RECRUITMENT AND RETENTION OF UNDERREPRESENTED MINORITY GRADUATE STUDENTS IN COMPUTER SCIENCE

Report of a Workshop March 4-5, 2000

BY WILLIAM ASPRAY AND ANDREW BERNAT

AUTHORS:
William Aspray and Andrew Bernat

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1. INTRODUCTION

Graduate enrollment numbers and doctoral degrees awarded in computer science have been persistently low among certain minority populations (African Americans, Hispanic Americans, Native Americans, and Pacific Islanders) in the United States since graduate programs in computer science were first offered in the 1960s. This report has been prepared to assist those involved in computing-related programs in research universities who want to improve their recruitment and retention of minority graduate students.

The body of the report offers 25 practical suggestions for departments to consider. Each contains a general discussion followed by a recommended course of action. Scattered through this discussion are examples of successful programs and new programs that seem promising, along with contact information for those who want to explore further.

The 25 suggestions are grouped under the following headings:
A. Recruiting Underrepresented Minority Students Into Your Graduate School Program
B. Facilitating Early Success in Your Graduate School Program
C. Retaining Students in Your Graduate Program
D. Organizational, Financial, and Structural Issues for Research Departments

There are four appendices:
A. Graduate education data on underrepresented minorities over time, taken from the annual Computing Research Association Taulbee surveys.
B. Lists of the principal minority-serving institutions of higher education in the United States, with their URLs.
C. Common objections a department might confront when considering action to increase diversity, and how to respond to them.
D. A list of websites and publications on mentoring.

Several points need to be emphasized:
• It will take a measure of commitment over a period of time for a department to realize strong positive results. At first, progress is likely to be slow and require intensive effort. The task will become easier as a critical mass of minority students is built up and the department institutionalizes successful practices.

- Many of the suggestions for recruiting and retaining minority graduate students discussed here are simply student-friendly actions that can improve the environment for all students.
- This report focuses on practical suggestions that can be implemented today. However, the knowledge available in this area is highly imperfect, and the recommendations suggest a research agenda that might warrant additional study. For example, it would be useful to do research to identify the skills that students authentically need to succeed in graduate school and their careers, or to experiment with various admissions criteria that rely less heavily on the "objective" criteria of grades and standardized tests. (The National Science Foundation organized a cyberconference in 1999 to establish a research agenda on minorities in information technology. The issues that emerged from that conference include, but are broader than, those covered in this report. See http://www.cise.nsf.gov/itminorities.html for more information about the NSF research agenda.)
- The recommendations are derived from comments by a number of computer scientists, diversity coordinators, and professional program evaluators who have in-depth experience in the recruitment and retention of minority graduate students. We have not undertaken any new systematic and methodological research for this report. Many of the claims made in the report are based on opinions expressed by the workshop participants, without citing any empirical studies.
- The recommendations are intended to be generic and are given without substantial detail. Because of widely varying local circumstances, it is impossible to give detailed discussions that work for everyone. Where examples of successful or promising practices are provided, interested readers are encouraged to talk directly with the organizations that sponsor them.

The principal source of material in this report is a workshop held March 4-5, 2000 in San Antonio, Texas. The workshop was organized by the Coalition to Diversify Computing, which is a joint venture of the Association for Computing (ACM), Computing Research Association (CRA), and the IEEE Computer Society. This project was funded by the Education, Outreach and Training Partnership for Advanced Computational Infrastructure (EOT-PACI), and a National Science Foundation grant awarded to the Computing Research Association for the study on the supply of information technology workers.

The workshop co-chairs were William Aspray, Executive Director of CRA, and Andrew Bernat, a computer science professor at the University of Texas at El Paso and co-chair of the Coalition to Diversify Computing. Jean Smith of CRA provided editorial support.

2. PRACTICAL ADVICE FOR GRADUATE DEPARTMENTS

A. RECRUITING UNDERREPRESENTED MINORITY STUDENTS INTO YOUR GRADUATE SCHOOL PROGRAM

1. Cultivate undergraduates for a research career.

Even highly performing undergraduate students do not necessarily understand what research is about. Their success is based on having learned how to successfully complete courses. This means they have learned how to study laid-out coursework and master well-known solution methods. They may have received little training in how to think on their own, invent new problems, and figure out ways to solve problems in relatively unconstrained situations. They are often very concerned about time commitments and do not see how research fits into their career plans. To stimulate their interest in a research career, students must be explicitly shown the nature, value, and intrinsic rewards of research.

Many minority students have a limited chance to learn about research because they attend undergraduate institutions where research activity is limited. The isolation that many undergraduate minorities experience in school also diminishes their chances to learn, in informal ways from faculty and other students, about the joys of research, the nature of a research career, and the means to achieve it. (For a telling discussion of why minority and other undergraduates with high aptitudes abandon plans for a scientific or engineering career, see Elaine Seymour and Nancy Hewitt, *Talking About Leaving: Why Undergraduates Leave the Science*s, Westview Press, 1997.)

A number of universities and professional organizations have established programs to provide minority and other undergraduate students first-hand experience in research. This report does not present a detailed analysis of what makes these programs successful, but it describes some relevant programs offered by the University of California at Berkeley, the University of Texas at El Paso, Oak Ridge National Laboratory, and the Coalition to Diversify Computing. A department interested in building a program modeled after any of these should contact the organization directly to discuss details of organizational structure, problems, costs, personnel requirements, and measured success.

One of the most successful programs is the SUPERB (Summer Undergraduate Program in Engineering Research at Berkeley) program at the University of California-Berkeley, which offers underrepresented engineering students the chance to gain research experience by

participating in research projects with engineering faculty and graduate students. The program is targeted at students of color, first-generation college students, educationally disadvantaged students, and students from Minority Serving Institutions. More than half of the students who have gone through the SUPERB program since it was initiated in 1990 have continued on to graduate school. Over the years, more than half of the electrical engineering and computer science faculty at Berkeley have served as mentors in the program. Students spend eight weeks on campus working on a research project. They are assigned both a faculty and a graduate student mentor. They receive a stipend, room and board on campus, and travel expenses. Berkeley has found that it gains an advantage in recruiting the best of these students to its own graduate program, based on their involvement in the SUPERB program.

Our next example is a program conducted during the regular academic year within a Minority Serving Institution. The Systems and Software Engineering Affinity Laboratory (SSEAL) at the University of Texas at El Paso (http://www.sseal.utep.edu) offers a program designed to meet the various objectives of the undergraduate research experience in a framework that is practical for both faculty and students. The SSEAL model provides a methodology and infrastructure for increasing the number of students who can benefit from an undergraduate research experience. In particular, it provides a good opportunity for students who have potential, but lack the confidence to engage in research. The model supports the development and management of large research groups.

SSEAL is essentially a highly structured, non-hierarchical, cooperative group effort to enhance faculty and student performance. The SSEAL model is comprised of six major components (Orientation, Research Project Framework, Defined Deliverables, Weekly Meetings, Monthly Meetings, and Outreach Involvement) built on a cooperative learning paradigm and facilitated by an electronic framework. Using the cooperative learning paradigm as the basis for structuring research groups enables the UTEP faculty to design activities that develop the process and skills necessary for students to succeed in research. These include not only technical skills, but also written and oral communication skills, analytical skills, critical review, and other high-level thinking skills. As a result, students provide role models for each other, interact with faculty outside the classroom, are provided settings in which they can competently interact and discuss issues, see continual improvement in their abilities and skills, receive help in clarifying and maintaining their goals, and are actively engaged in learning.

Increasing numbers of industrial and government research laboratories also offer research experiences to undergraduate students during the academic year or in the summer. One example is the Department of Energy's Oak Ridge National Laboratory (ORNL), which partners with various majority- and minority-serving institutions to offer research experiences to undergraduate students. Its Research Alliance for Minorities Program has multiple facets:

- Research experiences at ORNL
- Enrichment experiences to develop research skills
- Special seminars to introduce research life at ORNL
- Assistance in course and career planning
- Opportunities to develop learning and study skills
- High-performance computing hardware and software workshops and support
- Collaborative research experiences between scientists at ORNL and faculty at minority-serving institutions
- Summary paper, oral presentations, poster presentation, daily journal, and website describing the research project
- Social and community activities
- Employment opportunities at DOE laboratories

Several other ONRL projects that provide research experiences for undergraduates have diverse participation, although they are not specifically targeted at underrepresented minorities. For example, in fiscal year 1999, 27 percent of the 123 students holding the ORNL Energy Research Undergraduate Laboratory Fellowships were from underrepresented minority groups. Of the 34 students in ORNL's Community College Initiative in Biotechnology, Computing, and Environmental Science, 23.5 percent were African American, 17.6 percent were Hispanic, and 5.9 percent were Native American.

The Coalition to Diversify Computing offers three programs to help cultivate students for a research career. CDC has recently established a graduate school workshop that travels to Historically Black Colleges and other Minority Serving Institutions to inform undergraduates of both the value and the tradeoffs of enrolling in graduate programs in computer science. Presentations by visiting graduate students and faculty detail what graduate school is like, how to apply, how to get financial aid, and the benefits of attending.

Two other CDC programs give students a chance to experience a research conference. Making the most of a conference requires more than registering and showing up. One needs to learn how to select appropriate sessions to attend, budget time, meet people with similar interests, and connect with others who might provide valuable career assistance. To help minority students learn these skills, CDC offers a Minority Networking Event prior to selected conferences in which a small number of faculty members meet with the minority students, walk them through the program, and give them guidance on these issues. Another CDC program provides travel funds for minority students to participate in technical conferences and gain experience in preparing and presenting a paper, exhibiting posters, and serving on conference committees.

ACTIONS: Provide undergraduates with opportunities for hands-on research with guidance from and interaction with faculty, staff, and graduate students who are experienced in research and committed to it. Build research opportunities into your programs for your

undergraduates, and offer summer research programs for undergraduates who are enrolled at institutions that do not conduct computing research. Seek out partnerships with government and industrial research laboratories to provide your undergraduates with additional research opportunities, and encourage your students to attend these programs or ones that are offered by other research institutions. Partner with organizations such as the Coalition to Diversify Computing to run graduate school workshops for undergraduates and give students fulfilling research conference experiences. Take advantage of the National Science Foundation's Research Experiences for Undergraduates Program. Write undergraduate research positions into your regular grants to funding agencies. Apply to private foundations and corporations to fund your undergraduate research experience programs.

