A Bridge for All:

Higher Education Design Principles to Broaden Participation in Science, Technology, Engineering and Mathematics

February 2004

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Building Engineering & Science Talent

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BEST is a public-private partnership dedicated to building a stronger, more diverse U.S. workforce in science, engineering and technology by increasing the participation of underrepresented groups.

The national interest now calls for a far more robust effort to recruit and train a scientific and engineering workforce that reflects America's new demographic realities.

About BEST

BEST, an initiative of the Council on Competitiveness, was established as an independent, San Diego-based 501 (c)(3) organization in September 2001 at the recommendation of the Congressional Commission on the Advancement of Women in Science, Engineering, and Technology. Our mission is to spur action to build a strong, more diverse U.S. technical workforce. The nation's scientists, engineers, mathematicians and technologists comprise an indispensable strategic asset. Despite decades of effort, however, this pool of talent remains about three-quarters male and four-fifths white. The talent imperative we face is to prepare, attract and retain a larger share of all of our citizens in the technical fields that underpin U.S. economic strength, national security and quality of life.

BEST's objective has been to build a foundation for action through a two-year net assessment of best practices in pre-K-12, higher education and the workplace to increase the participation of women, African Americans, Hispanics, Native Americans and persons with disabilities in the science, engineering and technology professions. Three blue-ribbon panels have worked in parallel across the whole continuum of education and workforce development with the guidance and support of BEST's Board of Directors, National Leadership Council, Research Board and Project Integrators who are listed on the inside front and back covers of this report.

Based on available research evidence and the professional judgment of 120 nationally recognized practitioners and researchers, the assessment:

- Makes the case for national action to meet the U.S. talent imperative;
- Rates pre-K-12 programs that have research evidence of effectiveness or are worthy of investment in further research;
- Analyzes higher education and workplace exemplars;
- Distills the design principles that underpin effective programs; and
- Proposes an action agenda at the national and community levels engaging employers, educators, policy makers, professional societies and nonprofit organizations.

BEST will report its findings and recommendations to members of Congress in the spring of 2004.

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The BEST Evidence

The three expert panels assembled by BEST to identify what works in pre-K-12, higher education and the workforce faced the same task: how to identify and validate the effectiveness of programs developed to broaden the participation of women, underrepresented minorities and persons with disabilities in science, engineering and technology.

Each panel approached this task as rigorously as time, resources and availability of data allowed. Step one was to agree upon an analytical approach, recognizing the complexity and limits of using the same methods on groups as diverse as those underrepresented in technical fields. Step two was to create a national sample of programs by drawing upon the professional knowledge of the panelists as well as a review of the research literature. Step three was to apply specific analytical criteria to rate programs, giving targeted attention to third-party evaluation and research rigor as well as taking into account descriptive evidence generated by programs and, where appropriate, the judgment of the panel. Step four was to draw inferences from exemplary programs distilling a shared set of "design principles" that are not full explanations of effectiveness but a shorthand for what it takes to succeed.

None of the panels found the research base alone sufficient to draw conclusive judgments about what works. Moreover, the standards applied by BEST's panels only begin to define what is effective, adaptable, affordable and deserving of further consideration as an intervention. These challenges speak to the need for hard thinking and real-world strategies about practices in the classroom, on campus and in the workplace. What seems exemplary warrants close scrutiny, subject to local constraints, goals, belief systems, opportunities, personnel and populations. The findings of the panels represent a starting point, not the last word.

With these caveats, BEST's rigorous approach sets the bar high. Doing so will contribute to more informed decisions to meet an important and increasingly urgent national challenge. We do not ask that readers trust our evidence implicitly, but that they seriously consider our findings even as BEST and other committed organizations work to fill gaps in knowledge and translate our understanding of what works into action.

Contents

Acknowledgments

This report reflects generous contributions of time and expertise from many committed individuals. In particular, BEST wishes to thank Dr. Shirley Ann Jackson for her leadership as chair of the blue-ribbon panel on higher education; Dr. Willie Pearson, Jr. for his guidance as expert panel leader; Dr. Daryl Chubin and Dr. Wanda E. Ward for their pivotal roles in conceptualizing the issues and drafting the report; Dr. Shirley McBay, for chairing the sub-group of panel members who reviewed nominations of exemplary and promising programs; Dr. Suzanne Brainard and Dr. Carlos Rodriguez for their participation in this process; Dr. Shirley Malcom and Dr. Richard Tapia for co-chairing the research board that reviewed this report; and all of the project integrators and panel members who commented on successive drafts. Dr. Joan Burrelli of the National Science Foundation and Eleanor Babco, executive director of the Commission on Professionals in Science and Technology, provided valuable analysis of data issues. Dr. Joanne R. Gribble thoughtfully edited the report, for which BEST alone assumes responsibility.

Executive Summary

The Challenge to Higher Education

America's science and engineering workforce has been the primary driver of the nation's postwar economic prosperity and global technological leadership. Until now, the nation has drawn upon an ever-narrowing segment of its population to meet most of its needs for technical talent. But looking ahead, the national interest now calls for a far more robust effort to recruit and train our "best and brightest" that reflects the new demographic realities of the American school and workforce populations.

The nation's colleges and universities are the strategic bridge between a pre-kindergarten-to-12th-grade (pre-K-12) system, whose purpose is to provide foundational skills for all citizens, and the world of work in which knowledge commands an increasing premium. Higher education will be asked to meet three converging requirements: the replacement need to fill the shoes of the current science and engineering workforce (half of which is at least 40 years old); the structural need for scientists and engineers in promising technology sectors; and the competitive need to keep pace with an international surge in production of science and engineering talent.

The single most important test, then, for American higher education over the next decade will be to supply world-class talent in science, engineering and technology by developing an emerging domestic talent pool that looks different from decades past. Unless it can do so, the primacy of American innovation will be lost, even as employers access international technical talent or move operations offshore.

Figure 1 captures the scope of the challenge. A sorting process in science, engineering, and technology reduces the size of the potential talent pool at each successive phase of education. In the process, persons from underrepresented groups are eliminated in disproportionate numbers.

The cumulative impact of this process on the participation of African Americans, Hispanics and Native Americans is highlighted in Table 1 below. Women, underrepresented minorities and persons with disabilities comprise more than two-thirds of the U.S. workforce, but hold only about one-quarter of the science, engineering and technology jobs that underpin our economic strength. This narrow base has left America with an "underrepresented majority" in the very fields upon which the country's prosperity, security and quality of life hinge.

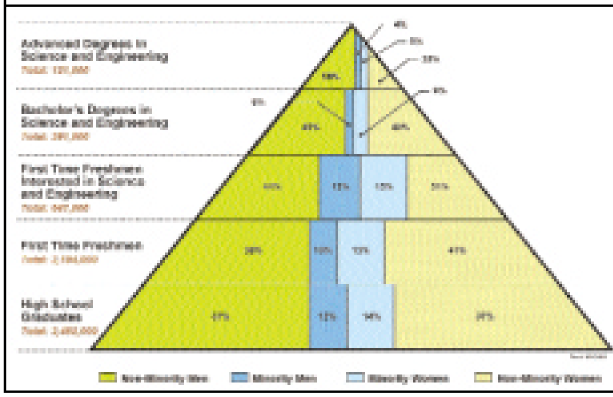
What precedes and follows higher education raises society's expectations of what can be accomplished after basic education. Postsecondary institutions confer the associate, baccalaureate, master's and doctoral degrees that certify competence in technical fields. But in a system of education that functions unevenly at best, the nation looks to

Figure 1

Milestones in Higher Education

Education Milestones by Race/Ethnicity and Gender

(Rounded Numbers)



Source: Joan Burrelli, NSF, based on 1999 Common Core of Data, U.S. Department of Education, National Center for Education Statistics (NCES); NCES, 1998 IPEDS Fall Enrollment Survey; UCLA Higher Education Research Institute,1998 American Freshman Survey (estimate); and NCES, 1998 IPEDS Completions Survey

Table 1

Persons Employed in S&E Occupations 2001, by Highest Degree Attained

% Distribution by Race/Ethnicity

	Overall	Hispanic	White	Black	Amer. Ind.	Asian
Doctorate/professional	593,713	2.1	76.7	3.6	0.0	17.6
Master's	1,155,659	3.3	76.9	3.1	0.2	16.5
Bachelor's	3,223,664	3.7	76.2	7.2	0.3	12.6
Associate's	657,444	2.1	80.0	11.6	0.5	5.7
High school diploma	1,657,136	5.5	77.8	11.3	1.0	4.4
Total	7,287,615	3.8	77.1	7.6	0.4	11.2

Source: Current Population Survey, April 2001

institutions of higher learning to remedy deficiencies in pre-K-12 and to open the way to economic and social mobility for all.

Research universities carry a particular burden of leadership because, with good reason, they are viewed as the crown jewels of American graduate education. The quality of research and technical talent they produce, the resources they command and the synergies they catalyze make these institutions a unique national resource. They must be at the center of any national effort to build a stronger, more diverse technical workforce along with minority-serving institutions, women's colleges and community colleges.

Clearly, higher education cannot on its own correct the demographic imbalances in the technical workforce. At its most fundamental, the challenge is fiscal: colleges and universities both public and private face funding constraints in even the best of economic times. Today, they are turning away some of the most promising of students for lack of resources. Likewise, they are limited in how much remedial help they can offer students whose high school careers may have left them unprepared for college work. Budgetary restrictions are the immediate constraint, but even under optimal funding condition the question lingers: how much of their students' academic shortcomings should institutions of higher learning be expected to put right?

At the other end of the higher education pipeline is the workplace. Employers are justified in expecting college graduates to be largely work-ready. But few of them have stepped up to their role as counselors and advisers to the institutions that train their employees-to-be. Who can expect universities to train students properly for technical careers without knowing what knowledge and skills S&E employers require?

Table 2

BEST Evaluation Criteria for Assessing Higher Education Programs/Practices

Questions/Criteria	Exemplary – actionable now	Promising	Not ready to adapt/scale
1. Were expected outcomes defined before program launch?	Yes	Soon after	Sort of/vague
2. Are outcome data attributable to the program intervention?	Far exceeded original expectations	Exceeded original expectations	Failed to meet expectations
3. Does it demonstrate excellence, which requires equity? – i.e., did it increase the diversity of the target population?	Chief outcome achieved and documented (positive trend)	Chief outcome implied (no monotonic trend)	Equity at core of program design, not an add-on
4. What was the value-add of the experience to the target population?	Related outcomes that move treatment group to next competitive level	Majority (but not most) of individuals in treatment population enhanced	Gains for some individuals that can be attributed to treatment
5. Is there evidence of adaptation/ institutionalization, i.e., multiple sites?	Explicit scale-up strategy w/evidence	Attempt to implement strategy and evaluate	Confined to a single site
6. Is there evidence of effectiveness with a population different from that originally targeted?	Planned and executed	Planned	Serendipitous
7. How long has it been in place?	Self-sustaining (10+ years)	Majority soft money (3-10 years)	New (<3 years)
8.Were there unexpected consequences?	Positive in intensity or extent (and measured)	Identification of possible/probable consequences	Evidence for systematic rather than random effect

Source: BEST Blue Ribbon Panel on Higher Education, 2002

Higher Education Programs that Work

As American institutions – regardless of industry, sector or size – have become increasingly performance-based, a "best practices" movement that first took hold in the corporate sector has fueled a wide-ranging search for excellence in organizational performance. This search today extends from the workforce-focused Malcolm Baldrige National Quality Awards to the school-based expectations contained in the No Child Left Behind Act. Higher education should not be exempt from this movement toward performance-based accountability but plainly could benefit from assistance in beginning the process as it relates to increasing the technical workforce.

Table 3

BEST Exemplary Higher Education Programs by Milestone

Undergraduate:	University of Michigan Women in Science and Engineering Residence Program (WISE-RP)
	Gateway Engineering Education Coalition
	University of Maryland, Baltimore County (UMBC) Meyerhoff Scholars Program
Graduate:	National Consortium for Graduate Degrees for Minorities in Science & Engineering (GEM)
Faculty:	Compact for Faculty Diversity
	Preparing Future Faculty (PFF)
Statewide Discipline-Focused:	Partnership for Minority Advancement in the

Source: BEST Blue Ribbon Panel on Higher Education, 2003

Thus the mission of BEST has been systematically to seek out those programs in higher education which show promise in developing talent from among those populations which are currently underrepresented in the science and engineering workforce, but which comprise the majority in American schools and workplaces.

To this end, BEST consulted the scholarly and government literatures, and rosters of individuals and institutions nationally recognized for excellence in human resource development for science and technology. BEST identified through this systematic search-and-nomination process a pool of 124 higher education-based programs. Each was asked to complete a Program Profile covering goals, impact, growth, sustainability and evidence of effectiveness. A total of 36 programs were rated by a subset of the BEST Higher Education Blue Ribbon Panel in January 2003.

BEST then developed evaluation criteria. These criteria (Table 2) were used to assess the soundness of programs and practices that foster achievement of educational milestones. Programs that had monitored their participants and tried to evaluate outcomes over their histories were favored in the panel review process. Seven programs (Table 3) were rated as exemplary on at least six of the eight criteria. Five other programs, not described here, were deemed promising. Profiles of exemplary and promising programs are in Appendix C of this report.

Building National Capacity

BEST has distilled eight design principles underpinning exemplary and promising programs (see box below). In concert, they play an integral role in successful outcomes across the milestones marking the transition from school to work.

These design principles represent a common-sense understanding of individuals, groups and institutions refined by trial and error, made operational and proven to work. While they are not ends in themselves, nor are they immutable, taken together these principles play an integral role in successful outcomes across the milestones which mark the transition from school to work. They may also be useful in other contexts. For example, on the demand side of the education equation, they can guide public and private sector sponsors toward the exemplary, and they can and should inform funding and educational policy decisions. They can also be helpful for stakeholders on the supply side. Students, parents, guidance counselors, university faculty and administrators all have high-stake decisions to make regarding the value of programs and institutions.

A ninth principle is not readily designed, but embodies a pervasive need: comprehensive financial assistance for low-income students. Few programs can provide full funding, but most of the institutions that are home to exemplary and promising programs identified by BEST work diligently to construct financial packages that combine merit and needs-based support. Such support makes academics – not part-time work unrelated to the course of study – the student's chief priority.

The findings of the Higher Education panel suggest a number of guidelines regarding the application of these design principles:

Design Principles to Expand Higher Education Capacity

Principle	*Evidence*
• Institutional leadership	Commitment to inclusiveness across the campus community
• Targeted recruitment	Investing in and executing a feeder system, K-12
• Engaged faculty	Developing student talent as a rewarded faculty outcome
• Personal attention	Addressing, through mentoring and tutoring, the learning needs of each student
• Peer support	Student interaction opportunities that build support across cohorts and allegiance to institution, discipline and profession
• Enriched research experience	Beyond-the-classroom hands-on opportunities and summer internships that connect to the world of work
• Bridging to the next level	Institutional relationships that help students and faculty to envision pathways to milestones and career development
• Continuous evaluation	Ongoing monitoring of process and outcomes that guide program adjustments to heighten impact

1. Design principles comprise a single package. The components of effective programs should not be viewed as an *a la carte* menu from which to pick and choose.

2. Failure is part of the learning curve. Outstanding programs have the capacity to acknowledge and learn from their mistakes.

3. Execution spells the difference. What often sets best-in-class apart is not a difference in kind but in degree. It is the quality of teaching, mentoring, research opportunity, etc., that separates top producers of technical talent from other institutions.

4. Context is critical. The next generation of scientists and engineers is being developed in an educational setting far different from the baby boomers that they will replace. New learning technologies, eroding boundaries between campus, home and work, and changing demographics demand a keen understanding of the role that culture and context play.

It may be helpful to regard these design principles as a set of tools that may be applied in various higher education contexts as we expand our national capacity to educate our technical workforce. This capacity-building effort must be followed along two paths. The path of deepening is to develop more talent within current high-producing institutions. The path of widening is to expand the circle of such institutions. In pursuing both, the design principles identified by BEST can be helpful to institutions and communities as they tackle the three tasks critical to meet the scope of the challenge:

- *sustaining* long-term ownership;
- *institutionalizing* that commitment to such depth that the successful program becomes synonymous with the institution itself; and
- *scaling* up support for building capacity by engaging the physical and virtual communities which surround institutions of higher learning as additional stakeholders for financial support and institutional buy-in.

The Promise of Community-Based Partnerships

Despite the globalization of higher education and growing significance of distance learning, America's colleges and universities are still intimately connected to the communities that surround them. While many institutions recruit nationally and internationally, they also draw students from nearby and their graduates often join the local workforce. Most universities have sought to promote stronger "town-gown" ties in the realm of technology transfer to the local economy. Thus communities that are home to colleges and universities should play important roles in the development of technically skilled workers, whether those workers remain in the local economy or go elsewhere as part of the national talent pool.

Communities can provide a strong foundation for capacity-building partnerships across the nation for three reasons. First, the prosperity of every community in America hinges on the quality of its workforce. Second, all of the major institutional stakeholders in technical workforce development are community-based: pre-K-12 schools, community colleges, teacher's colleges, technical degree-granting institutions and employers of scientists and engineers. Third, many communities have large populations of underrepresented minorities. While these are not the only talent pools that need to be further developed, they are the nation's fastest-growing groups.

Most of the nation's largest communities have populations that are at least 25 percent African American, Hispanic or Native American. Twenty-eight smaller communities fit the same profile. The inherent diversity among U.S. communities is the scaffolding on which higher education can build a more diverse science and engineering workforce.

Conclusions and Recommendations

Higher education will play a determining role in shaping the size and composition of the U.S. science and engineering workforce. The core test will be whether America's colleges and universities make long-term institutional commitments to diversity in fields that have been outliers from broadening participation in American education and society.

There are hopeful signs that the direction of change is positive. One is the growing number of women who head major institutions. Another is the increase of female Ph.D.s in science. A third is the ethic of accountability that has begun to take hold through self-evaluations of gender and ethnic-racial equity.

Nevertheless, several telling indicators suggest higher education is not on a trajectory to meet the challenge of underrepresentation. These include disproportionate attrition of undergraduate students from underrepresented groups from technical majors; insufficient Ph.D. completion rates for persons of color, as well as their dearth in junior faculty positions at the nation's leading research universities; and persistent underrepresentation in tenured faculty positions in the physical sciences and engineering.

By now it is axiomatic that the fragile, soft-money programs relied upon up to now will never be able to deliver results on the scale that is called for. In the face of national economic realities and the financial exigencies besetting every state and, therefore, their institutions of higher education, four conditions will shape the changes BEST advocates:

- More institutions will have to commit to making diversity in science, engineering, and technology a defining priority.
- The leaders of higher education will have to reframe the issue as capacity-building rather than securing competitive advantage.
- Higher education will have to apply its formidable human resources more strategically in community-based science and engineering workforce partnerships.
- Policy, practice and research will have to be more closely aligned to insure that knowledge and resources are used as productively as possible.

