and their families with stimulating information that describes what engineers do and produce.*
  - *increase collaborations among themselves and with informal education networks (e.g., community organizations, after-school programs) to jointly incorporate approaches that could be tailored to different constituencies and easily used by educators.*
- ***To support the nation's present need for a strong and productive engineering workforce, and to successfully respond to future challenges to prepare a learning centered and adaptable engineering workforce, policy makers should:***
  - *fund and implement a range of programs including teacher preparation in science and mathematics, pre-college engineering exploration, and related support for females and minority students (particularly in rural and urban areas).*
  - *bring together various constituencies (education, industry, professional organizations, community agencies, private funding sources) to help address key issues including enhanced academic standards in science and technology across the K–12 system.*

1

Introduction

As we begin a new century, the need for a large and diverse pool of skilled engineers remains as high as ever. Engineers design and develop the systems and products that support the infrastructure of our society. Their work ranges across domains that strive to increase national security, improve healthcare, facilitate transportation, enhance leisure time, and protect the environment. And they develop the high-technology goods, practical solutions, and myriad services that help to maintain the nation's economic status within the global marketplace.

Continued growth in national productivity requires a continuous supply of engineers who are highly competent in mathematics and science, and who are adaptable to the needs of a rapidly changing profession. While overall employment in engineering is expected to increase 3% to 9% during the 2000–2010 period, engineering degrees over this same time period are expected to remain stable (Bureau of Labor Statistics, 2002). Further, the projected demand for engineers will vary considerably by field (Bureau of Labor Statistics, 2002; National Science Board, 2000). Employment is expected to increase 10% to 20% in such traditional fields as aerospace, civil, electrical, and mechanical engineering; 21%–35% in fields such as biomedical engineering and environmental engineering; and 36% or more in fields such as computer software engineering (Bureau of Labor Statistics, 2002).

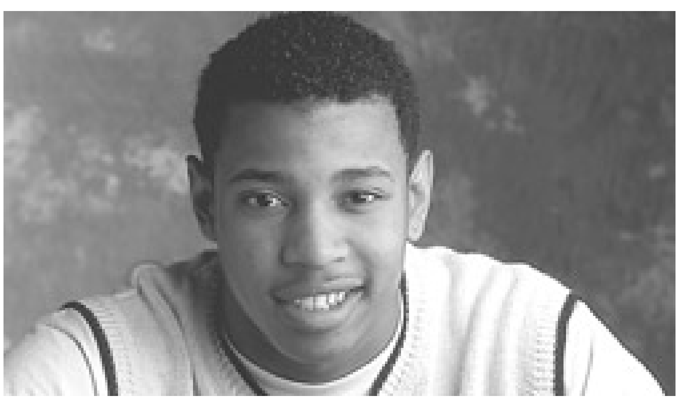
In spite of the projected high demand for engineers in many engineering fields, leaders in the engineering community (e.g., Wulf, 1998) have expressed concern about the supply of well-prepared engineers over the next few decades. Despite increases in the representation of females and minority groups, the current engineering workforce is still predominately Caucasian and male. Yet, given current demographic trends, Caucasians will make up a decreasing percentage of the population between the ages of 18 and 64 over the next few decades (U.S. Census Bureau, 2000). More immediately, while the number of 18–24 year olds will grow by three million by 2010, only 30% will be Caucasian. African Americans, American Indians, and Hispanics will make up almost 60% of the population increase over the next decade (Barton, 2002). By 2025 African Americans, American Indians, and Hispanics will make up 13.9%, 1.0%, and 18.2%, respectively, of the U.S. population (U.S. Census Bureau, 2000).

The consensus among leaders in the engineering community (Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development, 2000; National Science and Technology Council, 2000) is that the necessary increase in the engineering labor supply will come about only through the development of a more diverse workforce. This workforce must be well prepared academically and possess the science and mathematical knowledge and skills needed to learn and adapt in a time of technological advances and increased global competition. This future workforce will be called upon to provide the innovation and productivity necessary to sustain the nation's competitive edge.

The need for a diverse engineering workforce was recognized as early as 1980, when Congress passed the Science and Engineering Equal Opportunities Act, which states that:

> *it is the policy of the United States to encourage men and women, equally, of all ethnic, racial, and economic backgrounds to acquire skills in science, engineering and mathematics, to have equal opportunity in education, training, and employment in scientific and engineering fields, and thereby to promote scientific and engineering literacy and the full use of the human resources of the Nation in science and engineering. To this end, the Congress declares that the highest quality science and engineering over the long-term requires substantial support, from currently available research and educational funds, for increased participation in science and engineering by women and minorities.*
>
> *(Sec. 32(b))*

Engineering colleges have responded to the increasing demand for a diverse engineering workforce: the representation of females, African Americans, American Indians, and Hispanics in undergraduate engineering programs has increased over the past two decades (American Society for Engineering Education, 2001; National Center for Education Statistics, 2000a). Despite this improved representation, current percentages do not reflect the demographics of the college-going population. In 1997, 56.0% of all undergraduates (National Center for Education Statistics, 2000b), but only 19.4% of all engineering undergraduates, were female (Engineering Workforce Commission, 1998). African Americans, American Indians, and Hispanics made up, respectively, 11.2%, 1.0%, and 9.0% of all undergraduates in 1997 (National Center for Education Statistics, 2000b). Students from these groups, however, represented only 6.6%, .7%, and 7.9% of all engineering undergraduates (Engineering Workforce Commission, 1998).



Purpose

This policy report is intended to contribute to the growing body of information on potential engineering students. It provides descriptive data on the background and academic preparation of high school graduates who planned to major in engineering upon entrance to college and also presents this information by gender and by racial and ethnic group (i.e., African American, American Indian, Caucasian, and Hispanic)[1]. The findings, conclusions, and recommendations in this report are based on twelve years of data obtained from roughly 750,000 students from the graduating high school classes of 1991–2002 who registered for the ACT Assessment and who indicated they planned to major in an engineering field upon college entrance[2].

The primary audiences for this report are those policy makers, legislators, educational leaders, and educational and scientific organizations who work to enhance the preparation and diversity of America's future engineers. Combined with other available information, this report can help them learn more about trends in the demographics, high school preparation and performance, and educational needs of potential engineering majors.

This report can be useful in the development of more effective academic preparation, career exploration, and educational planning at the middle school and secondary school levels; the implementation of pre-engineering outreach programs; and the creation of stronger recruiting, student service, informal education, and retention programs at the college level. It can also help guide policy makers in the implementation of the No Child Left Behind Act (U.S. Department of Education, 2002), as its findings address diversity, academic preparation, P–16 alignment, and issues of science and mathematics education. The recommended combination of policies, programs, and services can help shape a better-informed, collaborative, and aligned response to the challenges posed by the nation's continuing need for a well-prepared and diverse engineering workforce.

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[1] Planned engineering major is a particularly telling indicator of enrollment status because engineering programs, unlike other college majors, generally require students to declare a major as freshmen (National Science Board, 2000).

[2] Although recognizing the importance of engineering student retention in postsecondary education, the primary focus of this report is on the preparation and diversity of potential engineering majors prior to college entrance and its potential impact on America's future engineering workforce.

2

Plans and Aspirations

More than 1.1 million students from the graduating high school class of 2002 completed the ACT Assessment. Of those who selected a four-year (baccalaureate) college major on the registration form (85.1%), 52,112 indicated that they planned to major in engineering upon entrance to college. The number of potential[3] engineering majors declined between 1999 and 2002, and this number is well below a high of 67,764 students in 1993 (Table 1). Similarly, the representation of potential engineering majors among those students who selected a college major has steadily decreased since 1992 (ACT, 1991–2002). The percentage of students who planned to major in engineering reached a low of 5.5% in 2002, compared with a high of 8.6% in 1992 (Figure 1).

Table 1

Potential Engineering Majors

High School Class	Number
1991	63,653
1992	66,475
1993	67,764
1994	64,571
1995	64,937
1996	63,329
1997	63,601
1998	65,329
1999	65,776
2000	61,648
2001	54,175
2002	52,112

[3] The terms “planned” and “potential” will be used interchangeably to designate those high school students who selected an engineering field as a planned college major when registering for the ACT Assessment. Students typically complete the ACT Assessment in the spring of their junior year and/or in the fall of their senior year.

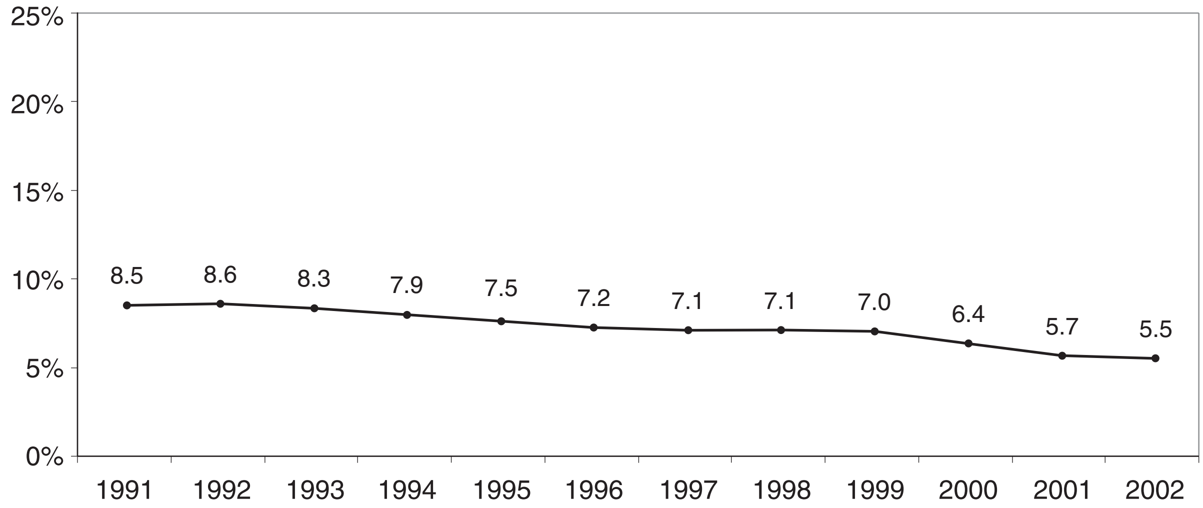

Figure 1: Percent Who Selected an Engineering Major

Annual reports by the College Board (1991–2002) show a similar trend for those students who completed the SAT I. Of those who selected a major in 2002 (74.9%), 88,711 (8.9%) planned to enter college as engineering majors, compared to 97,939 (10.5%) in 1991[4].

Changes in academic interests and occupational preferences of high school students are likely explanations for the decline of potential engineering majors over time. The ACT Assessment registration booklet lists six other college majors that might potentially appeal to students with an interest in engineering: engineering-related technologies, business and management, health sciences and allied health fields, mathematics, biological and physical sciences, and computer and information sciences. Of these six majors, only three exhibited continuous growth over the past decade: engineering-related technologies, biological and physical sciences, and computer and information science.

Between 1991 and 2002, the representation of engineering-related technologies majors increased 57.9% and the representation of biological and physical sciences increased 20.1%. The percentage who selected computer and information sciences experienced the largest gains, increasing by over 94% between 1991 and 2002. (A similar trend was evident for those students who registered for the SAT I, with the representation of computer and information sciences and technologies majors increasing over 251% between 1991 and 2002.)

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[4] Although trends were similar, the percentages that planned to major in engineering were consistently greater for those who registered for the SAT I than for those who registered for the ACT Assessment. This gap may partly have been a result of the different criteria used to allocate college majors within the ACT Assessment and SAT I registration schemas. While engineering and engineering technology majors were listed and reported separately on the ACT Assessment, engineering and engineering technology (e.g., two year degrees such as drafting and design technology) majors were listed and reported together on the SAT I under the "engineering" heading. When engineering technology majors were reported in combination with engineering majors for those students who registered for the ACT Assessment, the resulting percentages were comparable to those for the SAT I.