2. Communicate to students the opportunities a doctorate offers for a fulfilling career and life.

Undergraduates may readily see the sacrifices involved in earning a doctorate, such as the many years of hard study and the loss of years in the workplace earning a good salary. However, they are unlikely to appreciate the full set of potential benefits of staying in school to complete this degree. Some of the benefits that should be mentioned to students include:

- The doctorate is the union card for a faculty position or a senior position in an industrial research laboratory.
  - This degree not only affects the highest position on the graduate's career trajectory, but also the nature of the work he is assigned and the compensation he receives from the day he enters the industrial world. There are significant salary differences based on education. The National Society of Professional Engineers has provided median salaries for engineers, based on highest degree: doctorate $92,800, master's $74,229, and bachelor's $66,874 (*1999 Professional Engineer Income Salary Survey*). The salaries for engineers in information technology are at the high end of the salary range for all engineers.
- People holding doctorates are generally given more responsibility than employees who hold only a bachelor's or master's degree; and they often have more independence in the workplace, more resources to work with, and greater freedom in choosing the projects they work on.
- The process of undertaking and completing the doctoral degree, as difficult as some students find it, can be very satisfying. It is often the first time in the student's life when he or she can explore a problem of personal interest and pursue it to the extent desired.
- A doctoral degree enhances stature and engenders respect.

Students should also be advised that it is never too late to pursue a doctoral degree. They can have this as a life goal, even if they have financial or family obligations that prevent them from graduate study immediately after college.

ACTIONS: Constantly reinforce the message to undergraduate students about the various advantages of undertaking doctoral study. Do this through student counseling, clubs, professional society chapters, student orientations, departmental brochures, and courses required for majors. Provide similar messages on recruiting trips and in exhibits at meetings attended by large numbers of minority students.

3. Involve your research university in partnerships with undergraduate and minority-serving institutions.

Such partnerships open up a rich source of new students for graduate school. The personal contact with the research university and its faculty will increase the likelihood that minority students at these undergraduate institutions will consider graduate education, and perhaps choose your school to pursue it. Faculty at minority-serving institutions like to ensure that their students will continue to have a supportive and enriching environment, and therefore prefer to send their students to a graduate school where they have contacts and some first-hand knowledge of the environment.

Relationships between faculty at the research university and students at these undergraduate institutions also benefit the graduate selection process. Many research departments are not equipped to properly evaluate the capabilities and qualities of students from these "non-traditional" sources. Through contacts with these schools—meeting some of the students, learning what they have been taught and what they have accomplished—your department can make a more informed judgment about their abilities to succeed in your program. Otherwise, you may be forced to rely on generic indicators such as grades and GRE scores. Apparent deficiencies in traditional academic credentials may be well compensated for by experiences these students have had outside the classroom in research or other settings, and it may be that these external factors are more accurate indicators of their likelihood to succeed in research programs.

Connections to the research universities will also help faculty at undergraduate institutions to direct their students to appropriate research institutions. Many highly qualified students at undergraduate institutions are open to teaching careers because they have had the advantage of personal contact with faculty at primarily teaching institutions who are teachers first and foremost. There may well be equally large numbers of students at the undergraduate institutions who could be attracted to research careers through exposure to research and research faculty.

It is probably easier to establish relationships between a research university and a minority-serving institution if the schools are geographically proximate. Then faculty and students can visit each other's campuses, attend each other's colloquia, give guest lectures in one another's courses, team teach with faculty from both campuses, provide cross-enroll-

ment, offer joint colloquia, and coordinate course offerings. In some cases, partnerships between the schools have been formed at the institution level, making it possible for the department simply to participate in an existing program. Even schools that are not geographically proximate can arrange for summer internships or course work for students at the other school, or offer faculty exchanges and places for faculty on sabbatical.

Such a partnership has recently been formed between the University of Colorado at Boulder and Tuskegee University in Alabama. The partnership is connected with two other programs at Colorado: the Alliance for Technology, Learning, and Society (ATLAS), which is a campus-wide initiative to infuse information and communication technologies into all aspects of academic life; and ATLAS's new certificate program in Technology, Arts, and Media (TAM).

Starting in fall 2000, the Colorado-Tuskegee partnership plans an annual exchange of one or more faculty members, and of undergraduate students, between the institutions. (The number of students will be 3 to 6 from each institution in the initial semester, and is expected to rise to 10 to 20 at a time.) The exchange is designed to implement a certificate program based on the TAM curriculum at Tuskegee, but adapted to local needs, including the development of courses in the TAM curriculum taken by students at both institutions that include the use of shared distance education. The institutions also will engage in shared research related to the TAM curriculum and to the use of technology in education. Support is being sought to help underwrite the costs of the faculty and student exchanges, curriculum development and delivery, research, and dissemination of the TAM curriculum—especially to other historically black colleges and universities. Planning is already underway for Tuskegee faculty to participate in Colorado's annual two-week summer faculty instructional technology workshop, starting this summer. Both institutions have a strong desire to use the partnership to foster a pipeline of students from Tuskegee who attend graduate school at Colorado, based in part on the shared interests in TAM, but also extending more broadly. Colorado's annual summer research program for minority students, SMART, is one component of this pipeline.

ACTIONS: Establish collaborative programs between your research department and undergraduate institutions—especially those with large minority populations—that bring the research faculty into contact with both the faculty and the students at the undergraduate institution. A list of Minority-Serving Institutions is provided in Appendix B, with URLs for most of them. Browsing the websites for departments that have common research interests is one way to begin the search for a partner. If some of the faculty members at the two institutions are already acquainted, this offers another excellent foundation on which to build a partnership.

4. Seek out new sources of minority students.

Most graduate departments do only a limited amount of searching to locate prospective stu-

dents from underrepresented minorities. Mostly, they rely on students to contact them, or they learn about students through their own faculty who have acquaintances at other institutions. Many minority students have paths through college that are different from those of majority students, and departments should not expect that these minority students will contact them or that the students will become known to them through their traditional set of research contacts. However, there are a number of places to contact minority students, some of which will also yield majority students who might otherwise not become known to you:

- Minority-Serving Institutions (Historically Black Colleges and Universities, Tribal Colleges, and Hispanic-Serving Institutions). (See a list of these schools in Appendix B.) Or consortia that include many minority-serving institutions, such as the NSF Louis Stokes Alliances for Minority Participation.
- Large public universities with good minority engineering programs, such as UCLA, the University of Michigan, and the University of Texas at Austin.
- Majority institutions with large minority enrollments, such as Arizona State University.
- Intervention programs with good track records, such as the Meyerhoff Program at the University of Maryland, Baltimore County. Almost all Meyerhoff students are African American and generally have at least a 600 score on the Mathematics SAT and a 3.0 high-school grade-point average. Meyerhoff students have historically obtained slightly higher grade-point averages in college than white students with comparable high-school credentials. Among Meyerhoff students in science and engineering majors, 94 percent graduate. Of the 1990-92 graduating classes of Meyerhoff students, 75 percent attended graduate or professional school. Of them, 60 percent were pursuing a doctorate in science or engineering. (For more information on the Meyerhoff Program, see Freeman A. Hrabowski, Kenneth I. Maton, Geoffrey L. Greif, Maton Greif Hrabowski, *Beating the Odds: Raising Academically Successful African American Males*, Oxford University Press, 1998.)
- Selective private colleges and universities that do an excellent job of enrolling a diverse student body, such as Harvard, Stanford, Wesleyan, and Yale Universities. For example, at Wesleyan, whose undergraduates have average SAT scores of about 1300, 26 percent of the students are people of color. According to one study, 75 percent of black students at a group of these selective colleges scored higher in the mathematics SAT than the national average for white test-takers. Black students from these selective colleges were five times as likely to earn professional degrees or doctorates as all black college graduates nationwide. (William G. Bowen and Derek Bok, *The Shape of the River*, Princeton, NJ: Princeton University Press, 1988, pp. 256-257.)
- Fellowship programs that focus on minorities in which computer science is included as a target field, such as the National Physical Sciences Consortium Fellowship, NSF Fellowship, GEM Fellows (from the National Consortium for Graduate Degrees for Minorities in Engineering and Science, Inc.), Ford Foundation Predoctoral Awards, and the Gates Millennium Scholars.

- Student organizations that focus on ethnicity in science, mathematics, and engineering, such as the National Society of Black Engineers, the Society of Hispanic Professionals, the Society of Mexican American Engineers and Scientists, the American Indian Science and Engineering Students, and the Society for Advancement of Chicanos and Native Americans in Science.
- In the workplace.
- Mathematics, physics, biology, and electrical engineering departments.
- Undergraduate research programs; for example, those that are supported through NSF's Research Experiences for Undergraduates (REU) program.

Statistics collected by the Engineering Workforce Commission of the American Association of Engineering Societies (*Engineering and Technology Degrees, 1999*) gives an indication of the pool of minority students available. In 1999, the nation's colleges and universities awarded baccalaureate degrees in computing disciplines to only 427 African Americans, 493 Hispanic Americans, and 41 Native Americans. However, if one is willing to draw entering graduate students from many engineering disciplines, not just computer disciplines, the pool is large. In 1999, the nation's colleges and universities awarded baccalaureate degrees in all engineering disciplines to 3,171 African Americans, 4,073 Hispanic Americans, and 328 Native Americans. Nationally, there are 22,695 African Americans, 25,815 Hispanic Americans, and 2,175 Native Americans enrolled in undergraduate engineering programs. (Engineering Workforce Commission of the American Association of Engineering Societies, *Engineering and Technology Enrollments*, fall 1998.)

(It is interesting to note that there is, presumably, significant attrition of minorities in these programs. Looking at the statistics on African American students, for example, the 3,171 graduates represent only about 13 percent of the number enrolled in undergraduate engineering programs. One would expect the percentage to be closer to 25 percent if these are four-year programs. The fact that the number of students enrolled in these majors has grown in recent years, and that the average time to graduation is greater than four years, partly explains the low figure of 13 percent. It might be useful to have additional breakdowns, such as graduation rates for minorities at Minority-Serving Institutions versus majority institutions.)

Over the next 15 years, the number of minority students at the undergraduate level is expected to increase significantly, both in absolute numbers and percentage of the student population. The Educational Testing Service has recently published a study on the future size and diversity of undergraduate enrollment through 2015. (Anthony P. Carnevale and Richard A. Fry, *Crossing the Great Divide*, Princeton, NJ: Educational Testing Service, 2000.) While the undergraduate population is expected to be more racially and ethnically mixed than it is today, it is still expected that African American and Hispanic American undergraduate enrollments will not match the percentage of these minorities between the ages of 18 and 24 in the U.S. population as a whole. It is projected that the total number of U.S. undergraduates will increase from 13.4 million to 16 million over the next 15

years, with 80 percent of the 2.6 million increase coming from additional minority enrollments. Minority enrollment is expected to increase from 29.4 percent to 37.2 percent of the total undergraduate enrollment. In California, Hawaii, New Mexico, and the District of Columbia, more than half of their enrolled undergraduates are expected to be minorities within 15 years.

ACTIONS: Actively pursue minority students by attending and exhibiting at conferences where they are likely to be present in large numbers, such as the national meetings of the minority professional engineering organizations. Recruiters should do preparatory work to learn what needs to be included in an exhibit to appeal to the targeted student population. In addition, exhibits should include information such as the flexibility of the program, support structures for students, faculty-student ratio, and financial support.

Establish contacts with a wide network of non-research universities that have large minority populations, or with consortia that include many of these institutions. Encourage your faculty to visit these campuses and establish professional contacts with their faculty.