Recommendations for Change

Given the conditions that must be met, BEST recommends the following leadership agenda:

- **Federal**. Federal agencies should adopt and enforce criteria taking diversity into account in awarding education and research grants to institutions of higher education.
- **State**. States should focus on the convergence of policy, practice and research within their purview, with particular focus on complementing federal programs, such as Pell Grants, that provide access and opportunity through needs-based financial aid. States have a lead role to play in documenting student progress through the collection and use of disaggregated data. Accountability matters, but it costs. Colleges and universities can afford no new "unfunded mandates."
- **Higher Education**. Drawing on the experience of industry, the "practitioners" of higher education – college presidents, deans and department chairs – should create a community of practice promoting what works in higher education to nurture the talents of women, underrepresented minorities and students with disabilities.
- **A Joint Focus on Effectiveness**. All of the stakeholders in science and engineering higher education should concentrate resources on proven enrichment opportunities that develop the technical talent of students from all groups. Expanding the base of effective programs will require more rigorous evaluation of outcomes, support for cutting-edge research on the issues that surround teaching and learning, and increased participation of underrepresented groups in national research and evaluation efforts.

The United States must develop and sustain a world-class technical and scientific workforce for the 21st century. We will only succeed if we are able to draw upon the strengths of every group in our society. The exemplars identified in this report confirm that we have produced pockets of excellence, but not nearly enough to get the job done. Now the test we face is to translate our knowledge of what works into action on a national scale. It is a challenge that can and must be met to keep our promises to the next generation of Americans.

Chapter 1

Educational Milestones: Keys to the Future

American colleges and universities are the strategic bridge between our foundation-building pre-K-12 system and the world of work, in which knowledge commands an increasing premium.

We are an immensely rich nation, with superb technology, an unmatched system of higher education and bedrock principles of justice and fairness that are the envy of the world. We are better at self-correcting than anybody. — *Andrew Tobias*[1]

In this first decade of the 21st century, the demographic, educational and technological trajectories of the United States have intersected on American college campuses. The majority of the collective student body, like the U.S. population at large, is now comprised of students that are female, African American, Hispanic, Native American and/or disabled.

Meanwhile, the science and engineering workforce on which American postwar prosperity has been built is now rapidly aging into retirement. This workforce, and the university departments that educated them, have been historically white and male. We know now that we need a far broader strategy to develop a new generation of technical talent. Perhaps the single most important test to face our institutions of higher learning will be to meet America's need for world-class talent in science, engineering and technology by developing a talent pool that looks different from that of decades past.

The clock on this task is ticking. That was the telling reminder of the U.S. Supreme Court in its 2003 decision to uphold the principle of affirmative action in college admissions.[2] While making clear that the use of diversity criteria is appropriate — even necessary — in a merit-based educational system, the Court also argued that affirmative action is a means and not an end. Justice Sandra Day O'Connor's majority opinion set 25 years as a target date when considerations of race, ethnicity or gender need not matter in opening the door to higher education.

The Supreme Court's timetable is breathtaking when measured against the demographic forces that are changing the face of America:

- By 2010, women will earn more degrees than men at every level of higher education from associate degrees to doctorates.
- By 2015, the nation's undergraduate population will expand by over 2.6 million students, two million of whom will be students of color.
- Almost half of this 2.6 million increase will occur in California, Texas and Florida, which also will have the highest representation of undergraduates of color. Much of the rest of projected growth will be concentrated in Arizona, Georgia, New Jersey, New York, Virginia and Washington.
- Even with these increases, Hispanic and African American students enrolled in post-secondary education in 2015 will greatly lag their respective shares of the U.S. population.[3]

American higher education will play a pivotal role in meeting these challenges. The nation's colleges and universities are the strategic bridge between a pre-kindergarten-to-12th-grade (pre-K-12) system, whose purpose is to provide foundational skills for all citizens, and a world of work in which knowledge commands an increasing premium. With the advent of learning technologies that have blurred the boundaries separating school, work and home, higher education is now a lifelong pursuit unbound by age or location. Skill acquisition and application is the name of the game throughout one's career.

Until now, U. S. universities relied largely upon the white male segment of the population to be their students in the technology-generating fields of science and engineering. But as the interest of American students in technical fields of study flagged after the mid-1980s, they were replaced in these disciplines by growing numbers of international graduate students. By 2001, 56 percent of the Ph.D. degrees in engineering and 36 percent of the Ph.D. degrees in natural sciences were awarded to foreign-born students.[4] Over time, roughly half of these graduates have remained permanently in the United States.

Looking ahead, our nation's interests require a far more robust and broadly gauged strategy for developing technical talent. Without an approach that reflects new demographic realities, the country will not meet three converging requirements: the replacement need to fill the shoes of current S&E workforce, half of which is at least 40 years old; the structural need for scientists and engineers in promising technology sectors; and the competitive need to keep pace with a surge in production of global science and engineering talent. If higher education does not supply the number and quality of degree holders to meet these needs, employers have an array of options to access them internationally or move operations offshore.[5]

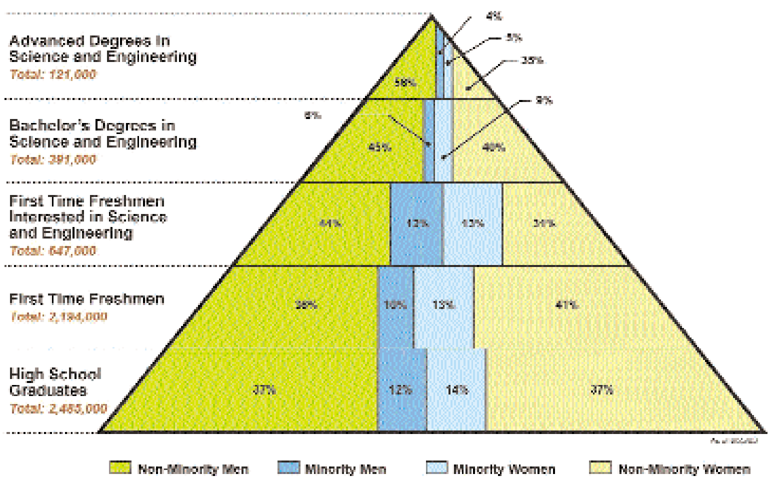
The United States will only meet this challenge if colleges and universities function as a gateway rather than a gatekeeper. The record to date, however, shows how profound a change will be called for. Women, underrepresented minorities and persons with disabilities comprise more than two-thirds of the U.S. workforce, but hold only about one-quarter of the science, engineering and technology jobs that underpin U.S. economic strength.[6] This narrow base has left America with an "underrepresented majority" in the very fields upon which the country's prosperity, security and quality of life hinge.

Figure 1-1

Milestones in Higher Education

Education Milestones by Race/Ethnicity and Gender

(Rounded Numbers)



Source: Joan Burrelli, NSF, based on 1999 Common Core of Data, U.S. Department of Education, National Center for Education Statistics (NCES); NCES, 1998 IPEDS Fall Enrollment Survey; UCLA Higher Education Research Institute,1998 American Freshman Survey (estimate); and NCES, 1998 IPEDS Completions Survey

Clearly, the nation's colleges and universities cannot get the job done alone. The pre-K-12 system, with 110,000 public schools and 53 million public school students, is under intense pressure to "leave no child behind." BEST's complementary report, *What It Takes: Broadening the Pre-K-12 Base in Science, Engineering, and Technology,* focuses on approaches to insure that larger numbers of all students are prepared for and interested in higher education in technical disciplines. At the same time, employers have a responsibility to create a work environment that makes the most of a diverse supply of talent. BEST's complementary report on best practices in the workplace, *The Talent Imperative: Diversifying America's Science and Engineering Workforce*, highlights this dimension of the challenge.

America's colleges and universities add value to the social, civic, economic and intellectual life of the nation. But our system of education often functions unevenly, and we look to our institutions of higher learning both to remedy deficiencies in pre-K-12 education and to open the way to economic and social mobility for all. In other words, what precedes and follows higher education raises society's expectations of what can be accomplished there. We also expect that our colleges and universities will recognize, develop and sort talent along the continuum of science and engineering education. And we trust that when these institutions confer the associate, baccalaureate, master's and doctoral degrees that certify competence in technical fields, that each degree will be both a personal milestone and a national asset.

Research universities carry a particular burden of leadership because, with good reason, they are viewed as the crown jewels of American graduate education. The quality of research and technical talent they produce, the resources they command and the synergies they catalyze make these institutions a unique national resource. They must be at the center of any national effort to build a stronger, more diverse technical workforce.

A pyramid of education "milestones" (Figure 1-1) captures the scope of the challenge. The sorting process in science, engineering and technology reduces the size of the talent pool at each successive phase of education, eliminating African Americans, Hispanics and Native American in disproportionate numbers. The higher up the educational ladder one goes, the more their participation rate declines.

The imbalance is further reflected in degrees attained. In 2000, one-third of all African American, Hispanic or Native American undergraduates earned a bachelor's degree in a technical discipline,

Table 1-1

Persons Employed in S&E Occupations 2001, by Highest Degree Attained

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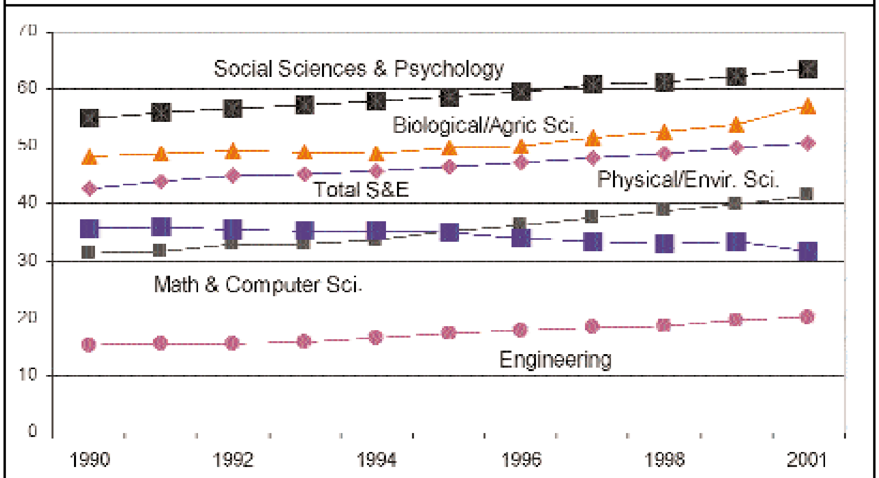
Total	7,287,615	3.8	77.1	7.6	0.4	11.2

Source: Current Population Survey, April 2001

Underrepresentation in the workforce is now an economic issue.

Figure 1-2

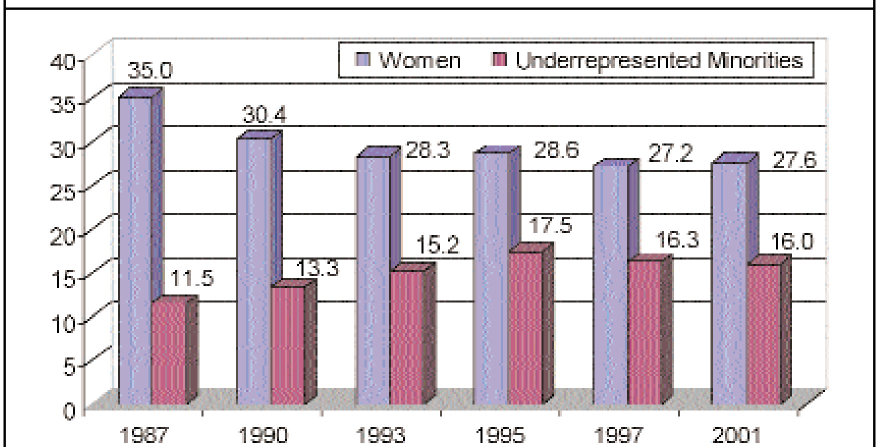
Proportion of Bachelor's Degrees Awarded to Women by Major S&E Fields, 1990-2001



Source: CPST, data derived from National Science Foundation

Figure 1-3

% of Baccalaureates Earned by Women and Underrepresented Minorities in Computer Science, 1987-2001



Note: Percentages for underrepresented minorities include both men and women.

Source: CPST, data derived from National Science Foundation, WebCASPAR

about the same ratio as other racial/ethnic groups (except Asian Americans). This fact would seem encouraging except that, in absolute numbers, these groups together made up only one-fifth of the total number of science and engineering degrees awarded overall. By the time these degree-holders make it to the U.S. technology workforce — even under its broadest definition — the minority groups that make up 25 percent of the population hold 12 percent of the jobs. The cumulative impact of this process on the participation of underrepresented groups is highlighted in Table 1-1.

Participation by gender is more encouraging. Women in the 1990s increased their share at the baccalaureate level in almost every broad technical field (see Figure 1-2). Still, women have opted out of engineering and the physical sciences in droves as evidenced by their choice of majors. The nation graduates 20 percent women in engineering and over 60 percent of the graduates in social sciences and psychology.

Alarmingly, in computer-related occupations projected to grow at three times the rate of all occupations, women's baccalaureate degrees peaked in 1985. Minorities' participation — both in absolute and percentage terms — has inched up slowly.[7] (For a comparison of trends, see Figure 1-3.)

At the doctoral level, the trends are more positive for women than underrepresented minorities. In 2001, women earned almost 37 percent of the Ph.D.s in science and engineering fields. Meanwhile, as a fraction of Ph.D.s granted to U.S. citizens and permanent residents, minorities earned 7.2 percent in the physical sciences and engineering and 7.4 percent in the life sciences. The numbers in specific fields are minuscule: fewer than 20 African American and 20 Hispanic Ph.D.s in mathematics or computer science, and fewer than 100 of each group in all of engineering. A total of 74 Native Americans earned doctorates in science and engineering fields in 2001.

Despite this grim picture, the role of minority-serving institutions in developing talent cannot be overlooked.

Historically Black Colleges and Universities (HBCUs) have been indispensable in educating African Americans who go on to earn a Ph.D. in science or engineering, as illustrated in Table 1-2. Hispanic Serving Institutions (HSIs) play a comparable role for that population as illustrated in Table 1-3.[8] Clearly, traditionally minority-serving institutions join certain research universities as critical sources of future Ph.D.s (see Figure 1-4 for a 10-year comparison).

Taken together, these data point to a structural problem, the chronic underrepresentation that sets technical fields apart. Although many individuals have overcome the odds and demonstrated immense capability, their success has not appreciably changed the field composition or opened up opportunities for others on a scale that reflects the potential talent in the pool.

The forces that have slowed progress are visible at every key transition point along the educational continuum in science, engineering and technology: college admission retention year-to-year, undergraduate degree completion, advanced degree completion and first post-degree job. The milestones that are being missed point to gaps that must be filled if the system is to support a range of needs, choices and students who seek additional education, training and the tools for continuous learning. This is the pivotal test for institutions of higher education. The following milestones thus provide a baseline for understanding both what works and what needs to work to broaden participation.

Undergraduate Education

A formidable array of enablers must converge if a student with an expressed interest in science, mathematics or engineering is to pursue a college major that will prepare him or her for a career in a technical field:

- academic preparation
- motivation

Table 1-2

Top Baccalaureate-Origin Institutions of African American Science and Engineering Doctorate Recipients: 1997-2001

Academic Institution	Number of Doctorates	% of Total
Total of All Academic Institutions	4,367	100.0
Top 51 Institutions[a]	1,325	30.3
Foreign Institutions	981	22.5
Unknown Institutions	253	5.8
HBCUs[b]	628	14.4
Howard University	110	2.5
Spelman College	68	1.6
Hampton University	54	1.2
Morehouse College	48	1.1
North Carolina Agricultural & Tech State Univ.	37	0.8
Southern Univ. A&M College at Baton Rouge	36	0.8
Xavier University of Louisiana	29	0.7
Jackson State University	28	0.6
Florida Agricultural and Mechanical Univ.	23	0.5
Alabama Agricultural and Mechanical Univ.	22	0.5
Clark Atlanta University	21	0.5
North Carolina Central University	21	0.5
Prairie View A&M University	20	0.5
Tougaloo College	19	0.4
Fisk University	18	0.4
Morgan State University	18	0.4
Norfolk State University	15	0.3
Tennessee State University	15	0.3
All Remaining Top 51 Institutions[b]	697	16.0

Source: National Science Foundation, SRS, Survey of Doctorate Recipients, 2001
[a] Each granting at least 14 PhDs
[b] Of the top 51 producing institutions, the HBCUs represent 47.4% (628 Ph.D. graduates) of the total, with other institutions accounting for the remaining 697.

Table 1-3

Top Baccalaureate-Origin Institutions of Hispanic Science and Engineering Doctorate Recipients: 1997-2001

Academic Institution	# of Doctorates	% of Total
Total of All Academic Institutions	5,827	100.0
Top 52 Institutions[a]	1,704	29.2
Foreign Institutions	2,118	36.3
Unknown Institutions	662	11.4
Hispanic Serving Institutions	662	11.4
University of Puerto Rico Rio Piedras	270	4.6
University of Puerto Rico Mayaguez	127	2.2
Florida International University	50	0.9
University of Texas at El Paso	41	0.7
University of Miami	38	0.7
University of New Mexico, All Campuses	36	0.6
California State University, Los Angeles	21	0.4
California State University, Northridge	18	0.3
University of Puerto Rico Cayey U.C.	17	0.3
St. Mary's University	16	0.9
All Remaining Top 52 Institutions[b]	1,042	17.9

Source: National Science Foundation, SRS, Survey of Doctorate Recipients, 2001
a Each granting at least 13 PhDs
b Of the top 52 producing institutions, the HSIs represent 38.8% (662 Ph.D. graduates) of the total, with other institutions accounting for the remaining 1,042.

- family/social encouragement
- role models
- access
- financial support[9]

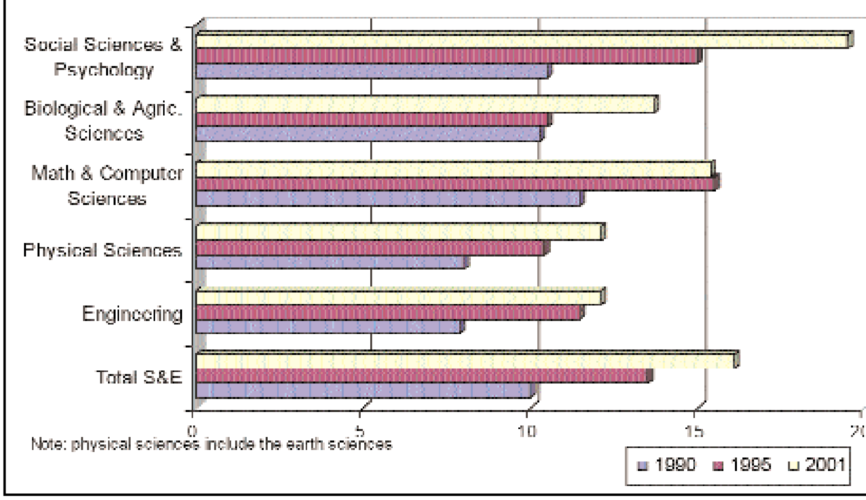
Some of these enablers lie outside the reach of colleges and universities. They are scarcely in a position to equalize learning opportunities in pre-K-12 for low-income students, neutralize negative portrayals of scientists and engineers in the media or dispel the impression that most technical fields are for men only.

