

Retention By *Design*

**Achieving Excellence
in Minority Engineering
Education**

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Author's note: This represents an update and republishing of "Retention by Design"—a monograph originally published in 1991 by the National Action Council for Minorities in Engineering (NACME). The "pipeline" data used to justify the need to redesign engineering college environments to meet the needs of minority students has been simplified and updated. The "community building/collaborative learning MEP model" is presented essentially in its original form. Only minor accommodations have been made for the impact of information technology advances including opportunities for communication with and among students by e-mail and information access through the Internet. I recognize that the "anti-affirmative action" movement and certain accompanying state ballot initiatives and court decisions could impact the implementation of such a program, particularly the use of ethnicity as a criteria for selecting student participants. Questions about or comments concerning this publication can be sent to: rlandis@calstatela.edu.

R. B. Landis, October 2005

INTRODUCTION

In 1972, J. Stanford Smith, then a top General Electric executive, challenged the nation "to take bold, innovative, all-out action to increase the supply of minority engineering graduates by 10- or 15-fold, and to get it done within the decade." Smith correctly pointed out that unless this increase occurred, minorities would be effectively excluded from leadership positions in U.S. industry into the twenty-first century. He called this situation "a formula for tragedy."¹

American corporations responded to the challenge offered by Smith. A symposium sponsored by the National Academy of Engineering in May 1973 kicked off the national minority engineering effort. The ensuing dialogue among leaders of industry, government, and academia led to the formation of the National Fund for Minority Engineering Students (NFMES), the National *Advisory* Council for Minorities in Engineering (NACME), the Committee on Minorities in Engineering (CME), and the Minority Engineering Education Effort (ME³). Ultimately, the four groups were consolidated into a single organization—the National *Action* Council for Minorities in Engineering, the current NACME (www.nacme.org).

Encouraged by the national thrust and by the willingness of corporations to provide funding, both directly and through NACME, many engineering colleges established minority engineering programs (MEPs) with the goal of improving the academic performance and graduation rates of minority engineering students. Michigan State University, Stevens Institute of Technology, the University of Kansas (<http://www.ku.edu/~nsbe/history.html>), California State University, Northridge (www.csun.edu/ecs/historyMEP.html), and the

University of Houston (www.egr.uh.edu/parameters/spring2002/?e=promes) were early pioneers in establishing MEPS.

The underlying motivation of most of the pre-college and university programs initiated in the decade following 1973 was “it’s the right thing to do.” The effectiveness of these programs was mixed. Most lacked strong institutional support. Many early MEPS did not have the involvement of faculty and were not well integrated into the mainstream of engineering college activity. Program directors were treated as “second-class citizens” holding low-paying positions that lacked status, job security, or a viable career path. Most of these programs relied heavily on private sector support and were inadequately funded. Because their funding lacked long-term stability, they were generally viewed as “pilots.” In the absence of faculty involvement in the program design, many of the programs were not well-conceived and lacked sound educational rationales. The programmatic approaches were not effective in compensating for the failure of our system of public education in preparing minority students for engineering study, for the educational environment those students would encounter in predominantly white engineering colleges, and for the lack of adequate financial aid to meet the financial needs of minority engineering students.

Table 1ⁱ
FALL SEMESTER FRESHMAN ENROLLMENTS IN ENGINEERING

Year	# Yrs into the “Effort”	African American	Hispanic	American Indian	Total Minority	Total Freshman	Percent Minority
73/74	Start	1,684	525	40	2,249	51,207	4.4
78/79	5	5,493	2,664	225	8,382	95,171	8.8
83/84	10	6,342	3,885	376	10,603	108,763	9.7
88/89	15	7,075	4,246	433	11,754	97,383	12.1
93/94	20	8,271	5,509	607	14,387	88,130	16.3
99/00	26	7,989	6,333	676	14,998	93,208	16.1
04/05	31	7,374	7,628	696	15,698	102,721	15.2

Given these facts, it is not surprising that the nation failed to meet the goals set forth by J. Stanford Smith. As indicated in Table 1, in the 31-year period from 1973 to 2004, the percentages of minorities in the engineering freshman class increased from 4.4 percent to only 15.2 percent—a factor of less than four. Particularly discouraging is that the percentage of minority engineering freshmen peaked in 1993/94 and has declined slightly since that time.

Despite the rise in enrollment cited above, the percentage of minorities receiving Bachelor of Science (B.S.) degrees in engineering increased by just over a factor of three—from 2.9 percent in 1972/73 to 9.9 percent in 2002/03 (see Table 2). More progress is evident in the absolute number of B.S. degrees granted to minorities, which increased by a factor of almost six in the three-decade period. However, while the number increased from 1,255 degrees in 1973 to 7,353 degrees in 2003, it still fell significantly short of the 10- to 15- fold increase called for by Smith.

ⁱ Source: Engineering Workforce Commission, “Engineering & Technology Enrollments” (various years), Washington, DC (www.ewc-online.org)

Table 2ⁱⁱ
BACHELOR'S DEGREES GRANTED IN ENGINEERING

Year	# Yrs into the "Effort"	African American	Hispanic	American Indian	Total Minority	Total Degrees	Percent Minority
72/73	Start	657	566	32	1,255	43,086	2.9
77/78	5	894	748	37	1,679	45,753	3.7
82/83	10	1,862	1,534	97	3,493	72,122	4.8
87/88	15	2,211	1,920	187	4,318	70,865	6.1
92/93	20	2,374	2,144	163	4,681	63,067	7.4
97/98	25	3,144	3,056	351	6,551	63,282	10.4
02/03	30	3,429	3,536	388	7,353	73,915	9.9

Despite the rise in enrollment cited above, the percentage of minorities receiving Bachelor of Science (B.S.) degrees in engineering increased by just over a factor of three—from 2.9 percent in 1972/73 to 9.9 percent in 2002/03 (see Table 2). More progress is evident in the absolute number of B.S. degrees granted to minorities, which increased by a factor of almost six in the three-decade period. However, while the number increased from 1,255 degrees in 1973 to 7,353 degrees in 2003, it still fell significantly short of the 10- to 15-fold increase called for by Smith.

Table 3ⁱⁱⁱ
NATIONAL PIPELINE FOR MINORITIES IN ENGINEERING

	AFRICAN AMERICANS	HISPANICS	AMERICAN INDIANS	TOTAL MINORITY
Public school students in 1998	17.1%	15.0%	1.1%	33.2%
Engineering freshmen in Fall 1999	8.6%	6.3%	0.7%	15.6%
Engineering B.S. degrees in 2003/04	4.9%	5.0%	0.5%	10.4%
Engineering M.S. degrees in 2003/04	2.3%	2.6%	0.2%	5.1%
Engineering Ph.D. degrees in 2003/04	1.6%	1.4%	0.1%	3.1%

The net result of the developments of the last three decades is that a serious problem continues to exist all along the engineering education pipeline (see Table 3). Nationally,

ⁱⁱ Source: Engineering Workforce Commission, "Engineering & Technology Degrees" (various years), Washington, DC (www.ewc-online.org)

ⁱⁱⁱ Source: U.S. Department of Education, *Digest of Education Statistics Tables and Figures* (<http://nces.ed.gov/programs/digest/d00/dt044.asp>). Engineering Workforce Commission, "Engineering & Technology Enrollments" and "Engineering & Technology Degrees" for selected years (www.ewc-online.org)

minorities made up 33.2 percent of public school students in 1998, but only 15.6 percent of engineering freshmen in fall, 1999 (see Table 3). This under-representation in the engineering freshman class indicates an access problem, but there is a retention problem as well. If minority students comprised 15.6 percent of the engineering freshman class in 1999, they should comprise 15.6 percent of engineering graduates four or five years later. However, in 2003/04 only 10.4 percent of those that received B.S. degrees in engineering were minority, indicating that minorities are being retained at only about two-thirds the retention rate of all students. Relative under-representation is much more severe at the graduate level. Minorities only comprised 5.1 percent of engineering Master of Science (M.S.) degree recipients and 3.1 percent of engineering Doctor of Philosophy (Ph.D.) recipients in 2003/04.