Females and Minorities. Concurrent with a decrease in the overall number of students who planned to major in engineering was a decrease in the number of females among this group (Table 2). The number of females among potential engineering majors has continually decreased since 1997; and, in 2002, 9,345 planned to major in engineering. Similarly, female representation has decreased, reaching a low of 18.0% for the high school class of 2002.

Table 2

Potential Female Engineering Majors

High School Class	Number	Percent
1991	11,710	18.4
1992	12,974	19.5
1993	13,483	19.9
1994	13,180	20.4
1995	13,389	20.6
1996	12,681	20.0
1997	12,803	20.1
1998	12,648	19.4
1999	12,480	19.0
2000	11,689	19.0
2001	10,073	18.7
2002	9,345	18.0

Between 1991 and 2002, the representation of African American and Hispanic students increased, and the representation of American Indian students remained fairly stable (Table 3). Together, these groups represented 22.2% of all potential engineering majors from the high school class of 2002. African American students had the largest gain in representation over time; in 2002, they made up 14.1% of all potential engineering majors. The representation of Hispanic students also increased; in 2002, they represented 6.9% of all potential engineering majors. American Indians experienced little continuous change in representation and represented 1.2% of all potential engineering majors in 2002.

Table 3

Potential Minority Engineering Majors

High School Class	African American		American Indian		Hispanic	
	Number	Percent	Number	Percent	Number	Percent
1991	7,085	11.3	824	1.3	3,274	5.2
1992	7,659	11.6	863	1.3	3,864	5.9
1993	7,962	11.9	885	1.3	3,964	5.9
1994	7,893	12.4	918	1.4	3,881	6.1
1995	8,492	13.3	838	1.3	4,036	6.3
1996	8,021	13.3	870	1.4	3,693	6.1
1997	8,068	13.4	814	1.4	3,670	6.1
1998	8,604	13.8	787	1.3	3,653	5.9
1999	8,571	13.7	748	1.2	3,674	5.9
2000	7,977	13.5	645	1.1	3,467	5.9
2001	7,028	13.5	592	1.1	3,272	6.3
2002	6,993	14.1	603	1.2	3,440	6.9

Although the *percentage* of potential engineering majors from some groups increased over the twelve years, this increase was not due to an increase in the *number* of potential engineering majors from each group. The actual number of African American and American Indian engineering majors was lower in 2002 than in 1991. The number of African American students who planned to major in an engineering field reached a low of 6,993 in 2002. The increase in percentage representation was actually the result of the larger decrease in the number of Caucasian students who planned to major in engineering (i.e., a decrease of over 6,500 across the twelve years).

Engineering Fields

The ACT Assessment registration booklet provides 26 engineering fields from which students may choose a course of study (see the Appendix for a complete listing of these engineering fields). General engineering/pre-engineering was most often selected, with 46.3% of all potential engineering majors choosing this field in 2002. The percentage who selected this field was fairly stable over the twelve years.

Of the specific engineering fields, the four that consistently received the largest representation of potential engineering majors were aerospace, aeronautical, and astronautical engineering; computer engineering; electrical, electronics, and communications engineering; and mechanical engineering. Although these four fields were among the most-selected engineering majors during the past twelve years, their positions relative to each other changed over time (Table 4).

Table 4

Percent of Potential Engineering Majors in the Most-Selected Engineering Fields

High School Class	Aerospace Engineering	Computer Engineering	Electrical Engineering	Mechanical Engineering
1991	12.4	4.0	10.0	7.4
1992	11.1	4.1	9.6	8.0
1993	9.3	4.6	9.8	7.9
1994	7.5	5.0	9.4	7.8
1995	6.6	6.0	9.0	7.7
1996	6.0	7.0	8.8	7.9
1997	6.1	8.1	8.5	8.1
1998	6.5	8.6	8.3	8.2
1999	7.1	9.7	7.9	8.2
2000	8.1	9.6	7.7	8.5
2001	8.6	9.6	7.0	9.2
2002	8.8	9.4	6.8	9.8

Notably, the representation of mechanical engineering majors increased, while the representation of electrical engineering majors decreased—each by roughly one-third. The representation of computer engineering majors exhibited the greatest gains, with an increase of 135% between 1991 and 2002. This increase in representation is similar to that (94%) for computer and information sciences majors (ACT, 1991–2002).

Females and Minorities. Females represented 18.0% of all potential engineering majors from the class of 2002; the most popular fields were aerospace, bio/biomedical, chemical, and computer engineering (Figure 2). For example, 10.1% of female potential engineering majors selected computer engineering as their field of study. Chemical engineering and bio/biomedical engineering, and environmental health engineering and general/pre-engineering, had the largest female representation. Females made up 51.7% of those who selected bio/biomedical engineering and 48.4% who selected environmental health engineering.

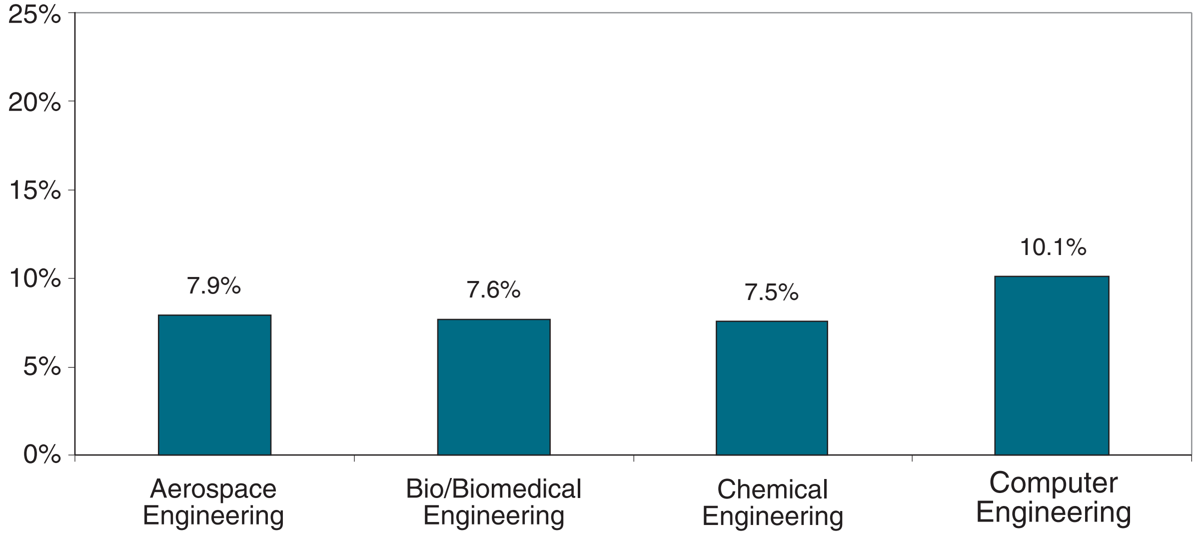

Figure 2: Most-Selected Engineering Fields among Females in 2002

Nearly one in four potential engineering majors from the high school class of 2002 was a student from a minority group. Within each minority group, the most-selected engineering fields were similar to those selected by all potential engineering majors. Computer engineering, for example, was the most popular field among all three groups, with 19.6% of African Americans, 9.8% of American Indians, and 10.6% of Hispanics selecting this field (Figure 3).

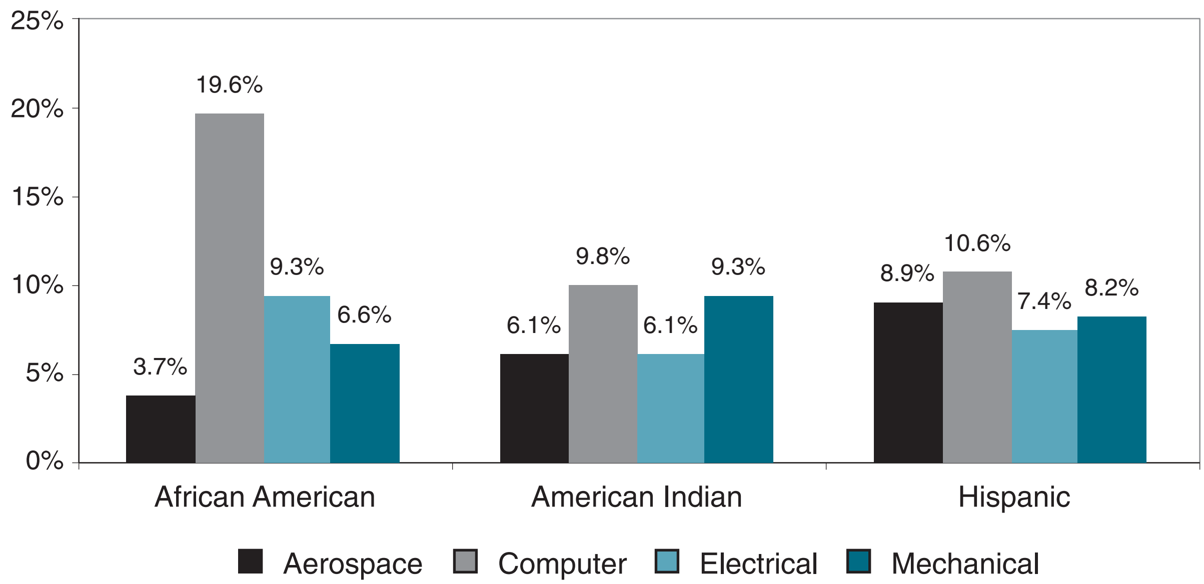

Figure 3: Most-Selected Engineering Fields among Minorities in 2002

Within many of the most-popular engineering fields, the percentage of students from minority groups was much smaller. Table 5 provides the representation of the three groups within the most-selected engineering fields overall. Students from each group made up less than their expected share of all potential engineering majors in at least one of the four most-selected engineering fields. For example, this was true for African Americans in aerospace engineering and mechanical engineering.

Table 5

Percent of Minorities within Most-Selected Engineering Fields in 2002

Field	African American	American Indian	Hispanic
Aerospace Engineering	5.8	0.8	7.0
Computer Engineering	29.3	1.3	7.8
Electrical Engineering	19.3	1.1	7.5
Mechanical Engineering	9.4	1.2	5.8

Certainty of Major

Between 1991 and 2002, the percentage of potential engineering majors who were very sure of their choice of major decreased[5]. Of the high school class of 2002, 34.0% were very sure of their choice of major. Between 1991 and 2002, the percentage of potential engineering majors who were not sure of their choice of major tended to increase. In 2001, a high of 14.3% were not sure of their choice of major.

[5] When registering for the ACT Assessment, students can indicate whether they are "very sure," "fairly sure," or "not sure" of their planned college major.

Table 6

Percent Who Were Very Sure of an Engineering Major

High School Class	Female	Male	African American	American Indian	Hispanic	Caucasian
1991	39.1	37.6	53.7	45.3	45.0	34.8
1992	40.5	37.7	52.9	46.8	44.7	35.0
1993	39.5	37.7	53.8	42.1	44.0	34.9
1994	38.5	37.0	54.0	40.2	44.4	33.7
1995	36.9	35.4	51.6	41.2	42.0	31.9
1996	37.0	34.8	53.1	39.8	40.5	31.3
1997	37.7	35.2	52.2	40.9	42.0	32.0
1998	35.8	34.2	52.1	36.6	41.9	30.2
1999	34.9	33.4	50.8	37.1	39.8	29.6
2000	35.0	33.0	50.2	37.9	41.1	29.3
2001	34.7	33.1	50.3	37.2	42.3	29.3
2002	35.3	33.7	50.2	33.7	39.9	30.1

Females and Minorities. For both females and males, the percentage who were very sure of their major decreased between 1991 and 2002, with a consistently greater percentage of females indicating that they were very sure of their choice of major. In 2002, 35.3% of females were very sure of their major (Table 6).