But some of these enabling factors do lie squarely within the purview of higher education. The admissions policy for example, poses the first critical test of an institution's commitment to inclusiveness. For example, holistic application review goes well beyond SAT scores, class rank and high school GPA to consider a host of factors, some not easy to quantify, in deciding the composition of the incoming freshman class. In an era of *U.S. News and World Report* ratings, what is often stressed by selective institutions trying to cope with thousands of applications does not translate into opportunities for those lacking the traditional college-going profile. Academic aptitude, however measured, is only part of the equation. Aspiration, perseverance, problem-solving ability and a propensity for teamwork are all valued workplace skills. They may not be so valued in college admissions.[10]

Once matriculated, the student must accommodate to and become

Figure 1-4

Proportion of Bachelor's Degrees Earned by Underrepresented Minorities by Broad Field, Selected Years



Source: CPST, data derived from National Science Foundation

Anticipating the Future

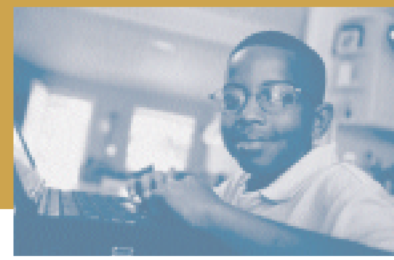
Demographic trends — an analytical summary of population characteristics primarily by age, race, ethnicity, and gender — are like a clouded crystal ball. While we can project the composition of various populations (who they are), we cannot predict with certainty how they will distribute by educational attainment or workforce location (what they do). We can anticipate and, based on historical patterns, act in purposeful ways to influence choices and outcomes. In a significant way, education structures this process of opportunity to prepare and guide students' decisions. Key trends include:

America's changing demography. Notably, Hispanics/Latinos are the largest minority group in the U.S., about one in eight Americans totaling 35 million or 13 percent of the nation's population.[11] Within this aggregation there is diversity by country of origin: about 59 percent Mexican, almost 10 percent Puerto Rican, five percent Central American, four percent South American, three and a half percent Cuban, and almost 20 percent other (including people from the Spanish-speaking Caribbean). By 2050, Hispanics will represent one in four Americans.

A generation to develop. Members of "Generation Next" — born 1980-2000 totaling almost 70 million, weaned on high-tech gadgetry and fast pace — are of keen interest. This is America's future to shape, socialize and utilize. At the same time, the definition of talent (skills, competencies), its identification, cultivation, review and accountability for various aspects of the process will become commonplace.

Evolving occupations. Futurists consult that cloudy crystal ball and dare to share what they see as emerging careers. The overwhelming majority are science and technology-based, including web cataloger, fiber optic technician, fuel cell engineer, water quality specialist, virtual set designer, data mapper, tissue engineer, technology recycler and bioinformaticist.[12] Regardless of the new job titles that join and replace the current roster, employers will intensify their search for and development of talent. This is a process that begins long before the dance of recruitment and hiring. Organizational investment in this process, both to sharpen the recognition and recruitment of talent and to refine its development post-hiring, is expected to rise.[13]

What makes a worker attractive to one employer is likely to foster transience through mobility. "Job scanners" are alert to prospects while not actively seeking new employment. They are in the workforce and are potentially future organizational leaders. It is just unclear which organizations they will lead. Anticipating the future demands organizational attention to changing worker orientations, styles and conceptions of "career."



integrated into a new learning environment. Without such integration, the likelihood of progression through stages of the undergraduate career is impaired. Clearly, a universe as far-flung and yet as specialized as higher education — 3,500 institutions, public and private, large and small, research and liberal arts, majority and minority-serving, two-year and four-year — produces many kinds of learning environments.

The institutional test is to create a learning environment in technical disciplines that can work for all students. We already know some of the ingredients. Among them: orientation programs that instill cultural sensitivity and intellectual rigor; early warning systems for identifying students experiencing academic difficulties; course and career counseling; administrative monitoring of retention and performance indicators. In addition, study groups, peer

Who is the "Underrepresented Majority"?

The so-called "underrepresented" groups in this report are actually the majority in American college classrooms and the workforce. Women alone make up the the majority of students on college campuses and almost half the total workforce. Add to that the roughly 20% of Americans with disabilities and the African Americans, Hispanics and Native Americans that make up 25% of our population. The demographic groups which define this "new majority" in population and workforce terms are those most underrepresented in the critical fields of science, engineering, and technology. And the imbalance will continue.

The 2000 U. S. Census illustrates these demographic inevitabilities.[14] In 1980, white non-Hispanics represented 83.1 percent of the U.S. population; by 1990, 80.3 percent; and by 2000, 69.1 percent. In contrast, the Hispanic population (which includes all races) increased from 6.4 percent of the U.S. population in 1980 to 12.5 percent in 2000, as shown in Figure 1-5.

Growth in America's minorities was explosive in the last decade of the 20th century — in percentage terms, 58 percent Hispanic, 53 percent Asian, 16 percent African American and 15 percent Native American.[15] The white population grew by slightly over three percent during the same period.

By 2010, the American population will be one-third "minority" (Hispanic/Latino, African American, Native American, Asian). By 2050, today's minorities will number one-half the U. S. population. In some regions this shift has already occurred; minorities in the aggregate are now the majority of the population.

What is often referred to as the "pre-K-12 talent pool" reflects other diversities as well. Today's 54 million children are educated primarily in public schools (47 million), with private or religious schools (six million) and homeschooling (one million) accounting for the rest. Public schools are increasingly multicultural, multilingual sites, making the classroom learning environment, class size and school resources (teacher preparation/skills, technology/connection to out-of-school content) key variables in how well students are equipped for higher education and the workplace.

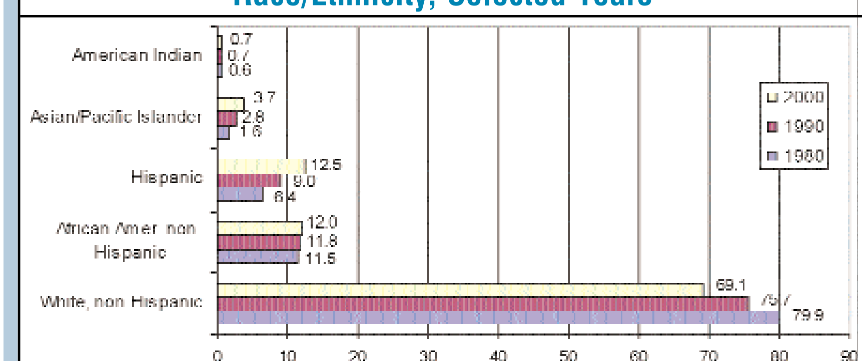
Inheriting the human resources produced by pre-K-12 education are 3,500 U.S. higher education institutions whose enrollments are projected to increase 15 percent between 2000 and 2012.[16] High school graduates will increase by nine percent, associate degrees 18 percent, bachelor's degrees 16 percent (20 percent increase among women), master's degrees by 10 percent and doctoral degrees four percent. The minority "share" among these increases, as well as their distribution across disciplines, remains indeterminate.

Today, students from underrepresented minority groups are less likely than whites and Asians to graduate from high school, enroll or graduate from college. But among those who do enroll in or graduate from college, they are about as likely to choose science and engineering fields. Women are more likely than men to graduate from high school, enroll in or graduate from college, but are less likely to choose science and engineering.

While total enrollment in U.S. higher education has continued upward, graduate enrollment in science and engineering programs, which grew for almost 20 years to peak at almost 436,000 students in 1993, declined over the next five years to nearly 405,000 in 1998. It has since rebounded but remains below the 1993 total.[17]

The very population groups which comprise the deepest pool of potential technical talent for the United States are those most overlooked in the history of American higher education.

Figure 1-5
Proportion of U.S. Population by Race/Ethnicity, Selected Years



Source: U.S. Census Bureau, Current Population Reports, P 25 1095 and Census 2000


tutoring, "gatekeeper" courses that reduce size, impersonality and a dependence on textbook learning are keys to perseverance in these majors.

In short, the question is whether institutions of higher education are willing or able to recognize the distinctive expectations, learning styles and needs that shape the academic performance of students from underrepresented groups. The underlying differences between minority and non-minority students, for example, can be sharp. For example, whereas non-minority students tend to blame others (i.e., faculty, departments, institutions) if they encounter problems, minority students tend to blame themselves for their difficulties. An awareness of these fundamental realities is particularly essential in math and science teaching.

The overarching issue, according to many, is the faculty reward structure. Do universities value undergraduate teaching, mentoring and service relative to research productivity in promotion and tenure decisions? Is faculty willing or even equipped to educate a student body that is more minority, more economically disadvantaged, less academically prepared and more likely to be the first in their family to attend college? Can colleges and universities sustain a learning environment that both honors excellence and instills tolerance for difference in those who attend and graduate from them?[18]

Graduate Training

Graduate education in science and engineering reflects a European model of apprenticeship. Fellowships, traineeships and assistantships tether student support to an individual faculty member, program or department. Students apply to highly specialized departments or programs, which retain decision-making authority well beyond any institutional requirements. Often students aspire to join a particular lab or work with a particular professor. Their graduate experience becomes centered in a research team, which consists of faculty, postdoctoral researchers and other graduate students. This becomes the site of accountability for student performance more so than the parent department, graduate school or the wider institution. In return, the student acquires knowledge and often an orientation to pursue research, typically in the academic sector.

The institutional test of graduate education for underrepresented minorities, then, should be one of attracting and then preventing students deemed capable from falling through the cracks. For students of color, the risk of isolation alone is high when one-on-one relationships with faculty count for so much and there is so little faculty diversity. But abundant evidence suggests that minorities and women are not encouraged even to consider graduate school and do not fare as well as their non-minority counterparts in securing funding for financing study for advanced degrees.

In addition, the infusion of foreign-born graduate students in graduate school has redefined the context of diversity. The potential for pressure — intellectual conflict and stylistic clashes, not to mention sexism and language barriers (for non-native English speakers) — is not uncommon in these enclaves. Student difficul-

Community Colleges Play an Increasingly Critical Role

The fastest-growing segment in higher education is two-year and community colleges. As access to higher education is a matter of cost and preparation, community colleges have become full-service providers for those seeking to reduce academic deficiencies, acquire new occupational skills and enter either the workforce or a four-year college or university. Community colleges today reflect the following characteristics:

1. More than 10 million students are enrolled in the approximately 1,200 community and technical colleges in the United States. These colleges award almost a half-million associate's degrees and nearly 200,000 certificates each year.[19] Of all associate degrees, 13 percent are awarded in science and engineering, overwhelmingly in either computer science or engineering technologies.[20]
2. Higher percentages of Hispanic and Native American undergraduates attend two-year colleges than members of other racial/ethnic groups: 56 percent of Hispanic and 50 percent of American Indian undergraduate students are enrolled in two-year colleges, compared with 41 percent of black students, 39 percent of Asian students and 36 percent of white students in 1999.[21]
3. Hispanic-Serving Institutions and Tribal Colleges are primarily two-year institutions. Just over half of Hispanic-Serving Institutions (53 percent) are two-year institutions of higher education.[22] Of the 34 Tribal Colleges or universities in the United States, the majority offer primarily two-year certificates and degrees; only six offer four-year degrees.
4. About 22 percent of those postsecondary students who entered a public two-year institution in 1989-90 transferred to a four-year institution within the next five years. Of the 1995 and 1996 science and engineering baccalaureate degree recipients, 13 percent had previously earned associate's degrees. [23]
5. Slightly less than 10 percent of 1996-2000 U.S. citizen doctorate recipients in science and engineering previously had attended two-year colleges. Native American and Hispanic (particularly Mexican American) doctorate recipients were more likely than doctorate recipients of other racial/ethnic groups to have previously attended two-year colleges (18 percent of Mexican American and 17 percent of Native American, compared with five percent of Asian, eight percent of Black and nine percent of white science and engineering doctorate recipients).[24]

A new study underscores the centrality of community colleges in the higher education world.[25] States that set clear goals and have stronger centralized higher-education governance structures tend to have better success with transferring students from two- to four-year institutions. Some states actually discourage four-year institutions from accepting transfer students by partially tying their state financial support to the number of students who graduate within five years. Greater incentives to transfer are needed, such as scholarships or other tuition assistance.

ties may remain unknown to those outside this research circle. And the consequences — delay in progress toward the degree and attrition from the program — can be devastating.

Clearly, a graduate degree opens doors to a breadth of organizations, roles and responsibilities not contemplated even a generation ago. Leaders emerge from these ranks, catapulted by accomplishments affirmed by professional peers. Still, the challenge of diversifying the university faculty, the national laboratories, and the corporate R&D structure looms large.

Passing the Institutional Tests

Until now, too few institutions have shown either the vision or the capacity to undertake the changes needed to make higher education in science, engineering and technology a gateway to all who are capable. Although thousands of faculty and students, minority and nonminority alike, have met the challenge, their achievements are more personal than institutional.[26]

It will take more than a few faculty mentors in a few academic departments to develop the expanding pool of talent among women and minority students. All institutions of higher learning can become "minority-serving," whether that has been their historical mission, or if they are among the most research-intensive, comprehensive or selective of their undergraduates. How successfully this transition occurs is the first test of American higher education in the 21st century.

There are guideposts to point the way. The purpose of this report is to identify some efforts which appear to be working in higher education to bring more underrepresented minorities, students with disabilities and women into the technical workforce, to understand the basic principles that underlie their success and to propose a model for a community-based national strategy to increase the contribution higher education can make to a stronger, more diverse American technical talent pool. The next chapter begins this exploration.

Professional Societies — Key Link in the Workforce Chain

As symbols of achievement and leadership, scientific and professional societies can play a major role in expanding opportunities for women and minorities in the science and engineering workforce. Through their basic activities, they ensure that women and minority scientists share in the professional rewards of their discipline and are given prominence as role models. Recognition by one's peers is a major source of satisfaction and often key to career advancement. These opportunities are primarily offered by professional societies. Most societies hold meetings, bestow prizes and awards, elect fellows and involve their members in society governance.

For example, giving an invited talk at a national meeting is an important sign of being a recognized expert in a field, yet women and minorities have often been overlooked. Professional societies can help correct this by appointing or electing balanced program committees. Similarly, selection committees for prizes and awards and for nominations for fellowship need to be diverse in composition and encouraged to seek nominations from the broadest candidate pool. Selection for editorial boards or key governance committees within professional societies not only rewards one's contributions, but also provides unique opportunities to work with a broad range of colleagues, thereby enlarging one's vision of the field and network of professional friends. Including women and minorities in all these professional opportunities gives them visibility and enhances their service as role models for future scientists.

Most professional societies have educational programs aimed at their members or students who may become their future members. Working to increase diversity should be an explicit part of whatever type of educational program is offered. Many societies have special committees dedicated to increasing the number of women and minorities. But just as professional societies can help increase the diversity within a field, so can they retard it. If the honors and recognitions they confer are narrowly distributed by and to members of an "old-boys club," the careers of women and minorities will be hindered in many ways. The field will look less attractive to the next generation, recruitment will suffer and the field will lose talent.

In recognition that one can't start too early in providing a taste of science, for example, the American Chemical Society (ACS) launched in 1995 a 10-year program to introduce minority undergraduates to the chemical science profession. Featuring scholarships, internships, mentoring and research opportunities, the program to date has awarded over 1,200 scholarships, with an average of 350 students supported each year. With a retention rate of over 80 percent, a majority of graduates have entered graduate school or the chemical science workforce. The association maintains a longitudinal database of career opportunities and makes networking opportunities a priority for members. In 2001, the ACS Scholars Program received the Presidential Award for Excellence in Mathematics, Engineering and Science Mentoring.

CHAPTER 1 ENDNOTES

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2. Schmidt, P. (2003, July 4). Affirmative action survives, and so does the debate, special report: the Michigan rulings. *The Chronicle of Higher Education.*

3. Swail, W. S. (2002, July/August). Higher Education and the New Demographics: Questions for Policy Change, pp. 15-23.

4. Guzman-Barron, I., S. Brown, B. L. Dugoni, T. B. Hoffer, A. R. Sanderson, S. Sederstrom and V. Welch, (2002). *Doctorate Recipients from United States Universities: Summary Report 2001*. Chicago, IL: National Science Foundation, National Institutes of Health, U.S. Department of Education, National Endowment for the Humanities, U.S. Department of Agriculture, National Aeronautics and Space Administration and NORC at the University of Chicago. The growing capacity for graduate education, especially in China, India, Australia and the former Soviet Union, is likely to attract fewer foreign students to the U.S. National Center for Education Statistics, Higher Education General Information Survey.

5. National Science Foundation, National Science Board. (2002, January). *Science and Engineering Indicators 2002* (NSB-02-1). (pp. 2-1-46). Arlington, VA.

6. National Science Foundation. (2002). *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2002*. Washington, DC.

7. An even less visible minority are disabled students and graduates. The U.S. Census Bureau reports in 2000 that one in six males (numbering over five million) and one in eight females (over four million) in the civilian population ages 18-34 is known to be disabled. No data by field of study are available, but a total of 1.3 million are enrolled in college or graduate school, and almost half attend community colleges. Over 600,000 have earned a baccalaureate and 2.3 million hold a graduate or professional degree. As colleges and universities build or renovate campus buildings, universally designed facilities and assistive technology will create better access to laboratories and libraries as well as public places and restrooms. Those with a physical disability form an educated cadre of citizens who represent a reservoir of talent not adequately tapped in S&E. See Stern V. and S. Malcom. (2002). *Persons with Disabilities in Science and Engineering: Barriers and Solutions; Setbacks and Successes*. Building Engineering & Science Talent: San Diego, CA.

8. The U.S. Department of Education defines HSIs as having at least 25 percent Hispanic FTE enrollment with at least half of those enrollees low-income students.

9. Chubin, D. E. and G. S. May. A retrospective on undergraduate engineering success for underrepresented minority students. *Journal of Engineering Education*, 92, 1-13.

10. Aside from affirmative action, a striking example of gender-related inclusiveness was Carnegie Mellon University's decision to waive the requirement of advanced placement calculus; it was eliminating virtually all girls from computer science. Post-admission enrichment provided for those who needed it had the desired effect. Likewise, MIT years ago quietly began to add 50 points to the math SAT scores of women who applied for admission and found that their performance at the end of the freshman year was comparable to that of men. These are local adjustments that level the playing field – and benefit all.