Ethnic differences also are apparent. African-Americans are more severely under-represented than Hispanics at every stage along the engineering education pipeline. As the pipeline data indicates, African-Americans are graduating at about one-half the rate of all students (4.9 percent of the graduates compared with 8.6 percent of the entering freshmen), while Hispanics are graduating at about three-quarters the rate for all students (5.0 percent of the graduates compared with 6.3 percent of the entering freshmen). Similar leakage along the pipeline is indicated for American Indians, although the small numbers combined with the large number of students who incorrectly identify themselves as Native Americans make the data less reliable.

When compared to 2000 census data,² African-Americans are under-represented by a factor of 2.6 (4.9% of B.S. degrees compared to 12.9% of the population), Hispanics are under-represented by a factor of 2.5 (5.0% of B.S. degrees compared to 12.5% of the population), and American Indians are under-represented by a factor of 3.0 (0.5% of B.S. degrees compared to 1.5% of the population). This is an improvement since the start of the minority engineering effort in 1973 when African-Americans were under-represented by a factor of 7.4 (1.5% of B.S. degrees compared to 11.1% of the population) and Hispanics were under-represented by a factor of 3.6 (1.3% of B.S. degrees compared to 4.7% of the population). In spite of the efforts to date, we still have a long way to go to achieve population parity. [Note: Similar conclusions were reached in an excellent recent NACME publication: *“Walking the Talk’ in Retention-to-Graduation: Institutional Production of Minority Engineers.”*³]

Academic performance appears to be a serious problem as well. Anecdotal data have indicated that the mean GPA of minority engineering graduates is significantly lower than that of non-minority graduates. This is also borne out by some studies. As an example, a study conducted by the Accreditation Board for Engineering and Technology (ABET), with funding from the Exxon Education Foundation,⁴ indicated that the mean GPA for African American engineering graduates was 2.15, for Hispanic engineering graduates 2.39, and for non-minority engineering graduates 2.67. If this data is correct, the vast majority of African-American and Hispanic students that do graduate have GPAs below 2.4. This has serious ramifications since students with such low GPAs are more apt to have negative feelings about their educational experience and their institution, have doubts about their career choice, and lack confidence in their ability.

The ABET/Exxon study also attempted to answer the question of whether student achievement in engineering study reasonably correlates with student qualification at the

point of entry by comparing the percentage of students entering engineering study with a B+ high school average with the percentage graduating with a B+ average in their college work. The data shows dramatic ethnic differences.

	Non-Minority	Hispanic	African-American
Percent entering with B+ high school average	45%	46%	37%
Percent graduating with B+ college average	33%	18%	5%

One ramification of this data is that only five of every 100 African American engineering graduates and 18 of every 100 Hispanic engineering graduates are qualified for full-time graduate study, compared to 33 of every 100 non-minority engineering graduates. Unless we increase the percentage of minority students that achieve a B+ grade point average in their undergraduate study, minorities will continue to be drastically under-represented among engineering faculty.

The purpose of this monograph is to discuss the barriers that prevent minority students from succeeding in engineering study and to identify a variety of successful intervention strategies for eliminating these barriers. In addition, those programmatic structures that have proven to be highly effective are discussed in some depth.

THE PROBLEM

America's engineering colleges are operating in one of three stages with regard to minority education:

- I. Inaction**
- II. Ineffective Action**
- III. Effective Action**

Of the approximately 300 universities in the U.S. that have accredited undergraduate engineering programs, it is estimated that fewer than 100 have established formal programs designed to improve the academic performance and retention of minority students⁵. Although many others report that they conduct some informal activities related to minority education, the vast majority of our engineering colleges are operating in Stage I.

Stage I - Inaction

There are a variety of reasons why a particular institution may not have established a minority engineering program. Some have so few minority students that they feel a special program would not be cost effective. Some may have been preempted by campus-wide minority student support programs. Others have merely lacked any self-starting spark. These and other passive reasons for inaction are unfortunate, but at least they leave room for something to be done in the future.

Of particular concern are institutions that have made conscious decisions not to establish such programs. While many of these institutions are well aware that their minority students are not performing well academically, they typically blame this on student deficiency. When asked, faculty at such schools readily provide a standard litany of deficiencies: “poorly prepared,” “lacking in ability,” “unmotivated,” “not willing to work,” “inadequately financed.” This tendency to blame the students has unfortunate ramifications. Faculty who hold these views generally have low expectations of minority students and transmit those expectations to the students, which in turn negatively impacts student performance. In addition, by holding these views faculty are not inclined to look elsewhere to discover what often are the real reasons behind the poor performance of minority students. Finally, since faculty are concerned about maintaining high standards of competence in the engineering profession, if they conclude that minority students do not “measure up,” they would certainly not support any special efforts to help them graduate as engineers. But of all these faculty attitudes, the one heard most often to justify inaction is “we believe in treating all students the same.” Because on the surface this argument seems plausible, it deserves the strongest rebuttal.

We do not treat all students the same. Think about athletes or hearing-impaired students, for example. More to the point, think about the situations that minority students face. If faculty have low expectations of minority students and transmit these expectations to the students, how is this “equal treatment”? Ethnic isolation also precludes equal treatment. While visiting one of our top technical institutions, I met with 11 Black engineering freshmen who were taking first-term calculus. Every one of them told me he or she was the only Black student in his or her class. Is the only Black student in a class of 30 receiving the same treatment as one of 29 white students in that class? Not if the attitudes and behavior of non-minority students resonate negative faculty attitudes, and it appears that they do. At university after university, minority engineering students have told me that white students won't form laboratory groups with them, act surprised when they do well on tests, and intentionally leave the seats next to them vacant. Is this equal treatment?

White students see an almost all white faculty, a white dean, a white vice president, a white president, and for the most part, white engineers. For minority students, not having any role models is bad enough, but then they must face a faculty who has little or no understanding of or sensitivity to the situation confronting them. Although these few observations alone expose the idea of “equal treatment” as a myth, the problems do not stop here.

Most college freshmen must adjust to being away from home for the first time and to the rigorous academic standards of engineering study. Being thrust into a predominantly white environment for the first time, however, presents minority students with a much greater adjustment problem. For a new engineering student, the support of peers—new friends going through the same adjustment—and the opportunity to share information and engage in group study with other engineering students are key ingredients for success. Yet this support is not readily available to minority students.

The primary factors that impede the success of minority students in engineering, then, are not poor preparation, lack of ability, lack of motivation, or any of the other reasons commonly attributed to minority students. Rather, they are ethnic isolation, lack of peer support, lack of role models, and low faculty expectations. This should come as good news, however, for these are factors that are within our control.

To those who decline to establish minority engineering programs because they believe in “treating all students the same,” I would suggest a redefinition of “equal treatment.” Equal treatment should mean that students of equal ability and comparable background achieve equal results; and further, that all students feel equally valued by the institution and have a comparable regard for the educational experience they are receiving. This is certainly not the case in many of our institutions today.

Some studies have shown that the academic performance of minority engineering students is below that of white students with comparable backgrounds.⁶ Some institutions have even found inverse correlations between the performance of minority students in college calculus, chemistry, and physics courses and their background as indicated by SAT scores, high school GPA, and level of math/science courses completed⁷. That better prepared minority students may do worse than less prepared non-minority students is a serious indictment of the educational environment we provide those students. Our institutions are a long way from providing “equal treatment.”

Stage II - Ineffective Action

Over the 20-year period from 1973-1993, approximately 100 engineering colleges established formal minority engineering programs (MEPs) to improve the academic performance and retention of their minority students. Unfortunately, this number appears to be declining. As evidence, only 85 universities submitted data for the 2003 National Association of Minority Engineering Program Administrators (NAMEPA) data book,^{iv} and not all of those programs are comprehensive in their approach.