All racial and ethnic groups experienced a decrease over time in the percentage of students who were very sure of their choice of an engineering major. A greater percentage of minority students than Caucasians indicated that they were very sure of their choice of major. In 2002, 50.2% of African Americans, 33.7% of American Indians, and 39.9% of Hispanics were very sure of their choice of engineering major.

3

High School Coursework

The percentage of potential engineering majors who participated in college preparatory programs decreased between 1991 and 2002 to a low of 70.6% in 2002 (Table 7). The percentage of students from all non-college preparatory programs (i.e., business or commercial, vocational-occupational, and "other or general") increased to 29.4% in 2002, with the percentage of students in "other or general" academic programs making the largest gains (to 17.8% in 2002). Although "other or general" programs may be quite diverse, some appear to have requirements similar to or the same as those of college preparatory programs.

Table 7

Percent of Potential Engineering Majors in Academic Programs

High School Class	College Preparatory	Other or General	Business/ Commercial	Vocational-Occupational
1991	83.4	9.2	1.7	5.7
1992	83.3	9.5	1.7	5.6
1993	82.9	9.8	1.7	5.6
1994	82.0	10.7	1.7	5.5
1995	81.2	11.1	2.0	5.7
1996	80.1	11.7	2.1	6.1
1997	79.0	12.2	2.2	6.5
1998	77.6	12.9	2.3	7.1
1999	76.7	13.5	2.5	7.3
2000	75.5	14.4	2.6	7.5
2001	74.3	15.7	2.8	7.2
2002	70.6	17.8	3.3	8.3

Females and Minorities. For both males and females, the percentage in college preparatory programs decreased between 1991 and 2002. A consistently greater percentage of females participated in these programs, although in 2002 female participation decreased to 77.3% and male participation to 69.2% (Table 8). Concurrently, the percentages who participated in non-college preparatory programs increased over the twelve years. Students in "other or general" academic programs made the greatest gains between 1991 and 2002, increasing from 6.8% to 15.6% for females, and 9.7% to 18.3% for males.

Table 8

Percent of Potential Engineering Majors in College Preparatory Programs

High School Class	Female	Male	African American	American Indian	Hispanic	Caucasian
1991	88.5	82.3	75.0	67.0	78.3	85.6
1992	88.7	82.0	75.8	65.8	78.2	85.5
1993	88.4	81.5	74.6	67.3	77.5	85.4
1994	87.1	80.7	74.7	64.8	75.3	84.6
1995	87.0	79.7	73.0	69.4	75.5	83.9
1996	85.0	78.9	70.7	65.4	73.7	83.2
1997	84.4	77.7	69.8	64.3	71.4	81.8
1998	82.9	76.3	67.9	66.1	68.9	80.7
1999	81.8	75.5	66.4	62.3	68.4	79.8
2000	81.0	74.3	65.5	59.4	66.9	78.7
2001	80.1	73.0	63.9	61.7	66.5	77.5
2002	77.3	69.2	60.6	50.7	60.9	74.1

For all racial and ethnic groups, the percentages who participated in a college preparatory program decreased over time. Smaller percentages of minority students than Caucasians were in college preparatory programs. In 2002, 60.6% of African Americans, 50.7% of American Indians, and 60.9% of Hispanics participated in college preparatory programs, compared with 74.1% of Caucasians. The largest percentages of non-college preparatory students were in “other or general” academic programs, with 21.2% of African Americans, 29.2% of American Indians, 15.9% of Caucasians, and 25.0% of Hispanics participating in these programs.

Core Coursework

Although the percentage of students who planned to major in engineering and who participated in college preparatory programs decreased between 1991 and 2002, the percentage who completed their high school core coursework requirements increased somewhat variably over the twelve years (Figure 4)[6]

- ***Core coursework is defined as at least four years of English courses, and three years each of mathematics, science, and social studies courses.***

[6] When students register for the ACT Assessment, they indicate whether they have taken, are taking, or will take each of 30 specific high school courses (e.g., algebra, chemistry, U.S. history).

Of the class of 2002, 73.7% of all potential engineering majors completed the core coursework or more. An increase in the percentage who completed the core coursework was even larger within academic program. Among those who participated in college preparatory programs, 80.7% completed the core coursework, compared with 58.2% in business or commercial programs, 49.3% in vocational-occupational programs, and 62.0% in "other or general" programs. Although a smaller percentage from non-college preparatory programs completed the core coursework, the percentages from these programs who completed this coursework increased more than the percentages from college preparatory programs. For example, the percentage from business or commercial programs who completed the core coursework increased substantially between 1991 (42.9%) and 2002 (58.2%).

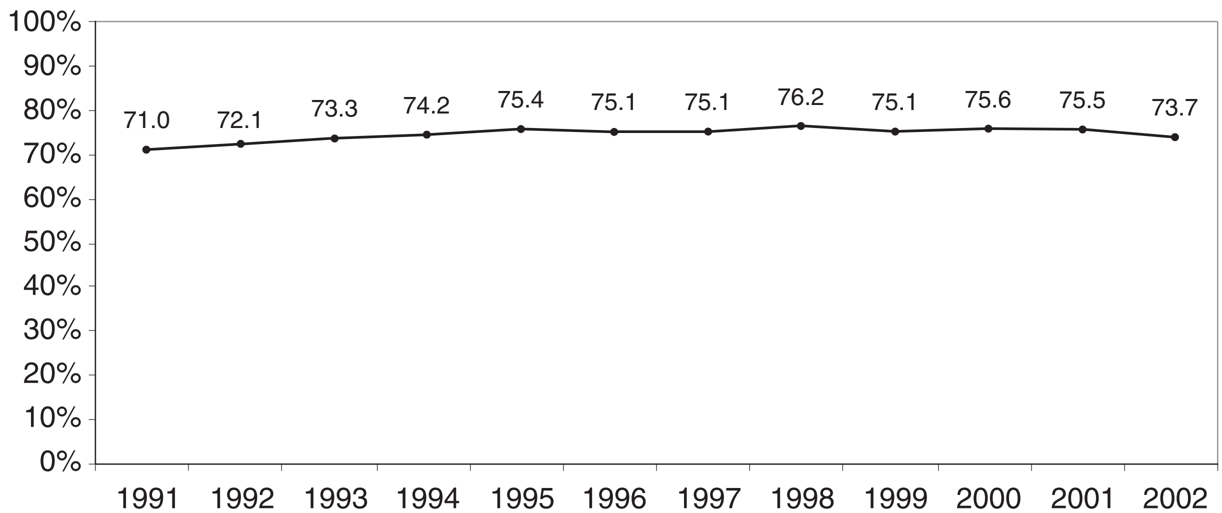

Figure 4:
Percent of Potential Engineering Majors Who Completed Core Coursework

Females and Minorities. For both males and females, the percentages who completed the core coursework increased over the past twelve years. A greater percentage of females than males completed the core coursework, with the gap remaining stable over time. Female core coursework participation was 79.4% and male participation was 72.4% in 2002 (Table 9).

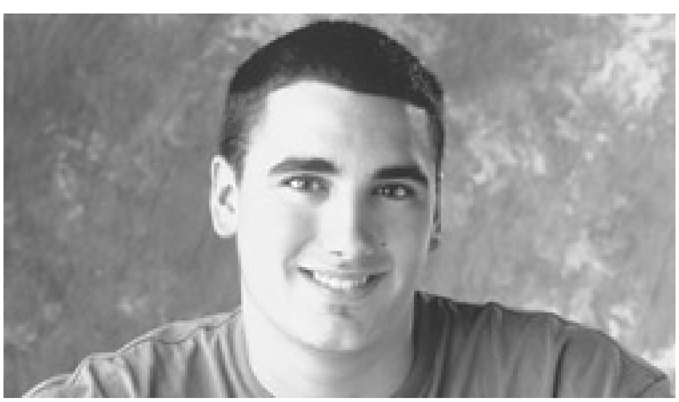

Table 9

Percent of Potential Engineering Majors by Group Who Completed Core Coursework

High School Class	Female	Male	African American	American Indian	Hispanic	Caucasian
1991	76.3	69.8	64.0	64.7	74.1	71.9
1992	77.3	70.9	65.3	66.0	74.1	73.2
1993	78.4	72.0	65.5	69.8	74.5	74.6
1994	79.5	72.8	67.2	69.1	75.5	75.5
1995	80.6	74.1	68.6	72.9	75.7	76.8
1996	80.3	73.8	68.4	70.1	75.0	76.4
1997	80.1	73.8	68.4	70.5	75.7	76.4
1998	80.9	75.1	69.7	71.6	76.0	77.6
1999	79.6	74.1	68.3	68.9	74.4	76.5
2000	81.0	74.3	70.6	65.4	74.3	76.8
2001	80.9	74.2	69.7	70.8	75.2	76.7
2002	79.4	72.4	67.7	63.7	71.1	75.5

For all racial and ethnic groups, the percentages who completed the core coursework peaked by the mid- to late-1990s, and decreased slightly by 2002. In 2002, a smaller percentage of students from minority groups compared to Caucasians completed the core coursework requirements, with 67.7% of African Americans, 63.7% of American Indians, 71.1% of Hispanics, and 75.5% of Caucasians completing these requirements.

Mathematics

Thorough preparation in mathematics is essential for entering engineering majors. First-year engineering students are often required to take calculus, and their performance in this and other mathematics courses is related to persistence in engineering programs. Waits and Demana (1988) found that more than 95% of the graduating students who majored in engineering had entered college with a mathematics placement level at or just below college calculus. They concluded that students with career interests in science, mathematics, or engineering are at serious risk if they enter postsecondary training with poor mathematics skills. Similarly, Lam, Doverspike, and Mawasha (1999) reported that many who did not persist in an engineering program had never completed or even attempted the first calculus course. Fraser and Ismail (1997) found that readiness to begin calculus study increases the student's chances of graduating by 32.7%.

Years Studied

On average, potential engineering majors completed 3.8 years of mathematics coursework in 2002; this average remained stable between 1991 and 2002. Females studied mathematics for slightly more years (3.9) than males (3.8), and the average number of years for both genders remained stable over the past twelve years. The number of years of mathematics coursework varied by racial and ethnic group (Figure 5), with minority students completing, on average, fewer years than Caucasians. The average number of years for all groups remained roughly stable between 1991 and 2002.