5. Revise admissions procedures to accurately reflect the requirements needed to succeed in the program, and to enable students with a wide variety of backgrounds to qualify for admission.

The traditional "standardized" indicators are not good predictors of success in graduate school, nor were they ever intended to be. For example, the GRE Computer Science exam often simply judges whether a student has had a course or not—not whether the student has the ability to be an independent thinker suitable for a research career. Examine the profiles of your best students and decide what stands out in their backgrounds, personalities, skills, and the like that correlates with their success in research efforts; and then look for those same qualities in your applicants. The best indicator is often a recommendation from someone you know and trust—so make connections with faculty at the institutions that supply your students.

There is more information available about the nature of "objective" criteria used for undergraduate admissions than for graduate admissions. This information is at least suggestive about the situation for graduate admission. Two former presidents of Princeton and Harvard Universities provide statistics from 28 highly selective colleges and universities, indicating that only in the lowest band of SAT scores (under 1000) are the graduation rates (at the end of six years) lower with statistical significance than in higher bands of SAT scores. (William G. Bowen and Derek Bok, *The Shape of the River: Long-Term Consequences of Considering Race in College and University Admissions*, Princeton, NJ: Princeton University Press, 1998.) Moreover, there was no statistically significant difference between the higher bands of SAT scores in predicting graduation rates. For example, students who attained SAT scores

in the 1200-1299 band did not graduate at a statistically significant higher rate than students scoring in the 1000-1099 band. Moreover, the under-1000 band of SAT scores had a graduation rate of 83 percent, which is only four percent lower than students who received the highest grades on the SAT (above 1299). Bowen and Bok report similar findings when considering only African-American students: that only the lowest band predicts slightly lower, but still statistically significant, six-year graduation rates.

Statistics for the University of California-Berkeley show a similar pattern in its graduation rates. The Berkeley statistics do show some correlation between SAT scores and two other measures of academic success: grade-point average and mean-time-to-degree. The Berkeley study also indicates that SAT scores are tied to socioeconomic factors. (Gregg Thomson, Director, Office of Student Research, University of California, Berkeley, "Is the SAT a 'Good Predictor' of Graduation Rates? The Failure of 'Common Sense' and Conventional Expertise and a New Approach to the Question," California Association for Institutional Research, November 11-13, 1998.)

ACTIONS: Review the correlation between the success of your graduate students (completion rate, placement in good jobs, mean time to completion, percentages entering the professoriate at major research institutions, etc.) and various admission criteria (GRE scores, grades, strength of letters, previous kinds of research experience or work experience, maturity/age of student, etc.). Based on this analysis, reexamine the application procedures for graduate admission to ascertain if you are really asking for and measuring information that predicts success. Even better, make this correlation by looking at the student populations of a number of departments that you believe to be your peers. They may have better data than your department does on the success rates and criteria for success of students from underrepresented groups.

6. Adjust regulations and programs to better serve students who have "split careers" that involve moving back and forth between work and education.

Practices that are friendly to students with split careers will be friendly to many kinds of students, and they will attract mature students who may be better prepared psychologically—more dedicated and serious—for the rigors of graduate school. More and more students are selecting careers that involve interleaved work and school, or simultaneous pursuit of work and school, instead of the traditional model of completing one's formal education before entering the workforce. Minority students may be more likely than white males to have these kinds of split careers, so departmental procedures that are "split-career friendly" are likely to be minority-friendly. (See, for example, M.B. McAfee, "From Their Voice: American Indians in Higher Education and the Phenomenon of Stepping Out," a presentation to a joint conference of the American Association for the Advancement of Science, the EMERGE Alliance, chaired by The Georgia Institute of

Technology and the National Science Foundation, Atlanta, Georgia, February 25, 2000.)

Some minorities who have stopped school for a period of time, perhaps because they have financial or family obligations, have tried the non-academic world and then become rededicated to a formal education. Such students often do not measure up well against traditional admissions criteria used for students who complete their education all at once in the traditional way, but they may have experience, maturity, and dedication that are not reflected in grades and test scores.

ACTIONS: Review your department's admission criteria and rules about timing for successful progression in the graduate program to ensure that they are not biased against "split-career" students. In your admission criteria, focus on life and work experiences as well as performance in formal education. Make it easier for students to attend graduate school while working part- or full-time; for example, by being sensitive to their needs when scheduling courses, relaxing rules that limit time-to-completion of various milestones in the degree program, and allowing students to resume their financial-aid packages upon reentry to graduate school. Sensitize faculty members who are handling admissions to these issues. Publicize the flexibility of your graduate programs in places where split-career students might learn of them.

For additional information on recruiting minority graduate students, order the low-cost publication "Recruiting Graduate Students" from the National Consortium for Graduate Degrees for Minorities in Engineering and Science, Inc. (order online at http://www.nd.edu/~gem/html/compat/publications.html).

B. FACILITATING EARLY SUCCESS IN YOUR GRADUATE SCHOOL PROGRAM

7. Build communities of minority students within the graduate school.

Strong support systems are one of the most effective means of keeping students in school. This applies to undergraduate as well as graduate students, majority as well as minority students. Building communities of minority students can be particularly valuable because these students tend to feel relatively isolated in the majority institutions where most research and advanced education take place. If a student is the first in the family to attend college, as is often the case for minority students, he or she cannot turn to a parent for advice on coping with higher education. If the student attends a college that does not send large numbers of students to graduate school in computer science, as many minority students do, the student may be less sure of his abilities or of his suitability for higher education. The very culture of higher education may be unfamiliar, and it may take time and effort to absorb cultural norms and values. These norms and values need to be taught and

demonstrated explicitly. Minority students may also lack social outlets in which they feel comfortable; and anecdotal evidence suggests that social factors can play a large role in how much a student enjoys the graduate experience and how well he or she succeeds. Communities are perhaps the most effective means for teaching these lessons, and peer support is probably the most effective type of support. Sometimes the students can form such communities on their own, but it behooves the department to take an active interest in and provide aid to these communities. (The important role of faculty in teaching students about the research culture is discussed below, under Recommendation 12.)

The Black Graduate Science and Engineering Students (BGESS) group at the University of California-Berkeley is an example of a successful support group. The program was founded in 1987 by a group of African-American engineering students to nurture academic and social support systems for students of African heritage. In addition to serving as a support network for individual members of the community, BGESS has established a number of programs. BGESS students have served as mentors to high-school students. BGESS has established an annual science fair for students in the Oakland high schools, which has been well received by teachers because of the notable improvements in performance among the high-school students who participate in the science fairs. BGESS has also:

- established, and continues to maintain, the Future Black Faculty Database (http://bgfess.berkeley.edu/fbf/) of doctoral candidates, recent graduates, and professionals seeking positions in academia;
- been actively involved in the summer undergraduate minority research program SUPERB (see Recommendation 1);
- influenced undergraduate retention through mentoring;
- influenced faculty hiring on campus; and
- made annual fall trips to Historically Black Colleges and Universities to promote graduate study.

The Coalition to Diversify Computing also maintains a database (http://www.sdsc.edu/cdcdb) of minority researchers (including graduate students, faculty, and industrial researchers) in the areas of computer science, computational science, and computer engineering. This database is being used to foster research collaborations, and to build communities.

Because some of the most successful work to attract underrepresented groups into computing-related disciplines is being done by Professor Richard Tapia at Rice University, we discuss his program at greater length than some of the other successful practices mentioned in this report. Much of this description is taken (mostly verbatim, without quotation marking) from the report written by the evaluating group, the LEAD Center at the University of Wisconsin. For more information, see Tapia's website (http://www.caam.rice.edu/~rat/). One of the best known elements of the program is the pyramidal or chair mentoring relationships—high-school students by undergraduates by graduate students by faculty. Thus there is an entire community providing support to one another.

The Spend a Summer With a Scientist (SaS) Program, sponsored by the Center for Research in Parallel Computation (CRPC) at Rice University, addresses both the recruitment and the retention of minority graduate students, particularly those in applied mathematics, the computational sciences, and technology. Tapia, who administers the program with the help of senior graduate student participants, created the program in 1989. Its ultimate goal is to increase the number of ethnic minorities and women in mathematics, the computational sciences, and technology by giving them the support and sense of community needed to succeed in graduate school. Undergraduates and graduate students are given summer financial support to participate in a research project under a mentor/advisor who is either a faculty member or graduate student at Rice University. The topic, degree of difficulty, and amount of structure associated with this project are adjusted to suit each student's needs, whether she is a graduate student completing dissertation research or an underclassman from a small college who has never done research before. Students who need to catch up on their requirements or prepare for upcoming courses may also have a program tailored to meet that need. Participants generally give an accounting of their activities at the end of the summer, either through a written report or a presentation.

There is a strong community aspect to the SaS Program. Participants from off-campus are recruited and given practical assistance by the Rice graduate students already in the program, and participants see each other often during the course of the summer, both formally and informally. The entire group of SaS participants attends a weekly seminar with Dr. Tapia to discuss issues of research and professional development, race and gender, and problems or issues that have come up during the week. This weekly get-together provides an opportunity to get to know and respect the other participants and to learn important lessons about what it means to be an academic, a researcher, and a minority in one's field. The program also includes an outreach component: participants serve as mentors to two groups of high-school students for two weeks during the summer, and they give presentations of their research to K-12 teachers who attend a CRPC-sponsored summer workshop.

This mix of students at different levels creates a large and permanent community matrix that: 1) surrounds participants with students from similar backgrounds who understand their experiences firsthand, 2) provides undergraduate participants with numerous graduate-student role models, 3) provides a matrix of mentoring relationships between students at different levels so that each student can both be a mentor and be mentored, 4) allows support and advice to come from many individuals rather than having students rely on a single mentoring relationship, and 5) has continuity and is sustained by having students participate for multiple years.

The role of the student community in the success of the Rice program cannot be underestimated. While the program director plays the role of mentor and guide for many of the students in the program, the size and cohesiveness of the student community allows support to come from multiple individuals rather than a single mentoring relationship. As a

result, students within the community can "fill in" for the program director when he is not available and can gain their own valuable experiences as mentors.

This experience at Rice is consistent with research on graduate school success and retention, which has found that interactions with peers (as well as interactions with faculty) were a more important determinant of success in graduate school than were undergraduate background and personal characteristics.[1] Therefore, for minority students in particular, interactions with graduate student peers may provide a connection to their department and to other researchers that would be difficult to make otherwise.

Because both graduate and undergraduate students participate in the SaS Program and because they are involved in the mentoring of minority high-school students, the SaS community creates a chain of mentoring relationships between students at different levels so that each student can both be a mentor and be mentored. Hence, not only are role models and guides provided by the students and professors that are "ahead" of a student, but each student becomes a role model and guide to those "behind." Many interviewees said this situation allowed them to feel like they were giving back to their ethnic communities, a "duty" that the program director himself repeatedly emphasizes. Past research has suggested that high-achieving minority students often feel the need to give back to their community in order to demonstrate that they have not abandoned it (Seymour & Hewitt, 1997). The SaS Program offers multiple opportunities for such reciprocation to occur, regardless of the student's level or length of time in the program. Participants expressed the belief that such relationships encourage both the mentor and the mentee to persist in pursuing their degrees. As one student remarked, "There are people here that count on me and who would be disappointed if I didn't finish."