Although some of these programs were created through faculty initiative with the program structure designed by faculty, most were created through administrative initiative with very little faculty involvement. Generally, a full-time staff director was hired and given the responsibility for designing and implementing a program. Few of these MEP directors had any substantial technical background or in-depth understanding of the engineering education process. Many possessed strong “student service” backgrounds (i.e. experience in outreach, admissions, advising, counseling, financial aid). Most minority engineering programs, therefore, were designed to deliver services to their students.

Broadly interpreted “student services” could include the traditional services—tutoring, counseling, and advising—as well as other types of services such as helping students obtain scholarships, placing them in engineering-related summer jobs, and overseeing student organizations. Engineering faculty and administrators typically maintain a polite distance from these programs because they feel that the staff director knows better how to meet the needs of minority students. Furthermore, they have no objection to the student service approach because it is in accord with their view that minority students are deficient and need help.

However, MEPs that focus primarily on delivering services to students have little or no impact on their students' academic performance for several reasons. First, the average amount of services delivered per student is by necessity too small to have a significant

^{iv} Available to university, corporate, and individual members of NAMEPA (www.namepa.org)

impact on student success. Consider a program that serves 200 students and offers 40 hours of tutoring per week, 20 hours of counseling per week, \$40,000 per year in scholarships, places 40 students in summer jobs in industry, and oversees a student organization having 30 highly active members. On average, each program participant receives 12 minutes of tutoring and six minutes of counseling each week, \$200 per year in financial support, and a summer job every five years. Fifteen percent of program participants benefit from the activities of the student organization. Though this analysis is a bit oversimplified, it does illustrate a primary limitation of the student service model.

The ineffectiveness of programs that focus primarily on delivering services to their students is exacerbated by the fact that many of the services offered require student initiative. As a result, there is a strong tendency for the students who need the services the least to get them the most; whereas the students who need the services the most, get them the least.

Finally, student service delivery models ignore the most significant barrier to minority students' success in engineering study in predominantly white institutions, which is the diminished quality of the learning environment resulting from ethnic isolation, lack of peer support, lack of role models, and low faculty expectations. If they are to be effective, programs whose purpose is to improve the academic performance and graduation rates of minority engineering students must address these primary barriers to student success.

THE SOLUTION

Stage III - Effective Action

In 1985, the California Postsecondary Education Commission evaluated 12 minority engineering programs operating under the sponsorship of the California Mathematics, Science, Engineering Achievement (MESA) organization with some remarkable findings.⁸ The Commission determined that students participating in these programs were being retained at higher rates than all engineering students at each of the 12 institutions, and at three times the rate of minority students not participating in the programs. A summary of this data is presented in Table 4.

**Table 4
THREE-YEAR RETENTION OF FALL 1982 ENGINEERING FRESHMEN**

	University of California	California State University
All Students	47%	67%
African-Americans in MEP	64%	79%
African-Americans not in MEP	13%	30%
Mexican-Americans in MEP	57%	88%
Mexican-Americans not in MEP	21%	41%

Equally impressive are statistics from the Professional Development Program at the University of California, Berkeley. Participating minority students earned on average one letter grade higher in their math and science courses than non-participating minority students. In addition, they exceeded the average grades achieved by white students in the same courses.⁹

Given national academic performance and retention figures, how is it that minority students outperformed white engineering students and were retained at significantly higher rates than all engineering students? After all, myth has it that minority students are less well-prepared, less motivated, and more burdened by personal and family problems. The answer is very simple. If we create an optimal learning environment for minority students, one that is equal to that which we provide for all students, then minority students will perform on a par with all students. To understand this requires a shift in our belief system—from believing that students' academic performance is primarily a function of their background and ability to believing that students' academic performance is primarily related to the quality of their educational environment. A good educational environment produces good academic performance, and a poor educational environment produces poor academic performance.

A Model Learning Environment

Central to creating a good educational environment is the simple but highly effective concept of collaborative learning. The idea of building students into a collaborative learning community is not new. My own college experience almost 50 years ago is an example of the type of collaborative learning community that white male students have benefited from for decades. When I entered MIT in 1957, as a 17-year-old freshman away from home for the first time, I immediately joined a fraternity and moved into a house with 37 other students. Twelve of us were freshmen, all taking the same four courses—calculus, chemistry, physics, and humanities—plus an elective. We became inseparable, studying and socializing together, and functioned as a team. Whether intentionally or not, MIT helped to promote group study by having common exams—every Friday at noon—one week was calculus, the next physics, the next chemistry, then humanities. All 900 freshmen, including the 12 of us, were always preparing for the same exam.

The upper-class students with whom we lived were very much invested in our academic success for two very practical reasons. First, most of the costs of running the fraternity were fixed—rent, staff salaries, utilities—and our monthly house bill was computed by dividing the total cost by 38. If one of us dropped out or flunked out, everyone's house bill went up. Second, the MIT administration kept track of each fraternity's average GPA, and if it dropped, the leadership of the house was “called on the carpet.”

So lots of mechanisms were in place to ensure that we succeeded. We each had a big brother who was responsible for our academic performance. The upper-class students were required to have “bibles” of their notes, tests, homework, and laboratory reports for every course they had taken, so we had access to 26 sets of materials on each course we were taking. There was no shortage of tutoring. The house was full of “experts” who were willing to show-off their knowledge in the subjects we were taking. Quiet hours were enforced and if it was felt that one of us was not taking his academic work seriously, he would be called in for a “heart-to-heart” talk with several upper-class students.

That educational environment is one of the best models conceivable. First, there was strong peer support—a group of students who were all taking the same courses, working on the same homework, and preparing for the same tests—a group working together and socializing together. Second, there was strong support from upper-class role models—students who had already traveled the road and who cared about us and were invested in our success. Given this environment, how could one fail? Almost none of us did.

While my experience is anecdotal, there is an extensive research base that substantiates the efficacy of collaborative learning. That is, when institutions promote a high level of collaborative learning among a group of students, positive outcomes including improved academic performance, improved retention, enhanced student satisfaction with the learning experience, improved oral communication skills, and higher student self-esteem are achieved.¹⁰

Implementation of Stage III - Building a Collaborative Learning Community

Unfortunately, the application of these principles to improving the educational environment for minority students is not common. This is surprising given the evidence (as, for example, is shown in Table 4) that when engineering colleges have worked to build minority students into a supportive community and promote a high level of collaborative learning, those students have been retained at a higher rate than all engineering students and their academic performance level has matched that of all students.

Successful minority engineering programs have used two basic strategies for promoting collaborative learning among their students. The first is to create the conditions necessary for students to work collaboratively through their own initiative. The second is to mandate collaborative learning through the implementation of structured study groups. Each of these approaches has proven to be effective in bringing about significant improvement in the students' academic performance and retention. They are not mutually exclusive, however, and results are optimum when both strategies are implemented simultaneously.

In order for students to engage in meaningful group study, four conditions must be met. First, the students must be taking the same courses. Second, they must be in the same sections of those courses so they have the same homework and tests. Third, they must know each other—not only by name but also through their relationship as participants in the minority engineering program. And fourth, they must be taught the benefits of group study and how to best go about it, while being “untaught” attitudes they may have acquired that support a preference to study alone.

Although there are many ways to meet these four conditions, the approach taken at 18 California universities and more recently at universities outside of California, such as the University of Washington and the University of Colorado at Boulder, has proven highly successful. At heart of the MEP model are three structural elements that ensure that the conditions for students to work collaboratively are met. These structural elements are: clustering of students in common sections of their classes, a freshman orientation course, and a student study center. Implementation of each of these structures will be discussed in the following sections.

Clustering Students in Common Sections of Their Courses

If a university wishes to do one thing that costs little and will greatly enhance the quality of the educational environment and the academic performance of minority engineering students, it would be to cluster students—that is, to enroll groups of minority students in common sections of their courses. Through clustering, the first two conditions required for collaborative learning are met—students are not only taking the same courses, but are in the same sections of those courses. Because they have the same homework to do and the same tests to prepare for and see each other regularly, the opportunities for sharing information and working collaboratively are greatly enhanced. Clustering also has the additional benefit of reducing ethnic isolation normally experienced by minority engineering students.

