

AC 2007-2282: EVALUATING SUPPORT FOR UNDERREPRESENTED STUDENTS IN ENGINEERING DEGREE PROGRAMS

Carol Haden, Northern Arizona University

Carol Haden is the Evaluation Coordinator for the Center for Science Teaching and Learning at Northern Arizona University where she received her doctorate in Curriculum & Instruction. She is involved in the evaluation of multiple projects intended to improve undergraduate education in the sciences and engineering.

Evaluating Support for Underrepresented Students in Engineering Degree Programs

Abstract

A study was undertaken to examine sources of support and challenges to retention of underrepresented women and minorities at Northern Arizona University. The study was evaluative in nature in that it sought to understand how well underrepresented students are being supported to complete their degree programs, and to gain insights into how programs might be enhanced or developed to support these students to degree completion. A mixed-methods research design involving a survey and in-depth interviews of students, faculty and staff yielded several factors that support and challenge students toward degree completion at this institution. Applications to programmatic decision-making are discussed.

Introduction and Background

It is common knowledge in the field of engineering education that numbers of women and minorities obtaining engineering degrees is far below their representation in the U.S. population^[1]. Many studies have sought to discern reasons for lack of representation of women and minorities in science, mathematics and engineering degree programs. Studies related to minority students point to, among other factors, lack of pre-college academic preparation, financial difficulties, barriers related to being first generation college students^[e.g. 2, 3, 4] and socio-cultural factors^[5]. Studies related to female student underrepresentation in S&E fields have suggested that women leave not from a lack of academic ability, but among other reasons, because of socio-cultural factors^[1, 5, 6], and issues of confidence^[7-9]. It is essential to understand not only what factors act as barriers to persistence for underrepresented students, but also what essential elements support the persistence of these students who are crucial to ensuring a more diverse engineering work force.

Research on student persistence in higher education has revealed that once a student enters an institution of higher learning, social and academic factors interplay with his or her level of commitment to completing a degree program^[10, 11]. In other words, once enrolled, students have academic and social experiences, including interactions with faculty and peers, experiences in the classroom, and experiences with the curriculum which interact to lead to new levels of commitment to their goals and to the individual institution. Social and academic activities and experiences during college can serve to either reinforce or weaken the individual's goal and institutional commitments leading to decisions of whether to remain or leave the institution (or program). This study was approached from the perspective of better understanding the social and academic integration factors that support and hinder underrepresented students in persisting toward graduation from engineering and engineering-related degree programs.

In the spring of 2003 the engineering programs at Northern Arizona University began the Engineering Talent Pipeline (ETP) project, funded through the William and Flora Hewlett Foundation's Engineering Schools of the West Initiative. The five year award funds activities directly related to increasing recruitment and retention of students in engineering and engineering-related degree programs, with special emphasis on underrepresented women and

minority students. Northern Arizona University is a mid-sized university offering four degree programs in engineering: electrical engineering, mechanical engineering, civil engineering and environmental engineering, plus two engineering-related degree programs in computer science and construction management. Student demographics for engineering degree programs at the university are close to the national averages except for a proportionally higher number of Native American students (7% as compared to 0.7% nationally).

As one aspect of the ETP project, this study was undertaken to evaluate support for women and minority students in engineering degree programs at Northern Arizona University. Evaluation research is a field of research that seeks to uncover the merit, worth and value of the program being evaluated^[12, 13]. Formative evaluations are done with the intent of improving programs in operation by uncovering strengths and weaknesses within the design and delivery of those programs^[13, 14]. Patton^[15] described the differences between evaluation and other forms of social science research by placing them on a theory to action continuum. In this view, basic research is “knowledge for knowledge sake” and may generate theoretical underpinnings that, in turn, inform program design. Evaluations are at the action end of the continuum, in that they are designed to make judgmental claims about programs in operation, with the ultimate outcome being information for decision-making purposes. They can provide information about the perceptions of the intended program audience as to the program’s effectiveness, so that decisions can be made about program activities that are based on authentic and accurate data rather than on the assumptions of the program planners.

This study sought to examine factors that influence persistence of underrepresented women and minority students in engineering degree programs at Northern Arizona University. The study is evaluative in nature in that it was intended to provide insights into how well these students are being supported to complete their degrees and to identify potential barriers to degree completion. Study results were intended to inform the engineering faculty and staff as to what needs are and are not being met for underrepresented students, and how to best modify or sustain existing support programs intended to enhance retention in this critical group of students.