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22. Hispanic Association of Colleges and Universities.

23. National Center for Education Statistics. (1998). *The Condition of Education 1998*. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement. National Science Foundation, Division of Science Resources and Statistics. (1997). *National Survey of Recent College Graduates*. Arlington, VA.

24. National Science Foundation, Division of Science Resources & Statistics. (2001). *Survey of Earned Doctorates*. Arlington, VA.

25. Wellman, J. V. (2002, August). *State Policy and Community College-Baccalaureate Transfer*. San Jose, CA: National Center for Public Policy and Higher Education and the Institute for Higher Education Policy.

26. Longitudinal evidence is contained in Bowen W. G. and D. Bok. (2000). *The Shape of the River: Long Term Consequences of Considering Race in College and University. Admissions, 2nd Ed*. Princeton: Princeton U. Press. One gauge of the conviction of defending race-conscious admissions policies is the more than 60 "friend of the court" Supreme Court briefs filed in support of the University of Michigan. Among the 300-plus organizations represented, besides colleges and higher education associations, are "nearly 70 Fortune 500 companies, 29 former top-ranking officers and civilian leaders of the military, 22 states' attorneys general, and more than 110 members of Congress." See Schmidt P. (2003, February 28). Hundreds of groups back University of Michigan on affirmative action. *The Chronicle of Higher Education*.

Chapter 2

Gateways that Work: A Guide to Design Principles

BEST implemented a systematic process to find a group of university-based programs that have been documented, sustained and recognized for deepening and diversifying the nation's technical talent pool.

More than ever before, in the "new economy" research and innovation will need to be housed in those places where there are parallel agendas and multiple means of support. Universities can fit this profile because their other "product line," besides research, is people. - Nicholas Negroponte, MIT[1]

American institutions, regardless of industry, sector or size, have become increasingly performance-based. Examples range from the workforce-focused Malcolm Baldrige National Quality Awards to the school-based expectations contained in the No Child Left Behind Act. The "best practices" aspect of the movement has fueled a wide-ranging search for excellence in organizational performance. Evaluators using relevant criteria identify what the leaders in the field are doing that make them leaders, be it increasing productivity, adopting family-friendly workplace policies or implementing innovation in customer service.

This chapter presents the findings of the BEST Blue Ribbon Panel on Higher Education in its search for "best practices," a representative group of university-based programs that have been documented, sustained and recognized for deepening and diversifying the nation's technical talent pool.

An Approach to Identifying Best-in-Class

The expert panel assembled by BEST approached the task of identifying exemplary practices comprehensively. First, this panel consulted the research literature on science, technology, engineering and technology (STEM) evaluation to develop the criteria that define "best-in-class." Second, the panel examined a series of clearinghouse reports on the performance of federal STEM programs, including the Carnegie Commission on Science, Technology and Government, and the Federal Coordinating Council for Science, Engineering and Technology/Committee on Education and Human Resources.[2] Third, the panel reviewed major national awards honoring individuals and programs for achievement in science and engineering diversity (see Appendix A). Although these awards are generally based more on professional judgment than documented outcomes, they have great symbolic and functional significance. Finally, the panel studied the testimony and program recommendations of the Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development.

This systematic process produced a pool of 124 nominated programs whose characteristics were sorted according to a simple typology:

• Educational stage	undergraduate, graduate, faculty, high school-college bridge
• Focus group	women, minorities, particular minority group, persons with disabilities, all
• Campus scope	single, multiple, statewide, regional, national (including inter-institutional alliances or consortia), or type (e.g., minority-serving or two-year institution)
• Focus discipline	STEM, life sciences, engineering, other single discipline, all

Typically, the programs were single university-based, STEM-focused, women- or minority-targeted. A modest number, however, were distinguished by each of the following characteristics: dedicated to students with disabilities (5), based at a minority-serving institution (e.g., Historically Black College and University) (5) or a community college (2), sponsored and/or operated by a federal research and development agency (6), or designed as a statewide effort (2).

The panel invited all nominated programs to complete a Program Profile covering goals, impact, growth, sustainability and evidence of effectiveness (see Appendix B). From these nominations and submissions, 55 contacts were made to update and clarify evidence of activity and effects on the focus population. With this additional information in hand, a total of 36 programs (not studies, databases, or meta-analyses) were rated by a subset of the BEST Higher Education Blue Ribbon Panel in January 2003.

The chief finding from the inventory of 124 programs reviewed, including the vast majority of the finalists, was an absence of documentation on program outcomes. Often program developers admitted that nothing more than students involved in the intervention had been enumerated. Even those with long (i.e., 10-year-plus) histories tended to lack fundamental longitudinal impact data, e.g., academic gains sustained or immediate post-graduation aspirations realized.

Nor did many programs respond to BEST's invitation to augment what had been written about them in reports or the education literature. Thus, despite escalating pressure from government, corporate and foundation sponsors, the truism of intervention programs was confirmed: scarce resources are devoted to the inter-

vention rather than to documenting participants, processes and outcomes.[3] Without an evaluation component designed into an intervention, it is unlikely that the reach and texture of the program will ever be measured (except perhaps through oral history of founders and other principals). In the end, programs that had monitored their participants and tried to evaluate outcomes over time were favored in the BEST panel review process.

The BEST subpanel also consciously chose to focus on programs rather than policies or research that seek to increase the participation of underrepresented groups. Of course, the panel recognized that best practice extends to these arenas as well as to specific programs. Likewise, education policies are discussed in Chapters 3 and 4, including recommendations that span all categories of intervention.

Table 2-1

BEST Evaluation Criteria for Assessing Education Programs/Practices

Questions/Criteria	Exemplary – actionable now	Promising	Not ready to adapt/scale
1. Were expected outcomes defined before program launch?	Yes	Soon after	Sort of/vague
2. Are outcome data attributable to the program intervention?	Far exceeded original expectations	Exceeded original expectations	Failed to meet expectations
3. Does it demonstrate excellence, which requires equity? – i.e., did it increase the diversity of the target population?	Chief outcome achieved and documented (positive trend)	Chief outcome implied (no monotonic trend)	Equity at core of program design, not an add-on
4. What was the value-add of the experience to the target population?	Related outcomes that move treatment group to next competitive level	Majority (but not most) of individuals in treatment population enhanced	Gains for some individuals that can be attributed to treatment
5. Is there evidence of adaptation/ institutionalization, i.e., multiple sites?	Explicit scale-up strategy w/evidence	Attempt to implement strategy and evaluate	Confined to a single site
6. Is there evidence of effectiveness with a population different from that originally targeted?	Planned and executed	Planned	Serendipitous
7. How long has it been in place?	Self-sustaining (10+ years)	Majority soft money (3-10 years)	New (<3 years)
8.Were there unexpected consequences?	Positive in intensity or extent (and measured)	Identification of possible/probable consequences	Evidence for systematic rather than random effect

Source: BEST Blue Ribbon Panel on Higher Education, 2002

A Program Evaluation Template

Identifying what is "promising," and why, is an interim step toward declaring "exemplary" practices. Recommending them for emulation and funding are prerequisites for scaling up programs that work and spreading them to new sites and populations.[4] Following a recent compendium notable for rigorous review of claims and measurable impacts of programs, BEST developed a template of evaluation criteria. These criteria, described and illustrated in Table 2-1, were used to assess the soundness of programs and practices that foster achievement of educational milestones.[5]

With the template, the panel sought to cull out mature programs from the universe of nominees and to distill the causes of program effectiveness. To do so required attention to important contextual issues, namely, what works under what circumstances, why, and for whom? This is tantamount to a sorting of higher education practice. Ratings of the eight criteria were not weighted equally. Questions 1 through 3 required "exemplary" ratings and, overall, five of the eight were taken as a subpanelist's evaluation of program effectiveness. These ratings were then summed across all members of the subpanel.[6]

Exemplary Programs

Exemplary programs all shared the following characteristics: convincing evidence over time that the expected outcomes, documented for at least a decade, were attributable to the intervention; excellence and equity in participation were achieved simultaneously and by design; the treatment group in the aggregate was better prepared for subsequent success in the pursuit of STEM careers; the intervention had indeed been institutionalized at its source and begun to be adapted in other sites; and the program was well-planned and executed so that its success was beyond a doubt and beyond the expectations of the program developers and leaders.

Seven programs were rated as exemplary on at least six of the eight criteria (Table 2-2). They represent an empirically defensible short list of programs that are profiled in the accompanying sidebars. The program profiles of those judged exemplary are arranged by educational milestone. The reviewers sought to accumulate lessons learned over time from the community of STEM interventions.

Programs Geared Towards Achieving the Undergraduate Degree Milestone

Three programs are exemplary in this category. One targets women on a research university campus, one focuses on engineering in a coalition of public and private institutions located predominantly in the northeastern U.S., and one supports minorities (and now students regardless of race or ethnicity) in a public university which has itself been transformed through the success of the program. All three underscore a common set of institutional commitments from the leadership and the faculty in the trenches that value diversity and the education of all students.

Another common element is the effort to address the needs of the "whole student," which is accomplished through a residential experience or ongoing informal but intense peer study groups. These interactions form a web of support, locally and inter-institutionally, that develop a sense of community. It is this sense of belonging that facilitates coursework performance, the free exchange of ideas and the seeking of information without fear of reprisal or stigma, and a sense that the campus is dedicated to students' academic success. Such interventions counter stereotypes about why students are underrepresented in STEM fields, and shift the responsibility to institutions and faculty members. It is their role to raise expectations and help students fulfill their capabilities. In the process, these programs have developed their own capability to offer such support as the only way to do business.

Table 2-2
BEST Exemplary Higher Education Programs, by Milestone

Undergraduate:	University of Michigan Women in Science and Engineering Residence Program (WISE-RP)
	Gateway Engineering Education Coalition
	University of Maryland, Baltimore County (UMBC) Meyerhoff Scholars Program
Graduate:	National Consortium for Graduate Degrees for Minorities in Science & Engineering (GEM)
Faculty:	Compact for Faculty Diversity
	Preparing Future Faculty (PFF)
Statewide Discipline-Focused:	Partnership for Minority Advancement in the Biomolecular Sciences (PMABS)

Source: BEST Blue Ribbon Panel on Higher Education, 2003

Programs Geared Towards Achieving the Graduate Degree Milestone

The sole exemplary graduate-focused program has supported minority master's and Ph.D. students for over a quarter-century. This national fellowship program addresses a key ingredient in the pathway to science and engineering careers — funding. GEM's selection is a reminder that the need for financial support is a constant, and is often the difference between pursuing a graduate degree and entering the workforce with a baccalaureate degree. GEM identifies qualified students, and provides a bridge from universities to corporate employers. Its contribution, which amounts to connecting students to resources, is literally life-changing.

Programs Geared Toward Achieving the Faculty Milestone

Two programs — one the consolidation of three regional higher education organization partnerships, the other an institution-level consortium — have been exemplary in transitioning women and minority Ph.D.s to college and university faculty positions. Without diversifying the faculty, especially in tenure-track positions, the demographic opportunities presented by the student populations will fail to translate into role models, mentors and leaders who look like America.

Both of these programs are collaborations that afford institutional and interpersonal support that is campus-wide and eclectic. They embody systemic change in informing, preparing and developing faculty as versatile professionals embarking on academic careers that will influence students who follow. Identifying leading departments in this effort and providing a network of local and national support are demonstrable strategies for expanding the faculty pool, especially in science and engineering.

Programs Geared Towards Achieving Multiple Milestones through an Integrated Statewide Program

A unique comprehensive program operating in North Carolina for over a dozen years attests to

the power of collaboration focused on one broad field — life sciences — and the pathway from precollege preparation to graduate school. Partnership for Minority Advancement in the Biomolecular Sciences (PMABS) illuminates these pathways through joint ownership of the constituent activities, shared resources, and the commitment of institutions, administrators and faculty. It may take a "village" of institutions forming a consortium devoted to a well-specified set of research-oriented, process-centered goals to help students achieve the milestones of degrees, choices and careers. The seamlessness — both of design and impact — of PMABS bears close scrutiny as an exemplary practice.

Promising Programs

The BEST Blue Ribbon Panel also identified a set of programs that, while not exemplary on most of the eight dimensions, exhibit ingredients of effectiveness that show promise in increasing student preparation, participation and professional development (Table 2-3). Therefore, they yield lessons for future planning and action. Some of these programs are young, some lack compelling outcome data, and some have been victimized by the political culture and policy shifts that have swept their states and hamstrung their efforts to institutionalize, scale up and disseminate the interventions. Following are thumbnail sketches of programs we consider the most promising for adaptation and further evaluation in new sites.

Three programs can be singled out — one a precollege, Latino-focused program; one for undergraduate women in engineering; and one a precollege-through-professional women's program. Notably, two of these have residential components and peer support as core features. The other is a skills-development bridge program that has been adapted in various urban communities.

Promising Minority Programs Impacted by State Policies

Since the mid-1990s, the climate of opportunity for students of color has deteriorated as state legislatures, voters and the judiciary have limited, and in some cases eliminated, the use of targeted admissions and financial aid tools. One result has been to add pressure and further slow the progress of those students whose participation in STEM majors and careers has lagged the male majority and foreign national populations.

Despite these limitations, two programs of exceptional promise located in the legally constrained states of Texas and California merit consideration. One is an undergraduate, multi-institutional program that participates as a member of the National Science Foundation Louis Stokes Alliances for Minority Participation. The other is a K-20 engineering program founded at UCLA, which is emblematic of the range of university-hosted precollege bridge and outreach programs that work, often in collaboration with pre-K-12 school districts, to develop the full diversity of student talent.

The lessons of these programs are many, including the use of institution-wide reforms and inter-institutional partnerships that serve all students, even though their original purpose was targeted to those of greatest academic and financial disadvantage. The conversion of a program into a mainstream educational experience is, in principle, desirable. In practice, what was targeted to the needs of some may help all but at the risk of losing its focus on those students who will not achieve to the next level without the benefit of the intervention. This is not a palatable tradeoff. Yet it is the climate in which some educators and those committed to the milestones of academic and career achievement must prevail.

It will be difficult to redefine excellence to be inclusive and supportive of all, while recognizing the individual differences with which students negotiate academic cultures. But if more institutions and faculty were to take up the cause of mainstreaming participation, then students of color and women would not continue to be marginalized in science and engineering. American higher education and U.S. industry would enjoy the benefits of a broader, deeper pool of talent, ranging from potential degree recipients to the cadre of disciplinary faculty who advise, mentor and model professional excellence for those who come after them.

Table 2-3
BEST Promising Education Programs, by Milestone

Admission	Center for the Advancement of Hispanics in Science and Engineering Education (CAH SEE) Science, Technology, Engineering, and Mathematics (STEM) Institute
Undergraduate Degree Completion	Texas A&M Clusters of Resident Engineering Women (CREW)
	Texas Louis Stokes Alliance for Minority Participation (TX LSAMP)
Multiple - Admissions Through Advanced Degree Completion	Stevens Institute of Technology Lore-El Center for Women in Engineering and Science
	UCLA Center for Excellence in Engineering and Diversity (CEED)

Design Principles That Link Programs and Milestones

Looking across the exemplary and promising programs highlighted above, this chapter has sought to use existing programs with a history of experimentation and outcomes as building blocks, or "design principles," of new research and experience-based programs. By specifying key criteria of success and assembling them

as design principles, BEST hopes to guide program developers, sponsors, researchers and policymakers toward future investments and the character of interventions.

BEST's examination of the Meyerhoff Scholars Program of the University of Maryland, Baltimore County, exemplifies the process of first extracting the design principles of a successful program, then understanding its lessons. Paramount in this case was the institution's commitment to supporting talented minority students. This factor reflects the convictions of the program's founder, who has also been the university's president for most of the program's history. Thus several lessons are ours to behold: Leadership matters. Transforming a campus culture is possible. Evaluating the journey as it unfolds (with data) adds value for all. The proof is that the Meyerhoff Scholars Program has raised the profile and performance of the University of Maryland, Baltimore County. The challenge is to convert such specific ingredients into recipes that others can reproduce, adding their own ingredients in whatever measure is appropriate.[7]

The following eight principles (previously summarized on page five) represent a distillation of shared features among the exemplary and promising programs that BEST has identified (for a more detailed reference guide to the programs cited below, see Appendix C). They are principles that future higher education program exemplars should incorporate as essential ingredients in their recipes for producing talent of all colors for science and engineering:

Institutional leadership. The climate of inclusiveness in which exemplary programs grow requires institutional leadership that supports broad commitment. Such commitment, encompassing the administration and senior faculty, ensures that the values, goals and pathways toward increased participation are central to the campus as a community. If efforts take root in only certain pockets within the university, they lose potency as deeds that reinforce what should be widely shared and articulated. For example, the president of the University of Maryland, Baltimore County, expanded the vision of the Meyerhoff Program — which initially focused on financial support for African American males — into a comprehensive research-oriented institution for all students.

Targeted recruitment. Certain programs identify and attract the best available students and faculty from underrepresented groups. Establishing, sustaining and improving a feeder system — pre-K-12, undergraduate and graduate — demands an extra measure of institutional investment, extraordinary networking across communities and active participation by program graduates. For example, GEM serves as a kind of talent scout, information clearinghouse and matchmaker in connecting talented minority bache-

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The Vanguard Learning Colleges http://www.league.org/league/projects/lcp/vanguard.htm

Workshop for New Physics Faculty http://www.aapt.org

lor's degree recipients in science and engineering with graduate program opportunities, including the financial support students often assume is unavailable.

Engaged faculty. Tenured and non-tenured faculty in some programs view student outcomes as critical measures of their performance and they are rewarded accordingly. While research productivity and service still matter, these traditional performance indicators do not substitute for the ongoing commitment to developing student talent. Preparing Future Faculty (PFF) takes this commitment as the cornerstone of professional development and essential for fulfilling the faculty role, in contrast to the "research vs. teaching-learning" tradeoff dominating many institutions.

Personal attention. Exemplary and many promising programs meet the individual learning needs of students. The starting point is the classroom, but mentoring is an integral part of the educational experience and tutoring is available as needed. The value of personal attention remains high at every stage of higher education. Residential programs such as WISE-RP and Lore-El build faculty-student interaction,

National Recognition Awards for Individual and Institutional/Program Accomplishments

Recognition Awards for Individuals

NSF Presidential Awards for Excellence in Science, Mathematics, and Engineering Mentoring

To recognize mentoring efforts which enhance the participation of underrepresented groups in science, mathematics and engineering at pre-K-12 through the graduate level. Up to 10 individuals are honored annually. Recipients receive a $10,000 grant.

NAE Bernard M. Gordon Prize for Innovation in Engineering and Technology Education

Inaugurated in 2001, the Gordon Prize is intended to encourage the improvement of engineering and technology education relevant to the practice of engineering, maintenance of a strong and diverse engineering workforce, encouragement of innovation and inventiveness, and promotion of technology development. Awarded biennially, the Gordon Prize carries a cash award of $500,000 that is split 50-50 between recipient and recipient's institution.