Clustering should be distinguished from “minority-only” sections. I personally have no philosophical opposition to special sections of classes for minority students. We certainly didn't object when the students in our classes were exclusively white males. There is some evidence that minority students would benefit from “minority-only” sections. As one example, students in minority sections of calculus at Pennsylvania State University outperformed the class average on common exams. However, my own experience has shown that when minority sections are created within predominantly white universities, an enormous amount of energy will be spent in defending their efficacy.

Implementation of clustering requires three steps: 1) identifying the cluster sections; 2) advising students to enroll in those sections; and 3) ensuring that the students are able to register in the sections they are advised to take. The mechanics of clustering will depend on each institution's process for advising and registering students. Cluster sections might be chosen as those that are taught by faculty who are effective teachers and are concerned about the education of minority students. If an advising system is in place that assists students in planning their course schedule for the next term, all that may be required is to inform the advisors of the cluster sections. If such an advising system does not exist, one must be set up. Advising students into specific sections of courses does not ensure that they will be able to register in those sections. The institution may need to be persuaded to provide registration accommodations to ensure that students get the classes they were advised into. Priority registration, block registration, and restricted sections are three possible approaches.

As each university considers the concept of clustering minority students, inevitable questions will arise. “Shouldn't we be 'mainstreaming' minority students? Aren't we segregating these students and therefore keeping them from learning how to work with white students?” These questions can be answered on a number of levels. Of course, the ultimate objective is mainstreaming. Just look beyond the university and you will see that there are very few minority engineering companies. Most minority engineering graduates will work in predominantly white corporations. The real question, then, is how best to prepare them for that. What do we accomplish by bringing a 17-year-old minority engineering freshman, away from home for the first time, in a predominantly white environment for the first time, ethnically isolated in that environment, and dealing with the demanding academic standards of an engineering curriculum, only to have that student flunk out or at best change to a less rigorous major?

I suggest it is better to bring those students into a supportive environment where they can develop their confidence, strengthen their study skills, learn the value of collaborative study, and build a strong foundation in mathematics and science, and then as the curriculum diverges become progressively more involved in the broader student environment. This approach recognizes the need to provide students with a “transition” period. We are all familiar with transitions. Corporate representatives tell us that it takes two or three years before one of our engineering graduates earns his or her salary. Corporations provide new engineers with close supervision, formal training, on-the-job training, and time to mature. But we expect that students will be ready to handle calculus, chemistry, and physics the day they arrive at our institutions. This “sink or swim” approach has not worked for minority students. It's time to try something that will work.

Orientation Course for Minority Engineering Freshmen

A freshman orientation course is a very powerful and efficient structure for meeting the third and fourth conditions necessary for collaborative learning and for accomplishing many other objectives of a minority engineering program. My first thought when I started the Minority Engineering Program at California State University, Northridge was that if I were to have any significant impact on the students, it was essential that I have regular contact with them at least during their first year. I felt so strongly about this that the only way a student could join MEP was by taking the freshman orientation course. And the value of this course was again and again substantiated by the students. Over the years, we frequently had panels of upper-class students explain the program to various constituencies. The format we used was to have each student respond to the question: “What are the two things about the MEP program that benefited you the most and why?” Without exception, every single student indicated that their participation in the freshman orientation course was one of the two things about MEP that had benefited them the most.

To understand the importance of the freshman orientation course to students requires an examination of the course objectives. Several years ago, as part of an all-day workshop on MEP freshman orientation courses, the directors of the 18 California MEPs ranked the following five objectives in order of importance:

- Community Building
- Academic Survival Skills
- Personal Development
- Professional Development
- Orientation to MEP, the School or College of Engineering, and the University

The following sections will discuss each of these objectives and outline approaches for achieving them. Resources to support instructors of such courses can be found at: www.discovery-press.com/catalog/studyengr/ssresource.htm. *Studying Engineering: A Road Map to a Rewarding Career*,¹¹ which was the outgrowth of my experience in teaching the MEP freshman orientation course, is an ideal student text for the course.

Community Building. The most important objective of the freshman orientation course is building the students in the class into a supportive academic community. MEP freshman students represent an enormous resource to each other. They can support each other

academically through the sharing of information and group study. They can support each other socially. Having friends who share common goals and similar workloads is of great value. When one's friends are all studying, studying becomes the order of the day. Personal sacrifice becomes easier when it is the norm. And they can support each other psychologically. Many times I had MEP students tell me, "I'm going to make it here because I like it here." Students who are part of a supportive community are likely to do whatever is required to stay in that community.

The community building process can be divided logically into three components: 1) socialization; 2) group building; and 3) human relations training. These components need not be implemented sequentially, but rather can be implemented in any order. And all three should be part of an ongoing process.

The purpose of the *socialization* component is to get the students to know each other. A critical first step is for each student to learn the name of every other student in the group. This can be accomplished through name learning exercises, small group discussions, and group projects. Ensuring that the students know each others' names will take some class time, but the benefits to the students will be enormous. Once they know each other by name, interpersonal relationships will develop and grow, particularly among students who are clustered in their key courses. But don't take it for granted that the students will get to know each other on their own. I often see colleagues on campus whose names I should know, but I am embarrassed to show that I don't by asking. Without help, students can be in that same situation.

The second component in the community building process is *group building*, i.e., creating a strong sense of group cohesiveness and mutual support. To foster this sense, the following message needs to be transmitted:

The students in this group are your greatest resource. We are a team. If we support each other, we will all benefit. We sink or swim together. If one of us fails, it will reflect on all of us. By working together, we develop the skills that will make us effective as team players in the engineering work-world.

This process of shifting students' perspective from being "individual-centered" to being "group-centered" and from one of being in competition with each other to one of cooperation and mutual support is extremely important. Not only will this shift enhance their effectiveness as engineering students but also as engineering professionals.

The third component in the community building process is to provide the students with some basic *human relations training*. Even if students are committed to supporting each other, they may lack the skills to do so. One simple but effective class exercise is to have each student write down a list of things that they "want and need from other students in the group" and another list of things that they "don't want and don't need from other students in the group." A compilation of all the students' lists will provide an excellent basis for discussing those behaviors that are supportive of others and those behaviors that are not supportive of others. Where the course facilitator lacks expertise in the area of human relations training, help from professionals can be sought. Generally, experienced human relations trainers can be found in the university counseling center or the psychology or educational psychology departments.

Academic Survival Skills. Another very important objective of the freshman orientation course is to teach students what they need to know to be effective as students in math, science, and engineering courses. In my view, there are a few extremely powerful principles that if put into practice by students will virtually assure their academic success. The challenge is to develop a teaching methodology that will bring about behavioral changes called for by these principles. One effective approach is to teach a principle, ask the students to put it into practice, and then have them report back to the class on how it worked for them. As students hear that their peers are making changes to more productive behaviors and that these changes are producing tangible results, they are influenced to “get with the program.” This pedagogy is discussed in more detail in my 1997 ASEE paper.¹²

What are these powerful principles? Alexander Astin's outstanding article “Involvement: The Cornerstone of Excellence”¹³ provides one excellent model for identifying them and for giving the students a framework from which to view their education. Astin indicates that excellence in education is directly related to “student involvement” as measured by five indicators:

- Time and energy devoted to studying
- Time spent on campus
- Participation in student organizations
- Interaction with faculty
- Interaction with other students

Time and Energy Devoted to Studying. The overall message for students is that if they want to get an excellent education, they should devote considerable time and energy to studying, immerse themselves in the academic environment of the campus, participate actively in student organizations, make effective use of their professors, and work collaboratively with other students. The following sections expand briefly on each of these principles.

There are many important concepts that students need to be taught in relation to “time and energy devoted to studying.” However, virtually all are in support of one underlying principle:

Don't allow the next class session in a course to come without having mastered the material presented in the previous session.

This is easier said than done. The tendency of most students is to fall into the trap of studying from test to test rather than from class to class. They need to be taught that this approach will not be effective for problem-solving courses where each new concept builds on prior ones; that by not keeping up in their classes they are converting a sound educational process into an unsound one.