ACTIONS: If the department has a sufficiently large minority student population, especially of the same minority group, form a support group or at least provide the facilities and resources so that the students can form a group themselves. If the minority population is too small, arrange for a support group that cuts across the school or college. For example, there might be one cluster group for the entire college of engineering, another

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[1] J.E. Blackwell, *Mainstreaming Outsiders: The Production of Black Professionals* (New York: General Hall, 1987); J.E. Girves and V. Wemmerus, "Developing a Model of Graduate Student Degree Programs," paper presented at the annual meeting of the Association for the Study of Higher Education, San Antonio, Texas, 1986; R.T. Hartnett, "Environments for Advanced Learning," in J. Katz and R.T. Hartnett (eds.), *Scholars in the Making* (Cambridge, Mass: Ballinger, 1976); M.T. Nettles, "Success in Doctoral Programs: Experiences of Minority and White Students," *American Journal of Education*, August 1990, pp. 494-522. Minority students often feel outside the mainstream of their departments and often have problems interacting with faculty members [C.H. Carrington and W.E. Sedlacek, *Attitudes and Characteristics of Black Graduate Students* (College Park, MD: University of Maryland, Cultural Study Center, 1976); W.R. Allen, A. Haddad, and M. Kirkland, *1982 Graduate Professional Survey, National Study of Black College Students* (Ann Arbor, MI: University of Michigan Center for Afro-American and African Studies, 1984); B.C. Clewell, *Retention of Black and Hispanic Doctoral Students* (Princeton, NJ: Educational Testing Service, 1987); E.P. Smith and W.S. Davidson II, "Mentoring and the Development of African-American Graduate Students," *Journal of College Student Development*, November 1992, pp. 531-539; C.S.V. Turner and J.R. Thompson, "Socializing Women Doctoral Students: Minority and Majority Experiences," *The Review of Higher Education*, vol. 16, spring 1993, pp. 355-370.

for the life and environmental sciences, and a third for mathematics, statistics, computer science, and the physical sciences. Publicize support groups. Encourage minority students to participate, both as entering students and later in their student careers, when they can serve as valuable mentors or role models to the beginning students.

Meet with the support group at least once each term to learn about concerns and issues from the community and to demonstrate your interest and support. Work with these support groups and emphasize the importance of recruiting new graduate students. Provide these groups with a list of entering students and organize a welcoming event where information about the groups is disseminated. Appoint a faculty or staff support person to whom the support group can turn when there is need for an advocate within the department or university administration. If possible, provide administrative assistance from the department to help run the support group. This avoids overburdening the students with this task in addition to their principal task of being a student.

8. Make it straightforward for students with a wide variety of backgrounds and experiences to be able to enter and successfully move into graduate course work.

Departments should anticipate that students will enter their programs with a variety of backgrounds, and these differences should not be ignored. Departments aiming to have a diverse graduate student population, or even a fully populated graduate program, should expect that their students will come from many different institutions and have differing backgrounds within those institutions. They will also have a wide range of life experiences.

Departments should have standardized procedures for bringing all students to a base level of proficiency in key background areas within the first year of graduate school. This should be done in a way that is not seen as punitive or remedial to the student, but instead is part of the standard educational process for all students. Although these programs are intended for all students, they can be of particular value to many minority students. Many of these students come from colleges whose curricula differ from those of the research universities. Also, many minority students received their undergraduate education some years ago when the topics taught in computer science were different, and their knowledge may not reflect the rapid changes that have taken place in the field. Thus, many minority students will benefit from faculty and organizational sensitivity to the varying backgrounds of students, as well as from established, non-punitive ways of addressing these differences.

ACTIONS: Develop a realistic list—not a wish list—of skills and knowledge that students need to succeed in their graduate program. (Such a list might include, for example, knowledge of and experience applying the basic concepts of object-oriented programming, but the department should not expect familiarity with any particular programming language since that can be learned quickly, when needed.) Identify in advance a standard path for obtain-

ing particular skills or knowledge that are lacking, such as auditing or enrolling in a particular advanced undergraduate course; taking a particular short course; reading particular chapters in a particular textbook; and the like. Communicate this standard path to all faculty or staff who advise students, and keep their information about course content up to date. Review the background of every entering graduate student, and uniformly apply this rounding out of background across the entire entering student population. Count the successful completion of these background preparations as progress in the graduate program. Timetables for taking and passing the preliminary and qualifying examinations in the department should not be so short that students who have to undertake a significant amount of background preparation would be penalized by the next looming educational hurdle.

9. Increase the advising of entering graduate students, especially one-on-one advising.

General meetings for new students to go over the curricular requirements are useful, as are carefully prepared and regularly updated student handbooks. However, they do not replace careful, attentive, and ongoing individualized counseling of graduate students. Faculty members familiar with what the department has to offer, where its pitfalls lie, and what it takes to succeed in the program need to get to know the new student as an individual. These advisors need to probe to learn what their advisees do and do not know, both in the way of technical skills and knowledge and in terms of the culture of research. They need to help the student form a reasonable set of goals and objectives for her education and career, and set a course of study that gives the student latitude to move down a variety of career paths as her education advances. They also need to help the student identify, and rectify in the early years of graduate school, any shortcomings in background that might spell trouble later in her educational program or career.

Such counseling is valuable to every student and should be given to every student. It is particularly valuable, however, to the student who needs reassurance about his ability to handle graduate school, who is not sure how to map his previous course work or work experience onto the course or program requirements at the new institution, who has limited exposure to a research environment, or who does not know anyone in the department. As your minority student population grows, many of the minority students are likely to fall under one or more of these categories, further increasing the value of this kind of counseling.

ACTIONS: Strengthen your individualized faculty advising programs for new students. Continue advising until the student has passed qualifiers, joined a research group, and been accepted by a thesis advisor (who should then become responsible for ongoing, individualized advice). Create guidelines for advising, and enlist as advisors those faculty members who are thoroughly familiar with the department's strengths and weaknesses. Advisors need to have an ongoing relationship with the student, arranging to meet at least

several times each semester. They need to help the student not only to pick this semester's courses, but also to round out his or her background, fit into the department, and embark on a realistic and sufficiently flexible career path.

10. Make a special effort to place strong teachers in the introductory graduate courses and other courses that prepare students for their qualifying examinations.

After students have been in graduate school for several years, they have a better sense of their capabilities and, to an increasing degree, they share a common academic preparation with their fellow graduate students. However, at the beginning of graduate school, there is a much wider variation in academic preparation—in the material that has been covered and the way in which it has been covered. The goal should be to have every graduate student succeed academically, and it takes a more able teacher to meet the needs of a student population whose technical preparation varies widely. It takes someone who can both lecture clearly and understand the needs of individual students. It also requires someone who can bolster the confidence of beginning students who are not sure what graduate school is all about and whether they are cut out for it.

Again, these are problems that all beginning graduate students face. But, in many cases, the problems appear to be more acute for minority students. Anecdotal evidence suggests that, in the beginning, minority graduate students are more likely to lack confidence than their majority peers. This may be because they attended a less prestigious undergraduate institution, had time away from school, or feel that they are different from the other students. There may be other reasons as well that they cannot or do not articulate. For example, some minority students may feel uncomfortable asking questions in class. Others might assume the fault lies with them if they do not understand the material in a poorly taught course.

ACTIONS: Place strong teachers in the courses in which beginning students are most likely to enroll. These courses are likely to be the core introductory graduate courses and perhaps some of the core upper-level undergraduate courses. Teachers need to be sensitive to diversity issues. Be aware that students may have learned the foundational material on which their lecture material rests in many different ways, through a variety of different courses, on the job, or through self-instruction. Do not assume that everyone knows the material exactly as it is taught in your own university's undergraduate course. Similarly, select for discussion in class and class assignments real-world problems that do not require a student to have specialized knowledge. (At one school, for example, many of the foreign students, women, and males not interested in sports were at a disadvantage trying to solve a problem that required knowledge of American football rules.)

11. Foster a sense of belonging for minority students in the department.

All students have an easier time succeeding in graduate school if they feel that they belong and are valued members of the department. This is particularly important for minority students who may believe that they are there to meet externally imposed diversity requirements, or who simply feel different from the white males who comprise the power structure in most departments. It is important that minority students do their part to try to fit in by learning about the department and becoming thoroughly involved in its activities; and departmental advisors and support groups should convey this message to incoming minority students. It is even more important, however, for the department as a whole to learn to value cultural diversity. This means hiring a diverse faculty, admitting a diverse student body, and teaching all members of the department (minority and majority, faculty members and staff, and other students) about the value of cultural diversity. This kind of change will not occur quickly, but it will never happen if the department does not consciously set out to make it so.

ACTIONS: In addition to the longer-term actions of hiring a diverse faculty, building a diverse student body, and teaching all department members about the value of cultural diversity to the department's mission, there are some short-term actions that the department can take. Authority figures in a graduate department, such as the department chair, vice chairs, and full professors, need to take a leadership role in this area. They must pay regular attention to the minority students, seek them out, and instill in them a sense of belonging. Other department members must see this as their responsibility as well. Build cultural diversity into departmental events. Something as simple as having foods from different cultures at a graduate student gathering can help to foster interaction and respect for diversity.

To be successful, a diversity program at a research university must be mainstreamed within the department. While having a diversity coordinator and establishing affinity support groups are important steps, the department should not believe this is all it needs to do. Bridges must be built between these affinity programs and the core research and educational structures of the department. If the department delegates the responsibility for diversity to a single member of the faculty or staff, both the students and the program are likely to be marginalized. Students are likely to find themselves being viewed as tokens, and being treated as such.

12. Faculty should help minority students to understand the culture of the research university and learn how to function well within it.

Students may have been raised in any of a variety of different cultures, and for some the culture of the research department will not be familiar. Some cultures, for example, value

respect for elders above critical commentary. Minority students may be unaccustomed to the rhetoric used in the department, and unfamiliar or uncomfortable with the aggressive "lone wolf" mentality of many students.

Students generally strive to learn how things work in the department—through discussions with family members and friends who have attended university, by talking with other students, and by observing what is going on around them. But it is not an easy task to become acculturated, and the students may need faculty help.

ACTIONS: Remind the faculty that the research culture is exactly that—a culture. Fitting in may be both difficult and painful for students from different backgrounds. The faculty should feel as great an obligation to teach this skill as to teach any technical subject to the students; and they should understand that, in fact, this acculturation may be more important to the student's long-term success than any particular technical knowledge. Faculty should monitor their students carefully and intervene with direct advice on how to handle various situations. But there should also be a department-wide expectation that all students will learn the norms of behavior of the research department and that, until they do, they are not ready to advance in a research career.