AAAS Mentor Awards and Lifetime Mentor Awards

To honor individuals who during their careers demonstrate extraordinary leadership to increase the participation of underrepresented groups in science and engineering fields and careers. The Mentor Award recognizes individuals who have served the role of mentor for less than 10 years. The award includes a monetary prize of $2,500. The Lifetime Mentor Award recognizes individuals who have served the role of mentor for more than 10 years. It includes a monetary prize of $5,000.

QEM Giants in Science Awards

To honor individuals who are outstanding mentors, teachers and researchers, as well as strong advocates of quality MSE education for all students. Each has a special interest and commitment to students underserved by our educational system.

Sloan Minority Ph.D. Program

To increase the number of underrepresented minority students (African Americans, Hispanic Americans and Native Americans) receiving Ph.D.s in mathematics, natural science and engineering. The program focuses primarily on students who are enrolled in Ph.D. programs. However, a small part of the program includes undergraduate or master's level feeder programs. The program identifies faculty (individual, group, or an entire department) who have a track record in successfully recruiting, mentoring and graduating minority students with Ph.D.s. New minority students of the selected faculty are designated as "Sloan Scholars" who are provided modest financial support. A small number of three-year renewable grants also are made to undergraduate and master's level departments that send a significant number of their minority graduates on for Ph.D.s in mathematics, natural science and engineering.

NSF ADVANCE Leadership Awards

To increase the participation of women in scientific and engineering workforce through the increased representation and advancement of women in academic science and engineering careers, Leadership awards are one of three types of awards offered by ADVANCE and are designed to facilitate women's advancement to the highest ranks of academic leadership. Annually, eight to 12 leadership awards will be made.

Recognition Awards for Institutional/Program Accomplishments

NSF Presidential Awards for Excellence in Science, Mathematics, and Engineering Mentoring — Institutional Awards

To recognize programs that enhance the participation of underrepresented groups in science, mathematics and engineering at pre-K-12 through the graduate level. Up to 10 programs will be recognized annually. Recipients receive a $10,000 grant.

QEM Exemplary MSE Education and Partnership Awards

To recognize collaborative efforts that increase the participation of underrepresented minority students in mathematics, science, and engineering.

Source: QEM, April 2003
Note: For data on individual awards, see Appendix A.

in class and out, into the learning experience and address the "whole person" needs of the undergraduate. CAHSEE/STEM does the same for precollege students through a rigorous summer experience.

Peer support. Model programs enable students of diverse backgrounds and interest to interact routinely and intensively. Seamless opportunities for undergraduates, graduate students, postdocs and junior faculty to provide mutual support, guidance and advice for those who follow instill an ethic of "family responsibility." It can be a decisive plus for developing allegiance and dedication to institution, discipline and professional group. Peer teaching and summer immersion engender both a can-do attitude and an *esprit de corps* that reminds the student, as illustrated by TX-LSAMP and CREW, that science and engineering is a "contact sport" where teamwork, cooperation and collaboration matter.

Enriched research opportunities. Standout programs extend research experience beyond classroom hours during the academic year. Summer internships and other research opportunities outside the classroom are transitional activities. They connect the student's experiences to the world of work, establish mentoring relationships and open a window on career options. PMABS offers a multi-level range of programs to reinforce student interest and curiosity, evolving through hands-on pedagogy into an introduction to research culture of the academic life sciences.

Bridging to the next level. Too few programs recognize that they are part of an education and workforce continuum. Those that do build the institutional relationships and provide the personal skills that enable students to pursue further study and faculty to envision the evolution of their educational and career achievements. A program of such scope, such as CEED, must be constructed to draw sustenance and intellectual support from both higher education and industry patrons — with a constant eye on student progress from one milestone to the next.

Continuous evaluation. Effective programs never stop asking basic questions about process and outcomes: What is being achieved? How do these outcomes measure up against program goals? How do they compare to other programs? What is the national impact on who is participating in science and engineering? Continuous monitoring, evaluation and program adjustment are hallmarks of best-in-class. The Gateway Coalition is a virtual template on documenting reform through performance metrics, first at a single institution, then spread to eight others as a testament to accountability, management and leadership.

A ninth principle is one not readily designed, but embodies a pervasive need: comprehensive financial assistance. Savvy programs recognize that low-income students are much more likely to stay the course if they receive funding in the form of grants rather than loans. The provision of funding beyond tuition and fees also affords students the freedom of action to focus on coursework and professional development. Few programs can provide full funding, but most of the institutions that are home to the exemplary and promising programs identified by BEST work diligently to construct a financial package (e.g., scholarship and loan) that combines merit - and needs-based support. Moreover, they make academics — not part-time work unrelated to course of study — the student's chief priority.

We conclude with this thought: words like "replicate" and "transfer" hardly capture the complexities of sustaining programs and practices that work. However, the design principles that have emerged from BEST's search for promising and exemplary programs do provide tools — if used in conjunction — for extending the use of best practices, as well as expanding the capacities of existing programs distinguished by their longevity, leadership and performance.[8]

What BEST has presented in this chapter is that access alone is not enough, money is not enough, single-component programs are not enough and even public acclaim is not enough. The application of design principles that underpin best-in-class programs must be inclusive, comprehensive, persistent and respectful of the whole person, as well as of the institution it calls home.

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3. Systematic evidence was skimpy. Quasi-experimental designs, matched samples, and control groups were hardly more than a gleam in the eye. Third-party evaluations, i.e., paid and executed from outside the program host, were virtually nonexistent. Internal, self-initiated evaluations by staff were more common, almost as a bookkeeping practice rather than a research-driven inquiry to learn about what makes a difference, with whom, and how.

4. Note that policy and research may require a different template of evaluation criteria not considered here, but addressed in chapters 3 and 4.

5. James, D. Walker, S. Jurich and S. Estes. (2001). *Raising minority academic achievement: A compendium of education programs and practices.* Washington, DC: American Youth Policy Forum. Available: http://www.aypf.org/pubs.htm.

6. Consistent with agency panel review practice, those having a conflict of interest with a particular program recused themselves from rating it and left the room during that portion of the panel's discussion.

7. The conversion of individual conviction into institutional will is addressed, for example, in Fox, Mary Frank "Women, Academia, and Careers in Science and Engineering." In Davis, C.-S., A. B. Ginorio, C. S. Hollenshead, B. B. Lazarus, P. M. Rayman. (1996). *The equity equation: fostering the advancement of women in the sciences, mathematics, and engineering*. San Francisco: Jossey-Bass.

8. Human capacity-building takes time. Arguably, much of higher education's progress in serving all students has been made on the basis of relatively short-term, under-funded and often poorly-defined (mostly federal) programs that lack realism in scale, goals, and methodology for measuring progress and effectiveness. Uncoordinated across the missions of the R&D agencies, they tend to constrain outcomes, preserve parochialism, and inhibit learning across institutions with a stake in bootstrapping educational attainment. Money talks: performance expectations belong in program RFPs. So do accountability regimens, including incentives for exemplary impacts and real consequences for nonperformance. For perspectives that have withstood the test of time, see Matyas, M. L. and S. M. Malcom. (1991). *Investing in human potential: Science and engineering at the crossroads*. Washington D.C.: American Association for the Advancement of Science.

Chapter 3

Breaking Through: Adapting Exemplary Design Principles To America's Communities

Extending effective policies and practices across America requires a national strategy that begins within the nation's communities.

During the closing decades of the 20th century a series of powerful forces delivered jarring shocks to the conventional roles and relationships among government, business, and nonprofit organizations . . . Today, such cross-sector collaborations, partnerships, and alliances are more important than ever in addressing the increasing number of complex public issues that spill over sectoral boundaries.[1]

A number of the nation's institutions of higher education have asserted leadership in the national debate on diversity because they recognize how much needs to be done, as well as their role as the bridge between the educational foundation of pre-kindergarten through 12th grade and the competencies for the world of work. But even the most successful college and university-based programs have made scarcely a dent in the production of a well-educated, well-prepared and diverse scientific and technical workforce. The reason is that doing so is one of America's most complex public issues, and as such transcends sectoral boundaries.

Change on the scale required will never be achieved one department or one campus at a time (see sidebar: Stumbling Blocks in Higher Education Institutions). Neither can institutions of higher education get the job done on their own. Extending effective policies and practices across America requires a national strategy that begins in the nation's communities.

One building block is a firm understanding of the design principles that underpin the limited successes gained thus far. These design principles, spelled out in Chapter 2, are neither magic bullets nor rarified insights. For the most part, they represent common sense understanding on the part of individuals, groups and institutions refined by trial and error, made operational, and proven to work. Design principles are not ends in themselves, but rather a set of tools that may be applied in program development funding decisions and other contexts.

The second strategic building block is a grasp of the dynamics of extending best practices. On one hand is a key horizontal dimension to scaling interventions to reach more students across the expanse of the U.S. On the other, there is a vertical requirement of sustaining and institutionalizing effective interventions to reach a greater number of students over time. Both needs must be met.

A third component of national strategy is collaboration among major stakeholders. Higher education is at the nexus of policy, practice and research — each of which brings diverse interests into play. Only through partnerships can these interests be aligned around the objectives of learning what works and making that knowledge actionable.

The fourth component is community engagement. Despite the globalization of higher education and growing significance of distance learning, America's colleges and universities are still place-based. The marshalling of key resources within a community will develop its local workforce, and thereby contribute to the national production of talent.

Building Block I: The Use of Design Principles

BEST has distilled nine design principles underpinning exemplary and promising programs. It is significant but not surprising that the same features can be found in standout interventions varying widely by target group, type of institution, scope and educational milestone achieved. Acknowledging the overarching pervasive need for comprehensive financial assistance, eight design principles played an integral role in successful outcomes across the board:

- Institutional leadership
- Targeted recruitment
- Engaged faculty
- Personal attention
- Peer support
- Enriched research opportunities
- Bridging to the next level
- Continuous evaluation

The shared features of standout programs create a starting point for addressing the practical challenge of expanding national capacity. On the demand side, public and private sector sponsors need to know what to look for. Design principles embody a set of criteria that can and should inform the evaluation of funding decisions. The same requirement holds for stakeholders on the supply side. Students, parents, guidance counselors, university faculty and administrators all have high-stake decisions to make regarding the value of programs and institutions. Many make choices and set priorities based on trusted advice but without clear points of reference. The success factors that emerged from BEST's inquiry into what works begin to fill this gap. The findings of the higher education panel suggest a number of guidelines regarding their application:

Design principles comprise a single package. The components of effective programs should not be viewed as an *a la carte* menu from which to pick and choose. In fact, university heads cannot meet the leadership challenge without engaged faculty. Targeted recruitment cannot succeed without a learning environment and support infrastructure that fosters the success of all students. Enriched research experiences are not possible without personal attention. Interdependence has the potential to create a reinforcing culture, which is reflected in all of the exemplary and promising programs identified by BEST. But if a program is not truly embedded, this very interdependence can create vulnerability when a key component is weakened or lost.

Failure is part of the learning curve. Outstanding programs have the capacity to acknowledge and learn from their mistakes. The further removed one is from the operating level, however, the harder it becomes to learn from failure. Too many sponsors persist in throwing support to efforts that may be ill-conceived or poorly monitored. At the same time, too many practitioners try to mimic or replicate effective programs without understanding the imperative of continuous refinement to adapt to a specific context. Knowledge of what has not worked is as valuable in extending best practices as knowledge of what has succeeded.

Execution spells the difference. Significant numbers of colleges and universities can lay claim to possessing most, if not all, of the design principles of exemplary programs. But in fact, what often sets best-in-class apart from the rest is not a difference in kind but in degree. Top producers of diverse technical talent create quality and synergy in teaching, mentoring and research opportunity, and they combine the design principles in ways that respond to the local context. This is why design principles can represent only a point of departure in seeking to expand national technical capacity.

Stumbling Blocks in Higher Education Institutions

The only way to open up the opportunity structure in higher education is by overcoming the stumbling blocks that have hampered progress for decades. It is helpful to distinguish between those obstacles that *inhibit* change within institutions and those that *limit* change among them. An accumulating knowledge base reveals a host of internal stumbling blocks. The most widely recognized can be sorted into three categories: **resources and infrastructure, tradition, and the climate of competition.**

Resources and Infrastructure: *Inequitable resources and access*. Many colleges and universities that have the will to produce more technical talent from underrepresented groups lack the means to do so. Persisting inequities in financial resources and research facilities — as well as in access to knowledge and technology — have hit minority-serving institutions, community colleges and women's colleges especially hard. Many are unable to offer even the most talented students opportunities to learn at the leading edge of such new fields as genomics, nanotechnology, computational biosciences and cognitive sciences.

Inadequate support infrastructure. Research and experience both confirm the link between the performance of underrepresented groups and the availability of support at every level: undergraduate, graduate and postdoctoral students, and new faculty. The lack of investment in a seamless support structure is a critical and still widespread deficiency.

Tradition: *Academic governance structures.* The governance and reward system in U.S. universities has changed less than any other major institution in America society. Little has changed in the weighting of teaching and service (e.g., mentoring) relative to research productivity in tenure and promotion decisions. The features most associated with institutions that embrace change — flexibility, openness and agility — represent the exception rather than the norm.

An 'ivory tower' mentality. Too many institutions of higher education still view themselves as islands unto themselves. This pervasive mindset blunts aggressive and strategic recruitment of students and faculty. It also undermines effective community outreach and emphasizes exclusivity — an invitation to the best and brightest — instead of inclusiveness and a commitment to develop the best in those with the promise to succeed. Colleges and universities have found it difficult to create a learning environment that both honors excellence and embraces diversity.

Negative faculty attitudes. Senior faculty members shape the learning environment in their departments and in the university as a whole. When they adopt inflexible learning modalities and racial or ethnic stereotypes about learners, they create a chilling environment and effectively repel potential adherents to their disciplines for reasons unrelated to student capability. Thus, resistance to broadened participation in technical fields is one symptom of the more pervasive structural and attitudinal problems that persist.

The Climate of Competition: Beyond these long-acknowledged stumbling blocks, there are additional reasons why institutions of higher education have not learned as much as they could from each other on how to reduce conditions of underrepresentation. On the one hand, the incentives to share knowledge in these areas are quite limited. While U.S. universities are unsurpassed in creating an open and very efficient marketplace of ideas in academic disciplines where the rewards are high, there are no comparable benefits for the exchange of organizational know-how. The competitive structure of U.S. universities, a source of strength in many ways, weighs against sharing an advantage in matters of recruitment or retention of underrepresented groups. The most effective day-to-day collaboration is among peer institutions whose missions are complementary, such as between two- and four-year colleges.

These realities underscore why a comprehensive strategy is both so necessary and so difficult. The only strategy that has a serious chance of making a difference is one based on solid building blocks, leverage points and partnerships.

Context is critical. The next generation of scientists and engineers is being developed in an educational setting far different from the baby boomers that they will replace. New learning technologies, eroding boundaries between campus, home and work, and changing demographics demand a keen understanding of the role that culture and context play. The shift from a single, discrete educational context to a more complex, varied learning environment must be embraced to develop a more diverse talent pool (see sidebar: Fast-Forward on the Dynamics of Diversity). In practical terms, this means that today's design principles are not fixed in stone. They must be continuously reexamined and fitted to new circumstances.

Building Block II: Paths to Expanding National Capacity — Extending Best Practices

There has not been enough strategic thinking in higher education about what it will take to increase substantially the number of graduates with technical degrees from underrepresented groups. The familiar refrain, "pre-K-12 isn't producing enough," puts the onus elsewhere and presumes that the challenge will take care of itself as soon as America's feeder system delivers.

In fact, there are two paths to increased capacity whose viability depends on changes in the higher education system. The path of deepening is to develop more talent within current, high-producing institutions. The path of widening is to expand the circle of such institutions. Clearly, we must pursue both.

The minimum step is to ensure that strong existing programs are sustained. Next, these programs must become an integral part of the structure and culture of a university. In addition, they must be expanded beyond the boundaries of a single institution. Indeed, the aforementioned design principles must be applied to new contexts through at least three modes: *sustainability, institutionalization and scalability.*

Sustainability implies a long-term ownership commitment, a challenge of the first order for many programs whose base of support is usually in the form of external funding from the state or federal government. Historically, virtually all of the startup support designed to broaden participation of underrepresented groups in science and technology has come from these "soft monies."

Such seed funding of even successful programs must graduate to hard monies, allocations that come to or are provided through planning and budgeting by the host institution. This is especially critical to community colleges, minority-serving institutions and women's colleges.

The transition from external funding (or a cost-sharing arrangement in partnership with other funders) to a more permanent finan-

Fast-forward on the Dynamics of Diversity: Context and Content on Campus

A growing number of individuals now enter higher education with a mix of individualized characteristics described as their cultural context. These learned preferences influence how they interact and associate with others, use living spaces, perceive concepts of time and include many other factors that were imprinted on them in childhood by family and community and continue to help shape their world view. In addition, they express a variety of personality, cultural, living and learning styles generated by two distinct cognitive and contextual conditions associated with majority and minority ethnic cultures. In essence, these individuals are multicontextual, with different thinking and perception skills formulated around strategies of cultural adjustment that help them adapt to their current circumstances (Ibarra, Robert A. *Beyond Affirmative Action: Reframing the Context of Higher Education,* 2001).

The cultures of our colleges and universities are permeated by cultural contexts forged from different ethnic roots. This heritage is a combination of colonial British liberal arts colleges capped by an imported German research model and infused with nineteenth century Euro-American immigrant ethos dominated by males. While the ethnic markers disappeared long ago, the cultural contexts in higher education — preferences for individual learning over group work or technical teaching styles over informal styles, as well as many gender preferences — have not. They have been incorporated into U.S. academic traditions, and especially our science, math and engineering disciplines, remaining relatively unchanged and unnoticed by nearly everyone. Therein lies the conflict.

Multicontextual students and faculty reveal preferences for cultural contexts and ways of knowing that are often the antithesis of academic culture. Most minority students and faculty who arrive at our doors can and do adapt. But they do so with the historical disadvantage of chronic underperformance in our educational systems. That academic gap continues to take a huge toll of women and minorities in academe. Latino experiences in higher education, like many other ethnic minorities and women, have been dominated by conflicts with academic culture that affect almost every measure of academic performance — tests, class work and even faculty work toward gaining tenure.

Today's economic, political and demographic realities demand new solutions and different perspectives. Reexamining our academic cultural systems, generating fresh guidelines for teaching, research, promotion and tenure, while improving the climate for diversity, cannot long remain an elusive goal for institutions of higher learning. The future is here.

cial base signifies a readiness on the part of the host institution to embrace a program as part of its mission. This is a fundamental — and all too rare — shift. It reflects a commitment to the goals and practices of an intervention as well as confidence in its leadership.