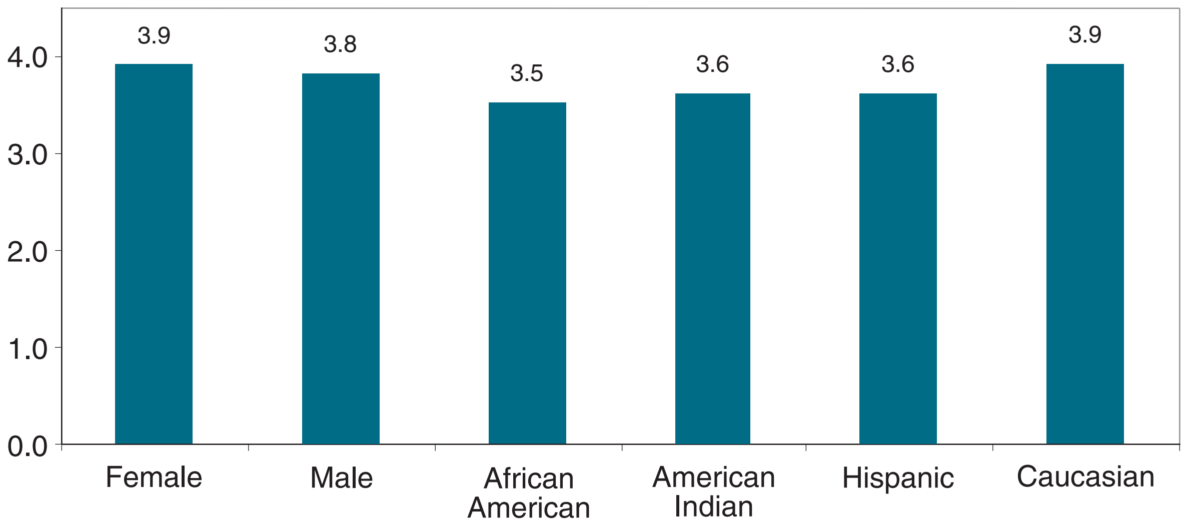

Figure 5:
Average Years of Mathematics Coursework of Potential Engineering Majors in 2002

Courses Taken

Many high school students complete algebra 1, geometry, and algebra 2, and take advanced mathematics coursework beyond algebra 2. Nearly all potential engineering majors from the class of 2002 took algebra 1, geometry, and algebra 2. The percentages who completed upper-level mathematics courses varied, with 67.7% taking trigonometry, 62.9% taking another advanced math course beyond algebra 2, and 56.0% taking calculus. Although the percentage who completed calculus was lower than for other advanced mathematics courses, this percentage generally increased over time as shown in Table 10.

Table 10

Percent of Potential Engineering Majors Who Took Calculus

High School Class	Female	Male	African American	American Indian	Hispanic	Caucasian
1991	54.3	47.3	37.6	34.1	46.4	49.0
1992	54.8	48.2	38.4	38.1	47.6	49.9
1993	56.6	50.2	39.6	40.9	49.8	52.0
1994	58.4	50.6	39.5	39.9	49.4	53.1
1995	59.6	51.5	40.7	43.8	51.1	54.1
1996	59.4	52.1	38.6	41.7	52.1	55.0
1997	60.2	52.4	38.5	44.2	51.2	55.4
1998	60.7	53.5	37.0	43.7	51.1	57.0
1999	61.6	54.0	37.7	42.4	52.5	57.4
2000	64.0	55.4	39.3	42.2	52.7	59.2
2001	64.5	56.2	38.9	50.2	54.4	60.1
2002	64.0	54.2	37.5	45.8	48.4	58.9

Females and Minorities. For both females and males, the percentage who completed upper-level mathematics courses increased over the past twelve years. A consistently greater percentage of females took upper-level mathematics courses, and the gap between females and males remained roughly stable over time. In 2002, 71.8% of females took trigonometry, compared with 66.8% of males. Similarly, 67.6% of females completed at least one advanced mathematics course beyond algebra 2, compared with 61.9% of males; and 64.0% of females took calculus, compared with 54.2% of males.

With the exception of African Americans, the percentages from all groups who took upper-level mathematics increased over the past twelve years. A consistently smaller percentage of minority students than Caucasians took upper-level mathematics courses, and the gap between Caucasians and African Americans and Hispanics increased over time. In 2002, 70.6% of Caucasians completed trigonometry, compared with 53.3% of African Americans, 58.5% of American Indians, and 56.8% of Hispanics. Similarly, 64.7% of Caucasians completed other advanced math beyond algebra 2, compared with 53.7% for African Americans, 51.7% for American Indians, and 58.5% for Hispanics. Finally, 58.9% of Caucasians completed calculus, compared with 37.5% for African Americans, 45.8% for American Indians, and 48.4% for Hispanics.

Course-Taking Patterns

Table 11 provides course-taking patterns in mathematics for planned engineering majors from the high school class of 2002. Among this group, 13.6% completed all six mathematics courses; 10.9% completed only the algebra 1, geometry, and algebra 2 sequence.

Table 11

Common Mathematics Course-Taking Patterns of Potential Engineering Majors in 2002

Course-Taking Pattern	Percent
Algebra 1, Algebra 2, Geometry, Trigonometry, Advanced Math, Calculus	13.6
Algebra 1, Algebra 2, Geometry, Trigonometry, Calculus	10.5
Algebra 1, Algebra 2, Geometry, Advanced Math, Calculus	4.1
Algebra 1, Algebra 2, Geometry, Trigonometry, Advanced Math	7.7
Algebra 1, Algebra 2, Geometry, Trigonometry	7.7
Algebra 1, Algebra 2, Geometry, Advanced Math	8.4
Algebra 1, Algebra 2, Geometry	10.9

Note: Percentages do not total 100% because other, less common course-taking patterns were not included.

Females and Minorities. The course-taking patterns of a greater percentage of females than males included upper-level mathematics (Table 12). Although the largest percentages of females and males completed all six mathematics courses, more females completed this sequence. In addition, the largest percentage-point gap in favor of females was in this most-advanced sequence of mathematics courses, while the largest percentage-point gap in favor of males was in the least-advanced sequence of mathematics courses.

Table 12

Percent of Potential Engineering Majors with Common Mathematics Course-Taking Patterns in 2002

Course-Taking Pattern	Female	Male	African American	American Indian	Hispanic	Caucasian
Alg 1, Alg 2, Geom, Trig, Adv Math, Calc	18.9	12.5	6.2	8.8	8.3	16.0
Alg 1, Alg 2, Geom, Trig, Calc	12.7	10.1	5.8	8.1	7.7	11.9
Alg 1, Alg 2, Geom, Adv Math, Calc	5.6	3.7	2.9	3.0	4.1	4.4
Alg 1, Alg 2, Geom, Trig, Adv Math	8.0	7.6	6.3	5.6	6.1	8.4
Alg 1, Alg 2, Geom, Trig	6.7	7.9	9.6	7.6	7.5	7.4
Alg 1, Alg 2, Geom, Adv Math	7.8	8.5	10.8	7.5	10.0	8.1
Alg 1, Alg 2, Geom	7.2	11.7	20.2	14.9	15.5	8.9

Note: Percentages do not total 100% because other, less common course-taking patterns were not included.

Smaller percentages of minority students than Caucasians had course-taking patterns that included upper-level mathematics; and the largest percentages of African Americans, American Indians, and Hispanics completed only the algebra 1, geometry, and algebra 2 sequence. Caucasians tended to take more advanced mathematics sequences; American Indian and Hispanics tended to take either the most-advanced or the least-advanced course sequences, and African Americans tended to complete the least advanced sequences.

Advanced, Accelerated, or Honors Mathematics Coursework

In addition to the regular course-taking sequences, students enrolled in advanced, accelerated, or honors mathematics courses. Over the twelve years, the percentage who enrolled in such courses increased only slightly (Table 13).

Table 13

Percent of Potential Engineering Majors Who Took Accelerated Mathematics

High School Class	Female	Male	African American	American Indian	Hispanic	Caucasian
1991	63.4	52.4	48.4	45.2	54.7	54.6
1992	64.2	53.1	49.2	48.2	56.9	55.3
1993	66.0	54.2	49.0	48.9	58.6	56.8
1994	65.9	54.8	48.2	45.8	56.7	57.8
1995	66.3	55.2	47.7	51.1	58.6	58.3
1996	66.0	55.3	47.0	49.4	56.0	58.7
1997	66.6	56.0	47.1	49.2	58.0	59.2
1998	65.7	54.9	44.3	48.1	55.7	58.7
1999	65.9	54.8	44.0	45.3	56.7	58.5
2000	66.7	55.4	44.9	45.9	56.2	59.3
2001	67.0	55.2	42.7	47.9	55.3	59.6
2002	66.3	53.6	43.5	45.6	52.5	58.1

Females and Minorities. For both females and males, the percentages who took accelerated mathematics courses increased. A consistently greater percentage of females completed these courses; in 2002 66.3% of females and 53.6% of males took accelerated mathematics courses.

The percentage of Caucasian students who took accelerated mathematics tended to increase over time, while the percentage of African American students in such courses decreased. The percentages of American Indians and Hispanics did not vary consistently. With the exception of Hispanics, consistently smaller percentages of minority students than Caucasians had taken accelerated mathematics courses. In 2002, 58.1% of Caucasians completed accelerated mathematics, compared with 43.5% of African Americans, 45.6% of American Indians, and 52.5% of Hispanics.

Science

As does mathematics, broad and in-depth study of science in secondary school provides a foundation for engineering study in college that is both contextual in nature and enhances the ability of students to reason scientifically. For example, the National Center for Education Statistics (2000a) found that students who had taken advanced science courses and who were self-motivated to study science had a greater likelihood of majoring in a science or engineering field in college.

However, many students planning to major in a science field are not prepared to succeed in basic college science courses (Ziomek & Maxey, 1995). The under-representation of African Americans, American Indians, and Hispanics in science and mathematics-related career fields reflects to a large extent the outcomes of their education at all levels (National Center for Education Statistics, 1995).

Years Studied

Students from the graduating high school class of 2002 who planned to major in engineering completed an average of 3.5 years of science coursework, an average that has remained stable since 1991. Females completed slightly more years of science coursework (3.7) than males (3.5), and both averages remained stable over time. Years of science coursework varied somewhat by racial and ethnic group, with minority students completing fewer years than Caucasians (Figure 6). The average number of years of mathematics studied remained roughly stable between 1991 and 2002 for all groups.

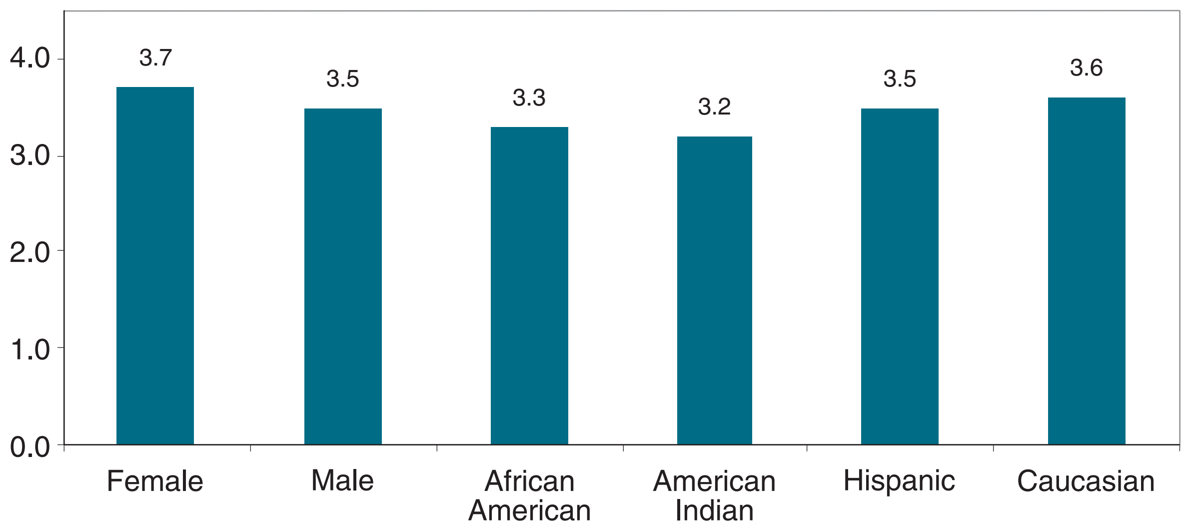

Figure 6:
Average Years of Science Coursework of Potential Engineering Majors in 2002

Courses Taken

Many high school students take a general science course and biology, and upper-level science courses such as chemistry and physics. Almost all potential engineering majors from the class of 2002 took general science and biology. Smaller percentages took upper-level sciences; 90.7% took chemistry and 76.7% completed physics. The percentage of students taking high school physics has remained roughly stable since 1991.

