EFFORTS TO RETAIN WOMEN AND MINORITIES IN ENGINEERING: A PERSPECTIVE OF THE FOUNDATION COALITION PROJECT

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The need and efforts to increase the number of women and minority BS graduates in the engineering and science fields are well documented. In addition, many employers and educators have recognized a need to change engineering education in order to better prepare all students. A coalition of seven schools has undertaken the challenges of innovating the educational experience for engineering students, particularly those in the first two years, or foundation years. A special emphasis has been placed on enhancing the experience of a more demographically represented student body. The schools have formed the Foundation Coalition and include: Arizona State University, Maricopa Community College District (Arizona), Rose-Hulman Institute of Technology (Indiana), Texas A&M University-College Station, Texas A&M University-Kingsville, Texas Women's University, and the University of Alabama.

The Foundation Coalition (FC) is one of eight coalitions funded by the National Science Foundation. All eight coalitions have the expressed purpose of enhancing engineering education, in order to improve the quality of the graduates. Members of the FC draw on their diverse strengths and mutual support to construct improved curricula and learning environments, to attract and retain a more demographically representative student body, and to graduate a new generation of engineers who can more effectively solve the increasingly complex, rapidly changing societal problems. An important uniqueness of the FC lies in the fact that it has brought together diverse institutions to implement and assess a common set of experiments in curricula and learning environment in engineering education. This includes development and piloting of an integrated first and second year curricula, uniquely tailored to the student body of each campus. These integrated curricula also must incorporate cooperative learning and technology in the classroom environment. While the FC is striving to link with existing Women in Engineering or Minority in Engineering Programs in order to strengthen the educational experience for students, it also is working to change the classroom and faculty - student relationship in order to enhance the success of women and minorities in engineering.

THE FC INSTITUTIONS

The seven institutions are very different in size, student body, location and mission. Maricopa Community College District, MCCD, is one of the largest Community College districts in the nation. Located in the Phoenix area, it serves a very ethnically diverse student body at several campuses. Texas Woman's University, TWU, serves a predominantly female student body, and has no engineering degrees. None the less, TWU has developed strong dual degree and 3-2 programs with several institutions which do have engineering degree programs. Rose-Hulman Institute of Technology, RHIT, was an all male institution until the Fall of 1995. Texas A&M University Kingsville, TAMUK, is a predominantly Hispanic institution. Texas A&M University, TAMU, has one of the largest Colleges of engineering in the nation, and typically is one of the top three schools in graduating Hispanic B.S. level engineers. In addition, TAMU had the largest enrollment of women in engineering in 1995. Arizona State University, ASU, is well known for incorporating teaming into the engineering curricula, and for a significant enrollment of Hispanic and Native American students. ASU also has a significant number of students who enter the engineering program as transfer students from community colleges. The University of Alabama, UA, has a significant enrollment of African American students.

The Foundation Coalition must develop curricula and an academic environment at each institution that are accessible and provides equitable opportunity for success for all students. The focus on underrepresented minorities (African Americans, Hispanics, Native Americans, and Pacific Islanders) and women is

necessary because these groups have a history of being significantly underrepresented in engineering graduates. This underrepresentation is due to both low initial numbers in the first year and to higher attrition rates in the engineering programs. This has been pointed out as a concern both nationally and at all of the FC institutions. Table 1 gives a perspective of what the representation levels were before the initiation of the FC.

Table 1 Percentage of underrepresented groups enrolled in undergraduate engineering programs in Fall 1993

INSTITUTION	African-American	Hispanic-American	Native-American	Women
National	6.9%	6.5%	0.51%	17.7%
ASU	1.8%	8.9%	2.4%	18.1%
MCCD*	n/a	n/a	n/a	n/a
RHIT	1.8%	0.9%	0.08%	0%
TAMU	3.2%	10.8%	0.25%	19.7%
TAMUK	1.5%	52.6%	1.15%	16.3%
TWU*	n/a	n/a	n/a	n/a
UA	17.5%	1.1%	0.49%	20.3%

*MCCD and TWU data is not available on engineering students since they do not declare majors the same as the other institutions

The FC is focusing on the recruitment, retention, and the graduation of students from underrepresented groups. The graduation focus implies timely completion of the degree and quality placement, in industry, government, or graduate school, of the students receiving B.S. degrees. Since the FC institutions are in their second year of offering courses, and these courses have been focused on the first and second year of the curricula, it is premature to report on graduation at this time. The recruitment of underrepresented minorities and women for the institutions and the FC curricula will be discussed in the following sections.