Students also need to understand the concept of “time on task” and realize that the amount of effort they put in will be the most important factor in how well they do. They need to realize that learning is a reinforcement process—that we learn by many, many exposures to concepts over a long period of time, not by cramming for tests at the last minute. They need to recognize that their study time is more important than their class time and that when they negotiate it away they are borrowing time from the future, time that will not be there. And

they need to develop time management skills and a commitment to using their time effectively.

Time Spent on Campus. The importance of spending time on campus and of participation in student organizations should also be emphasized. Students will benefit from immersion in the academic environment of the university. Students who come to campus for their classes and leave as soon as they are over miss out on many important resources.

Participation in Student Organizations. Students should also be encouraged to participate actively in student organizations. Through this participation, they will develop their leadership and communication skills, and learn how to work effectively with others to accomplish objectives. They should be particularly encouraged to become active in minority engineering student organizations such as student chapters of the National Society of Black Engineers (NSBE), the Society of Hispanic Professional Engineers (SHPE), and the American Indian Science and Engineering Society (AISES). Freshman students will not only benefit from many of the activities of these organizations but from the close association with successful upper-class students. Furthermore, involvement on the part of freshman students will begin to build future leadership for these organizations.

Interaction with Faculty. Students should be strongly encouraged to make effective use of their professors. Professors can provide students with valuable one-on-one instruction, academic advising, career guidance, and job references. The first step is to help students overcome any fear or intimidation they feel toward professors. Some human relations training can be helpful in this regard. There are three things about professors that students can be taught to use to their benefit: 1) professors have chosen to devote their careers to teaching and believe that they are good at it; 2) professors like their areas of technical specialty and think they are vitally important; and 3) professors are very knowledgeable and enjoy communicating their knowledge to others. Students should be taught what behaviors support these characteristics of professors and what behaviors are in conflict with them.

Obviously, students know that they should refrain from behaviors such as being late to class, sleeping in class, talking in class, and not turning in their homework. But do they realize the benefits of visiting their professors during their office hours and talking with them? Students report tremendously positive experiences when they visit a professor in his or her office and ask such simple questions as “How did you decide to become a professor?” or “Can you tell me more about the field of civil engineering?”

Interaction with Other Students. Making effective use of one's peers is perhaps the most important academic survival skill that can be taught in the freshman orientation course. The benefits of collaborative learning and group study are enormous. Unfortunately, many minority students developed a pattern in high school of doing all their studying alone and separating their academic life from their social life. They may have found their high school work to be easy and thus had no need to study with other students. This pattern of behavior, however, will not work in engineering study except for students with extraordinary academic preparation and ability. And even though these students may get through, it is likely that they will not achieve up to their full potential and will miss the many valuable lessons collaborative learning offers.

When I visit universities to review their minority engineering programs, I make it a point to meet with groups of freshmen and successful upper-class students. One of the questions I

ask is, “How much of your studying do you do alone, and how much do you do with other students?” There's a striking contrast between the freshmen, most of whom indicate that they study almost entirely alone, and the upper-class students, who generally do a significant amount of their studying with other students. It seems to be more than mere coincidence that the students who have achieved academic success are the ones who have recognized the value of collaborative learning. Interestingly, students who say they do almost all of their studying alone always have a reason. The three most common ones are: “I learn better working alone”; “I don't have anyone to study with”; and “It's not right. You're supposed to do your own work.” All three of these attitudes can be readily changed by discussing the efficacy of collaborative learning in the freshman orientation class. There are three points that I have found to be very effective in persuading students of the benefits of collaborative learning: they will learn the subject much better; they will be better prepared for the engineering world of work; and it's more fun so they will probably do more of it.

The starting point for addressing all three of these justifications for group study is to give students a higher context from which to view their education. Studying alone might be defensible if one views an education as becoming proficient at working alone to master knowledge. However, an education should be much more than that. A quality engineering education involves not only mastering knowledge, but also becoming proficient at communicating that knowledge to others. Students who spend four years working alone will have missed out on much of what is important in their education and will not be well prepared for the engineering work world where communication skills and the ability to work with others are highly valued.

I encourage students to spend about two-thirds of their study time mastering the material and one-third of their time discussing it with other students. Using this approach strengthens their ability to communicate their knowledge and receive feedback about whether they are understood. They also develop their ability to listen to others present their ideas—an ability that we too often ignore or take for granted. Through the collaborative process, students will also develop a better understanding of the subject matter. Since more points of view on the subject will be brought to bear, students will broaden their thinking skills. As they teach each other, they will be challenged to deepen their understanding. Finally, collaborative learning allows students to meet social needs while they are learning. Because studying with others is more enjoyable, they will be likely to do more of it.

Personal Development. Another important objective of the freshman orientation course is to assist students in their personal development. The human relations training that helps students develop their interpersonal skills is particularly effective when paired with a strong cultural awareness component. This can be designed to help students appreciate their own culture and also to appreciate other cultures. MEPs are generally multicultural environments, and one challenge faced by the program is to build a diverse student group into a supportive community.

Another goal of the freshman orientation course should be to assist students in building self-esteem and self-confidence. Students need to understand that they are special and that they are valued by the institution. The old cliché where the dean comes in and tells the freshmen students, “Look to the right, look to the left. Two of the three of you won't be here

at graduation,” is no longer operative. Students need to hear that each and every one of them can be successful in graduating in engineering.

There are wonderful motivational messages, like Jesse Jackson's “excel” message, which can really benefit students. Jackson's basic theme is that people should strive to do their best in whatever they undertake. This concept can be reinforced with a class exercise in which students brainstorm and discuss all of the reasons why it’s true. Football coach Lou Holtz offers inspirational messages as well. Perhaps his strongest is that everyone who sets a goal and strives to achieve it will encounter adversity. The main difference between people who succeed and people who fail is how they handle that adversity. The message for students is that the most likely reason they will not graduate is that they will encounter some adversity and give up. I tell students: “Your success here will depend primarily on your determination to persist; your effort; and your effectiveness in putting the academic survival principles you learn in this course into practice.”

Students can also be assisted in the development of leadership and organizational skills. While stressing the importance of working effectively with others, students can be taught principles of organizational management including building organizational structures, setting objectives, and managing organizations to meet those objectives.

Other areas of personal development that might be addressed in the freshman orientation course are stress reduction, conflict resolution, assertiveness training, learning styles, goal setting, and management of personal finances.

Professional Development. The freshman orientation course can also assist students in the area of professional development. Here the primary focus should be to motivate students through an increased understanding of engineering as a field of study and as a profession. Many students may have chosen to study engineering almost by default, having received encouragement to do so because they were good in mathematics and science. Most will know very little about engineering. This is a serious problem given the hard work and personal sacrifices required of engineering study. Interestingly, if engineering students don't learn about engineering in the freshman orientation course, they will not learn about it during their first two years in college where the primary curricular focus is on calculus, chemistry, physics, and general education. Increasing students understanding of engineering can be approached on three levels: 1) motivating them through an increased awareness of the rewards and opportunities of a career in engineering; 2) giving them an understanding of the “engineering process”; 3) exposing them to the different technical specialties and job functions of the engineering profession.

Rewards and Opportunities. Giving students an in-depth perspective on what it will mean to their lives if they are successful in engineering study has enormous motivational value. One excellent class exercise is to have students brainstorm a list of the rewards and opportunities that will come to them if they graduate in engineering. Except for the idea that engineers are well paid, most students have given little or no thought to the many other rewards an engineering education will bring to them. With a little help from the course facilitator, the list might number thirty or forty items including:

- Good income
- Challenging work

- Professional respect
- Solving society's problems
- Development of logical thinking ability
- Job satisfaction
- Variety of career paths
- Good employment opportunity
- Enhanced self-esteem
- Job security
- Good health and retirement benefits
- Professional work environment
- Association with interesting people
- Opportunity to travel
- Opportunity to express creativity
- Involvement at the forefront of technology

Students will benefit from not only discussing these items in class but from writing an essay on “Why I Want to Be an Engineer,” focusing on which of these rewards and opportunities are important to them and why.