13. Promote the activities of professional societies in your department and on your campus.

Anecdotal evidence from a number of minority students suggests that student and departmental chapters of professional societies have been helpful to them in becoming professional computer scientists, especially during their undergraduate and early graduate school years. The chapters provide a sense of community, help the students to network and find mentors, expose them to high-quality professional talks and research, encourage them to read professional journals, and allow them to meet computer scientists from other organizations.

ACTIONS: The faculty should encourage students, especially minority students, to participate in the local and national programs offered by the professional societies. Provide financial support, as well as faculty and staff advisors, to ensure there are active society programs within their departments. Faculty and staff can also invite students to attend meetings of local information technology professional and business associations to broaden their professional and networking skills.

C. RETAINING STUDENTS IN YOUR GRADUATE PROGRAM

14. Retention requires constant vigilance.

Statistical data are lacking, but it appears that graduate programs experience significant problems retaining minority students. Many schools make an effort to get students started on their graduate career through orientation and advising, but these efforts tend to fall off as the student progresses through the program. Because it is so easy for a minority student to feel different from the other students and alienated from the graduate program, it is critically important to reinforce a sense of belonging at every stage of the graduate career. In particular, this means getting the student deeply involved in the two major activities of the department—teaching and research.

ACTIONS: Establish an advising program that continues beyond the first year of graduate school. Transfer the student to an appropriate advisor as soon as he or she is ready to commit to a research area. Provide summer support or a research assistantship to enable the student to become familiar with faculty members and other graduate students and to integrate the student into a research group within the department. Give students a chance to teach to help them decide whether they wish to pursue an academic career. (This is especially important today, given the small number of minority doctorates who choose an academic career in computer science.) Provide an appropriate faculty member or more senior graduate student as a mentor to create a sense of belonging, and give the student a chance to be a mentor to a more junior graduate student. Establish a minority support group or other cultural outlets, since some minority graduate students drop out of graduate school because of dissatisfaction with the social life rather than the intellectual environment. Apply the same standards and expectations to minority students as you do to other students. Do not put them into a special class of "affirmative-action" students who are not expected to perform as well as other students. Show a personal interest in their successes and viewpoints.

15. Faculty members need to serve as mentors to minority students, and they should receive training in how to be an effective mentor.

A mentor is someone who can be a trusted counselor to a student—someone who can serve as a role model, help the student to identify goals as well as the steps needed to achieve them, provide constructive criticism, and provide emotional support. According to an IEEE document on mentoring (http://www.ieee.org/organizations/committee/women/wiement.htm), a student receives a variety of benefits from a mentor:
- Experience that can be applied when working on new or difficult projects, jobs, or decisions.

- Honest feedback. Direction on where to concentrate improvements to match expectations.
- Advice/help with career guidance.
- Access to the mentor's network of professional connections.
- Knowledge of the appropriate/expected behavior for various professional settings.
- Access to information the student might not otherwise have.
- Support from a mentor who serves as cheerleader and protector.
- Improvement of skills (technical, interpersonal).
- Emotional support, such as tips on balancing work and personal life.
- Someone to vent frustration to without fear of reprisal or breach of trust.

One of the most interesting discussions in this same IEEE web document is the set of benefits the mentor derives from this relationship:
- Access to information that the mentor may not otherwise have.
- Visibility/recognition for the mentor who is perceived to team up with "winners."
- Access to the student's network.
- Opportunities to find out and learn about other operations, activities, or cultures that may not otherwise be available.
- Better understanding of yourself when trying to help others.
- Fresh perspective.
- Good feeling about yourself.
- Better use of your own mentor by being a mentor to others.
- "Reverse mentoring" by the student on issues that were not an initial part of the relationship—often outside the work arena.

Mentoring is serious business because of the enormous impact mentors often have on students. Many students learn how to behave by observing faculty members and treating them, consciously or unconsciously, as role models. As a result, poor mentoring can cause considerable damage. This is as true for faculty members who come to serve as mentors through happenstance as for those who become mentors through formal assignment.

Mentoring is easiest when the mentor and the student share a common background. This is true not only of similarities in physical profile, but also in intellectual, social, and economic profiles. Lacking commonality, it is more difficult, but not impossible, to build the ties and trust essential for a strong mentoring relationship. Some of the ties that seem to be effective for building a mentoring relationship are: sharing gender or ethnicity; growing up in similar circumstances (in a big city or in a rural area, in a poor family, in the suburbs, from the same geographical region); or working in the same research field. For these reasons, it is important to establish a process that supports mutual selection.

For a mentoring relationship to work effectively, both sides have to contribute. The student must be trustworthy about information provided in confidence by the mentor, be willing to advance in his or her career and make an effort to do so, and be able to accept

constructive criticism. Similarly, the mentor must be able to keep confidences, provide honest feedback, take the time to give advice, share his or her professional network of contacts and promote the student within this network, protect the student, and create opportunities for the student.

The McKnight Doctoral Fellows Program, which extends across a number of campuses in Florida, shows the value of mentoring. Operated by the Florida Educational Fund since 1984, the program provides up to 25 fellowships per year—renewable for up to five years—to African American students to study in doctoral programs at one of 10 Florida universities. The students are required to study in one of 10 subject areas in which African Americans have been underrepresented. The program has a very high success rate— 89 percent retention in graduate school. Of the 130 people to receive doctorates through the program to date, eight have been awarded in computer science.

The McKnight Program would not be nearly so successful if all it did was provide financial support. Integral to the program are activities to provide mentoring and to support communities. Several kinds of mentoring activities are built into the program. At the annual fellows meeting every October, all fellows share their experiences with each other in both informal and formal settings. Fellows are selected from time to time to make presentations to the group, and graduates are invited back to give talks on specific topics that relate to getting through the Ph.D. process. There is a council of elders composed of senior black faculty members from around the country. These elders share their experiences with the fellows in the same manner. Informal social events are held at the annual meeting, and talks are given by elders. In addition to the annual meeting, there has typically been a mid-year meeting with a similar intent as the annual meeting, but focused on the current fellows. Groups of fellows at different schools around the state also meet on their own. The McKnight Alumni Association has established its own formal mentoring program to match each new fellow with McKnight graduates who may be on the faculty either at their current institutions or at another one nearby. As one former McKnight Fellow stated:

> Students in the program have the feeling that there is a network of people and resources available to them. It really helps with the feeling of isolation that often comes with graduate school. For me, the lessons learned at the annual meetings were the most valuable. It was all practical advice that related to exactly the things I was going through at the time. (Ernest McDuffie, computer science professor, Florida State University.)

Typically, the most effective mentoring will occur within the graduate department, with either a faculty member or a more advanced graduate student serving as the mentor. There are a number of publications describing how an individual can be an effective mentor and how a department can set up an effective mentoring program. Appendix D provides a list of websites and publications on mentoring. Two are of particular interest. The

National Academies have published an excellent guide, *Adviser, Teacher, Role Model, Friend* (National Academy Press 1997; www.nap.edu/readingroom/books/mentor). The National Consortium for Graduate Degrees for Minorities in Engineering and Science, Inc. provides a series of low-cost publications on mentoring that can be ordered online (http://www.nd.edu/em/html/compat/publications.html). Examples include "The Mentorship Briefing Guide: Handbook for Establishing/Implementing a Mentoring Program" and "Mentoring: An Essential Factor in the Doctoral Process."

ACTIONS: Ensure that every student has a mentor. Faculty should consider it part of their responsibilities to serve as mentors to students. Because knowing how to be a good mentor is not necessarily intuitive, faculty members should seek out training. Bring in experts to provide faculty with practical advice about how to mentor, or provide them with written materials on mentoring. Mentors for minority graduate students need to be committed to cultural diversity and familiar with the issues facing minority students. The publications of the National Consortium for Graduate Degrees for Minorities in Engineering and Science, mentioned above, are particularly valuable in this regard.

D. ORGANIZATIONAL, FINANCIAL, AND STRUCTURAL ISSUES FOR RESEARCH DEPARTMENTS

16. Money matters.

Many minority students are the first ones in their family to seek higher education. Often, they may be able to earn considerably more money than their parents with only a bachelor's degree. For this reason, it is often a hard decision for these students to choose to go to graduate school. Doing so defers their earning a good salary, which often was the principal reason the family sacrificed to send the student to college. The student and his or her family may be concerned about paying off college loans or incurring further debt. Many students would like to be able to help out with family finances, or to help send a younger sibling to college. Often, the family has stretched its finances as far as it can to help the student through four years as an undergraduate. Student and parents are often unaware that support other than loans is commonly available for graduate study. Not only are many minority students unlikely to have alternative sources of funding available, they will also have a hard time justifying to themselves and their families the deferred reward system implicit in graduate study.

ACTIONS: For both financial and psychological reasons, departments must be prepared to provide full support to qualified minority students, covering tuition, fees, and complete living expenses. Advertise the availability of this financial support to prospective students in ways and places where the target audience is most likely to see them.

17. Money strategies matter.

Many minority students need financial support to succeed, but the way in which the financial support is provided may be almost as important to long-term success as the support itself. Fellowship support looks good at first glance, but it can have two shortcomings when distributed improperly to minority students: 1) It sometimes makes them look special, as if they were on a special track with standards different from those applied to non-minority students; and 2) It can isolate them from the community of students and from the research and teaching activities of the department. Teaching assistantships provide some teaching experience and provide contacts with perhaps a few other students and faculty, although these may not be the members of the department in the student's research area. In the 1990s, most minority students earning a doctorate in computer science accepted an industrial job rather than a faculty position upon graduation, so it is not clear how valuable the teaching experience is. There is also growing evidence that the earlier the minority student becomes involved in research in the graduate school years, the greater the likelihood he or she will complete the degree. A research assistantship that is tuned to the needs of the student, and not just to the needs of the faculty member's research project, can immerse the student in research and provide valuable research contacts.

ACTIONS: Provide minority students with the kind of financial support that assures them personal contacts and experience with research and teaching. From this perspective, it may be better to provide research assistantships rather than teaching assistantships or fellowships, which can isolate a student or provide irrelevant experience. Provide support in a way that not only increases but also expedites the student's involvement in the research life of the department.

18. Diversity is a matter for everyone in the department.

Some larger and richer departments have been able to hire diversity officers, or use the services of diversity offices operated at the college or university level. Both can be very helpful in:
- coordinating programs, activities, and funding;
- running specialized training programs;
- collecting, analyzing, and disseminating data about practices nationally;
- evaluating how well your department is doing; and
- providing other specialized activities.

They cannot and will not replace the participation of faculty. If the department's primary effort is vested in such an individual office or officer, the minority students may feel marginalized and both recruitment and retention are likely to suffer.

Diversity workshops, led by your department or university diversity officer, can be beneficial to all teaching staff, both graduate students and faculty.

ACTIONS: Build up and utilize special diversity offices and officers, but recognize that they augment rather than replace the critical role of the entire faculty in the success of minority recruitment and retention. Hire a diverse faculty.