Methodology

A mixed-method research design was utilized incorporating both quantitative and qualitative data collection and analyses. Multiple methods of data gathering allowed for validation of study results based on triangulation of methods and data sources. The following data sources were incorporated into the study design.

On-line Engineering Student Survey

An on-line engineering student survey was developed and administered to gather information on various aspects of the study. The survey was developed by the researcher and the Multicultural Engineering Program director. Among other survey items, respondents were asked to rate the importance of thirteen factors as sources of support while working toward degree completion in engineering and engineering-related programs. The scale for response was a 1 to 5 Likert scale with 1 being “unimportant” and 5 being “extremely important.” Students were also questioned about their knowledge and usage of MEP activities and services, use of campus support programs, and types of support they are not receiving but would like to have. Survey items were

piloted with engineering students and non-engineering students for the purpose of determining face and content validity. One hundred-thirty students responded to the survey. Survey respondent demographics closely mirrored the demographics of all students in engineering degree programs at the university, therefore giving a representative sample of the engineering student population.

Student Interviews

In-depth student interviews were undertaken to examine issues affecting retention of underrepresented women and minority students. Interview questions for this study were intended to be generative in nature allowing for interviewees to respond based on their own perceptions of what hinders and supports women and minorities while pursuing engineering degrees. Where themes of interest emerged, the researcher probed for depth and understanding.

Students were asked about what have been the most important sources of support and the toughest challenges they have had to overcome to persist in their degree programs. These interviews examined social and academic integration factors including such things as faculty and peer interactions, family influences, and perceptions related to teaching and learning in the degree.

Faculty/Staff Interviews

Engineering faculty members from across the engineering disciplines were interviewed to explore their perceptions of factors that influence underrepresented women and minority student persistence in engineering and engineering-related degree programs. Faculty interviews also served to provide faculty perceptions as to the functioning and effectiveness of the MEP in helping to retain underrepresented students. Faculty were selected for interviews based on the criteria of teaching or having taught the core engineering core courses required of all students, and/or sponsoring clubs or research projects involving minority and women students.

Data Analysis

Interview Data Analysis

Content analysis is a process by which qualitative data are reduced for the purpose of “sense-making and the identification of core consistencies and meanings” [15, p. 453]. Interview transcripts, as well as program documents were examined for recurrent themes, relationships, patterns, and anomalies. Data from digitally recorded interviews was transcribed to text files which were then imported into N6, a qualitative analysis software program. Data analysis began with the process of open coding of the data. Open coding of qualitative data involves a generative process of identifying concepts contained in the data [16]. Assertions were generated from the body of the interview data and then checked by repeated review of the data to test the validity of the assertions [17].

Survey Data Analysis

Survey ratings were examined for gender and racial/ethnic differences in what students identified as important sources of support in helping them to persist in their engineering degree programs. For each of the thirteen items that students were asked to rate as sources of support, the original scores were rank ordered and a Mann-Whitney U-test was conducted to compare the

ranks for differences by gender. A second Mann-Whitney U-test was conducted to compare ranks for differences based on ethnicity. In each case, significance was compared against a conservative alpha of .01 to minimize Type I error across the thirteen items.

Survey items concerning familiarity with and use of the Multicultural Engineering Program services and other campus support programs were examined with descriptive statistics.

Results

Web survey respondents included African Americans (2), Asian American (1), Hispanic (8), Native American (17), White (93), International (5), mixed-race (2) and two students of unreported ethnicity for a total of 130 respondents. By percentage, respondent make-up closely paralleled the demographics of total students enrolled in engineering degree programs.

Purposeful sampling of female and minority students resulted in fourteen individual in-depth interviews. Interviewees included 11 women (1 Native American, 2 Hispanic, and 7 white females), and four men (3 Native American, and 1 Hispanic males). In addition, a single focus group interview consisting of one female Native American student and two male first generation students was conducted that focused on the effectiveness of services and support offered through the Multicultural Engineering Program (MEP).

Eight faculty members (5 males and 3 females) across four of the engineering departments including mechanical, electrical, civil, and environmental engineering were interviewed. The university's Multicultural Engineering Program director and her support staff were interviewed to gain perspective on issues related to support of students through the MEP offerings.