Understanding the Engineering Process. Students also benefit from an understanding of the “engineering process”—or put more directly, students should be able to answer the question, “What is engineering?” As an example, students need to be taught that engineering is the process of producing a technical product to meet a specific need. They should understand that the need is generally described by a set of specifications: performance specifications (e.g. weight, size, speed, safety, reliability); economic specifications (e.g. cost); and scheduling specifications (e.g. delivery date).

Students should know that the first step in the engineering process involves coming up with several different designs that meet the specifications and that the design process relies on not only engineering tools such as computer-aided drafting, structural analysis, computer modeling, material science, and manufacturing processes, but also on a great deal of engineering common sense and experience. The students should understand that eventually one or more of the designs will be fabricated and put through a series of tests to see how well they meet the performance specifications. Finally, they should be aware that there might be many iterations through this entire process before the final design is selected. It is particularly important that students be taught that, whereas in school most problems have a single right answer, in engineering there may be many solutions to a single problem.

Students' understanding of the engineering process is greatly enhanced by illustrating it with examples or case studies, particularly ones that are interesting or relevant to young lives: developing a machine to pitch baseballs; a guard rail along a mountain road; a device which would cause a video recorder to skip the commercials while taping a TV show; a device to electronically mark the forward progress of a football; or a “fail-proof” car alarm. A challenge for the freshman orientation course facilitator will be identifying an individual to cover this topic. Many engineering professors and practicing engineers are very effective at communicating specific areas of the engineering process. However, it is an the exceptional

person who has both the breadth of practical experience and the communication skills required to give a stimulating presentation on the engineering process to freshman students.

Technical Specialties and Job Functions. The task of exposing students to the technical specialties and job functions that categorize engineers is much easier. Students should be given some exposure to the five traditional engineering specialties—electrical (including computer engineering), mechanical, civil, chemical, and industrial—along with an awareness of the many non-traditional specialties (e.g. nuclear, environmental, aerospace, petroleum, biomedical, mining, etc.). Department chairs or faculty can be brought in as guest lecturers for this purpose. However, too much of this can be boring and repetitive.

Students should also be made aware of the different job functions that engineers perform, most commonly: design, analysis, test, development, research, and management. There are also field engineers, sales engineers, and service engineers, and opportunities exist for engineers in training and teaching. Guest speakers from industry can be brought in to talk about these various job functions. Alumni of the MEP program would be ideal in this role. An assignment to interview a practicing engineer and write a report of the experience can further enhance students' understanding of what engineers do.

Students should learn about various industry sectors and how they utilize engineers. Oil companies, aircraft manufacturers, utility companies, aerospace electronics firms, large constructors, computer manufacturers, biotechnology companies, and chemical companies are examples of major industry sectors. Field trips to local engineering firms can enhance students' awareness of the engineering work place. Students can also be exposed to industry through required attendance at university or MEP-sponsored career days.

Other important topics in professional development include resume writing, preparing for interviews, evaluating opportunities for graduate study, and negotiating the engineering professional registration process.

Orientation to MEP, School or College of Engineering, and University. The final objective of the freshman orientation course is to orient students to MEP, the school or college of engineering, and the university. A comprehensive orientation to the minority engineering program includes information about the program's purpose, staff, philosophy, rationale, student services, and programmatic structure. The point is to make students aware of how they can best take advantage of what the program offers and what is expected from them as program participants.

Orientation to the school or college of engineering should include topics such as administrative organization, faculty, curriculum, academic advising system, facilities, student organizations, and academic regulations. It is important that students thoroughly understand important academic regulations and procedures such as drop/add procedures, the grading system, and the academic disqualification system. Orientation to the university should put the students in touch with campus resources including the library, financial aid system, academic support centers, counseling center, student health center, and placement office.

Administrative Issues. The previous sections have detailed five primary objectives of an MEP freshman orientation course that can be of enormous benefit to MEP students.

Achieving these objectives requires adequate course time and adequate incentives to guarantee serious student participation. In my experience, 60 to 70 hours of total contact time are necessary to meet course objectives. Ideally, the course spans the entire freshman year with more contact time in the first semester (e.g. three or four hours per week for the fall semester and one hour per week for the spring semester). It is doubtful that any incentive other than academic credit will effectively motivate student participation. Where universities have tried to bring their minority engineering freshmen together on a voluntary basis, attendance has been extremely poor. Even incentives such as scholarships, priority registration, and summer jobs in industry have not been able to compete with an upcoming calculus exam for the students' time.

Receptivity of faculty to giving academic credit for the MEP freshman orientation course varies greatly from one institution to the next. At some schools, faculty recognize the educational benefits of orientation and the course gains approval through the curriculum approval process. At other institutions, faculty feel that the content of orientation courses is not “academic” and that such courses should not be given academic status. At a number of these institutions, the MEP freshman orientation course has been offered using an existing course number. Possible vehicles for the MEP freshman orientation course are engineering courses for non-engineering majors, special topic or experimental courses, university-wide orientation courses, and courses in problem solving. Whether officially approved or not, there is general agreement that the MEP freshman orientation course should not be used to satisfy engineering graduation requirements, as doing so might elicit charges that graduation requirements for minority students are different from those for non-minority students.

Student Study Center

An engineering college can further improve the educational environment for minority students by establishing an MEP student study center. The study center becomes the focal point for an effective minority engineering program. The study center provides minority engineering students with a place to study individually or in groups, and is a convenient place to offer tutoring services. The study center's first and foremost benefit, then, is that it promotes collaborative learning. It also serves as a home base for students, a place where they can leave their personal belongings, meet with fellow students, plan activities, or just find a friendly face. The study center thus has the additional benefit of sending minority students signals that they are accepted and valued by the institution—that they belong. Finally, the study center promotes communications within the minority engineering program. It enables program staff to transmit messages to students; it enables students to contact one another; and it serves as a center for announcing student organization activities and other program and school or college functions.^v

The study center should be centrally located in the engineering facility and accessible to students. Ideally, it should be open 24 hours a day, seven days a week. The space designated for the center should be of good quality, as second-rate space sends a strong message to minority students that they are not valued. The space must be of adequate size,

^v Certainly the proliferation of e-mail and cellular phones has the potential of enhancing communication among students. But these and other technological advances can also have the effect of isolating students. In this light, a student study center may be even more critical to successful community building efforts.

as cramped quarters can defeat the purpose of the center. When study centers are too small, they tend to be taken over by cliques of upper-class students who send signals to other students that there is no room for them. A good rule-of-thumb is that the study center should be large enough to comfortably accommodate 20 percent of the college's minority engineering students. The study center should have ample tables, chairs, and whiteboards to encourage group study. Book lockers are also desirable, for they promote a high level of study center usage. Having a place to keep their books and materials encourages students to come to the study center between classes, rather than going to less "academic" places like their dorm room, apartment, or the student union. Finally, the study center should clearly belong to the students. It should never be co-opted for other purposes. The effectiveness of the study center will be greatly reduced if students cannot count on it being accessible to them.

Where study space for all students is inadequate, non-minority students may express resentment that space is being provided to minority engineering students. Since the minority engineering program receives funding, one way to diffuse these attitudes is to point out that this space is being provided to accomplish the objectives of a funded program. In my experience, many non-minority students have given little thought to the need for a minority engineering program. Often, an explanation of the history, rationale, need, funding, and overall benefit to the engineering college will win their support.

A final point. Space everywhere is at a premium. There is, I'm certain, a fundamental law that "The need for space always exceeds the space available." Allocation of space is basically a priority issue. Our experience in establishing MEPs in California suggests that engineering schools *can* find space for an MEP student study center. Today, there are eighteen MEPs operating in California and all have outstanding student study centers. Our approach for bringing this about was very straightforward. When funding was offered to engineering schools to establish MEPs, space for a student study center was made a contractual requirement. We found that where space is extremely tight, one of the best ways to create an MEP student study center is to convert a classroom. Classrooms are ideal since they are generally accessible, about the right size, and have abundant board space. And since no one owns classrooms, resentments that might occur when one's space is taken away are avoided. Furthermore, the impact of taking one of the hundreds of classrooms on a campus out of circulation is diffuse. The worst-case impact is that the university must reduce the number of courses offered in some prime time slots by one.