19. Improving programs for all students will benefit minorities.

With only a few exceptions, most of the recommendations for creating a good environment for minority students also pertain to creating a good environment for all graduate students. In an era when it is increasingly difficult politically to run affirmative action programs for minorities, it may make more sense to run better programs for all students. Any good student program will be sensitive to and respond to the differing needs of individual students and student groups, so this approach would not represent special treatment for minorities.

ACTIONS: Develop strong programs for all graduate students. Identify the needs of individual students and student groups, and respond to those needs quickly.

20. Build programs to last.

In too many cases, minority programs succeed only as long as soft money lasts or as long as a small number of committed individuals remain involved. Programs need to be established in ways that are sustainable. In particular, they need to have an organizational structure and secure funding behind them; otherwise, programs will come and go with funding variations and academic whims. Building and sustaining a significant, sustainable minority student population will not occur overnight.

ACTIONS: Create organizational structures and funding sources that are sustainable, and recognize that a considerable amount of time is required to build and sustain a minority student population. If the department does not have the financial means to do so, the chair should present the funding case to the university senior administration, university board of trustees, state legislature, or to others directly or indirectly responsible for departmental funding.

21. Evaluate your minority programs in a scientific manner.

Departments should take a scientific approach to evaluating the success of their efforts to diversify their student population. Ongoing assessment enables a department to recognize

problems and identify methods for improvement. The rigorous collection and analysis of data are central to good evaluation practice. Various metrics can be used. Some measure how well the minority population does in comparison to the majority student population: percentage completion, time to completion, grade-point average, percentage employment, quality of employment (percentage in tenure-track jobs, percentage receiving tenure), number and location of publications, conference talks given, grants awarded, and honors received. Other metrics gauge success at recruiting and retaining a diverse graduate student population: number of minority applications, percentage of applications from minorities, percentage of minority admissions who matriculate, percentage of minority matriculants who pass qualifiers, and percentage of post-qualifier minority students who graduate.

There are advantages to employing an independent evaluator to assess your program. Professionally trained evaluators with broad experience are often able to provide a more independent assessment. They typically use a combination of qualitative and quantitative methods to analyze your programs. Multiple sources of information and multiple evaluators may enhance triangulation during the analysis process. Information is often gathered through structured open-ended interviews of students, their mentors, and faculty; email surveys; tracking surveys; "matched" comparison groups; observations; creation of longitudinal databases; and faculty and student documentation of research experiences. The evaluator should assess the degree to which successful practice is a planned component of the program, the extent to which the practice becomes part of the program, and the relationship of the practice to the follow-up activities.

Even if your department does not employ an outside evaluator, there is useful information the department needs to collect and monitor over time. Here is the baseline data that one leading evaluation group (the LEAD Center at the University of Wisconsin) recommends that you track on each student (minority and majority):
- Matriculation date
- Name
- Student ID #
- Gender
- Race/ethnicity
- Undergraduate institution
- Undergraduate major and degree
- Undergraduate cumulative GPA
- GRE scores
- Graduate financial aid information
- Graduate department
- Degree sought (masters, Ph.D.)
- Years enrolled in department
- Preliminary and qualifier exams passed and year(s)
- Year master's degree was received

- Year Ph.D. was received
- Graduate GPA at last record
- Undergraduate research internships, whether institution or industry, and years
- Graduate research experiences, institution or industry, and years
- If applicable, year student dropped out of the program and reasons given in exit interview
- School e-mail address, phone number, and address
- Permanent e-mail address, phone number, and address

ACTIONS: Collect, analyze, and report data on your minority recruitment and retention efforts on an ongoing basis. Whenever possible, use a professional external evaluator to conduct the department's evaluation or to supplement it. Use the evaluation results to improve your program.

22. Actively publicize your departmental successes in increasing student diversity.

Recognition is self-perpetuating. Gaining recognition for your department's successes will encourage more minority students to enroll, and more non-traditional sources of minority students to encourage their students to apply to your institution.

ACTIONS: Actively publicize your department's success in recruiting and retaining minority graduate students—to your department, your college and university, the professional community, and the various institutions whose bachelor's degree recipients you want to attract to your graduate student body. In the department's annual report, talk about the year's performance in creating a diverse student body. If the department does not prepare an annual report, write a memorandum on this particular issue and circulate it to your dean, provost, president, and other department heads in your division. In department catalogs, brochures, and recruiting, include materials and statistics about the diversity of the student body and the successes of your minority students (awards won, jobs received after graduation, etc.). Add material to your departmental website about the diversity of your student body and the mentoring programs and support groups you have established. Send examples of successes to the university's admissions office and the public relations office, and ask them to spread the word for you. Participate in conferences that minority students attend, as well as workshops on national diversity issues, and talk about your programs.

23. Seek out industrial advice and funding.

Many companies already understand the value of diversity in the workforce and have experience in developing and operating diversity programs. Industry is often interested in supporting higher education in its efforts to educate a diverse workforce, and industry has few of the political problems associated with federal funding caused by anti-affirmative-

action sentiments. Working with industry also may help your university to develop ways to avoid losing its future faculty or its diversity to industry positions. Industry may be able to provide resources and advice on training programs, advice about recruiting, support for visits by prospective students, and scholarships and work opportunities for students. Industrial research laboratories, which share the interest of universities in preparing students for research careers, may be particularly appropriate partners.

ACTIONS: Actively solicit industry for advice about, and financial support for, your diversity programs.

24. Act now.

The stock market is at a high mark, leading to great wealth in the hands of concerned companies, individuals, and foundations. The technology sector is leading the market, and the IT industry is leading the technology sector. Even beyond the technology sector, IT is seen as a driver of the good economic times. There is a tremendous demand for IT labor; greater participation of minorities in the field would help meet this demand and provide companies with the diverse workforce they are seeking. The federal government has recently made a major investment in information technology research, to include both education and workforce programs. Moreover, U.S. demographics are shifting. Within several decades, non-Hispanic whites will probably comprise less than 50 percent of the population; so we should act now to train a diverse workforce to fill the advanced technical positions that will be vacated by retiring white males.

ACTIONS: Departments should take advantage of the current strong economic times and the shortage of IT workers to solicit funds from industry, government, and foundations to build up their minority populations.

25. Seek long-term solutions to the seed-corn problem in part through long-term strategies to diversify your student population.

The academic community is very concerned about the loss of graduate students and faculty to industry, diminishing the ranks of faculty members who will train tomorrow's generation of information technology students. The pull of students and faculty toward jobs in industry is not a short-term phenomenon created by Y2K or the Internet boom. It is a long-term phenomenon requiring long-term solutions. The academy must make long-term efforts to become competitively attractive as an employer or to increase the supply of graduates to match total demand, rather than seeking quick fixes or hoping to wait out the supply-demand mismatch. Attracting a diverse graduate student population and making the research universities more attractive to minority students will increase the poten-

tial pool of faculty for training the next generation of students. It will also show both majority and minority students that the university is a friendly environment, which may encourage more people to pursue academic careers.

ACTIONS: Seek long-term solutions to recruiting more minority graduate students and persuading them to embark on an academic career, so as to attract both majority and minority students to faculty positions.

3. APPENDICES

APPENDIX A

Ph.D. Degrees in Computer Science and Engineering Granted in the United States and Canada, by Ethnicity, 1970-1999

YEAR	AFRICAN-AMERICAN NON-HISPANIC		NATIVE AMERICAN		HISPANIC		TOTAL # OF DEGREES HAVE DATA FOR
	total #	%	total #	%	total #	%	
1970	1	1%	-	-	-	-	112
1971	1	1%	-	-	-	-	124
1972	2	1%	-	-	-	-	206
1973	2	1%	-	-	-	-	208
1974	2	1%	-	-	-	-	203
1975	1	0%	-	-	-	-	256
1976	0	0%	-	-	-	-	246
1977	0	0%	-	-	-	-	208
1978	2	1%	-	-	-	-	223
1979	1	0%	-	-	-	-	248
1980	0	0%	-	-	-	-	230
1981	0	0%	-	-	-	-	235
1982	1	0%	-	-	-	-	244
1983	2	1%	-	-	-	-	256
1984-85	3	1%	-	-	7	2%	326
1985-86	6	2%	-	-	6	2%	383
1986-87	3	1%	-	-	9	2%	559
1987-88	6	1%	-	-	8	1%	744
1988-89	0	0%	-	-	12	1%	807
1989-90	4	0%	-	-	11	1%	907
1990-91	8	1%	-	-	26	2%	1,074
1991-92	11	1%	-	-	17	2%	1,113
1992-93	8	1%	-	-	13	1%	999
1993-94	14	1%	0	0%	9	1%	962
1994-95	9	1%	1	0%	28	3%	941
1995-96	11	1%	5	1%	27	3%	880
1996-97	6	1%	0	0%	8	1%	867
1997-98	10	1%	6	1%	6	1%	904
1998-99	15	2%	1	0%	18	2%	818

Source: Computing Research Association's Taulbee Surveys.

APPENDIX B

LIST OF MINORITY-SERVING INSTITUTIONS

Native American Institution	URL
Bay Mills Community College	www.bmcc.org
Blackfeet Community College	www.montana.edu/wwwbcc
Cankdesk Cikana Community College	Hoopster.little-hoop.ec.nd.us
Cheyenne Institute of Technology	
College of the Menominee Nation	www.menominee.com
Crownpoint Institute of Technology	
Dine' College	www.ncc.cc.nm.us
D-Q University	Dcn.davis.ca.us/go/dquaaa
Dull Knife Memorial College	www.dkmc.cc.mt.us
Fond du Lac Community College	www.fdl.cc.mn.us
Fort Belknap Community College	www.montana.edu/~wwwse/fbc/fbc.htm
Fort Berthold Community College	www.fort-berthold.cc.nd.us
Fort Peck Community College	www.montana.edu/wwwfpcc
Haskell Indian Nations University	www.haskell.edu
Institute of American Indian Arts	www.iaiancad.org
Lac Courte Oreilles Ojibwa Community College	www.lco-college.edu
Leech Lake Tribal College	
Little Big Horn College	www.lbhc.cc.mt.us
Little Priest Tribal College	www.lptc.cc.ne.us
Nebraska Indian Community College	
Northwest Indian Community College	
Oglala Lakota College	www.olc.edu
Salish Kootenai College	www.skc.edu
Sinte Gleska University	Sinte.indian.com
Sisseton Wahpeton Community College	Swcc.cc.sd.us/cc.htm
Sitting Bull College	
Southwestern Indian Polytechnic Institute	www.sipi.bia.edu
Stone Child College	www.montana.edu/~wwwai/scc.html
Turtle Mountain Community College	www.turtle-mountain.cc.nd.us
United Tribes Technical College	www.united-tribes.tec.nd.us