RECRUITMENT OF UNDERREPRESENTED MINORITIES AND WOMEN

How students in pre-college are attracted to and successfully matriculated into engineering programs is a very complex issue. Stereotyping any group of people as having a single or unique method for recruitment is dangerously misleading. The FC schools recognize this and have approached recruitment of underrepresented groups through a variety of activities. The common idea for all students is that they must develop an aspiration for engineering and an expectation of success in the field.

Aspiration in an area requires an awareness and valuing of the field, as well as an interest in serving in the roles found in that field. Expectations are influenced by individuals confidence that they can achieve and their aspirations. It is crucial to provide mentors, role models, and sound information networks so that underrepresented minorities and women, whose expectations typically fall well below their aspirations, have opportunities to raise both their aspirations and expectations. Many people who have focused on this issue will confirm that it is never too early to start influencing the students aspirations. In the FC schools, outreach efforts to pre-college students are facilitated by numerous internal organizations. For the engineering programs, most of these efforts are led by personnel in the Minority and Women Engineering Programs.

At ASU, TAMU, TAMUK, and UA, Minority Engineering Programs, MEPs, existed prior to the formation of the FC. In addition MCCD and TWU had numerous activities to outreach to underrepresented minorities and women in their communities. TAMU and TAMUK had existing programs that outreached

to girls. The FC has aided in the formal organization of Women in Engineering Programs, (WEPs), at ASU, TAMU, TAMUK, and UA. These programs now conduct numerous conferences and camps for minorities and girls at the pre-college level. The FC teams on the campuses have all provided some level of cooperation with these programs. It is important to recognize that the directors for the MEPs and WEPs are continually raising internal and external funds to support their efforts, and on most campuses the FC has been only a small part of these efforts. The following table is meant to illustrate examples of the type of outreach and level of FC involvement.

Table 2 Examples of Pre-College Outreach Efforts

LEVEL	School	Comment	FC Involvement
Elementary	TAMU	Engineering students and faculty take design activities to the 5th and 6th grade campuses at local schools (250 students)	Several FC faculty have volunteered time and materials
	TAMU	Tours of campus and laboratory activities for local community centers serving 2nd through 4th graders. (45 students)	One FC faculty arranged with MEP and WEP the tours and raised funds for the buses.
	ASU	Collaboration with girl scouts to offer 1 week camps for 1&2, 3&4, and 5&6 graders. (68 students)	WISE program supported by FC
Middle School	TAMU	SWE one week residential camp (50 students)	FC faculty gave many of the tours and demonstrations. FC faculty developed team projects for the camp.
	TAMU	Mentoring for at risk students (20 students)	FC faculty made contacts, MEP and WEP matched undergraduate mentors to middle school students
High School	ASU, TAMU TAMUK	3 day activities for students to expose them to design and teaming (ASU 78 students, TAMU 305 students)	ASU-direct FC support TAMU & TAMUK-FC faculty facilitated design competition
	RHIT TAMU	three one week camps: RHIT- 30 women non-residential, TAMU- 100 minority focus in 2 residential camps, and 50 women in one residential camp	FC faculty helped develop activities and design projects. FC faculty and undergraduate students delivered team training
	TAMU TAMUK	2-3 week camps (sponsored by Young Scholars program in NSF and/or NASA) demographically representative of State	FC faculty PI for the camp. Included integrated course materials, technology and teaming. Faculty also serve as research mentors at TAMUK.
	TAMU TAMUK	Year round interaction with predominantly minority high schools	FC faculty and students provided tours and activities.

In addition to these outreach efforts, the FC teams had to recruit students into their pilot curricula programs. These efforts included mail outs describing the programs. At TAMU students come to register prior to the start of the semester and sessions are arranged for parents and students from underrepresented groups to discuss campus life and the FC curricula. The initial enrollments for these groups in the FC curricula are shown on the next page in Table 3.