Structured Study Groups

Experience has shown that clustering, a freshman orientation course, and a student study center are effective structures for improving the educational environment of minority students in predominantly white engineering schools. Students who take advantage of a supportive peer community and work collaboratively with each other will perform well academically and be much more likely to graduate. However, this approach requires students to take the primary initiative in developing study partners or study groups. A desirable adjunct, then, is offering structured study groups. Mandating group study, particularly in early key math and science courses, ensures not only that all students have experienced the collaborative learning process, but also that they acquire a strong foundation in mathematics and science.

The most effective model for structured study groups is the math/science workshop model pioneered by P. Uri Treisman at the Professional Development Program (PDP) at the University of California, Berkeley. These workshops have come to be called Academic Excellence Workshops because, rather than providing academic support through remediation, they promote the highest levels of achievement.

Academic Excellence Workshops are structured group study sessions. Workshop participants—students who are clustered in common sections of their math or science course—meet as a group with a workshop leader for two or three two-hour sessions each week. The students are required to have attempted the assigned homework before coming to the workshop. At the workshop, the students work in small groups on sets of problems prepared by the workshop leader in consultation with the course instructor. Consistent with the stated objective of the workshop—that all participants achieve a grade of either “A” or “B” in the course—the problem sets are generally more challenging than the assigned homework. The workshop leader assists groups as problems arise and may give a short lecture when several groups are encountering common problems. Lecturing, however, is kept to a bare minimum, since the emphasis of the workshop is on group study.

Since their inception at the University of California, Berkeley, these workshops have been replicated at a large number of both undergraduate teaching institutions and Ph.D.-granting institutions, and for a wide range of courses—from college algebra to differential equations, all of the chemistry and physics courses required of engineering majors, and some engineering courses. Workshop leaders have been faculty, graduate students, and in some cases even undergraduate students. Workshop participants have shown an average improvement of 0.5 to 1.5 in their grade in the course, compared to students of similar characteristics not in the workshops.

As one dramatic example of the effectiveness of the workshops, at California State Polytechnic University, Pomona, minority students participating in a workshop in engineering statics who had an average math SAT of 451 achieved an average GPA of 2.88 in the course; whereas non-minority students in the class who had an average math SAT of 563 achieved an average GPA of 1.89 in the course.¹⁴

Excellent articles on the workshops are available.¹⁵ Generally, they suggest that, in beginning a workshop program, it's advisable to start small with a pilot effort in one or two courses. Include an assessment component that allows for comparison between the academic performance of workshop students and a comparable control group. Evaluation is essential if the workshop program is to gain support and grow. Although implementation appears straightforward, there are important details which impact program effectiveness. Fortunately, there is no need to reinvent the wheel. There is a significant body of experience in implementing Academic Excellence Workshops (see reference 14), avoiding potential pitfalls and ensuring an effective program. An excellent recent publication is “Academic Excellence Workshops—Developing an Academic Community.”^{vi}

^{vi} Hudspeth, M. Catharine, “Academic Excellence Workshops—Developing an Academic Community” (<http://profj.us/aew.pdf>)

Need for Student Services

While it's been suggested here that minority engineering programs designed to build students into a supportive community and promote a high level of collaborative learning and group study are more effective than those based on a student service delivery model, I would not like to leave the impression that MEPs should not deliver services to their students. Providing students with personal counseling, academic advising, tutoring, scholarships, assistance with summer job placement, and fostering the development of active minority engineering student organizations are important functions of a minority engineering program and its staff. These services are of minimal benefit, however, to students who must cope with the negative ramifications of ethnic isolation, lack of peer support, lack of role models, and low faculty expectations. Unless these primary barriers are eliminated, most students will not be around to utilize the services.

An excellent resource on delivery of student services to MEP students is the NACME/NAMEPA Handbook *Improving the Retention and Graduation of Minorities in Engineering*¹⁶. Detailed information on monitoring student progress, providing students with academic advising and personal counseling, setting up tutoring programs, assisting students with the financial aid process, and helping students in identifying pre-professional employment opportunities can be found there. The chapter on developing minority engineering student organizations is outstanding.

Although delivery of services is an important part of a community building/collaborative-learning MEP, in my experience once such a program is fully developed, the need for these services diminishes. There are several reasons for this. First, significant efficiencies result from the programmatic structures. As one example, through the freshman orientation course much of what students need to know can be communicated to the group as a whole, reducing the need for MEP staff to meet with students individually. As another example, Academic Excellence Workshops are much more cost effective than individual tutoring since workshop leaders can reach 10 to 15 students at the same time. Further, experience has shown that when the MEP community building structures are in place, the development of minority engineering student organizations is enhanced and those organizations are more effective in supporting students in the areas of social interaction, academic development, and career and professional development.

The need for services also diminishes because, in a supportive academic community, students provide services to each other. Where there is extensive sharing of information among students, the need for academic, personal, and career advising is reduced. Where students are studying collaboratively, the need for tutoring is reduced. And when students do need help they can get it from upper-class MEP students. Upper-class students also serve as mentors providing information on academic, career, and personal issues. And students in a supportive community generally have less need for personal counseling because they have friends they can confide in.

Finally, students who are performing well academically generally need fewer services. Therefore, as a community building/collaborative learning model MEP develops and the academic performance of its students improves, the need for the program to provide services will diminish.

Starting a Minority Engineering Program

A natural inclination, when starting a minority engineering program, is to seek out students already in the pipeline, many of who may be having academic difficulty. Unfortunately, the impact an MEP program can have on these students is limited. Many may lack an adequate foundation in the fundamental mathematics and science courses. It is doubtful that intervention on the part of MEP staff can overcome the cumulative consequences of several years of poor academic performance. However, some students may benefit from individual counseling; others from help in developing study partners. Yet, if most of the MEP staff time is devoted to working individually with these students, the current situation will perpetuate itself.

The primary focus of a minority engineering program should be on the incoming freshman class. The program can have a major impact on the academic success of these students. By working to get freshmen on track, a new program builds a strong future. Within a few years, there will be MEP students who are performing well all along the pipeline.

There are two primary tasks involved in starting a minority engineering program: 1) putting the programmatic structures into place; and 2) identifying incoming MEP freshman students and programming them into those structures.

As detailed earlier, the MEP programmatic structures to be put in place are:

- academic advising and registration systems that will cluster students in common sections of their key classes;
- a freshman orientation course to build community and teach academic survival skills;
- a student study center; and
- Academic Excellence Workshops.

While the process of implementing these structures will vary greatly between institutions, the primary task is to persuade key decision makers of the efficacy of this model. Implementation will not require a great deal of resources; however, it will take “institutional commitment.”

To build the MEP freshman class, an essential first step is to establish communication with potential new students during the application and admissions process. My suggestion is to set up a procedure whereby students are invited to apply for admission into the MEP program. To ensure that most incoming freshmen do apply, the invitation should “sell” MEP by emphasizing those things about the program that would be most attractive to new students (e.g. scholarships, summer jobs placement, priority registration). The invitation to apply should emphasize that the purpose of MEP is to promote academic excellence and that not all students are admitted. One benefit of admitting students into MEP is that it provides the opportunity to set conditions for admission such as enrollment in the MEP freshman orientation course and participation in Academic Excellence Workshops.

New MEP students should be assisted with the matriculation process to ensure that they take the proper placement tests, receive academic advisement, are oriented to MEP and to the university, and register in the proper courses. As the fall term begins, new MEP students should be enrolled in the right courses, be taught by the best teachers, be clustered

with other MEP students, be scheduled into Academic Excellence Workshops in their key math and science classes, be enrolled in the MEP freshman orientation course, have an upper-class MEP student mentor, and have their own book locker in the MEP study center. This is the type of educational environment that will promote academic success.