Hispanic-Serving Institution	URL
American University of Puerto Rico	
Bakersfield College	www.bc.cc.ca.us
Barry University	www.barry.edu
Boricua College	
* California State University - Bakersfield	www.csubak.edu
California State University - LA	www.calstatela.edu
College of Aeronautics	www.aero.edu
College of Santa Fe	www.csf.edu
College of the Sequoias	www.sequoias.cc.ca.us
Community College of Denver	www.ccd.ccoes.edu
Del Mar College	www.delmar.edu
East Los Angeles College	www.elac.cc.ca.us
El Paso Community College	www.epcc.edu
* Florida International University	www.fiu.edu
Hartnell College	www.hartnell.cc.ca.us
Herbert H. Lehman College	www.lehman.cuny.edu
Hostos Community College	www.hostos.cuny.edu
Hudson County Community College	www.hudson.cc.nj.us
Imperial Valley College	www.imperial.cc.ca.us
Inter American University of Puerto Rico	www.sg.inter.edu/Bigg.htm
John Jay College of Criminal Justice	www.jjay.cuny.edu
LaGuardia Community College	www.lagcc.cuny.edu
Laredo Community College	www.laredo.cc.tx.us
MacCormac College	www.maccormac.edu
Malcolm X College	Ccweb.ccc.edu/malcolmx/home.htm
Mercy College	www.mercynet.edu
Miami-Dade Community College	www.mdcc.edu
Mount St. Mary's College	www.msmary.edu
Mt. San Antonio College	www.mtsac.edu
* New Mexico Highlands University	www.nmhu.edu
* New Mexico State University	www.nmsu.edu
Northern New Mexico Community College	www.nnm.cc.nm.us
Texas A&M University - Corpus Christi	www.tamucc.edu
The City College of New York	www.ccny.cuny.edu
* University of New Mexico	www.unm.edu
University of Puerto Rico	www.upr.edu
* University of Texas - El Paso	www.utep.edu
University of the Incarnate Word	www.uiw.edu
University of the Sacred Heart	
Western New Mexico University	www.wnmu.edu

*indicates institution has Centers of Excellence or Research Centers.

Historically Black Colleges & Universities	URL
Alabama A&M Univeristy	www.aamu.edu
Alabama State Univeristy	www.alasu.edu
Albany State University	Argus.asurams.edu/asu/
Alcorn State University	www.alcorn.edu
Allen University	www.icusc.org/allen/auhome.htm
Arkansas Baptist College	
University of Arkansas – Pine Bluff	www.uapb.edu
Barber-Scotia College	
Benedict College	www.benedict.edu
Bennett College	www.bennett.edu
Bethune Cookman College	www.bethune.cookman.edu
Bishop State Community College	www.bscc.cc.al.us
Bluefield State College	www.bluefield.edu
Central State University	www.ces.edu
Cheyney State University	www.cheyney.edu
Claflin College	www.claflin.edu
* Clark-Atlanta University	www.cau.edu
Coahoma Community College	www.clarksdale.com/ccc/ccc.html
Concordia College	www.cord.edu
Coppin State College	www.coppin.edu
Delaware State University	www.dsc.edu
Denmark Technical College	dtc401.den.tec.sc.us:8000/
Dillard University	www.dillard.edu
* University of the District of Columbia	www.udc.edu
Edward Waters College	www.ewc.edu
Elizabeth City State University	www.ecsu.edu
Fayetteville State University	www.uncfsu.edu
* Florida A&M Univeristy	www.famu.edu
Florida Memorial College	www.fmu.edu
* Fisk University	www.fisk.edu
Fort Valley State University	www.fvsc.edu
Grambling State University	www.gram.edu
Hampton University	www.hamptonu.edu
Harris-Stowe State College	www.hssc.edu
Hinds Community College	www.hinds.cc.ms.us
* Howard University	www.howard.edu
Huston-Tillotson College	
Interdenominational Theological Center	
J.F. Drake State Technical College	www.dstc.cc.al.us
* Jackson State University	www.jsums.edu
Jarvis Christian College	
*Johnson C. Smith University	www.jcsu.edu
Kentucky State University	www.kysu.edu
Knoxville College	falcon.nest.kxcol.edu
Lane College	www.lane-college.edu

Historically Black Colleges & Universities Continued   URL

Langston University

Lawson State Community College

LeMoyne-Owen College .... www.lemoyne-owen.edu

Lewis College of Business .... www.lewiscollege.edu

Lincoln University, MO .... www.lincolnu.edu

Lincoln University, PA .... www.lincoln.edu

Livingstone College .... www.livingstone.edu

Mary Holmes College .... www.maryholmes.edu

University of Maryland – Eastern Shore .... www.umes.edu

Meharry Medical College .... www.mmc.edu

Miles College .... www.miles.edu

Mississippi Valley State University .... www.mvsu.edu

Morehouse College .... www.morehouse.edu

Morehouse School of Medicine .... www.msm.edu

Morgan State University .... www.morgan.edu

Morris Brown College

Morris College .... www.scicu.org/morris/mchome.htm

Norfolk State University .... www.nsu.edu

* North Carolina A&T University .... www.ncat.edu

North Carolina Central University .... www.nccu.edu

Oakwood College .... www.oakwood.edu

Paine College .... www.paine.edu

Paul Quinn College .... www.pqc.edu

Philander Smith .... www.philander.edu

* Prairie View A&M University .... www.pvamu.edu

Rust College

Savannah State College .... www.savstate.edu

Selma University

Shaw University

Shelton State Community College – Fredd Campus

Shorter College .... www.shorter.edu

Sojourner Douglass College .... Host.sdc.edu

* South Carolina State University .... www.scsu.edu

* Southern University .... www.subr.edu

Southwestern Christian College

* Spelman College .... www.spelman.edu

St. Augustine's College

St. Paul's College

Stillman College .... www.stillman.edu

Talladega College .... www.talladega.edu

* Tennessee State University .... www.tnstate.edu

Texas College .... www.texascollege.edu

* Texas Southern University .... www.tsu.edu

Tougaloo College .... www.tougaloo.edu

Trenholm State Technical College

* Tuskegee University ....www.tusk.edu
University of the Virgin Islands ....www.uvi.edu
Virginia State University ....www.vsu.edu
Virginia Union University ....www.vuu.edu
Voorhees College ....www.voorhees.edu
West Virginia State College ....www.wvsc.edu
Wilberforce University...www.wilberforce.edu
Winston-Salem State University ....www.wssu.edu
Wiley College ....www.wiley.edu
Xavier University..www.xula.edu

APPENDIX C

This appendix sketches responses to five objections that are sometimes raised about programs intended to increase minority recruitment and retention. The material presented here suggests a line of argument without presenting all the details. Many of the details, including hard data, can be found in the main section of this report, and on the websites and in the publications cited.

Objection 1: There is no problem here.

There is an acute demand for information technology workers in the United States, which is likely to continue for many years. The research universities play an important role in the supply of these workers. Society and industry will hold the universities accountable for developing the technical workforce of the future. Where will the students for your program and for these jobs come from? Many foreign students choose to return to their home countries after completing their education, or they are forced to do so by immigration regulations. U.S. demographics are changing, and it is predicted that by the year 2030 African Americans, Hispanics, Native Americans, and Asian/Pacific Islanders together will outnumber non-Hispanic whites in elementary schools, high schools, and new entrants into college and the workforce. Thus it is important, simply from a numbers perspective, that the research departments recruit and retain increasing numbers and percentages of students who are from groups that are now underrepresented (women and minorities).

Even if your department is not so concerned about this national issue, these same demographic trends affect the kinds of people you will increasingly need to recruit in order to maintain the size and quality of your own programs.

There is an equity argument as well. Minority students should have the same opportunity as majority students to occupy the fulfilling and highly compensated jobs in the information technology field. However, the percentages of minority students entering and completing graduate study in computer science are significantly lower than the percentages of these groups in the population as a whole, or even than the percentage of these minority groups enrolled in higher education. It is incumbent on the higher education system to change this situation.

When there is limited diversity in the student population of a research department, its ability to carry out research and train the students that it does enroll is affected. The department is then populated with students having a limited range of experiences and viewpoints, which may in turn limit the range of new ideas generated for research. In a department

with limited diversity it is also more difficult to train students for a workplace that includes a diverse group of colleagues and customers; yet this is exactly what industry expects.

Objection 2: There are no minorities in the applicant pool.

It is unlikely that a graduate department will admit and graduate many minority students (other than Asian Americans perhaps), or even receive many inquiries and applications from these populations, unless it takes a proactive stance. As discussed earlier under Recommendation 4, there is a pool of students available. For example, last year some 50,000 minority students graduated with undergraduate engineering degrees. However, to recruit a more diverse student body, departments have to work harder at recruitment and they have to do it more intelligently. They need to match admission criteria with the credentials really needed for success in a computer science graduate program (Recommendation 5), and they have to recruit where there are significant pools of minority students (Recommendation 4).

Objection 3: We cannot compromise quality.

This is not an issue of quality. Everybody agrees that a department should do everything it can to maintain and increase its quality standards. It is hard to believe that the quality of matriculants would not improve significantly if the applicant pool was much larger. One problem is that many of the best and brightest minority students do not consider graduate training in computer science. As the distinguished educator Sheila Tobias has noted, there must be many potential computer scientists moving through the educational system who are never exposed to the early factors that encourage the elite to pursue a career in computer science. (Sheila Tobias, *They're Not Dumb, They're Different: Stalking the Second Tier*, Tucson, Arizona: Research Corporation, 1990.) This is a problem that the research universities can address.

Altogether too often, the question of quality is conflated with the issue of "objective" criteria for admission, such as particular GRE scores or grade-point averages. It is easy for departments to employ these criteria as cornerstones of their admissions process, but it is much harder to know if they are meaningful or desirable criteria. An excellent study of the "objective" criteria for undergraduate admissions has been published (William G. Bowen and Derek Bok, with a foreword by Glenn C. Loury, *The Shape of the River: Long-Term Consequences of Considering Race in College and University Admissions*, Princeton, NJ: Princeton University Press, 1998), and presumably a similar case could be made for "objective" graduate admission criteria. In this study the former presidents of Princeton and Harvard Universities point out that there is a minimum threshold that students must attain in their SATs in order to succeed in the undergraduate computing major. Above that threshold, a difference in scores is not very meaningful. They also point out that test scores may be affected by the quality of teaching received or by familiarity with strategies for taking standardized tests. Turning to the

graduate school situation, what does the College Board GRE specialty exam in computer science measure? Mainly, it measures exposure to a particular body of material during the undergraduate years; not the ability to succeed at graduate research.

What about the other twin pillar of "objective" criteria for graduate admission—grade-point average? Grading systems are not standardized across colleges. There has been tremendous grade inflation, particularly at many of the most selective colleges and universities, making it hard to use grades to differentiate between outstanding and average students. Poor grades are often not a reflection of ability, but instead of poor public school preparation for college, or of insufficient time to adjust to college pace and practices.

These "objective" criteria miss many critical factors, such as other work or life experiences or determination to succeed. Until your department has taken a fresh look at admission criteria and made an empirical correlation between various admissions criteria and the success of matriculants, you cannot really identify the right indicators to search for in the admissions process. In the meantime, one of the best ways to make selections is to rely on the advice of people whom you trust in making recommendations about students. But in doing this, you should make a point to get to know faculty and students from a diverse range of schools.