Females and Minorities. For both females and males, the percentage who took upper-level science courses remained roughly stable between 1991 and 2002. A greater percentage of females completed these courses and this gap remained stable over the twelve years. In 2002, 94.5% of females took chemistry, compared with 89.9% of males; 80.3% of females took physics compared with 75.8% of males (Table 14).

Table 14

Percent of Potential Engineering Majors Who Took Physics

High School Class	Female	Male	African American	American Indian	Hispanic	Caucasian
1991	81.1	79.2	67.2	66.7	73.3	81.2
1992	82.1	79.5	68.3	64.7	75.0	81.6
1993	83.0	80.4	68.9	66.5	76.3	82.6
1994	82.4	80.2	67.6	67.4	75.3	82.6
1995	82.6	79.5	67.8	69.9	75.6	82.0
1996	80.9	79.0	65.4	63.9	74.8	81.6
1997	81.4	78.4	64.5	68.0	74.3	80.9
1998	81.0	78.2	63.8	63.9	74.3	80.9
1999	80.8	78.0	62.6	62.4	75.4	80.6
2000	81.6	78.5	64.3	60.6	75.8	81.1
2001	80.8	77.8	62.3	66.9	76.8	80.5
2002	80.3	75.8	62.0	58.5	73.4	79.0

A consistently larger percentage of Caucasians than minority students completed the upper-level science courses of chemistry and physics. Of the class of 2002, 91.1% of Caucasians took chemistry, compared with 88.6% of African Americans, 81.6% of American Indians, and 90.4% of Hispanics. Similarly, 79.0% of Caucasians completed physics, compared to 62.0% of African Americans, 58.5% of American Indians, and 73.4% of Hispanics.

Course-Taking Patterns

Table 15 provides course-taking patterns in science for the high school class of 2002. Over 64% of the students completed all four science courses, including the two upper-level courses (chemistry and physics); 7.5% completed only general science and biology.

Table 15

Common Science Course-Taking Patterns of Potential Engineering Majors in 2002

Course-Taking Pattern	Percent
General Science, Biology, Chemistry, Physics	64.2
General Science, Biology, Physics	3.0
General Science, Biology, Chemistry	19.2
General Science, Biology	7.5

Note: Percentages do not total 100% because other, less common course-taking patterns were not included.

Females and Minorities. Although the largest percentages of female and male potential engineering majors took all four science courses, a greater percentage of females completed this sequence (Table 16). As with mathematics, the largest percentage point-gap in favor of females occurred in the most-advanced sequence of science courses. The largest percentage point-gap in favor of males occurred in the least-advanced sequence of science coursework.

Table 16

Percent of Potential Engineering Majors with Common Science Course-Taking Patterns in 2002

Course-Taking Pattern	Female	Male	African American	American Indian	Hispanic	Caucasian
General Science, Biology, Chemistry, Physics	71.2	62.7	48.7	43.5	58.5	67.7
General Science, Biology, Physics	1.8	3.3	2.6	2.5	3.6	3.0
General Science, Biology, Chemistry	18.0	19.5	31.4	26.0	22.8	17.1
General Science, Biology	4.5	8.2	11.6	16.9	8.1	6.6

Note: Percentages do not total 100% because other, less common course-taking patterns were not included.

Although the largest percentages of students within each racial and ethnic group completed all four years of science, a greater percentage of Caucasians than minority students took this science sequence. In addition, among African American and American Indian students, relatively large percentages completed only general science and biology courses.

Advanced, Accelerated, or Honors Science Coursework.

In addition to the regular course-taking sequences, students have the option to enroll in advanced, accelerated, or honors science courses. Over the past decade, the percentage of students who enrolled in such courses increased slightly (Table 17).

Table 17

Percent of Potential Engineering Majors Who Took Accelerated Science

High School Class	Female	Male	African American	American Indian	Hispanic	Caucasian
1991	50.6	43.0	40.5	34.1	46.4	44.1
1992	52.3	44.1	40.4	35.8	48.5	45.5
1993	54.7	44.9	40.5	37.2	50.3	46.8
1994	55.4	45.9	41.1	38.5	47.8	47.9
1995	56.0	46.1	39.6	41.4	49.2	48.8
1996	55.7	45.9	39.5	38.4	48.6	48.5
1997	56.8	46.7	40.0	40.5	50.2	49.0
1998	56.9	45.6	38.2	39.2	46.9	48.6
1999	56.4	45.0	37.8	39.1	47.1	47.8
2000	57.5	45.5	37.6	34.9	48.6	48.6
2001	57.4	45.1	36.3	37.4	47.2	48.5
2002	56.8	43.1	35.1	31.6	42.7	46.9

Females and Minorities. For both females and males, the percentage who completed accelerated science courses increased over time. A greater percentage of females completed these courses, however, and the gap appears to be increasing. In 2002, 56.8% of females and 43.1 % of males had taken accelerated science courses.

The percentage of Caucasians who took accelerated science tended to increase over time, while the percentage of African American students in such courses decreased. Although the percentages of American Indians and Hispanics did not illustrate a consistent trend, the percentages for these groups reached a twelve-year low in 2002. With the exception of Hispanics, consistently smaller percentages of minority students than Caucasians took accelerated science courses. In 2002, 46.9% of Caucasians completed accelerated science, compared with 35.1% of African Americans, 31.6% of American Indians, and 42.7% of Hispanics.

4

Academic Performance in High School

High school grade point average (GPA) is calculated for the core academic areas (i.e., English, mathematics, natural science, and social studies) and is based on the grades students report when they register for the ACT Assessment. Over the past twelve years, mean high school GPA steadily increased for all potential engineering majors to a high of 3.36 in 2001 (Figure 7).

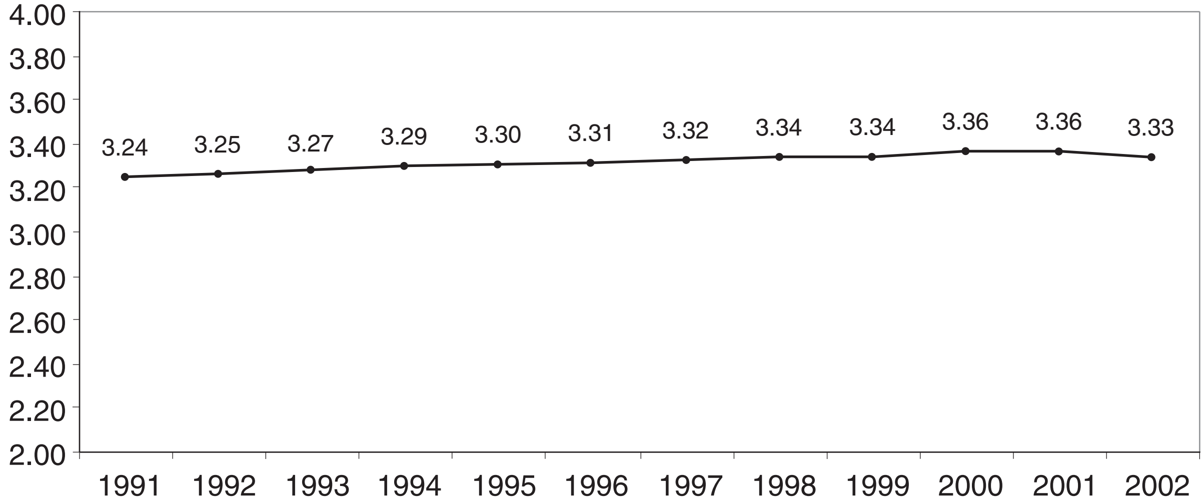

Figure 7: Grade Point Average of Potential Engineering Majors

Females and Minorities. Between 1991 and 2002, high school GPA generally increased for both females and males. Females had a consistently higher overall GPA than males. From the class of 2002, females had a GPA of 3.52 and males had a GPA of 3.29 (Table 18).

Table 18

Grade Point Average of Potential Engineering Majors by Group

High School Class	Female	Male	African American	American Indian	Hispanic	Caucasian
1991	3.42	3.20	2.87	2.98	3.20	3.30
1992	3.43	3.21	2.88	3.04	3.20	3.31
1993	3.45	3.23	2.89	3.07	3.21	3.33
1994	3.47	3.24	2.91	3.08	3.20	3.36
1995	3.48	3.25	2.91	3.14	3.23	3.37
1996	3.48	3.26	2.91	3.13	3.23	3.38
1997	3.49	3.28	2.92	3.15	3.24	3.40
1998	3.50	3.30	2.93	3.17	3.25	3.41
1999	3.50	3.30	2.93	3.15	3.26	3.41
2000	3.53	3.32	2.95	3.18	3.27	3.44
2001	3.52	3.32	2.94	3.23	3.28	3.44
2002	3.52	3.29	2.91	3.15	3.20	3.42

The overall GPA for all racial and ethnic groups increased between 1991 and 2001. Over the twelve years, minority students had lower overall GPAs than Caucasians. The gap between American Indians and Caucasians remained roughly stable over time, but the gap between African Americans and Caucasians, and between Hispanics and Caucasians increased over time. Of the class of 2002, Caucasians had a GPA of 3.42 compared with a GPA of 2.91 for African Americans, 3.15 for American Indians, and 3.20 for Hispanics.

Mathematics GPA

The average GPA for all potential engineering majors across high school mathematics coursework increased to a high of 3.32 in 2001 (Figure 8).

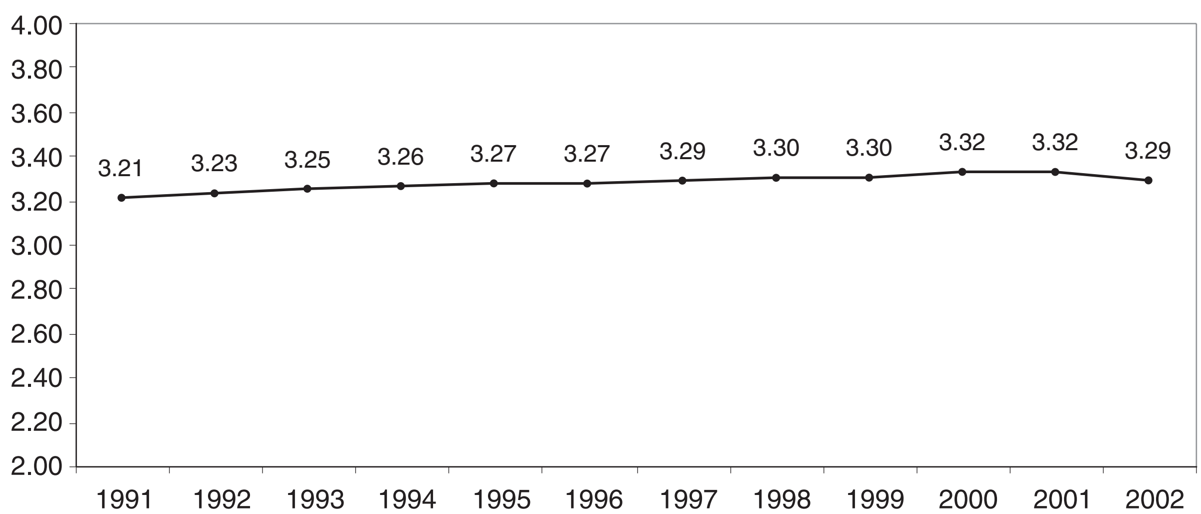

Figure 8: Mathematics Grade Point Average of Potential Engineering Majors

Females and Minorities. Although the average mathematics GPAs for both females and males generally increased over the past twelve years, females consistently had a higher average mathematics GPA. In 2002, females had a mathematics GPA of 3.47 and males had a mathematics GPA of 3.25 (Table 19). The gap between females and males has remained fairly constant over time.