Interview results expanded upon the survey providing deeper insights into factors affecting underrepresented engineering student persistence from both student and faculty perspectives. Themes related to both social and academic integration emerged and where they were supported across the body of the data, validated. For women, several common themes emerged. Issues of self-confidence, gender isolation, and interactions with peers both positive and negative profoundly impacted their college experiences and offered challenges and support to persistence. For minorities, issues related to family, teaching styles that clashed with the ways in which they best learn, and interactions with peers emerged as common themes in the interview data. These will be explored in the following sections of the paper.

Factors Supporting Underrepresented Student Persistence

For the thirteen items asking students to rate the importance of individual factors on helping them to persist in their degree programs, factors related to finances (scholarships and internships) were rated highest in importance followed closely by faculty member support for all students including white, males. When survey ratings were examined for gender differences in what students identified as important sources of support in helping them to persist, several factors emerged (Table 1). Women ranked five factors significantly higher than male students: family emotional support ($z = -2.756$, $p < .01$), peer study groups ($z = -2.672$, $p < .01$), scholarships ($z = -3.073$, $p < .01$), MEP tutoring ($z = -2.742$, $p < .01$), and MEP staff support ($z = -2.919$, $p < .01$).

Table 1. Comparison of importance ratings by gender.

Factor	Male (N=98)		Female (N=31)	
	Mean	SD	Mean	SD
Internships	4.05	1.19	4.16	1.07
Scholarships	3.78	1.42	4.61	0.88
Faculty member support	3.90	1.00	4.00	0.86
Family emotional support	3.70	1.21	4.35	0.88
Peer social interactions	3.56	1.19	3.71	0.97
Family financial support	3.50	1.45	3.58	1.31
Peer study groups	3.27	1.24	3.94	0.99
Career counseling	3.19	1.37	3.45	1.06
LAC tutoring	2.97	1.48	3.74	1.12
Student loans	3.06	1.62	3.13	1.54
Clubs/Organizations	2.92	1.22	3.32	1.11
MEP staff	2.03	1.11	2.68	1.11
MEP tutoring	2.03	1.18	2.68	1.19

A few differences also emerged when minority and non-minority student ratings were compared (Table 2). Non-white students rated three factors significantly higher ($p < .01$) than did white students: scholarships ($z = -4.450$, $p = .000$), MEP tutoring ($z = -3.984$, $p = .000$), and MEP staff support ($z = -3.984$, $p = .000$).

Table 2. Comparison of importance ratings by ethnicity.

Factor	Minority (N=35)		Non-Minority (N=93)	
	Mean	SD	Mean	SD
Internships	4.26	1.07	4.04	1.16
Scholarships	4.51	1.04	3.81	1.39
Faculty member support	3.63	0.97	4.03	0.94
Family emotional support	3.89	1.32	3.87	1.10
Peer social interactions	3.34	1.33	3.73	1.02
Family financial support	3.49	1.44	3.58	1.40
Peer study groups	3.43	1.22	3.44	1.19
Career counseling	3.65	1.25	3.13	1.29
LAC tutoring	3.54	1.31	3.01	1.44
Student loans	3.26	1.56	3.02	1.62
Clubs/Organizations	3.20	1.08	2.96	1.22
MEP staff	3.00	1.08	1.91	1.01
MEP tutoring	2.97	1.22	1.92	1.08

Financial Aid

Students and faculty noted that financial support plays an important role in bringing students to Northern Arizona University and in retaining them. Proactive strategies of the director of the MEP program and the Engineering Scholarship office were essential in helping students connect with opportunities they might not have found on their own. These strategies included sending notices by email and by phone to students who fit the qualifications for scholarships and following up with assistance in filling out application forms.

Peer Support

Faculty, staff and students alike all emphasize the need for students to identify other students with whom they can establish productive relationships for studying, mentoring and emotional support. For many students, peer support takes the form of study groups. Successful students find the advantages of study groups early in their careers and often stay with the same groups of students for studying throughout their years as a student. For the female students in the study, study groups are equally important in fulfilling the needs for social interaction as for helping to work through course assignments and test preparation. Being involved in a rigorous and intensive degree program allows most students little time for socializing. Peer study groups become a social outlet as well as an academic necessity. A typical comment was expressed by a female interviewee: “we study but we have fun too, we’re pretty laid back. It takes more time because we slack off; but really study groups [make things more bearable].” Another said: “The support from my peers is most important because it really does suck most of the time and we don’t have much of a life, but everyone is going through the same thing.” Students and faculty members alike felt strongly that students will have a better chance to be successful if peer study groups are formed early in the students’ academic careers. Peer relationships in the form of formalized or informal peer mentoring are beneficial in helping newer students to learn the ropes and in helping older students to stay connected and motivated while completing their degrees.