RETENTION OF UNDERREPRESENTED MINORITIES AND WOMEN

Retention of undergraduates in engineering is also a very complex situation. Many students who enter engineering or pre-engineering leave the field for other science, mathematics, business or educational fields. Across the nation and at the FC schools, the retention of underrepresented minorities and women is below the retention levels of other engineering students. All of the schools participate in numerous activities to address these issues. The NSF has a highly successful program called the Alliances in Minority Participation, which focus on networks of 4 and 2 year institutions targeting the retention and graduation of BS level science, mathematics, engineering and technology students from underrepresented minorities. TAMU and TAMUK are part of the Texas AMP, ASU is part of the Southern Rocky Mountain AMP, and UA is part of the Alabama AMP.

Table 3 Number and (Percentage) of Students Enrolled in the FC First Year in Engineering (Fall '94 & Fall '95)

SCHOOL	Students in FC 1st year Fall 1994	Students in FC 1st year Fall 1995
ASU	Afr.Am 1(3%) Hisp 6(19%) women- 6(19%)	Afr.Am 1(3%) Hisp 4(13%) Nat Am 1(3%) women- 11(35%)
GCC	did not offer curricula in 1994-95	Afr.Am 1(7%) Hisp 3(20%) women- 1(7%)
MCC	Afr.Am 0(0%) Hisp 2(7%) women- 3(11%)	Afr.Am 0(0%) Hisp 2(11%) women- 3(17%)
RHIT	Afr.Am 0(0%) Hisp 0(0%) women- 0(0%)	Afr.Am 2(2%) Hisp 4(3%) women- 27(23%)
TAMU	Afr.Am 4(4%) Hisp 15(15%) women- 25(25%)	Afr.Am 10(5%) Hisp 32(16%) women- 48(24%)
TAMUK	Afr.Am 1(7%) Hisp 8(57%) women- 2(14%)	Afr.Am 0(0%) Hisp 14(58%) women- 8(33%)
TWU	Afr.Am 0(0%) Hisp 1(17%) women- 5(83%)	Afr.Am 1(6%) Hisp 1(6%) women- 14(88%)
UA	Afr.Am 10(28%) Hisp 0(0%) women- 10(28%)	Afr.Am 8(13%) Hisp 0(0%) women- 19(31%)

At these schools the FC teams have worked to get involved in numerous bridge, mentoring, and research programs sponsored by the AMPs. At TAMU, the bridge programs for matriculating first year students and for transfer students were modified to better facilitate entry into the FC curricula. All of these campuses have worked to interface the FC students with programs (such as brown bag luncheons, lecture series, peer tutoring, mentoring, internships, and undergraduate research) and organizations (such as NSBE, MAES, SHPE, AISES, SWE, and SOCNAS). Supported by the Foundation Coalition, the OMEP at ASU has now begun an Academic Excellence Program that clusters underrepresented minority students enrolled in ECE 100, a course designed to teach engineering concepts and computer skills. Non-minority students in the course are also invited to participate in these workshops. The students develop their own community of learners and collectively come to conclusions on how to process information. The Academic Excellence Workshops help to move away from traditional tutoring that is often a short term fix. Rather, these sessions enhance the mastery of engineering concepts as opposed to isolated problems. This process prepares students for potential curriculum integration in the future, as well as team participation in industry. At TAMUK, a chemistry bridge program was developed to address poor freshmen grades in chemistry. This was done in collaboration with the Women and Minority Program and the FC faculty.

Table 4 Course Hours Integrated in First Year Pilot During 1995/1996

INSTITUTION	PHYSICS	CALCULUS	ENGINEERING	ENGLISH	CHEMISTRY
ASU	8	8	4	4	6
GCC	4	6	6		
MCC**	3	3	3		
RHIT*	6	9	15	6	
TAMU	6	8	5	4	3
TAMUK	4	4	4	4	
TWU	4	4			
UA	8	8	4	6	

**RHIT is quarter hours and all others are semester hours*

***MCC offered courses in coordinated clusters: Physics & Engr, Calculus & Engr, Physics & Calculus & Engr*

In the FC, curricula research is underway to study the effects of the curricula content, teaming and cooperative learning, and technology on the underrepresented groups. Table 4 shows the courses which have been integrated together at the different institutions in the first year engineering curricula. Table 5 shows the retention numbers and rates for students from underrepresented groups in the FC curricula. The retention data shown is most valid when compared to how well students in the traditional course offerings at an institution are retained. At Texas A&M University, for example, in a parallel set of courses with 488 students who began in the Fall of 1994, 67% of the women and 67% of underrepresented minorities were retained in engineering the following Fall. Comparative numbers in the FC Fall 1994 courses were that 72% of the women and 93% of the underrepresented minorities were retained in engineering in the following Fall.