Institutionalization denotes a commitment of such depth that a successful program becomes synonymous with the mission of the host institution. An example would be the integration of a program or a center into a department or campus-wide unit. When this occurs, the host institution adopts the design principles of an intervention as its own: the incentive system rewards faculty for contributing to the success of the program; the learning environment is viewed as a campus-wide asset; and the university throws its full weight behind the effort. Institutionalization insures that diversity becomes the norm — developing the talent of all students.

Scalability is what it takes to expand national capacity via the path of widening. Doing so engages additional stakeholders to secure financial support and institutional buy-in. The permutations and combinations include single provider, inter-institutional, statewide, regional and multi-sectoral. The issues that surround scaling warrant increased attention because America will not meet the talent imperative without bold new approaches. Scaling cannot simply be more of the same. It must break new ground in the pooling of resources, use of technology, delivery of knowledge and management of interpersonal relationships. Without such groundbreaking, the inability to scale up innovations will beleaguer higher education here just as reform of the decentralized pre-K-12 public school system has been inhibited for decades in the name of "local control." Promising opportunities for promoting scaling include the following:

- Strong advocacy— industry, the military and learned societies such as the National Academies of Science recently demonstrated how effective advocacy of a diverse workforce can be through their friends-of-the-court briefs in support of affirmative action.
- Support for "master" mentors — support scalable programs charged with the responsibility to expand themselves to other institutions/organizations.
- Linking important existing reforms — for example, regional accrediting bodies such as the Accrediting Board for Engineering and Technology (ABET) are now requiring that colleges and universities assess student learning and demonstrate educational effectiveness as a condition of accreditation, and some include inclusiveness as a priority on their list of requirements.
- Creating national diversity measure — Convince the *US News and World Report* to include in its higher education ranking a diversity measure for the faculty, student body and curricula.

Effective Use of Technologies: The Internet has opened up scaling opportunities that were unthinkable a decade ago. New technologies not only support distance teaching and learning; they are redefining and expanding the meaning of "community" and "inclusion." For many in remote locations throughout the U.S.,

Policy, Practice and Research Connecting Communities

As the familiar saying, "All politics is local" implies, the importance of local connections goes well beyond politics. Global, national and even regional issues may have little impact on us until they are tied to our communities, our jobs and our families. Politics may need to be practiced at a variety of levels but at its heart it is local. So, interestingly, are data.

National and international data are needed, but a governor wants to know what the "quiet crisis" means in her state, a school superintendent wants to know what it means in his district and parents want to know what this means for their child. Data should be disaggregated by race/ethnicity and sex. That is a given. But they also need to be broken out by state, community and even by school. When presented at the proper level of specificity, the data can enable a citizen to say, "When I see what the data are for my group, whatever that group is, it helps me see where my group fits into the broader picture and how the problem may be mine."

Focusing on the local is not just about problems. It is also about solutions. We must move from looking for "what works" to answering the more complex question of "what works for whom." Strategies may not work equally well for all students or all communities, but without disaggregated data we won't know that. We also won't learn if different strategies need to be used in different situations.

Our goal is not to find the "silver bullet" or to recommend a specific strategy or policy. It is to increase the production and diversity of American scientific and technical talent. The measures should be national, but the problems and the solutions are local and community-based.

This doesn't mean that each group should go it alone. Strategies need to be built on the back of tested theory and controlled research. But they need to be implementable locally, tested and tweaked until they work within that community environment. Not every community can or should do an experimental research study of the impact of their policy or practice. All, however, should be collecting information on how things are working and how they can be improved. This information can then be shared and used both locally and nationally.

It is important to have a vision, a national vision. For that vision to become a reality, it must be adapted to meet the needs and realities of different groups defined by geography, population, race/ethnicity, gender, disability and community. All change is ultimately local. To be successful, so must be all policies, practices and research.

"virtual" is not only better; it is the only choice (see sidebar: Learning Technologies and Connecting Remote Populations).

While new technologies must be exploited in full, they are unlikely to supplant traditional modes of scaling in the short run. These multilateral collaborations are based on a common set of objectives, a willingness to share resources and control, and a flexible strategy of implementation that can be adapted to varying contexts. The most critical components — as they are in sustaining and institutionalizing effective programs — are effective leadership at all levels and genuine partnerships. Partnerships that truly work encompass a commitment to inclusiveness, buy-in to the mission and dedicated pursuit of a vision that is both strategic and tactical.

Building Block III: The Need For Capacity-Building Partnerships

Partnerships are undervalued as part of a winning strategy, underestimated as a mechanism for heightening impact and poorly understood as a resource necessary to develop more of the technical talent of underrepresented groups. For example, partnerships between majority- and minority-serving institutions provide an important pathway from undergraduate to graduate school for underrepresented minority students attending predominantly minority-serving institutions (also see sidebar: Sustaining Through Partnerships — The Exemplary Case of the Compact for Faculty Diversity).

At a broader level, a prerequisite for effective capacity-building partnerships is the convergence of policy, practice and research. This report has asserted that policy sets objectives and allocates resources. Policymakers must make broadening the science and engineering workforce a high priority and ensure that operational funding is concentrated on programs that work across all levels of education. Practitioners shape the learning environment in higher education. They must commit to making education in technical disciplines as effective as possible for all students. Research must extend beyond the study of effective interventions to capture basic characteristics and dynamics of learning and teaching both within and among various groups. Exemplary research should better inform both policy and practice, heightening community and nationwide impact.

A recent report on partnerships, *Working Better Together: How Government, Business, and Nonprofit Organizations Can Achieve Public Purposes Through Cross-Sector Collaboration, Alliance and Partnerships*, illuminates the elements and stages needed to build the kind of civic capacity that will be required to develop a more diverse scientific and technological workforce. Noting that there are different types and time horizons for cross-sector collaborations, the report identifies the following stages in successful partnerships:

- Recognizing common needs and convening potential
- Mutual planning for performance
- Agreement on operational design

Learning Technologies and Connecting Remote Populations

Three examples illustrate how technology harbors potential for the further globalization of knowledge and growth in how people learn and, moreover, shrink the worlds of education and work.

1. **NSF's Rural Systemic Initiatives in Science, Mathematics and Technology Education Program** was developed in 1994 to stimulate system-wide educational reform of science, mathematics and technology. The program focuses on improving K-12 education for students in rural, economically disadvantaged regions of the nation (www.ehr.nsf.gov/esr/programs/rsi). Today, RSI operates in eight regions/states including Alaska, Appalachia, the Delta, Hawaii, and the Navajo (of the Desert Southwest) and ten other Native American tribes of Montana, Wyoming and North Dakota. One of RSI's four goals is "the preparation of a technologically competent workforce to enhance the infrastructure of economic development activities within a community or region, by strengthening the science, mathematics and technology instructional capacities of regional colleges and universities."

2. A higher education system built on distance-learning technologies is the **National Technological University**. Founded in 1984 as the first accredited "virtual" university, NTU is an accredited private, for-profit, online institution that offers 19 master's degrees in key engineering, technical and management disciplines (www.ntu.edu). With the support of major technology companies such as IBM, Motorola and Hewlett-Packard, NTU was formed to deliver academic courses via unique satellite network directly to corporations' training facilities. Today, NTU remains committed to provide "best-in-class" higher education, with more than 200 courses or programs offered via the web and hundred available on CD-ROM. A customer base of more than 200 major corporations and government entities can select from a portfolio of approximately 1,400 graduate-level courses taught by 400 instructors from over 50 leading U.S. universities.

3. **MentorNet**, a web-based interface between women studying technical disciplines and professionals in those fields, has ramped up from serving 204 students in 1997 to almost 3,000 students from 116 campuses in 2002. Founding partners were the AT&T Foundation and Intel. Other supporting partners include IBM, Cisco and Microsoft. The strategic insight that effective mentoring could be provided at a distance by mobilizing volunteer e-mentors from hundreds of employers enabled MentorNet to create a unique niche of national and international reach (www.mentornet.net). MentorNet pairs proteges and mentors from all 50 U.S. states and 55 countries on six continents.

- Startup
- Operation and management
- Performance monitoring, communication, learning and improving
- Termination or modification

The design principles distilled by BEST can support capacity-building partnerships by supplying a shared frame of reference to define needs, articulate public purpose, develop an operational design, execute, evaluate and improve. The insights gained from examining best practices, however, are no substitute for leadership and incentives to build a stronger, more diverse talent pool. In the view of BEST, the most promising opportunities to find leadership and create incentives lie in the nation's communities.

Building Block IV: The Promise of Community Engagement

First, the prosperity of every community in America hinges on the quality of its workforce. High-wage jobs linked to high-value products and services create the population and tax base that all metropolitan areas seek. Science, engineering and technology are an important part of the wealth-creating equation in many fields. As a result, as one researcher of innovation points out, communities fuel demand for talent:

"I have seen the community try just about everything possible to remake itself so as to attract and retain talented young people. [Such efforts] represent a profound new force in the economy and life of America . . . what I call the creative class: a fast-growing, highly educated, and well-paid segment of the workforce on whose efforts corporate profits and economic growth increasingly depend. Members of the creative class do a wide variety of work in a wide variety of industries — from technology to entertainment, journalism to finance, high-end manufacturing to the arts. They do not consciously think of themselves as a class. Yet they share a common ethos that values creativity, individuality, difference and merit."[2]

Second, all of the major institutional stakeholders in technical workforce development are community-based: pre-K-12 schools, community colleges, teachers colleges, technical degree granting institutions and employers of scientists and engineers. Over 120 metropolitan statistical areas (MSAs), as defined by the U.S. Census Bureau and the Office of Management and Budget, have a complete range of degree-granting institutions in mathematics, science and engineering within their boundaries. These include not only 93 metropolitan areas with populations of more than 250,000, but also 27 areas with fewer than that number (see Table 1). The

Sustaining Through Partnerships — The Exemplary Case of the Compact for Faculty Diversity

The ***Compact for Faculty Diversity*** is a partnership of three regional higher education associations — the Western Interstate Commission for Higher Education, the Southern Regional Education Board and the New England Board of Higher Education — created to address the chronic problem of minority faculty underrepresentation in our nation's colleges and universities. Far more than the traditional "check and a handshake" approach that characterizes many past minority fellowship efforts, the Compact draws upon the resources of state higher education offices, colleges and universities, graduate departments, faculty and students. It promises not only to increase the representation of faculty of color in our nation's universities, but also to provide a framework for systemic change in graduate education.

While the number of African Americans, Native Americans and Hispanics receiving doctoral degrees has shown modest increases over the past 10 years, in 2001 they represented only seven percent of the total doctoral recipients. Faculty representation by these three groups has remained virtually unchanged in the past 20 years, the most recent data showing that they comprise only eight percent of full-time faculty, with most of those employed at minority-serving institutions.

In contrast to student attrition approaching 50 percent across all doctoral programs nationally, the Compact has retained 90 percent of the 650 minority doctoral scholars who have entered the program since its inception in 1994. Each of the partners in the program has a specific role in ensuring student success: states, universities, federal agencies and foundations provide financial support; academic departments create environments of social and academic support; and faculty offer mentoring and advising. The three regional partners in the Compact sponsor an annual Institute on Teaching and Mentoring that brings students and faculty together to participate in seminars on preparing for faculty careers and effective mentoring.

By forging successful partnerships with states, universities, administrators, faculty, foundations and federal agencies, the Compact has enlarged the group of stakeholders in the program and developed multiple points of accountability for student and program success. Through the Compact's intervention, colleges and universities are learning to succeed with diverse students and, especially in the science disciplines where they are so severely underrepresented, changing the departmental cultures in those fields.

As minority scholars complete their degrees and enter the professoriate, their presence will magnify the diverse intellectual talents they bring with them, and the unique contributions they make as members of groups long underrepresented in the science faculty ranks. Such diversity can only enhance the quality of our nation's postsecondary enterprise, while changing the face of the role models for succeeding generations of scholars and citizens.

Table 3-1

High Concentrations of Underrepresented Minorities by Community

Area Name Designation	% Population African American	% Population Hispanic	% Population Native American	% Population Black, Hispanic, or Native American	% Employed Labor Force in Science and Technology Occupations
Atlanta, GA MSA	28.8	6.5	0.3	35.6	10.5
Baltimore, MD PMSA	27.2	2.0	0.3	29.5	13.4
Chicago, IL PMSA	18.8	17.1	0.2	36.1	10.5
Dallas, TX PMSA	14.9	23.0	0.6	38.5	11.1
Denver, CO PMSA	5.4	18.8	0.9	25.1	12.3
Detroit, MI PMSA	22.8	2.9	0.4	26.1	11.7
Houston, TX PMSA	17.4	29.9	0.4	47.8	11.0
Los Angeles-Long Beach, CA PMSA	9.6	44.6	0.7	54.9	8.6
Miami, FL PMSA	20.1	57.3	0.2	77.6	7.3
New York, NY PMSA	24.4	25.1	0.4	50.0	9.4
Oakland, CA PMSA	12.5	18.5	0.6	31.6	23.1
Philadelphia, PA-NJ PMSA	20.0	5.0	0.2	25.2	12.0
San Diego, CA MSA	5.6	26.7	0.8	33.2	11.9
Washington, DC-MD-VA-WV PMSA	25.9	8.7	0.3	35.0	15.6

Based on U.S. Census Bureau data for metropolitan statistical areas provided by Judy Kass, American Association for the Advancement of Science.

resulting base is truly national and very broad.

Third, many communities have large populations of underrepresented minorities. While these are not the only talent pools that need to be further developed, they encompass the nation's fastest growing groups. Table 3-1 displays characteristics of race and ethnicity, science and engineering workforce density and number of technical degree-granting institutions in the nation's largest communities whose populations are at least 25 percent African American, Hispanic, or Native American. Twenty-eight smaller communities fit the same profile.

The inherent diversity among U.S. communities is the scaffolding on which higher education can build a more diverse science and engineering workforce. With vision and leadership, dozens of metropolitan areas have the wherewithal to produce innovative partnerships:

- A significant concentration of underrepresented minorities;
- A full set of educational institutions to develop technical talent;
- Substantial local demand for scientists, engineers and other technically skilled workers;
- Demonstrated commitment to math/science education and workforce development;
- An engaged community that has had success addressing civic issues.

This chapter has spelled out the core components of a national strategy to increase higher education's contribution to creating a stronger, more diverse technical talent pool: a shared understanding of the design principles of best practice, a focus on the paths of deepening and widening to increase capacity, a commitment to partnerships across sectors to get the job done and awareness that communities are the most fertile ground for collaboration. The conclusion of this report presents recommendations to meet the challenge.

CHAPTER 3 ENDNOTES

1. Fosler, R. S. (2002). *Working better together: How government, business, and nonprofit organizations can achieve public purposes through cross-sector collaboration, alliances, and partnerships*. Washington, DC: The Three Sector Initiative.

2. Florida, R. (2002) The rise of the creative class. Washington, DC: Washington Monthly.

Chapter 4

Conclusions and Recommendations

Higher education alone cannot provide the impetus to create favorable conditions for change. It will take national leadership, fresh incentives and additional pressure to secure the engagement of the nation's colleges and universities.

This report has asserted that higher education will play a pivotal — even determining — role in shaping the size and composition of the U.S. science and engineering workforce. The core test will be whether America's colleges and universities make long-term institutional commitments to diversity in fields that have been outliers from broadening participation in American education and society. That test will be decided in countless day-to-day decisions on undergraduate and graduate admissions, faculty hires and promotions, learning environments to be fostered and the kinds of careers launched.

There are hopeful signs that the direction of change is positive. One is the growing number of women who head major institutions. Another is the increase of female Ph.D.s in science. A third is the ethic of accountability that has begun to take hold through self-evaluations of gender and ethnic-racial equity.

Nevertheless, several telling indicators suggest America's colleges and universities are not doing all they can to help the nation meet its workforce needs in science and engineering. These include disproportionate attrition of undergraduate students from underrepresented groups from technical majors; insufficient Ph.D. completion rates of persons of color, as well as their dearth in junior faculty positions at the nation's leading research universities; and their persistent underrepresentation in tenured faculty positions in the physical sciences and engineering. In addition, by now it is axiomatic that fragile, soft-money programs will never be able to deliver results on the scale that is called for.

Four conditions, elaborated below, will have to be met to change the situation:

- First, more institutions will have to commit to making diversity in science, engineering, and technology a defining priority.
- Second, the leaders of higher education will have to reframe the issue of diversity as capacity building that enables the entire enterprise rather than securing a competitive advantage for any particular institution.
- Third, higher education will have to apply its formidable human resources more strategically in community-based science and engineering workforce partnerships
- Fourth, policy, practice and research will have to be more closely aligned to insure that knowledge and resources are used as productively as possible.

Higher education on its own cannot provide the impetus to create all of these conditions. It will take national leadership, fresh incentives and additional pressure to secure the engagement of the nation's colleges and universities. At the same time, however, their full and willing participation will be indispensable because of higher education's unique position at the nexus of workforce development, innovation and society.

Institutional Commitment. This report has underscored the importance of embedding programs that work into institutions of higher education. Doing so increases the probability that developing the talent of all students becomes the norm. To accelerate and deepen the process of commitment to diversity in technical fields, BEST recommends:

- All institutions granting technical degrees should adopt as standard operating procedure the conduct of publicly accessible self-evaluations of gender and racial-ethnic equity among faculty, staff, administrators and students.
- Federal and state funding agencies should make the conduct and follow-up of these self-evaluations a consideration in awarding support.
- Corporate and foundation sponsors should make clear that diverse human resources are an expected outcome of university-industry and university-foundation research partnerships.

Capacity Building. This report has stressed that broadening the participation of underrepresented groups is a matter of capacity building rather than a zero-sum game of achievement. The United States needs to draw on the strength of its demographics to develop a more inclusive, skilled and versatile technical talent pool. This investment in capacity will serve to educate more students, renew the current science and engineering workforce, enhance domestic security, capitalize on opportunities in leading-edge technology sectors and keep pace with a surge in global production of scientists and engineers. To this end, BEST recommends:

- Leaders from industry, government and higher education should set a national goal of developing a stronger, more inclusive science and engineering workforce.
- Federal policy should provide incentives and reward all institutions — community and women's colleges, minority-serving institutions and research universities — that contribute to meeting this objective.
- Higher education should make and enforce structural changes that accrediting associations will adopt, and that will increase retention rates in technical disciplines, with special focus on transitions between education and career milestones.
- Industry and federal agencies should expand internship opportunities to undergraduate and graduate students, as well as professional development opportunities for teachers and faculty from underrepresented groups.

Community-based Workforce Partnerships: Government, Business and Higher Education Working Together. This report has identified communities as a foundation for capacity-building partnerships. Higher education is a natural linchpin for such multi-sector partnerships, whose pooling of resources and competencies could do much to bolster precollege mathematics and science preparation, boost undergraduate and graduate retention-to-degree, and meet local workforce needs. Indeed, successful programs have managed to stay alive past single funding cycles, learned from their earlier mistakes/missteps through mid-course corrections, and have established and achieved long-term goals.