Family Support

For minorities and women in engineering degree programs, family is an important source of support. For many students, following a sibling or other relative into the university gives them someone to turn to for help in navigating campus life. Several of the minority and female students in the study are first generation college students who credit their parents with instilling in them the importance of a college education, even though it was not something they themselves had experienced. A Hispanic computer science major stated: “My parents, brothers and sisters have been extremely supportive. I come from a very successful family, academically speaking. Although, my mother barely finished high school and my father barely finished junior-high school in Mexico, I have three sisters who all have degrees – one’s a programmer, one’s a doctor, one’s a hotel manager. My older brother has a degree from here in HRM and my younger brother is graduating this semester and another one on the way.”

For Native American students, geographic proximity to family was a strong reason for attending Northern Arizona University. Students spoke of going home for ceremonies that were intended to help them succeed, and relying on siblings or other relatives who came to the university before them to help them navigate the world of higher education. Faculty and staff noted that while closeness to family can provide emotional support, it can also place additional demands and responsibilities for some that extend beyond their life as a college student. Attending ceremonies

and family celebrations, helping parents raise siblings, and attending to household duties were common occurrences for Native American and Hispanic students in the study. These responsibilities can place additional strains on students' time and energies while working through an intensive degree program.

Faculty Support

Students overwhelmingly agreed that the support of faculty members is a very important factor in persistence in engineering and engineering-related degree programs. Faculty "approachability" was very important in helping underrepresented students to persist. The majority of students in the study felt that faculty members they encountered in their degree programs were concerned about their progress and ready to assist them in understanding course work, and in finding their way in terms of internships and career opportunities. A female student's comments were echoed by many students in the study: "I have always been intimidated the first time I go to see a professor but they have always been very welcoming, helpful and supportive. The professors have helped me to feel comfortable in class and to understand the material." This emerged as a particularly powerful source of support in both interviews and in survey data.

Challenges to Underrepresented Student Persistence

Isolation: Issues of Race and Gender

When asked what has been particularly challenging to persistence for the students in the study, several factors emerged. For female students, the gender ratio in their programs and classes posed challenges especially early on in their careers as students. As one female student stated, "In one class for the first few weeks I was the only female in the class, now there is one other, but I look around and see 19 and 20 year old guys and it is almost a culture shock"

All of the women interviewed for this study discussed the gender ratios of their classes as something they were immediately confronted with upon entering their degree programs. For many women, this gender ratio presented an environment that was (at least initially) uncomfortable, and challenged their confidence in their abilities. Assimilation into the white male culture can be a key to the success of female students. The gender imbalance and all of the nuances that go along with it can very possibly deter highly capable women who do not choose to assimilate into a male environment – those who do not want to become "one of the guys" to quote a female student. Lack of female professors as role models exacerbates the issue.

When asked what types of support would have been helpful to her that she did not get while pursuing her degree one female responded that there needed to be female faculty in her major: "...because I'm not sure how you would get the female perspective into this engineering world without actually having a girl there. I mean an actual female professor."

Women often spoke of the feeling that they had to "prove themselves" in a way that their male peers did not to gain acceptance into the male environment. Proving themselves was most often mentioned in the context of discussing peer relationships, although some women felt that they were also proving themselves to male faculty members to gain acceptance.

Negative interactions with male peers were cited by many of the women interviewed in the study as challenges to overcome while working on their degrees. These interactions could range from such things as being relegated to secretarial roles and being hindered from participating fully in

team activities, to more overt comments directed at them by male peers. A female, Hispanic student said: “We always get comments about how ‘we’re women and we’re minorities so we get all the scholarships and that’s not fair. There’s nothing for white males.’ But you have to defend yourself because we get it because we’re qualified.” Another female student stated: “a lot of the male students will jokingly but also hurtfully make comments such as “you’ll only have a job because you’re a girl.” Female students related that they were on the receiving end of such comments “all the time.” Faculty members acknowledged that there are negative peer interactions in the classroom that are often not dealt with effectively and could contribute to the loss of females from the programs.

For minority students, lack of representation posed some of the same issues as for female students. Minority students felt the lack of diversity within the engineering programs more acutely than their professors. Because of the lack of representation within engineering education, exposure to engineering environments that are more diverse than those they encounter within the university is essential. For some students, belonging to student organizations and attending national conferences of minority engineers, provided strong motivation for continuing in their degrees. One Hispanic student spoke of the life changing experience of going to the national convention for the Society for Hispanic Professional Engineers and seeing herself in the faces around her. Likewise, interning at large national corporations that were committed to increasing diversity allowed students similar opportunities to see other minorities working as professionals in their chosen fields.