Table 19

Mathematics Grade Point Average of Potential Engineering Majors by Group

High School Class	Female	Male	African American	American Indian	Hispanic	Caucasian
1991	3.37	3.18	2.78	2.92	3.16	3.27
1992	3.39	3.19	2.79	3.02	3.15	3.29
1993	3.40	3.21	2.81	2.98	3.17	3.32
1994	3.42	3.22	2.83	3.01	3.15	3.34
1995	3.43	3.23	2.82	3.07	3.19	3.36
1996	3.43	3.24	2.81	3.07	3.18	3.36
1997	3.44	3.25	2.83	3.05	3.20	3.37
1998	3.45	3.26	2.84	3.08	3.20	3.39
1999	3.45	3.26	2.84	3.04	3.21	3.38
2000	3.48	3.28	2.86	3.08	3.22	3.41
2001	3.46	3.28	2.84	3.14	3.24	3.40
2002	3.47	3.25	2.83	3.10	3.15	3.39

Grade point average across mathematics coursework increased for all racial and ethnic groups between 1991 and 2001; in 2002, the mathematics GPA for all groups dropped. Minority students had consistently lower GPAs than Caucasians; African Americans had the largest gap. In 2002, Caucasians had an average mathematics GPA of 3.39, compared to 2.83 for African Americans, 3.10 for American Indians, and 3.15 for Hispanics.

Science GPA

The average GPA for all potential engineering majors across high school science coursework generally increased over the past twelve years to a high of 3.36 in 2001 (Figure 9).

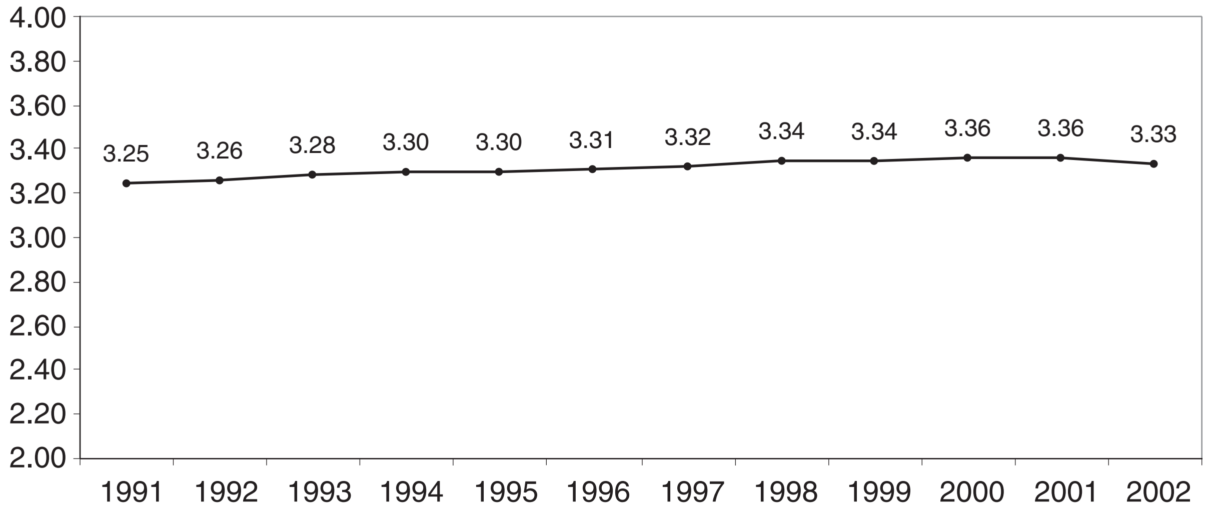

Figure 9: Science Grade Point Average of Potential Engineering Majors

Females and Minorities. Although the GPA across science coursework increased for both females and males, females consistently had a higher science GPA. In 2002, females had a science GPA of 3.50 and males had a science GPA of 3.29 (Table 20).

Table 20

Science Grade Point Average of Potential Engineering Majors by Group

High School Class	Female	Male	African American	American Indian	Hispanic	Caucasian
1991	3.39	3.21	2.85	2.99	3.17	3.31
1992	3.41	3.22	2.86	3.02	3.18	3.33
1993	3.42	3.24	2.87	3.09	3.19	3.35
1994	3.44	3.26	2.90	3.09	3.19	3.37
1995	3.45	3.26	2.89	3.16	3.21	3.38
1996	3.45	3.27	2.89	3.12	3.20	3.40
1997	3.46	3.29	2.90	3.12	3.24	3.40
1998	3.48	3.30	2.92	3.17	3.23	3.42
1999	3.48	3.31	2.93	3.14	3.24	3.42
2000	3.51	3.32	2.93	3.19	3.26	3.44
2001	3.50	3.33	2.92	3.23	3.24	3.45
2002	3.50	3.29	2.90	3.13	3.18	3.43

Between 1991 and 2001, grade point average across science coursework increased for all racial and ethnic groups; in 2002, the science GPA for these groups dropped. Over the twelve years, minority students had consistently lower average science GPAs than Caucasians; African Americans had the largest gap. In 2002, Caucasians had an average science GPA of 3.43, compared to a 2.90 for African Americans, 3.13 for American Indians, and 3.18 for Hispanics.

Class Rank

Students report their class rank by quartile when they register to take the ACT Assessment. The percentage of students who ranked within the top quartile of their graduating high school class decreased between 1991 and 2002 (Figure 10). In 2002, 55.6% of all potential engineering majors were in the top quarter of their class.

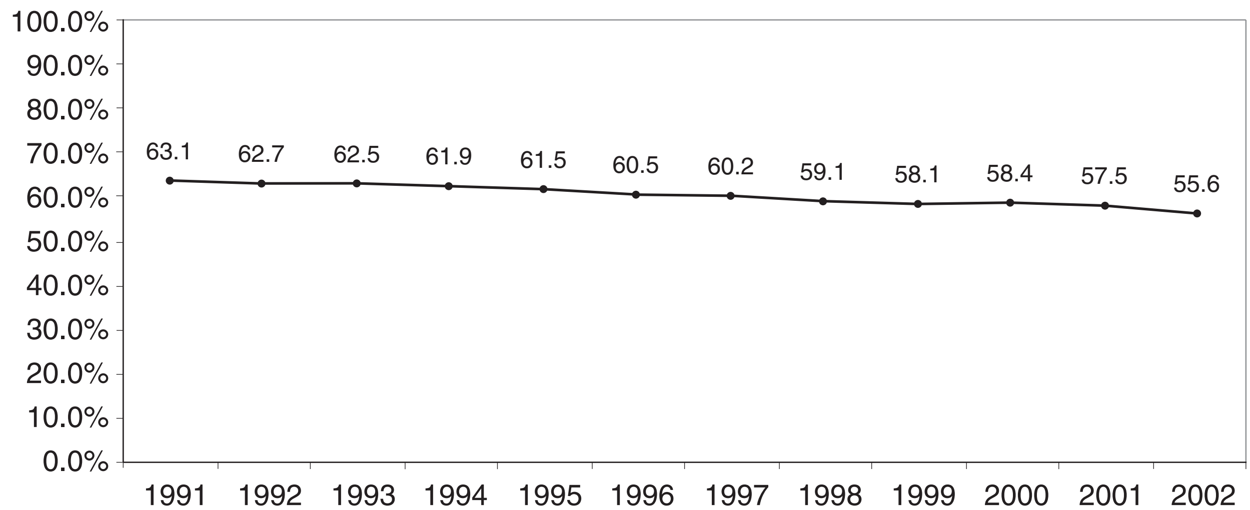

Figure 10: Percent of Potential Engineering Majors in Top Quarter of Graduating Class

Females and Minorities. For both females and males, the percentage ranked in the top quartile of their graduating class decreased. Over the past twelve years, a consistently greater percentage of females were ranked in the top quartile of their graduating class (Table 21). In 2002, 67.0% of females and 53.2% of males were ranked in the top quartile of their graduating class.

Table 21

Percent of Potential Engineering Majors in Top Quarter of Graduating Class by Group

High School Class	Female	Male	African American	American Indian	Hispanic	Caucasian
1991	72.9	60.9	42.6	46.3	58.0	67.0
1992	72.6	60.3	41.2	50.9	57.6	66.7
1993	72.7	60.0	41.1	50.9	57.2	66.9
1994	72.1	59.3	40.3	49.2	54.5	66.5
1995	72.0	58.8	39.7	50.8	55.0	66.4
1996	70.6	58.0	36.9	48.7	54.9	65.6
1997	70.6	57.6	37.0	50.6	54.4	65.0
1998	68.8	56.8	34.7	50.5	52.4	64.6
1999	68.1	55.8	33.3	47.6	52.6	63.3
2000	68.8	56.0	33.3	46.9	51.5	63.9
2001	67.7	55.3	31.7	47.9	51.3	63.1
2002	67.0	53.2	31.2	46.3	46.0	61.8

With the exception of American Indians, the percentages of students from all ethnic groups who ranked in the top quartile of their class decreased between 1991 and 2002. A smaller percentage of students from minority groups than Caucasians were ranked within the top quartile of their graduating high school class; African Americans had the largest gap. Of the class of 2002, 61.8% of Caucasians were ranked in the top quartile compared with 31.2% for African Americans, 46.3% of American Indians, and 46.0% for Hispanics.

ACT Assessment Scores

Over the past twelve years, potential engineering majors had consistently higher ACT Composite scores[7] than the national group of all ACT-tested graduates (Table 22). This gap has decreased over time. The Composite score for potential engineering majors remained roughly stable from 1991 to 1998 and decreased after 1998.

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[7]ACT Assessment scores are reported on a 1–36 score scale in four subject areas: English, Mathematics, Reading, and Science Reasoning. The ACT Composite score is a numerical average of the scores in the four subject test areas.

Table 22

ACT Composite Scores

High School Class	Engineering	National
1991	22.9	20.6
1992	22.9	20.6
1993	23.0	20.7
1994	22.9	20.8
1995	22.8	20.8
1996	22.7	20.9
1997	22.9	21.0
1998	22.8	21.0
1999	22.6	21.0
2000	22.6	21.0
2001	22.5	21.0
2002	22.2	20.8

Over the past twelve years, ACT test scores for potential engineering majors have varied by subject (Table 23). Between 1991 and 2002, scores on the English and Reading Tests steadily decreased. Scores on the Mathematics and Science Reasoning Tests increased in the mid- to late-1990s, and then decreased somewhat by early 2000.

Table 23

ACT Test Scores of Potential Engineering Majors

High School Class	ACT English	ACT Mathematics	ACT Reading	ACT Science Reasoning
1991	21.6	23.4	23.0	23.1
1992	21.5	23.5	22.8	23.1
1993	21.6	23.6	22.9	23.2
1994	21.5	23.6	22.7	23.4
1995	21.4	23.5	22.6	23.2
1996	21.4	23.4	22.4	23.3
1997	21.4	23.8	22.5	23.2
1998	21.2	23.8	22.3	23.2
1999	21.3	23.6	22.2	22.8
2000	21.2	23.7	22.2	22.9
2001	21.1	23.5	22.0	22.9
2002	20.8	23.2	21.7	22.5

Females and Minorities. Between 1991 and 2002, Composite scores have remained roughly stable for females and decreased for males. Over this time, females had consistently higher Composite scores (Table 24). The gap between females and males increased over time as the average Composite score of males declined in the late 1990s and in early 2000.