Yet while we have reached the point of acknowledging that a diverse scientific and technological workforce is an important goal, we have not reached the point where each key sector of the community is willing to play a role in achieving it. Community-based collaborations of industry, government, education and the nonprofit sector must work together to create long-term, coordinated, adequately funded, fiscally stable partnerships in math and science education.

To this end, BEST recommends:

- Federal agencies should expand upon and adapt models that employ partnerships in communities in which they have a significant R&D workforce presence.
- The eight states that account for 70 percent of the underrepresented minority high school-age population (through 2010), even in the face of tight fiscal constraints, should take the lead in forging a test bed of partnerships to implement best-in-class education and workforce strategies. In order of concentration these states are California, Texas, Florida, Arizona, Georgia, New Jersey, New York, Virginia and Washington.
- Industry and professional associations, companies, universities and foundations in communities where the demand for technical talent is projected to be strong should use their convening power to bring stakeholders to the table around a best practices agenda.

Alignment of Policy, Practice and Research. This report has emphasized that the direction of policy, allocation of resources, delivery systems and creation of knowledge must align to meet the challenge of underrepresentation. In its recent pivotal decision to uphold the principle of affirmative action in college admissions, the U.S. Supreme Court made it clear that the use of diversity criteria is appropriate — even necessary — in a merit-based educational system. The Court also argued, however, that affirmative action is a means and not an end, and set 25 years as a target date when considerations of race, ethnicity, or gender need not matter in opening the door to higher education (see sidebar: Affirmative Action for Diversity is Upheld by Supreme Court). While the Supreme Court has clarified the policy setting, the larger disconnection between policy, practice and research cannot be allowed to persist.

To this end, BEST recommends:

- Federal agencies should adopt and enforce criteria taking diversity into account in awarding education and research grants to institutions of higher education.
- States should focus on the convergence of policy, practice and research within their purview, with particular focus on complementing federal programs, such as Pell Grants, that provide access and opportunity through needs-based financial aid. States have a lead role to play in documenting student progress through the collection and use of disaggregated data. Accountability matters, but it costs. Colleges and universities can afford no new "unfunded mandates."
- Drawing on the experience of industry, the "practitioners" of higher education — college presidents, deans and department chairs — should create a community of practice promoting what works in higher education to nurture the talents of women, underrepresented minorities and students with disabilities.
- All of the stakeholders in science and engineering higher education should concentrate resources on proven enrichment opportunities that develop the technical talent of students from all groups. Expanding the base of effective programs will require more rigorous evaluation of outcomes, support for cutting edge research on the issues that surround teaching and learning, and increased participation of underrepresented groups in national research and evaluation efforts.

Policies Dedicated to Participation

Democracy is grounded in the concept of participation, and so are its benefits. In the United States, public policies determine how benefits are distributed, often in the form of new laws, court rulings, executive orders and special initiatives.

Public policy plays a determining role in education. Generally, we express our cultural value of opportunity in educational policy. For example, participation in science is predicated on student ability and experiences that build on interest and curiosity. Preparation as judged by academic performance and degree completion permits one to advance and compete for jobs, admission to graduate study, scarce research resources, etc. For those who pass these preparation and participation filters, public policy ensures opportunity, not success.

Thwarting educational opportunity restricts occupational mobility and national productivity across generations. American science and technology, steeped in ideals of competitive merit and the open pursuit of knowledge, cannot abide the denial of opportunity based on characteristics irrelevant to the judgment of performance, such as gender, ethnicity, age or the ability to pay. Nor can American society afford to reduce the pool of eligible people seeking to participate in science and engineering based on stereotypes and low expectations.

Federal policy changes are a constant. Currently pending are the reauthorization of the Higher Education Act, (which seeks to increase institutional accountability for awarding financial aid to students while controlling costs and increasing retention to graduation); and the U.S. Citizenship and Immigration Service reporting requirements of the Student and Exchange Visitor Information System (or Sevis database), which will track students carrying F (academic) and M (vocational) visas and authorize institutions to accept international students.

Each of these will have significant impacts on who goes where to college and who pursues a science or engineering career — in short, who participates.

In the final analysis, higher education can and should serve as a gateway for all in science, engineering and technology. What has eluded us until now and must be secured is a national commitment develop a more representative talent pool.

Postscript … and Promises to Keep

America's manifest destiny for the 21st century is the optimum development of her most precious resource, her human resources — and her domestic scientific and technical talent, in particular. For it is through such talent that as yet unimagined discoveries and innovations of tomorrow will come.

BEST has undertaken this innovative examination to identify exemplars and promising prospects in the development and advancement of such talent from groups traditionally underrepresented in these critical fields, groups who ironically comprise America's underrepresented majority. America must exact the national will through creative and collective community engagement to succeed in this mission of most compelling national interest.

The mission transcends traditional boundaries and players and requires no less than the effective engagement of everyone, at every level and across every sector — from the classroom to the boardroom. We all have a role and a stake in developing and sustaining an excellent, diversified scientific and technical workforce for the 21st century. We as a nation historically have overcome many seemingly intractable challenges and even most recently have displayed remarkable resilience in the adversity of unprecedented tragedies since September 11, 2001.

We must demand no less of ourselves as a nation in this nationwide human resource challenge, for America yet has miles to go before she sleeps . . . and promises to keep!

Affirmative Action for Diversity is Upheld by Supreme Court

Excerpts of U.S. Supreme Court Decision in *Grutter v. Bollinger*, et. al., June 23, 2003

Today, we hold that the [U. of Michigan] Law School has a compelling interest in attaining a diverse student body… We have long recognized that, given the important purpose of public education and the expansive freedoms of speech and thought associated with the university environment, universities occupy a special niche in our constitutional tradition... Our conclusion that the Law School has a compelling interest in a diverse student body is informed by our view that attaining a diverse student body is at the heart of the Law School's proper institutional mission, and that "good faith" on the part of a university is "presumed" absent "a showing to the contrary." 438 U. S., at 318-319…

… As part of its goal of "assembling a class that is both exceptionally academically qualified and broadly diverse," the Law School seeks to "enroll a 'critical mass' of minority students…" [Rather,] the Law School's concept of critical mass is defined by reference to the educational benefits that diversity is designed to produce…These benefits are substantial. As the District Court emphasized, the Law School's admissions policy promotes "cross-racial understanding," helps to break down racial stereotypes, and "enables [students] to better understand persons of different races." The Law School's claim of a compelling interest is further bolstered by its *amici*, who point to the educational benefits that flow from student body diversity. In addition to the expert studies and reports entered into evidence at trial, numerous studies show that student body diversity promotes learning outcomes, and "better prepares students for an increasingly diverse workforce and society, and better prepares them as professionals…"

…These benefits are not theoretical but real, as major American businesses have made clear that the skills needed in today's increasingly global marketplace can only be developed through exposure to widely diverse people, cultures, ideas, and viewpoints. *Brief for 3M et al. as Amici Curiae 5; Brief for General Motors Corp. as Amicus Curiae 3-4.* What is more, high-ranking retired officers and civilian leaders of the United States military assert that, "[b]ased on [their] decades of experience," a "highly qualified, racially diverse officer corps ... is essential to the military's ability to fulfill its principle mission to provide national security."

…We have repeatedly acknowledged the overriding importance of preparing students for work and citizenship, describing education as pivotal to "sustaining our political and cultural heritage" with a fundamental role in maintaining the fabric of society. *Plyler v. Doe*, 457 U. S. 202, 221 (1982). This Court has long recognized that "education ... is the very foundation of good citizenship." *Brown v.* Board of Education, 347 U. S. 483, 493 (1954). For this reason, the diffusion of knowledge and opportunity through public institutions of higher education must be accessible to all individuals regardless of race or ethnicity. . ." *Grutter v. Bollinger*, 71 USLW 4498 (2003) or 123 S.Ct. 2325 (2003). "The United States, as *amicus curiae*, affirms that "[e]nsuring that public institutions are open and available to all segments of American society, including people of all races and ethnicities, represents a paramount government objective." *Brief for United States as Amicus Curiae 13*. And, "[n]owhere is the importance of such openness more acute than in the context of higher education." *Ibid*. Effective participation by members of all racial and ethnic groups in the civic life of our Nation is essential if the dream of one Nation, indivisible, is to be realized…" (Affirmative Action for Diversity is Upheld by Supreme Court; *Grutter v. Bollinger*, 71 USLW 4498 (2003) or 123 S.Ct. 2325 (2003).

Appendix A

Summary Data on National Recognition Awards for Individuals and Institutions/Programs

Award	Years Offered	# of Awardees	Male	Female
NSF PAESMEM	1996-2001	60	40	20
NAE Gordon Prize	2002	1	1	0
AAAS Mentor Awards*	1993-2000*	9**	2	7
AAAS Lifetime Mentor Awards*	1991-2000	15***	12	3
QEM Giants in Science Awards	1994-2002	44	32	12
Sloan Minority Ph.D. Program	1995-2002	62 (active grants)	55	7
NSF ADVANCE Leadership Awards	2001	13	0	13
TOTAL (includes duplicate counts)		**191**	**127**	**64**

** website information ends in 2000*
*** award was shared in 1998; brings total to nine individuals*
**** award was shared in 1991, 1993, 1994, 1996, and 2000; brings total to 15 individuals*
Note: Some individuals were recognized by more than one program/organization

Award	Number	Public	Private	HBCUs	HSIs	MSIs	PWIs	Other
NSF PAESMEM	58	38	20	8	5	4	41	2 public schools
NAE Gordon Prize	1		1				1	
AAAS Mentor Awards*	9**	8	1			1	8	
AAAS Lifetime Mentor Awards*	15***	7	8	2	1	1	11	
QEM Giants in Science Awards	32	17	15	17	3	1	11	3 fed. agency 2 industry
Sloan Minority Ph.D. Program	30	20	10	2	2	2	24	
NSF ADVANCE Leadership Awards	12	6	6	1	0	0	11	1 scientific organization
TOTAL (includes duplicate counts)	157	96	61	30	11	9	107	

** website information ends in 2000*
*** award was shared in 1998, bringing total to nine institutions*
**** award was shared in 1991, 1993, 1994, 1996, and 2000, bringing total to 15 institutions*

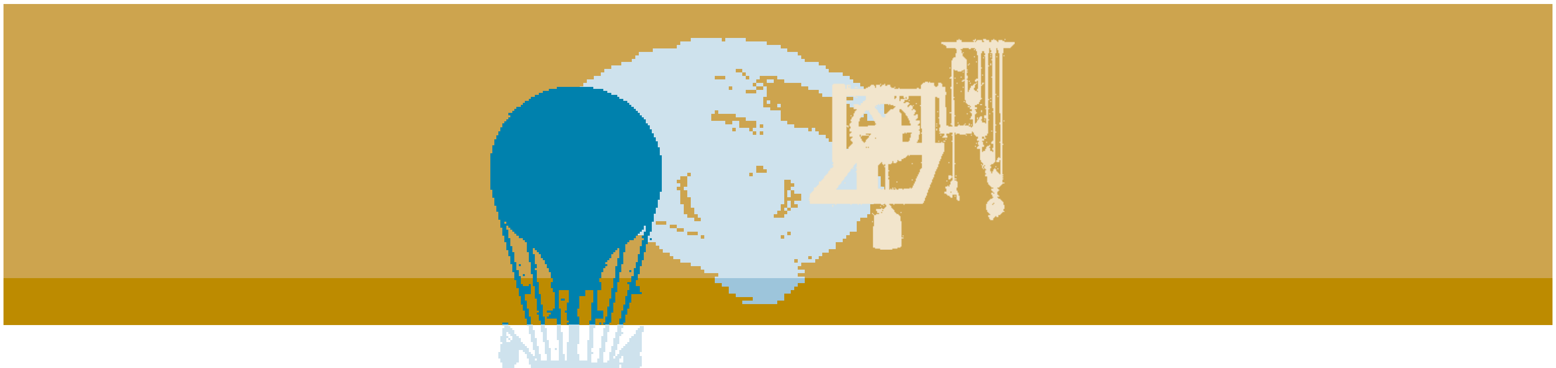
Note: Institutions with multiple recipients are counted only once for a given program (applies to QEM & Sloan); however, several institutions repeat across program.

Appendix A (cont'd.)

Summary Data on National Recognition Awards for Individuals and Institutions/Programs

Award	# of Awards	Award Recipients	Educational Level	Focus
PAESMEM Institutional Awards	49	34 colleges & universities (23 public, 11 private) 1 public school 1 industry 8 organizations 2 partnerships 3 statewide partnerships	K-12 16 K-12 + UG 9 K-12 to G 7 2-year to 4-year 1 UG 10 UG & G 3 G 3	21 Minority focused 10 Women 5 Minority & Women 3 Disability 3 American Indian 1 Hispanic 1 Hispanic & Native American 2 Public school 1 "Second tier" student focused 2 Unspecified
QEM Program and Partnership Awards	24	5 programs 6 organizations 8 partnerships 5 statewide partnerships	K-12 12 UG 7 G 3 Community 2	13 Minority 7 African American 4 Hispanic
TOTAL (includes duplicate counts)	73	34 colleges and universities 1 public school 1 industry 14 organizations 10 partnerships 8 statewide partnerships	K-12 28 K-12 + G 9 K-12 to G 7 2-year to 4-year 1 UG 17 UG & G 3 G 6 Community 2	34 Minority 10 Women 5 Minority & Women 3 Disability 7 African 3 Native American 5 Hispanic 1 Hispanic & Native American 2 Public school 1 "Second tier" student focused 2 Unspecified

Source: QEM, April 2003



Appendix B

Program Profile Template 2002

I. **DESCRIPTION**

A. Contact Information
Name ____
Title ____
Organization ____
Address ____
Telephone ____
Email Address ____

B. Description of Program/Policy/Research
Type (e.g., Comprehensive LSAMP, PGE, AGEP, PWD, mentoring, paid summer research/internships, teacher professional development)

____

Start Date: (d/m/y) _____________
End Date: (d/m/y _____________
Years of Duration _____________

Goals/Objectives (check all that apply)
❏ Recruitment
❏ Retention
❏ Job Placement
❏ Education/career development
❏ Utilization
❏ Promotion/advancement of underrepresented group
❏ Other, please specify

Funding
Start-up dollars
(ballpark, e.g., tens of thousands, six figures) ______
Current operating budget (ballpark) ______

Source of Funds (check all that apply)
Corporate________
Federal__________
State____________
University________
Private Foundation
Other, please specify_______

C. Target Population
Were the original goals/objectives accomplished?

____

What is the evidence of success?
(Please specify the types of data to support your evidence)

____

What worked? (e.g., increased enrollments or retention)

____

Cite an example(s) of change to the program based on evaluation results

____

What did not work?

____

ADAPTATION/SCALE-UP

A. Has the program/policy/research been adapted in other places?
_____No
_____Yes, please indicate where

B. Resources Needed to Adopt Program/Policy
Dollar amount _______________
Staffing ___________________
Top level commitment (specify level) _________
Other, please specify _________________________________

C. Planning/Development Time to Implement Policy or Program
Less than one year__________
One to two years __________
Other, specify __________

D. Time Needed for Measurable Impact
Less than one year__________
One to two years___________
Other, specify______________

E. Critical success factors for adaptation (check all that apply or rank order)
❏ Perceived need
❏ Individual leadership
❏ Institutional commitment
❏ Corporate commitment
❏ Technical assistance, e.g., training
❏ Customized to local needs
❏ Starting small is critical before expanding
❏ Evaluation is part of program
❏ Fund-raising
❏ Other, please specify_________________________________

F. Unanticipated Challenges and Successes (check all that apply or rank order)
❏ Perceived need
❏ Individual leadership
❏ Institutional commitment
❏ Corporate commitment
❏ Technical assistance, e.g., training
❏ Customized to local needs
❏ Starting small is critical before expanding
❏ Evaluation is part of program
❏ Fundraising
❏ Other, please specify_________________________________

G. Other comments: ____________________________________

Appendix C

Exemplary and Promising Programs in Higher Education

A total of 124 programs/activities were nominated through the Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology Development (CAWMSET) Public Hearing Testimony on Best Practices (July 1999) and by the BEST Blue Ribbon Panel on Higher Education. All were invited to complete an updated BEST Program Profile that documents program goals/description, impacts and adaptation/scale-up capability. Forty-one responses were submitted, but five were eliminated, leaving 36 programs for consideration (approximately 30 percent). Seven were ultimately judged to be exemplary and five to be promising. They are profiled here.

KEY

Focus/Group
precollege/transition
Undergraduate
Graduate
Early career
underrepresented minority
Women
PWD = persons with disabilities
STEM = science, technology, engineering, and mathematics
Engineering
Mathematics
Sciences
All disciplines

Sector Addressed
Education
Government
Business/industry
nonprofits/foundations

Undergraduate Degree Milestone

University of Michigan Women in Science and Engineering Resident Program (WISE-RP)
Focus: Undergraduate, women, STEM, engineering
Sector: Education

Brief Description

A living-learning community designed to provide academic and personal support to first-year undergraduate women interested in pursuing academic majors and careers in the sciences, mathematics and engineering, and to facilitate the retention of women in these academic fields.

Key Components

Informal and formal study groups (the latter including upper division or graduate student facilitators); workshops on academic- or career-oriented issues; student research experiences in science, engineering and mathematics; optional student co-enrollment in core engineering, science and mathematics classes, and course sections that are predominately all-female; peer support, role models and knowledge to negotiate the complex academic environments of their chosen disciplines; institutional commitment; collaborations between academic affairs and student affairs; rigorous evaluation using a variety of approaches; and staff with backgrounds in higher education.

WISE-RP is a residential program dedicated to the retention of women who share majors and career interests in science and engineering. Developed in 1993, the program is a living-learning community of scholars averaging 120 first-year and 33 sophomore-junior women interested in science, engineering and mathematics. It has become a particularly supportive environment for underrepresented minority women, who constitute 30 percent of WISE-RP students.

After an initial three-year grant from the U.S. Department of Education Fund to Improve Post-Secondary Education, WISE-RP was fully institutionalized with funding from the University's College of Engineering, University Housing Division and Office of the Vice President for Research. Over its history, program participants have earned science degrees at significantly higher rates than other students; 75 percent compared to 49 percent of female controls and 40 percent of male controls. In addition, annual end-of-year surveys, focus groups and alumnae testimony indicate that living-learning students are more likely to discuss socio-cultural issues with other students and to interact with faculty on a more frequent basis. WISE-RP positively affects student confidence, academic achievement and retention in science, engineering and mathematics.

WISE-RP has received the Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring, and the National Science Foundation Recognition Award for the Integration of Research and Education. The program continues

Undergraduate Degree Milestone (cont'd.)

to be consulted by WISE living-learning programs across the U.S., attributing success to institutional commitment, collaborations between WISE program staff/faculty and student affairs, and rigorous evaluation of processes and outcomes.