Objection 4: We are not doing these students any favors by admitting them.

The era of university's role *loco parentis* has long passed. Whether graduate school is in the student's best interest is the student's decision to make, not the university's. It is the department's responsibility to provide full and accurate information so that the student can make an informed decision. Probably some minority students who are admitted will not succeed; and a department should accept that it is not likely to have a success rate of 100 percent. And it is not so clear that a completion rate of 100 percent in a graduate program is a desirable goal for a university in either its minority or majority student populations. Such a perfect record may mean that a department is being too conservative in its admissions procedures.

Objection 5: It is against the law.

We are not lawyers, and these comments should not be construed as legal advice or opinion. Moreover, we are in an era of great flux in which affirmative action and race-, color- and ethnicity-sensitive practices are being challenged in executive orders, legislative action, court decisions, voter referenda at the state level, and the federal courts. Thus what is true at the time that this report is written may not be true at the time you read it.

The campaign against minority programs has taken place mainly at the state level. In 1996 Texas banned racial preferences in admissions by Texas universities. That same year, the California electorate passed Proposition 209, banning discrimination or preferential

treatment by state and other public entities to any group or individual in public employment, public education, or public contracting on the basis of race, sex, color, ethnicity, or natural origin. In 1998 the electorate of the State of Washington passed Initiative 200, which was similar in character to California's Proposition 209. Early in 2000, Governor Jeb Bush signed an executive order, which the state legislature endorsed, for the "One Florida" Plan. This plan eliminates race and gender as a consideration in university admissions. A number of states have considered or are considering similar legislation, referenda, and executive orders. However, these anti-affirmative action initiatives are not uniformly successful. For example, such initiatives have failed in the states of Arizona, Michigan, and New Jersey. (For a chronology of this subject and links to other electronic publications, see http://aad.english.ucsb.edu/pages/news.html)

Proposition 209 in California is perhaps the best known of these anti-affirmative action changes, so let us examine it more closely. (For more on the proposition, see http://Vote96.ss.ca.gov/Vote96/html/BP/209analysis.htm) In 1997 the Ninth Circuit Court upheld the Proposition and the Supreme Court refused to hear an appeal. The impact of the proposition has been serious for minority enrollment in the state colleges and universities, with the strongest, most research-oriented universities hit the hardest. The proposition eliminated financial aid, tutoring, mentoring, and outreach programs that were targeted at women and minorities. In turn, the minority community shunned Berkeley. In the first year after Proposition 209 was implemented, none of the 15 African American admitted to the law school matriculated. Freshman admissions of minorities at Berkeley were down significantly compared to the previous year: African-American admissions dropped by 66 percent and Latino/a admissions by 53 percent. Although admissions have rebounded in the university system somewhat over the past several years, it remains a hostile climate for attracting minorities to graduate study in computer science.

Not all opportunities to develop programs that increase minority participation have been lost, however. Proposition 209 does not prohibit consideration of economic disadvantage in admissions, financial aid, mentoring, or outreach programs. This leaves some room for building targeted programs that will reach minorities that are underrepresented in computer science in a higher percentage than their representation in the population as a whole. Proposition 209 also contains a loophole that allows the state to ignore the preferential treatment bans in order to accept federal funds. For example, Proposition 209 would not prohibit California women (or California public institutions) from sharing federal funds or other non-state funds targeted specifically at women and minorities. In the State of Washington, state officials called on the public universities to find other ways to maintain diversity, other than programs that gave specific racial or gender preferences. Programs that recruit heavily but not exclusively at minority institutions, for example, would presumably not be prohibited under the California or Washington rules. Indeed, the trend seems to be to find innovative ways to enhance campus diversity without resorting to preferential race or gender treatment, even in state or federal agencies that are not forbidden from having affirmative action programs.

APPENDIX D

WEBSITES AND PUBLICATIONS ON MENTORING

The following web sites have been suggested by Ruth Ann Manning of the University of Tennessee at Knoxville as being useful to computer scientists interested in mentoring. See http://edge.net/~bentley/cluster/menref.htm

Mentoring Guidebook

http://www.ieee.org/organizations/committee/women/wiement.htm

Mentoring Tips

http://www.cob.ohio-state.edu/~diversity/mentips.htm
http://www.nap.edu/readingroom/books/mentor/2.html

Other Sites

http://borg.lib.vt.edu/ejournals/JITE/v33n3/sloan.html
http://scholar.lib.vt.edu/ejournals/JITE/v33n3/sloan.html
http://www.engr.siu.edu/mep/mep.htm#REFERRAL
http://www.ntlf.com/html/lib/bib/95-3dig.htm
http://www.bc.edu/bc_org/svp/ahana/mentoring/
http://www.petersons.com:0080/graduate/transition4.html
http://cuok.cameron.edu/student_affairs/multicultural_disabled/culinks.html
http://www.igc.org/aaup/aafacdiv.htm
http://www.wheaton.edu/oma/programs/121.htm
http://www.computerworld.com/home/print9497.nsf/all/SL0728ld
http://www.awis.org/html/mentoring.html
http://www.cyberwerks.com/dataline/agenda/mentormn.html
http://www.gwu.edu/~eriche/Reviews/243a.html
http://www.pmc.edu/mentor.html

BOOKS AND ARTICLES

The following books and articles, which have been culled from the websites listed above, provide additional information on mentoring:

See especially:

Committee on Science, Engineering, and Public Policy, National Academy of Sciences, *Adviser, Teacher, Role Model, Friend* (Washington, DC: National Academy Press, 1997).

Other literature:

Association for Women in Science, *Mentoring Means Future Scientists* (Washington, DC: Association for Women in Science, 1993).

Audi, R., "On the Ethics of Teaching and the Ideals of Learning," *Academe,* September-October, 1994, pp. 27-36.

Bird, S.J., "Overlooked Aspects in the Education of Science Professionals: Mentoring, Ethics, and Professional Responsibility," *Journal of Science Education and Technology*, vol. 3, 1994, pp. 49-55.

Blackburn, R.T., Chapman, D.W., and Cameron, S.M., "'Cloning' in Academe: Mentorship and Academic Careers," *Research in Higher Education*, vol. 15, No. 4, 1981, pp. 315-327.

Blackwell, J.E., "Mentoring and Networking Among Blacks," in Pruitt, A.S. (ed.), *In Pursuit of Equality in Higher Education* (Dix Hills, NY: General Hall, 1987), pp. 146-162.

Blackwell, J.E., "Mentoring: An Action Strategy for Increasing Minority Faculty," *Academe*, vol. 75, 1989, pp. 8-14.

Blackwell, J.E., "Faculty Roles in Mentoring Minority Students," in Wadsworth, E., and Adams, M.C. (eds.), *The Role of the Faculty in Meeting the National Need for African American, American Indian, and Latino Scholars: Report of the Stony Brook Conference I* (Stony Brook, NY: State University of New York, 1989), pp. 25-35.

Boice, R., "Lessons Learned About Mentoring," *in Developing New and Junior Faculty*, Sorcinelli, M.D. and Austin, A.E. (eds.) (San Francisco, CA: Jossey-Bass, 1992), pp. 51-62.

Council of Graduate Schools, *Research Student and Supervisor: An Approach to Good Supervisory Practice* (Washington, DC: Council of Graduate Schools, 1990).

Council of Graduate Schools, *A Conversation About Mentoring: Trends and Models* (Washington, DC: Council of Graduate Schools, 1995).

Fort, C., Bird, S.J., and Didion, C.J. (eds.), *A Hand Up: Women Mentoring Women in Science* (Washington, DC: Association for Women in Science, 1993).

"Get a Mentor," *Black Enterprise*, May 1984.

Huang, Chungliang Al, and Lynch, Jerry, *Mentoring: The Tao of Giving and Receiving Wisdom* (San Francisco and New York: Harper, 1995).

Kanigel, R., Apprentice to Genius: *The Making of a Scientific Dynasty* (Baltimore, MD: Johns Hopkins University Press, 1986).

Kram, K.E., "Mentoring in the Workplace," in *Career Development in Organizations*, Katzell, R.A. (ed.) (San Francisco, CA: Jossey-Bass, 1986), pp. 160-201.

Levinson, D.J., Darrow, C.N., Klein, E.B., Levinson, M.A., and McKee, B., *The Seasons of a Man's Life* (New York, NY: Knopf, 1978).

Maack, M.N., and Passet, J., *Aspirations and Mentoring in an Academic Environment: Women Faculty in Library and Information Science* (Westport, CT, 1994).

Noe, R.A., "An Investigation of the Determinants of Successful Assigned Mentoring," *Personnel Psychology*, vol. 41, 1988, pp. 457-479.

Olmstead, M.A., "Mentoring New Faculty: Advice to Department Chairs," *CSWP, A Newsletter of the Committee on the Status of Women in Physics*, vol. 13, No. 1, pp. 1, 18-21 (Washington, DC: American Physical Society, August 1993).

Roberts, G.C., and Sprague, R.L., "To Compete or To Educate? Mentoring and the Research Climate," *Professional Ethics Report VIII*, vol. 1, fall 1995, pp. 6-7.

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PRACTICAL ADVICE FOR GRADUATE DEPARTMENTS

A. Recruiting Underrepresented Minority Students Into Your Graduate School Program

1. Cultivate undergraduates for a research career.
2. Communicate to students the opportunities a doctorate offers for a fulfilling career and life.
3. Involve your research university in partnerships with undergraduate and minority-serving institutions.
4. Seek out new sources of minority students.
5. Revise admissions procedures to accurately reflect the requirements needed to succeed in the program, and to enable students with a wide variety of backgrounds to qualify for admission.
6. Adjust regulations and programs to better serve students who have "split careers" that involve moving back and forth between work and education.

B. Facilitating Early Success in Your Graduate School Program

7. Build communities of minority students within the graduate school.
8. Make it straightforward for students with a wide variety of backgrounds and experiences to be able to enter and successfully move into graduate course work.
9. Increase the advising of entering graduate students, especially one-on-one advising.
10. Make a special effort to place strong teachers in the introductory graduate courses and other courses that prepare students for their qualifying examinations.
11. Foster a sense of belonging for minority students in the department.
12. Faculty should help minority students to understand the culture of the research university and learn how to function well within it.
13. Promote the activities of professional societies in your department and on your campus.

C. Retaining Students in Your Graduate Program

14. Retention requires constant vigilance.
15. Faculty members need to serve as mentors to minority students, and they should receive training in how to be an effective mentor.

D. Organizational, Financial, and Structural Issues for Research Departments

16. Money matters.
17. Money strategies matter.
18. Diversity is a matter for everyone in the department.
19. Improving programs for all students will benefit minorities.
20. Build programs to last.
21. Evaluate your minority programs in a scientific manner.
22. Actively publicize your departmental successes in increasing student diversity.
23. Seek out industrial advice and funding.
24. Act now.
25. Seek long-term solutions to the seed-corn problem in part through long-term strategies to diversify your student population.