Faculty Involvement in Minority Education

While much can be done to mitigate two of the key barriers to minority student success—ethnic isolation and lack of peer support—we face a much greater challenge in compensating for the lack of role models among engineering faculty. In the absence of faculty role models, there is a critical need to sensitize engineering faculty to the special problems and needs created for minority students by the engineering college environment and to increase faculty expectations of what these students can accomplish. By and large, non-minority faculty have not been involved in the education of minority students. We have generally relegated this responsibility to professional staff or to minority faculty who may be already overburdened with affirmative action tasks. Although these individuals perform admirably, the responsibility for the education of minority students belongs to the entire faculty.

Certainly there are reasons why non-minority faculty have not been involved. One, of course, is the reward system we operate under and its emphasis on research. Another is related to individual faculty member's attitudes—to their lack of understanding of the impact of ethnic isolation, lack of peer support, lack of role models, and low faculty expectations on minority student academic performance. A further problem is that even those faculty who are interested in working with minority students often lack the skills to be effective in meeting the needs of those students.

Faculty Training Model. One way to change faculty attitudes and give them the skills they need to be effective in working with minority students is through training. At California State University, Northridge we developed a faculty training program called FAMES—Faculty Advisors for Minority Engineering Students. The FAMES model was highly successful and was eventually replicated at seven other universities in California. The purpose of FAMES is to train faculty to be more effective in their roles as academic advisors, counselors, mentors, and teachers of minority students. The training has two parts: 1) training in interpersonal communications and counseling; and 2) training in cultural awareness and cross-cultural communication. Typically about ten to 15 faculty members participate in about 50 to 60 hours of training (one afternoon per week for a semester). A brief description of the FAMES model is presented here, and an excellent dissemination document is available for those interested in implementing a FAMES program.¹⁷

Prior to the start of the FAMES training, each faculty participant is videotaped in a 20-minute session with a minority engineering student who is having academic difficulty. Faculty are encouraged to interact as they normally would with a student with academic problems. The training begins with a discussion of the principles of “naive counseling.” A naive counselor is a person who wants to help but lacks the skills to be effective in doing so. The naive counselor tends to be very directive, asking pointed questions, and listening to very little of the response. Once the naive counselor feels he has adequate information, he typically

launches into a long lecture about what he would do if he were in the student's situation or about what he has advised other students in similar situations to do.

Faculty generally are very comfortable in their role as one-way communicators and information givers, and after the videotaping sessions, almost always indicate that they "enjoyed talking with the student." Next, however, they are invited to critique their videotapes, both in terms of what they like about their behavior and what they do not like. Faculty are generally positive about their concern for the student and their desire to help, but realize that they have not been particularly effective. In fact, after viewing their videotapes, faculty often, for the first time, become aware of the impact they have on students. They realize that what they are providing is not helpful and may even be harmful to the student. Through this experience, faculty develop a high level of motivation to learn how to be more effective in one-on-one interactions with students.

Training in Interpersonal Communications and Counseling. The first half of the training (approximately 25 hours) is devoted to teaching the principles of developmental counseling. The teaching of counseling is a very well-developed methodology, and individuals are available on every university campus, in the psychology or educational psychology departments or in the counseling center, who are qualified to teach counseling skills. There are four steps in developmental counseling: 1) relationship; 2) exploration; 3) personalizing; and 4) action. In the first step, faculty are taught the importance of building a relationship and rapport with the student. Emphasis is placed on the importance of non-verbal communication and on developing good listening skills. Next, faculty are taught how to aid the student in exploring his or her situation and in identifying any impasses. Many students face similar conflicts. Their desire to study hard, to make good grades, and to get all of the benefits these will bring, is in conflict with their need to have a good time, to spend time with their friends, and to get the immediate gratification that these bring. Finally, faculty are taught how to help the student identify his or her personal role in the impasse and to propose some actions to resolve the impasse and commit to those actions.

Training in Cultural Awareness and Cross-cultural Communication. The second half of the FAMES training is devoted to increasing the faculty members' awareness of the cultural and ethnic dilemmas facing minority students and to developing a sensitivity to the unique issues related to communicating and establishing relationships across cultures. The methodology for this part of the training is less well developed but most universities have experts in these subjects on their faculty or staff.

In the CSU Northridge FAMES program, we began the cultural awareness part of the training by playing a game in which a cultural or gender stereotype was placed on the back of each participant. The rules of the game were that each participant had to interact at least twice with each other participant and that they must approach them from the stereotype on their back. Once I had "feminist" on my back. Forty-five minutes of having people ask me if I read *Ms. Magazine*, what I thought of the equal rights amendment, and what I thought of "women's lib" gave me an appreciation of what it is like to always have people interact with you based on an image that is not you. This exercise provides a good introduction to a lengthy discussion of the subject of stereotyping. Another eye-opener is to have faculty brainstorm to develop a list of both positive and negative stereotypes of various ethnic groups (e.g. African-Americans, Mexican-Americans, Italians, Germans). It is truly shocking to see what highly educated people have in their heads.

Another useful exercise is to have faculty talk about personal experiences they have had in interacting with minority individuals, particularly early experiences, and about attitudes that were instilled by their parents. Further sensitivity can come from having minority professionals discuss the challenges of working and achieving in predominantly white institutions. We also wanted faculty to hear from minority students, though we found that very little was communicated in face-to-face interactions. Good results were obtained by videotaping minority students in non-threatening environments talking about their experiences in interacting with white faculty and white students.

FAMES was evaluated to be highly successful in changing faculty attitudes and providing needed skills. Post-training videotapes of faculty in one-on-one sessions with students indicated substantial improvement in the faculty members' counseling skills. Faculty participants indicated increased interest in minority education and many subsequently became personally involved.

CONCLUSIONS

This monograph has approached the challenge of improving the academic performance and graduation rates of minority engineering students through a logical problem solving process. The first step in this process answered the question: Do we have a problem? Data was presented indicating that we have serious problems all along the engineering education pipeline. Minorities are substantially under-represented among engineering freshman students, indicating an *access* problem. Those minority students who do begin engineering study are graduating at significantly lower rates than non-minority students, indicating a *retention* problem. And some evidence indicates that those minority students who do graduate have on average lower GPAs than non-minority engineering graduates, indicating an *academic performance* problem.

The second step in this problem solving process answered the question: What is the cause of the problem? The hypothesis put forth was that the primary barrier to minority student success at predominantly white institutions is the diminished quality of the learning environment, resulting from ethnic isolation, lack of peer support, lack of role models, and low faculty expectations. The strongest point made in support of this hypothesis is that where institutions have provided minority students with a good learning environment by implementing programmatic structures that eliminate these barriers, the academic performance and graduation rates of minority students have been on a par with or exceeded those of non-minority students. The low graduation rates of minority engineering students, substantiated by nationwide data, are consistent with evidence that the vast majority of engineering schools or colleges have either failed to take action or have taken ineffective action.

Third, we answered the question: What is the solution to the problem? To create an optimal learning environment, the solution proposed was to implement four programmatic structures designed to build minority engineering students within an engineering school into a supportive academic community and promote a high level of collaborative learning and group study among those students. The four programmatic structures are: 1) clustering of students in common sections of their key courses; 2) a freshman orientation course; 3) a student study center; and 4) structured study groups. In addition, a model program for

training faculty to be effective in their roles as teachers, advisors, and mentors to minority students was presented.

The final step in this problem solving process is to implement these structures and track their impact on the academic performance and retention of minority engineering students. Evidence provided indicates that when these structures have been implemented at a large number and wide variety of types of institutions, outstanding results have been achieved.

The fundamental tenet of this monograph is that we need to redesign our institutions if they are to work for minority students. For too long, we have ignored the question of how well our institutions serve students who differ ethnically and culturally from the larger student body. Now is the time to consider this question and to take action to ensure that we do “treat all students the same.”

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