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Gateway Engineering Education Coalition
Focus: Undergraduate, Engineering
Sector: Education

Brief Description

Partnership of nine institutions designed to change the engineering educational process and broaden diversity in engineering fields and careers.

Key Components

Curriculum innovation and adaptability; professional development of faculty and students; broadening diversity to enrich learning for all; technology as a tool to further the learning; embedded assessment and evaluation; and Freshman Participating in Engineering Design Experience.

Initiated in 1991 by a group of 10 institutions, the Gateway Coalition now encompasses nine universities, which show continuous progress on 40 measures including student retention, GPA and completion of the baccalaureate in engineering. Begun to address the freshman-sophomore culture of engineering, the Gateway Coalition has been a driver of change in junior-senior coursework; the development of leadership, presentation, organizational and management skills, and the faculty culture.

Since 1992, Coalition members (notably, Columbia, Cooper Union, Drexel, NJIT, Ohio State, Polytechnic) have institutionalized various curricular changes in the teaching and learning of almost 600 undergraduate engineering courses, many offered in integrated interdisciplinary (humanities and science) team settings using new media technologies. By 2002, almost 4,000 freshmen nationally were participating in such redesigned curricula. (www.gatewaycoalition.org)

Data on year-to-year student retention and graduation of women, underrepresented minorities, and all students participating at Gateway Coalition institutions indicate significant improvements over time and compared to national averages — while increasing the network adapting course innovations. After a decade of tracking outcomes, it is clear that the Coalition has redefined engineering education by embedding students in a "learning by doing" and "learning in context" experience that stresses applications, ethics and breadth of skills required of an emerging engineering professional.

By effectively disseminating its design approach, the Coalition has spread its repository of resources to faculty nationally and internationally, to community colleges and high schools, and through the respective engineering professional societies. For this and a sustained record of accomplishment, Dr. Eli Fromm, a principal co-founder of the Gateway Coalition, was awarded the 2002 Bernard M. Gordon Prize for inventiveness in engineering and technology education by the National Academy of Engineering.

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University of Maryland, Baltimore County (UMBC)
Meyerhoff Scholars Program
Focus: Minorities, STEM
Sector: Education

Brief Description

Comprehensive scholarship program to increase the production of bachelor's degrees in STEM by African American undergraduate students who intend to attain STEM Ph.D.s and M.D.s.

Key Components

Recruitment; financial support; summer bridge; program values; study groups; personal advising and counseling; tutoring; summer research internships; mentoring; faculty involvement; administrative involvement and public support; family involvement; community service; and evaluation.

The Robert and Jane Meyerhoff Foundation established the Meyerhoff Scholars program in 1988 to address the dearth of African Americans, especially males, preparing for careers in science and engineering. Since its inception, the program has become a model for nurturing academic excellence in a public university.

From the original 60 nominations and class of 19, Meyerhoff in 2002 attracted 1,700 nominations for 50 freshman slots. The program enrolls a total of 200 students supported by private, federal and university funds. To date, 298 students have graduated from the program, with half currently enrolled in Ph.D., M.D., M.D./Ph.D., M.S., and other programs. More than 100 alumni have completed graduate degrees.

Through a database that supports formative and summative evaluation, and publication of findings in books and the journal

Undergraduate Degree Milestone (cont'd.)

literature, the Meyerhoff Scholars Program has documented the dimensions of its success. Compared to matched samples, Meyerhoff students have achieved higher grade point averages, graduated in science and engineering majors with retention rates almost twice as high, and gained admission to graduate school at three times the frequency. Due to a legal challenge to targeted interventions in the state of Maryland, the program is now open to all students regardless of race or ethnicity.

The Meyerhoff Scholars Program is a rich source of experience for adaptation. More than 15 colleges and universities have visited the program to review the model and glimpse its workings up close. Surveys and interviews with program participants reveal the following critical ingredients: being part of a community (i.e., with responsibility for those who follow) contributes to academic success; financial support; summer research internships; how high faculty expectations increase student sense of progress; and changed faculty expectations of African American students, positive ripple effects on science in particular and the campus in general.

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Graduate Degree Milestone

National Consortium for Graduate Degrees for Minorities in Science & Engineering (GEM)
Focus: Graduate/Undergraduate, Minorities, STEM
Sector: Education/Business/Government

Brief description

A consortium of 89 universities and 52 employers to increase minority participation at master's degree and doctoral levels in engineering and science in higher education and industry.

Key components

Fellowships to undergraduate and graduate students and professionals; summer internships; mentoring.

The mission of GEM is to enhance the nation's workforce by increasing the participation of African Americans, Native Americans and Latinos at the master's and doctoral levels in engineering and science. Chartered in 1976 and headquartered at the University of Notre Dame, GEM offers M. S. engineering, Ph.D. engineering and Ph.D. science fellowships to students and professionals. Summer internships, which include mentoring for teaching and industry careers, are built into the fellowship experience.

GEM engineering alumni exceed 2,200 in engineering at the M.S. level and over 120 at the Ph.D. level (with twice as many engineers as scientists). Retention of GEM Fellows to degree is over 80 percent in engineering and 66 percent in science. Today, over 450 GEM Fellows are supported annually.

Alumni and employer/supervisor surveys indicate that the GEM fellowship facilitates both the choice and the transition to graduate study and the workforce. In the process, the program strengthens the collaboration between universities and industry, especially in fulfilling their diversity needs. These needs extend to leveraging K-16 programs, targeting college juniors and professionals in the technical workforce for graduate recruitment and providing access to a network of university and employer members. Above all, GEM works closely with institutions identified as leaders in workforce diversity.

The key to GEM's success is the commitment of university presidents, government officials and corporate CEOs to the development of diverse technical talent at the MS and Ph.D. levels.

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Faculty Milestone

Compact for Faculty Diversity
Focus: Graduation, Minorities, STEM
Sector: Education

Brief description

A partnership of the New England Board of Higher Education, the Southern Regional Education Board and the Western Interstate Commission for Higher Education designed to retain and graduate minority doctoral students who are committed to becoming faculty at postsecondary institutions.

Key components

Committed faculty mentors and program directors; expert consultants providing information and training; committed institutional administrators and state executives; broad-based webs of support that extend beyond the boundaries of campuses; peer interaction.

Since 1980, the composition of the faculty population has remained at less than 10 percent underrepresented minority. The Compact is a regional program that has taken on national importance as a vehicle for addressing this largely intractable problem. The Compact for Faculty Diversity is a partnership designed to recruit, retain and graduate minority (African American, Hispanic/Latino and Native American) doctoral students committed to faculty careers in higher education.

Since its inception in 1994, the Compact has grown tenfold from 50 doctoral students to almost 600 participating doctoral scholars, with 200 completing the Ph.D. Seventy percent of these professionals are employed as professors, administrators or postdoctoral researchers, with 75 percent concentrated in science, engineering and mathematics disciplines.

An evaluation of the Compact in 2000 revealed that multiple interventions have contributed to its success: mentoring and mentor training, long-term financial assistance, professional development and networking, strategies for succeeding in graduate school and preparing for the professoriate, career placement and the role of recognition. The Compact's annual Institute on Teaching and Mentoring is the nation's largest gathering of doctoral students of color aspiring to faculty careers. The National Science Foundation has adopted the Institute model for use in the multiple sites participating in the Alliances for Graduate Education and the Professoriate program.

Today, through state and institutional partnerships, the Compact operates in 36 states with support from the National Institutes of Health, National Science Foundation and U.S. Department of Education programs. However, like many state-based programs, anti-affirmative action policies pose a growing challenge to the continuing efforts of the Compact in the face of individual leadership and institutional commitment. The flow of resources has been curbed and programs such as the Compact for Faculty Diversity are in jeopardy.

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Preparing Future Faculty (PFF)
Focus: Graduate, All, STEM
Sector: Education

Brief description

A configuration of ideas and a national program involving 43 degree-granting institutions and more than 250 partner institutions to transform how doctoral programs prepare future faculty members.

Program description

Cluster of collaborating doctoral degree-granting institutions or departments; addresses the full range of faculty roles and responsibilities; multiple mentors.

The overarching goal of Preparing Future Faculty (PFF) programs has been to improve the quality of undergraduate education by changing the professoriate through new Ph.D. faculty. It has done this by preparing aspiring faculty members for careers focused on a full range of roles and responsibilities in academic institutions which might have varying missions, diverse student bodies and different expectations for faculty. A corollary hope was that the undergraduates taught by PFF-trained faculty would become elementary and secondary school teachers, thereby inspiring exemplary teaching and learning at the precollege level.

PFF has had three general phases over its life: developing alternative models of faculty preparation 1993-1997); institutionalizing those models (1997-2001); and launching model programs in science and mathematics departments in collaboration with the major disciplinary associations (1998-2002).

The impacts of PFF have been extensively documented since 1996 through surveys, interviews, focus groups and an NSF-funded evaluation, in a series of reports published by the Association of American Colleges and Universities (see www.preparing-futurefaculty.org/pffweb.publications.htm). Benefits include: learning about faculty roles and activities; developing expertise as a teacher to facilitate student learning; understanding the fit between various work settings and one's talents and aspirations; growing a network of professional colleagues; increasing competence and self-confidence; and clarifying and confirming career choices. Alumni believe that their doctoral experience was enriched by PFF and feel more sophisticated about faculty life.

Faculty Milestone (cont'd.)

Core features of PFF are a cluster anchored by a Ph.D.-granting institution or department collaborating with various partner institutions or departments; comprehensive exposure to faculty roles and responsibilities; and multiple mentors for doctoral students to receive reflective feedback on teaching and service activities as well as research. PFF alumni and program directors attribute success of the program to: graduate student interaction, autonomy and professional development; communication of what "professional" means as a scholar and faculty member; attention to diversity and discussions that cross disciplinary lines; and support and commitment from key individuals — faculty, deans, mentors — that breeds enthusiasm and synergy among students.

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Multiple Milestones

Partnership for Minority Advancement in the Biomolecular Sciences (PMABS)
Focus: Precollege through Graduate, Minorities, Science
Sector: Education

Brief description

Consortium of seven Historically Black Colleges and Universities and a research university (UNC-Chapel Hill) in North Carolina to reform bioscience education and increase underrepresented minorities' participation in the biomedical sciences.

Key components

Faculty professional development; undergraduate/graduate student development; equity of access to bioscience knowledge; sustained collaborations; curriculum reform; teaching/research/technology internships; committed administration.

PMABS is a unique consortium of eight universities in North Carolina. Since 1989, the Partnership has evolved a process approach to developing diversity in bioscience careers through a spectrum of complementary programs spanning secondary science education to postgraduate study. PMABS involves faculty development, infrastructure revitalization, curriculum modernization, technology adoption and collaborations for student development. (For details, see ww.unc.edu/pmabs)

The overarching goal of PMABS is to increase the number of knowledgeable, motivated underrepresented students (80+ percent African American, 67 percent women) attaining degrees and pursuing careers in bioscience disciplines. Thus, the Partnership is marked by its scope of activity, which demonstrates the effectiveness of large-scale collaborations between diverse academic cultures.

Formative and summative evaluation, including interviews with student, faculty and administrators attest to the Partnership's impact. Over 6,000 students and 100 courses have benefited from the program. Currently, over 2000 students are reached through Partnership components: Seeding Postdoctoral Innovators in Research and Education (SPIRE), Collaborative Electronic Learning Laboratory (CELL), BioScience Sharium and Traveling Science Laboratory Program.

Through public and private funding, PMABS has institutionalized, yet customized its resources. The sharing of resources among institutions, departments, faculty and students of various ages across the state is an innovative model for adaptation in a broad field. The use of information technology to support inquiry-based pedagogy, the introduction of summer research externships and the transition of students into faculty positions at U.S. institutions of higher education all attest to the holistic quality of the program.

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Promising Programs in Higher Education

Undergraduate Admissions Milestone (precollege)

Center for the Advancement of Hispanics in Science and Engineering Education (CAHSEE) Science, Technology, Engineering, and Mathematics (STEM) Institute
Focus: Precollege, Minorities, STEM
Sector: Education

Brief description

Five-week summer program designed to prepare 5th-11th graders to enter and succeed in S&E departments at colleges of their choice.

Key components

Rigorous college level accelerated courses taught by Latino S&E students that emphasize abstract skills; collaborative learning; high expectations; civic responsibility; annual evaluation.

In the CAHSEE suite of Latino-focused programs, the STEM Institute offers rigorous coursework that enhances problem-solving skills, e.g., abstraction, logic, visualization, model-building, pattern recognition and synthesis. The methodology includes collaborative learning, high expectations and weekly discussions of civic responsibility and the importance of success.

In operation since 1991, the Institute has enrolled over 1,000 precollege students (with parity by gender) and currently supports a total of 220+ students per year at four urban sites — Washington, DC, New York City, Chicago and Lawrence (MA). Ninety percent of the participants have enrolled in science or engineering majors with virtually no attrition. Several alumni are pursuing doctoral degrees. While a 10-year evaluation is in progress, the STEM Institute has been adapted and expanded to Los Angeles, San Jose and El Salvador (where the program has produced international math and physics medalists). Funding, facilities and staff-to-student ratio are ongoing challenges.

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Undergraduate Degree Milestone

Texas A&M Clusters of Resident Engineering Women (CREW)
Focus: Undergraduate, Women, Engineering
Sector: Education

Brief Description

Retention program that clusters first-year female engineering students in residence halls to increase retention rates and provide a conducive learning environment.

Key components

Student resident advisors; monthly academic seminars and social events.

CREW is a retention program in which upper-division engineering students serve as resident advisors. Initiated during the 1992-93 academic year, the program succeeds in increasing retention rates (while maintaining GPAs) of women freshman engineers through an environment that builds a cohesive peer support system as a foundation throughout one's professional career.

While evaluation results have not been published, CREW participants average 84 percent first-year retention (vs. 70 percent for the whole college) and 2.8 GPA (vs. 2.6). CREW has been adapted at the University of Texas, with program information disseminated through the Woman in Engineering Programs & Advocates Network (WEPAN) and the National Association of Minority Engineering Program Administrators (NAMEPA). Almost 90 women (20 percent underrepresented minority) are participating in 2002-03, with funding from corporate, foundation, state and university sources.

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Multiple Milestones (Undergraduate Admissions — Advanced Degree Completion)

Stevens Institute of Technology Lore-El Center for Women in Engineering and Science
Focus: Precollege/Undergraduate, Women, STEM
Sector: Education

Brief description

Formal women in engineering and science initiative offering professional and academic programs at precollege, undergraduate, graduate and national levels.

Key components

Residential program; professional development seminar series; academic advising; person-to-person industry mentoring program; scholarship and research opportunities; student employee program; student-group and university department collaborations; 2nd-12th grade precollege programs.

Since 1978, Stevens has provided access for women to careers in engineering and science. With the establishment of the Lore-El Center in 1999, Stevens offered a residential facility to house 10 undergraduate women students and support 275 through Center programs (which is roughly two-thirds the total female undergraduate population). The Center's freshman retention rate of 93 percent exceeds that for male students.

Mentoring and academic advising are cornerstones of Lore-El Center success. ECOES — Exploring Career Options in Engineering and Science Summer Program — is a national initiative targeted to male and female students in grades 10 and 11, which has attracted over 2,000 women participants since 1979. Today, a student employee program that orients students to the world of work links the precollege to undergraduate experience in collaboration with national programs of the Society of Women Engineers and the National Society of Black Engineers.

The Lore-El Center informs women about engineering and science career options and facilitates seamless transitions to them. In recognition, the Center was a recipient of the Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring.

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Promising Minority Programs Impacted by State Policies

Texas Louis Stokes Alliance for Minority Participation (TX LSAMP)
Focus: Undergraduate, Minorities, STEM
Sector: Education

Brief Description

Comprehensive STEM program designed to increase Bachelor's degrees awarded to underrepresented minority students.

Key components

Financial aid; summer bridge programs; student research experiences; student cohorts; "equalizing" learning opportunities; informal networking; rigorous evaluation.

On the National Science Foundation roster of LSAMPs, the TX LSAMP (headquartered in the Texas A&M System) is distinguished by its goal of doubling the number of baccalaureate degrees awarded to underrepresented minority students. While falling short in Phase 1 (1991-97), participating institutions in the alliance nonetheless enrolled over 7,000 STEM students while consistently retaining and graduating at almost double the rate of non-AMP students proportions of each cohort (see www.amp.tamu.edu).

Phase 2 of the TX LSAMP (1997-) was impeded by the Hopwood Decision, which affected statewide policies on admissions, financial aid awards and academic program targeting. Much of the hard-won ground gained during Phase 1 was lost. Yet several components of TX LSAMP speak to the efficacy of its design, including summer bridge experiences that assist in the transition to college, undergraduate research with STEM faculty, peer teaching assistance in the first core course, equalizing dialog between community college and university faculty to enhance the student transfer rate, and improved academic advising.

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UCLA Center for Excellence in Engineering and Diversity (CEED)
Focus: Precollege through Graduate, Minorities, STEM
Sector: Education

Brief Description

Comprehensive K-20 STEM program for the development, recruitment, retention and graduation of underrepresented engineering students.

Key components

Recruitment, counseling/advising, open house, summer bridge freshman engineering course, clustering, academic support services, summer internships, scholarships, corporate roundtable, student organizations.

Through UCLA's Henry Samueli School of Engineering and Applied Science, CEED since 1983 has supported comprehensive K-20 STEM education for the development, recruitment, retention and graduation of underrepresented engineering students. The CEED portfolio ranges from undergraduate efforts, including the Mathematics Engineering Science Achievement (MESA) Engineering Program and totaling over 230 students (mostly Latinos); to precollege and parental programming, via MESA, serving almost 2,000 students (African American, Latinos, Asians and whites); to teacher training provided to more than 50 teachers in the Los Angeles and Inglewood unified school districts; and graduate support to 23 students.

This synergy across levels of education persists to this day due to combined corporate, federal and university funding. Retention rates and GPAs of CEED freshman have exceeded non-participants at UCLA and national averages for the last decade. With Proposition 209 prohibiting the use of race in admissions to California institutions of higher education beginning in 1997, CEED worked to restore the two-thirds decline in underrepresented engineering students to pre-209 levels. Today, half of the freshman cohort earns degrees in engineering, a striking accomplishment in any environment.

CEED has spawned other intervention programs on the UCLA campus. With support from the Provost, in conjunction with the University of California Office of the President, engineering industry and federal agencies (especially NSF), the commitment to diversity in engineering can be realized. CEED and its director have garnered several public and private recognition awards. Leadership, commitment, evaluative data for tracking student progress and multi-year funding from diverse sources are essential elements. State budget shortfalls and the political climate are persistent enemies.

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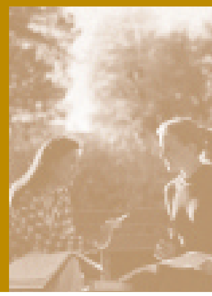

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