Table 24

ACT Composite Scores of Female and Male Potential Engineering Majors

High School Class	Female	Male
1991	23.2	22.8
1992	23.2	22.8
1993	23.3	22.9
1994	23.3	22.8
1995	23.3	22.7
1996	23.2	22.6
1997	23.3	22.8
1998	23.3	22.7
1999	23.1	22.5
2000	23.3	22.5
2001	23.1	22.4
2002	22.9	22.0

Table 25 presents ACT test scores by gender. In 2002, potential female and male engineering majors scored higher than all female and male tested graduates nationwide on all subject tests. The largest discrepancy in scores was found for the Mathematics Test. In the national population, females scored lower than males on the Mathematics and Science Reasoning Tests. In the population of potential engineering majors, however, females scored higher than males on all subject tests except Science Reasoning.

Table 25

2002 ACT Subject Test Scores of Females and Males

ACT Assessment	Female		Male	
	Engineering	National	Engineering	National
ACT English	22.3	20.6	20.4	19.7
ACT Mathematics	23.4	20.1	23.1	21.2
ACT Reading	22.9	21.3	21.5	20.9
ACT Science Reasoning	22.4	20.4	22.5	21.3

For African American, Hispanic, and Caucasian potential engineering majors, average Composite scores decreased over time. The average score for American Indians, however, increased slightly. Students from minority groups had consistently lower Composite scores than Caucasians. Although the score gap narrowed between Caucasians and American Indians, it widened between Caucasians and other minority groups (Table 26).

Table 26

ACT Composite Scores of Racial and Ethnic Group Potential Engineering Majors

High School Class	African American	American Indian	Hispanic	Caucasian
1991	18.5	19.2	20.6	23.9
1992	18.4	19.4	20.6	23.9
1993	18.4	19.9	20.5	24.0
1994	18.3	19.7	20.4	24.0
1995	18.2	20.0	20.4	24.0
1996	17.9	20.1	20.3	23.9
1997	17.9	20.1	20.5	24.1
1998	17.8	20.3	20.4	24.0
1999	17.7	19.7	20.1	23.8
2000	17.7	19.9	20.1	23.8
2001	17.4	19.9	20.0	23.7
2002	17.3	19.2	19.3	23.5

Table 27 presents engineering majors and national ACT test scores by race and ethnicity. For all groups, potential engineering majors scored higher on the Mathematics and Science Reasoning Tests, and had higher Composite scores, than students in their respective groups for the national population. African American and American Indian potential engineering majors scored lower than their respective national populations on the Reading Test, and American Indian potential engineering majors scored lower than their respective national population on the English Test. For the national population, as well as for potential engineering majors, Caucasians scored higher than minority group students on all subject tests.

Table 27

2002 ACT Subject Test Scores of Racial and Ethnic Groups

	African American		**American Indian**		**Hispanic**		**Caucasian**	
ACT Assessment	Engineer	National	Engineer	National	Engineer	National	Engineer	National
English	16.3	16.2	17.2	17.6	17.6	17.3	22.1	21.2
Mathematics	17.8	16.7	20.1	18.4	20.6	18.5	24.5	21.3
Reading	16.7	16.8	18.9	19.1	18.9	18.6	23.1	22.1
Science Reasoning	17.8	17.1	20.1	19.0	19.8	18.6	23.8	21.6

5

Perceived Needs for Academic Assistance

When registering for the ACT Assessment, students may indicate their perceived needs for assistance. These indicators alert colleges and universities to a student's desire to receive help in expressing ideas in writing, reading speed and comprehension, mathematical skills, and study skills. Besides being used for orientation, student services, and retention programs, self-reported needs for academic assistance might serve as an indicator of students' perceptions of their academic preparation for college coursework.

Writing Skills

Between 1991 and 2002, a decreasing percentage of students indicated that they needed help with their writing. In 2002, 25.0% of all potential engineering majors desired help with their writing.

Females and Minorities. For both females and males, the percentage who indicated they needed help with their writing decreased (Table 28). In 2002, 25.8% of females and 24.9% of males requested help with their writing. Although a greater percentage of females wanted help with writing skills, the gap diminished over time.

Table 28

Percent of Potential Engineering Majors Who Requested Help with Writing Skills

High School Class	Female	Male	African American	American Indian	Hispanic	Caucasian
1991	33.3	28.9	39.0	45.4	40.9	25.8
1992	33.4	28.9	38.8	40.8	39.1	26.1
1993	32.0	28.6	37.8	39.4	39.4	25.3
1994	30.9	27.7	36.7	37.2	38.5	24.5
1995	29.3	27.2	35.9	35.9	37.2	23.8
1996	28.6	26.6	35.6	37.9	36.7	23.1
1997	26.3	25.4	34.0	30.7	33.5	22.1
1998	25.5	23.8	32.7	27.3	31.6	20.4
1999	25.3	23.9	31.9	36.1	33.1	20.3
2000	25.1	24.0	31.9	31.7	33.3	20.5
2001	25.0	24.6	31.8	33.9	33.4	21.2
2002	25.8	24.9	31.6	35.3	34.6	21.2

For all racial and ethnic groups, the percentage who indicated they needed help with their writing decreased between 1991 and 2002. Over the past twelve years, however, a consistently greater percentage of minority students than Caucasians indicated that they needed help with their writing skills, and the gap between these groups remained roughly stable over time. In 2002, 21.2% of Caucasians requested help with their writing, as compared with 31.6% of African Americans, 35.3% of American Indians, and 34.6% of Hispanics.

Reading Skills

Between 1995 and 2001, the percentage of students who requested help to improve their reading speed and comprehension decreased. In 2002, 31% of all potential engineering majors indicated that they needed help with their reading skills.

Table 29

Percent of Potential Engineering Majors Who Requested Help with Reading Skills

High School Class	Female	Male	African American	American Indian	Hispanic	Caucasian
1991	33.0	32.3	41.3	46.5	42.0	28.4
1992	34.0	33.9	43.4	42.6	42.0	30.1
1993	33.6	33.5	41.5	41.0	42.5	29.6
1994	32.6	33.0	40.8	40.1	42.1	29.1
1995	33.1	34.0	41.6	41.9	42.3	29.9
1996	32.4	33.3	41.3	41.2	42.7	29.1
1997	31.7	33.1	41.0	38.5	40.6	29.1
1998	31.8	33.1	40.6	39.0	40.9	29.2
1999	30.8	32.8	39.8	43.0	41.3	28.5
2000	30.2	31.7	37.7	38.5	41.0	27.8
2001	29.5	31.2	38.1	39.0	39.5	27.2
2002	29.8	31.3	37.2	41.3	40.7	27.2

Females and Minorities. For both females and males, the percentage who wanted help with their reading skills decreased (Table 29). The gap between females and males slightly reversed itself over time, and was largely the result of a decrease in the percentage of females who requested help with their reading skills. In 2002, 29.8% of females and 31.3% of males indicated that they needed help with their reading speed and comprehension.

For all racial and ethnic groups, the percentage who wanted help in reading decreased slightly between 1991 and 2002. A consistently greater percentage of minority students than Caucasians indicated that they needed help with their reading speed and comprehension. The gap between minority and Caucasian students remained roughly constant over time. In 2002, 27.2% of Caucasians requested help with their reading skills, compared with 37.2% of African Americans, 41.3% of American Indians, and 40.7% of Hispanics.

Mathematics Skills

Between 1991 and 2002, the percentage of all potential engineers who indicated they needed help with their mathematics skills remained roughly stable. In 2002, 23.9% of potential engineering majors wanted help with their mathematics skills.

Table 30

Percent of Potential Engineering Majors Who Requested Help with Mathematics Skills

High School Class	Female	Male	African American	American Indian	Hispanic	Caucasian
1991	24.8	23.6	44.5	46.1	33.1	19.0
1992	25.2	24.0	44.5	42.7	33.2	19.5
1993	24.1	23.1	42.8	39.0	31.2	18.5
1994	23.9	22.4	42.6	40.9	30.7	17.6
1995	23.5	22.4	43.1	37.0	31.0	17.2
1996	24.9	22.9	45.3	39.7	32.7	17.5
1997	24.9	22.6	44.8	37.8	32.0	17.4
1998	24.2	22.4	43.9	35.2	31.0	17.1
1999	24.7	23.0	44.6	42.2	33.0	17.5
2000	24.0	22.9	43.8	40.5	32.7	17.6
2001	24.2	22.8	45.4	36.2	30.8	17.5
2002	24.7	23.7	44.0	38.3	33.9	17.9

Females and Minorities. For both females and males, the percentage who indicated they needed help with their mathematics skills remained roughly stable (Table 30). A slightly higher percentage of females indicated that they needed help with their mathematics skills over time. In 2002, 24.7% of females requested help with their mathematics skills, compared to 23.7% of males.

For all racial and ethnic groups, the percentage who indicated they needed help with their mathematics skills remained generally stable. A consistently greater percentage of minority students than Caucasians indicated that they needed help with their mathematics skills. The gap between Caucasians and minority students was largest for African Americans, followed by American Indians and Hispanics. The gap between Caucasians and American Indians decreased over time, while the gap between Caucasians and other minority groups has increased slightly. In 2002, 17.9% of Caucasians wanted help with their mathematics skills compared with 44.0% of African Americans, 38.3% of American Indians, and 33.9% of Hispanics.

Study Skills

Between 1991 and 2002, a decreasing percentage of potential engineering majors indicated they needed help with their study skills; in 2002, 37.4% desired help in improving study skills.

Table 31

Percent of Potential Engineering Majors Who Requested Help with Study Skills

High School Class	Female	Male	African American	American Indian	Hispanic	Caucasian
1991	37.2	40.5	58.4	57.1	46.8	36.0
1992	37.9	41.1	59.2	57.2	48.9	36.3
1993	37.1	40.8	58.9	53.2	46.3	35.8
1994	36.3	39.8	58.1	50.0	46.2	34.6
1995	35.0	39.8	58.2	51.2	46.4	33.8
1996	36.0	39.3	59.0	52.2	45.5	33.6
1997	34.6	38.0	58.0	50.9	43.0	32.4
1998	34.6	37.6	57.0	46.9	43.3	32.1
1999	33.9	38.2	56.6	51.6	43.3	32.6
2000	34.2	37.9	55.9	48.6	44.2	32.5
2001	34.0	38.2	57.0	47.6	42.9	32.8
2002	34.3	38.1	56.3	49.7	43.8	32.3

Females and Minorities. The percentage of both female and male students who indicated they needed help with their study skills decreased (Table 31). A consistently smaller percentage of females requested help with their study skills, and the gap remained fairly stable between 1991 and 2002; in 2002, 34.3% of females and 38.1% of males indicated that they requested help with their study skills.

For all racial and ethnic groups, the percentage who indicated they needed help with their study skills decreased. A greater percentage of minority students than Caucasians indicated that they needed help with their study skills. With the exception of American Indians, the gap between minority groups and Caucasians remained roughly stable. In 2002, 32.3% of Caucasians wanted help with their study skills compared with 56.3% of African Americans, 49.7% of American Indians, and 43.8% of Hispanics.

6

Conclusions and Recommendations

The issues addressed by this policy report focus on the national need to continually attract and develop a well-prepared and diverse engineering workforce. Demographic changes overlaid with future workforce demands demonstrate the necessity to substantially increase the number of well-prepared female and minority students entering and completing engineering programs. The primary question in examining these twelve years of ACT Assessment data for nearly 750,000 college-bound students planning to major in engineering is whether America's future engineering workforce will reflect the necessary levels of diversity and preparedness to continue the nation's competitive edge in the global marketplace. The answer, based upon the information presented in this report, appears uncertain.