Table 5 Number and (Percentage within group) of Students Finishing in the FC First Year 1994-95 and 1995-96

SCHOOL	Students in FC 1st year Fall 1994	Students in FC 1st year Fall 1995
ASU	Afr.Am 1(100%) Hisp 5(83%) women- 5(83%)	Afr.Am 0(0%) Hisp 4(100%) Nat Am 1(100%) women- 7(64%)
GCC	did not offer curricula in 1994-95	Afr.Am 0(0%) Hisp 3(100%) women- 0(0%)
MCC	Afr.Am 0(0%) Hisp 1(50%) women- 1(33%)	Afr.Am 0(n/a) Hisp 1(50%) women- 2(67%)
RHIT	Afr.Am 0(0%) Hisp 0(n/a) women- 0(n/a)	Afr.Am 2(100%) Hisp 1(100%) women- 18(67%)
TAMU	Afr.Am 3(75%) Hisp 15(100%) women- 18(72%)	Afr.Am 9(90%) Hisp 27(84%) women- 42(88%)
TAMUK	Afr.Am 0(0%) Hisp 2(25%) women- 2(100%)	Afr.Am 0(n/a) Hisp 9(64%) women- 2(25%)
TWU	Afr.Am 0(0%) Hisp 0(0%) women- 3(60%)	Afr.Am 1(100%) Hisp 0(0%) women- 12(86%)
UA	Afr.Am 7(70%) Hisp 0(n/a) women- 8(80%)	Afr.Am 4(50%) Hisp 0(n/a) women- 13(68%)

All of the FC institutions have confirmed that when the students first begin the year it is important to not have women in teams where they are the only woman. However, after the first term, at some institutions the women do not want this consideration and they do not seem academically affected if a random team

assignment results in their being the only woman on a team. This can be attributed, at least in part, to the students in the integrated courses knowing each other better than most students would in traditional courses. On the other hand, at one institution after the first term, when the students could form their own teams, most of the women clustered with one or more other woman on a team. Team assignments with race and ethnicity are still under review, and vary greatly from school to school. A study of the effects of learning styles on team assignment and team performance was investigated at Texas A&M University using the Gregorc Style Delineator. Initial results indicate that concrete-sequential learners had a positive and significant correlation with course grade. The abstract-random style correlated negatively with physics and English grades. The concrete-random style correlated negatively with the calculus grades. There were no strong interactions with sex or ethnicity in general, although several Hispanic students did show high abstract-random style scores. TAMUK conducted focus groups with women FC students to address the potentially different perceptions of the FC curriculum within genders.

ASU, RHIT, TAMU, and UA offered an integrated set of sophomore level courses in the 1995/1996 academic years. These courses included as little as 14 hours of calculus, mechanics, and materials, and as much as 25 hours of calculus, mechanics, materials, thermodynamics, circuits, and English. The retention rate for these courses was good and is now being studied in comparison with the traditional sophomore curricula.

Most of the FC schools have conducted workshops on gender and cultural issues in the classroom for faculty teaching the FC curricula. These workshops have clearly raised the faculty attention to the differences among students. The programs intend to have all faculty recognize that there are differences between and within different demographic groups, and to teach how to modify teaching styles to assist in the learning environment for all students.

The FC is also supporting assessment efforts at each school. For instance, in July 1994, at ASU, a graduate student developed a new MEP tracking system to monitor student participation and the services of the office. This information will focus on pre-college outreach effectiveness and MEP services. One major objective is to matriculate Mathematics, Engineering, Science Achievement (MESA) participants from local high schools to the ASU College of Engineering. The assessment will guide enhancements of academic and social intervention programs to help students prepare for transition from high school to college. The tracking system will also include industrial internships, graduation rates, and industry placement upon graduation.

CONCLUSIONS

The FC institutions are working to raise the awareness of faculty to issues of gender and ethnicity in the classroom. These institutions are in the process of developing curricula and learning environments which are more conducive to a diverse set of students persisting in engineering. For the next year the FC will focus attention on design projects, team exercises, and course demonstrations which enhance the visibility of the contributions of underrepresented groups to the fields of science, engineering and mathematics. Finally, the FC institutions will continue to encourage strong linkages between the efforts in MEPs and WEPs and curricula development.