The number of students who plan to major in engineering upon college entrance has continued to decrease. Moreover, these students have become less certain of their choice of major, and each year consistently over 40% indicate they need help deciding their educational and occupational plans. Decreasing levels of college major certainty may reflect a variety of factors. Some students may have been sure about engineering as a major, but unsure regarding a specific engineering field. Others may be considering several engineering fields, interdisciplinary programs, or perhaps were not yet fully informed about engineering study and practice.

Over the past twelve years, the percentages of potential engineering majors in college preparatory programs and in the top quarter of their high school graduating class have also decreased. However, a greater percentage of today's potential engineering majors are completing core course requirements and their overall high school GPA has increased.

Potential engineering majors are somewhat better prepared in mathematics than in the past. The percentage taking high school calculus and accelerated mathematics coursework has increased. The average GPA across mathematics coursework has increased over the past twelve years but scores on the ACT Mathematics Test have remained relatively stable.

Despite these indicators of improvement, more progress can clearly be made. Almost 11% of all potential engineering majors completed only algebra 1, geometry, and algebra 2, only 56% have taken calculus, and almost a quarter have indicated they need help with their mathematics skills.

Potential engineering majors have only modestly increased their science preparation. A majority have completed physics (76.7%) but that percentage has remained relatively stable over the past twelve years. Between 1991 and 2002, the percentage of all students enrolled in accelerated science courses has increased slightly and the average GPA across high school science coursework has increased as well. However, scores on the ACT Science Reasoning Test have dropped slightly.

Despite some indications of progress, further improvement is possible. Although the majority (64.2%) of potential engineering students took the entire high school science course sequence (i.e., general science, biology, chemistry, physics), 7.5% of the 2002 cohort completed only general science and biology, and another 19% only completed general science, biology, and chemistry. Clearly there is room for greater mathematics and science preparation for more potential engineering students. Such enhanced learning can result in better pre-college preparation, increased levels of measured achievement, and higher levels of persistence in engineering programs.

Females and Minorities. Over the past twelve years, gender representation has remained relatively unchanged, with females making up only 18%–20% of all potential engineering majors (the number of female potential engineering majors, however, has actually dropped). Although females represented only a smaller percentage of all potential engineering majors, they were among the better-prepared students. A greater percentage of females than males were certain of their choice of major, had higher GPAs and ACT scores, and took more advanced mathematics and science coursework.

One concern, however, is that the attitude of many females toward their performance in some academic areas appears to be inconsistent with their actual level of achievement. Despite higher levels of mathematics and English performance, for example, a greater percentage of females than males indicated that they needed help with their skills in these two areas. (A corollary observation, of course, is that males overestimate their levels of competence and readiness in these areas.) This finding often carries over into college studies, where female engineering students judge themselves as less likely to succeed in their academic programs than male students judge themselves, even though there was no empirical basis for this difference (Meinholdt & Murray, 1999; Seymour & Hewitt, 1997).

Females are an untapped source of talent to lead the high-tech economy and culture, but they must receive early encouragement (Jobe, 2002). This encouragement can include exploration of engineering in middle school, affirmation of the value of mathematics and science coursework in high school, and support for female engineering students in college via a variety of programs (e.g., mentorships, informal education programs, faculty-led study groups).

The percentage of potential engineering majors among various minority groups improved over the past twelve years, but the increase was due in large part to a decrease in the number of Caucasians who planned to major in engineering. In fact, the number of minority students planning to major in engineering has dropped in recent years.

For minority students there is a substantial misalignment between aspirations and preparation. Although many were very sure of their choice to enter an engineering major, many did not complete core coursework requirements and had taken only basic mathematics and science course sequences (i.e., algebra 1, algebra 2, and geometry; general science and biology). This includes lower levels of course taking in calculus and physics. Similar course-taking disparities are reported for the national high school population as well (National Science Board, 2002).

Minority potential engineering majors had significantly lower overall grade point averages, as well as lower mathematics and science GPAs in high school. Far fewer minority students ranked in the top quarter of their graduating classes, despite the fact that many did not take a rigorous core curriculum, and they had significantly lower average ACT scores than those of all college-bound test takers and of potential Caucasian engineering majors. Finally, minority students indicated high levels of perceived academic need, most frequently requesting help with study skills. Overall, it appears that many minority students may not have been prepared academically to enter an undergraduate engineering program.

The data presented in this report raise serious questions about the future of America's engineering workforce. On one hand, the nation needs more well-prepared engineers; and, given demographic trends, many future engineers will of necessity need to be female and minority. On the other hand, there has been little change in representation, and a decreasing trend in actual numbers, for potential female engineering majors—most of whom are well prepared to succeed in engineering studies. Further, the percentage of potential minority engineering majors has improved over time, but actual numbers have dropped; and many of these students appear poorly prepared to meet the challenges of rigorous engineering curricula.

Recommendations

This policy report has presented information on enrollment trends, academic preparation, and diversity for more than 750,000 potential engineering majors over the past twelve years. Such data can be an important element in the growing national information base on America's future engineering workforce. This report can hold a range of implications for K–12 educators, college and university engineering programs, engineering organizations and agencies, and policy makers at local, regional, and national levels. Consequently, this report concludes with a series of integrated policy and program recommendations for these and other constituent groups. Like others concerned about this national priority (e.g., Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development; National Commission on Mathematics and Science Teaching for the 21st Century) it urges a coordinated national agenda to meet these multi-dimensional challenges.

K–12 Education. Postsecondary exploration and planning for many students begins early in the educational pipeline. This may be especially true for those with interests and aspirations toward the engineering profession, where factors such as course requirements, course sequences, and college engineering programs are more formally prescripted and pursued than in other career areas. These realities underscore the need for early academic choices that keep educational and career paths open for all students accompanied by solid core academic courses with the expectation that all students will be prepared to engage such a curriculum in secondary school.

The Glenn Commission has noted that efforts to increase the flow of skilled workers must begin with the reform of K–12 education, which has failed to adequately prepare students–especially women and minorities–in science, mathematics, and technology (National Commission on Mathematics and Science Teaching for the 21st Century, 2000). Further, we know that capable females and members of minority groups do not pursue careers in engineering because they lack encouragement, information, opportunity, and role models (Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development, 2000; Wilson, 1999).

- ***To help more students consider, plan, and pursue engineering professions, school districts should:***
  - *provide challenging science and mathematics curricula and courses that align with postsecondary requirements, and engage qualified individuals to teach these courses, beginning no later than middle school, for all students.*
  - *provide contemporary and continual science, mathematics, and engineering-related outside-of-the-classroom experiences that are accessible and appealing to all students.*
  - *specifically target the educational and career explorations of female and minority students to assure that they have encouragement and support to consider and plan for a broad range of careers–especially those in science and engineering.*
  - *provide comprehensive, user-friendly, and up-to-date information about the opportunities and rewards for careers in engineering.*
  - *encourage concurrent enrollment and dual credit mathematics and science courses for advanced students in addition to Advanced Placement, International Baccalaureate, and honors high school courses.*

Postsecondary Education. In the past, engineering programs in colleges and universities had little influence on students at K–12 levels who were potentially interested in engineering education and careers. Today, many are playing active, collaborative, and creative roles in the preparation, support, and encouragement of those young people (Genalo, Bruning, & Adams, 2000; Sorby & Baartmans, 2001).

There are now many special pre-engineering programs designed to attract, educate, and encourage female and minority students to consider, explore, and plan for careers in engineering. These outreach programs often take advantage of alumni, mentors, and work with K–12 education and private organizations to bring pre-engineering career exploration and planning to local venues. Beyond this, colleges and universities are making concerted efforts to help enrolled students persist throughout their engineering studies.

- ***To nurture a broader interest in engineering, colleges and universities should:***
  - *in partnership with K–12 education leaders, expand their outreach activities at least into the middle school and include more institutional collaborations, and more innovative and experiential user-friendly outreach programs.*
  - *target many of their outreach programs toward female and minority group students, particularly those in rural and urban settings who may not have access to such programs, to ensure reaching as diverse a student population as possible.*
  - *work with school districts to strengthen middle school and high school mathematics and science courses and instruction, and to better align content with the needs for college courses content prerequisites.*
  - *include parents, teachers, and counselors in outreach programs that help them learn about engineering as a profession so that they can encourage and support the young people who rely on their knowledge and influence.*

Professional Organizations. A great many engineering organizations and agencies have developed extensive resources and programs to attract, inform, and encourage those considering engineering as a profession. Many of these resources are portable, Internet-based, and geared directly for use by teachers, counselors, mentors, and others (e.g., American Society for Engineering Education).

A number of these organizations focus on females and members of minority groups. For example, the National Action Council for Minorities in Engineering, National Society of Black Engineers, American Indian Science and Engineering Society, Society of Hispanic Professional Engineers, and Society of Women Engineers, among others, work with their constituencies to foster career exploration, academic preparation, and college persistence.

- ***To ensure a well-prepared and diverse engineering workforce, professional engineering organizations should:***
  - *strive to provide a broad range of responsive pre-college engineering resources, programs, and K–12 collaborations that include emerging specializations and interdisciplinary programs.*
  - *use a variety of mediums to provide students and their families with stimulating information that describes what engineers do and produce.*
  - *especially target female and minority groups in under-served areas such as rural and urban school districts.*
  - *increase collaborations among themselves and with informal education networks (e.g., community organizations, after-school programs) to jointly incorporate approaches that could be tailored to different constituencies and easily used by educators.*

Policy Makers. Policy makers face unique and complex challenges as they consider the job requirements of America's future engineering workforce, the training required to develop that labor force, and the need to instill a commitment to lifelong learning among all of its members. Growing national and international economic, social, and security issues compound these challenges.

Clearly the focus on mathematics and science partnerships in the No Child Left Behind Act (U.S. Department of Education, 2002) reinforces America's need to vigorously support and implement the Act's elements by inaugurating creative solutions to enhance the necessary development of an able and diverse engineering workforce and to broker the necessary legislation, resources, and partnerships to make this a reality.

- ***To support the nation's present need for a strong and productive engineering workforce, and to successfully respond to future challenges to prepare a learning centered and adaptable engineering workforce, policy makers should:***
  - *fund and implement a range of programs including teacher preparation in science and mathematics, pre-college engineering exploration, and related support for females and minority students (particularly in rural and urban areas).*
  - *bring together various constituencies (education, industry, professional organizations, community agencies, private funding sources) to help address key issues including enhanced academic standards in science and technology across the K–12 system.*
  - *consider, evaluate, and implement an array of financial aid incentives (like those for other professions) that attract and support students choosing to pursue engineering studies.*
  - *work with educational leaders across the K–16 spectrum to develop a seamless educational system that systemically aligns curricula, particularly in science and mathematics, so that students can make smooth transitions at key points and that teaching and learning across these transitions can become more intertwined and incremental in terms of in-depth subject matter development.*
  - *provide accessible information on the effectiveness of programs designed to increase engineering study so that current users and potential implementers can determine what might work best in their own given set of population, demographic, and social environments.*

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Appendix

ACT Assessment Engineering Majors

Engineering (Pre-Engineering), General

Aerospace, Aeronautical, and Astronautical Engineering

Agricultural Engineering

Architectural and Biosystems Engineering

Bioengineering and Biomedical Engineering

Ceramic Engineering

Chemical Engineering

Civil Engineering

Computer Engineering

Construction Engineering/ Construction Management

Electrical, Electronics, and Communications Engineering

Engineering Management

Engineering Physics

Engineering Science

Environmental Health Engineering

Geological and Geophysical Engineering

Industrial Engineering/ Technology

Materials Engineering

Mechanical Engineering

Metallurgical Engineering

Mining and Mineral Engineering

Naval Architecture and Marine Engineering

Nuclear Engineering

Ocean Engineering

Petroleum Engineering

Systems Engineering