Integration into Campus Life

For Native American students in particular, integration into the life of the university may pose unique challenges to overcome. For those who were preceded by a family member, the transition was not as disruptive. For students raised on the reservation where they were a part of the dominant culture, they enter an environment that is unfamiliar and become a part of a minority population. Upon entering the university, many Native American students not only enter a new academic environment, but also enter a new social paradigm. Many of the characteristics that are considered worthy of praise in the dominant white, male engineering student are antithetical to the way Native American students are raised. While taking control of a group, and “jumping in” to solve a problem are valued in engineering students, for Native Americans learning is often a matter of standing back and observing before doing. While engineering professors on one hand expressed the need for diversity in the engineering student body and profession, many viewed the cultural characteristics that set minority students apart as “challenges to their success.” An engineering staff member, herself a Native American, described it very well:

Native Americans... you’re told from kindergarten to be quiet in the classroom, be quiet in the hallways; don’t be loud. But you get here to college and you’re expected to speak up and you haven’t been taught that, or it’s not in your culture to do that, or it’s disrespectful. You don’t want to boast about yourself or highlight yourself or anything; then that’s difficult too because then you’re in a setting where you are expected to do that.

Native students also spoke of the way in which information is most often presented in engineering classes and how at times, it clashes with the way they best learn. A male, Native American student put it this way:

A lot of Native American students do learn through visual and tactile learning which I find is true for me as well. I have to visually see it in order to understand it so if it's like theory or anything like that I do kind of bad in it, because I can't visually see it. I have to kind of draw it as best as I can or put it in some format where I can see it. That's the major problem that most minorities have or at least within the Native American group is that they have to visually see it.

This student went on to suggest that it would be beneficial for professors to have a better understanding of learning styles of native students: "if teachers were to understand that Native American students do have a hard time learning through words alone that would help out a lot."

Discussion

Using Study Data to Inform Programmatic Decision-making

Information gathered in this study was meant to inform the operation of the Multicultural Engineering Program at Northern Arizona University as well as provide information to faculty and staff on further effective means of supporting underrepresented students in engineering and engineering-related degree programs at the university. Among its services, the MEP has offered a five-week residential summer bridge component to incoming freshmen students each year since its inception. Once enrolled, the program offers support to underrepresented students in the form of academic advising, a peer mentoring program, a student lounge with computers and social and career networking events designed to bring students together.

Where students were interviewed and surveyed regarding the MEP program several themes uncovered in this study emerged. By the very fact of being underrepresented, female and minority students are at risk of becoming isolated. Although not an expressed outcome of the MEP, reduction of student isolation has shown itself to be an important function of MEP facilities and MEP staff. A high proportion of students of color, especially Native Americans, find in the MEP a place where they can come together for both social and academic purposes. Students in the study placed a high value on support in the form of the MEP director who knows them by name and is concerned about their progress. MEP offers this to students who may be reluctant for a variety of reasons, including cultural ones, to seek such support from their professors. MEP social functions offered students opportunities to connect with other students and with faculty and staff that can assist them through their academic careers. A Diversity Reception offered in conjunction with a Career Fair provided many students in the study a chance to "pre-meet" with recruiters from major companies for employment and internship opportunities.

Students involved in the MEP peer-mentoring program indicate that support from another engineering student is important to them in persisting in their degree programs. Having someone who has been through what they are experiencing is invaluable in helping students to integrate into the university and into their degree programs. Mentors found in the experience, a chance to

“give back” to MEP for the support it had provided and a chance to give to new students the types of mentoring they would have liked to have received as they started their academic careers. This study has provided insights into expanding the peer mentoring and peer networking aspects of the MEP. Further data is being collected to inform operation of the summer bridge program for incoming freshmen.

What are the Unmet Needs?

This study suggests that for female students the need exists to bring them together with other female engineering students and faculty members early in their student careers. Successful female students interviewed in the study had found the support of other women as well as male engineering students in the forms of study groups. These women had passed the threshold of the first two years where the majority of students leave engineering programs at the university. The “culture shock” many female students experience as they enter their first engineering classes could be mitigated through programs and activities designed to bring them together formally or informally with other female engineering students perhaps through peer mentoring programs aimed specifically at pairing freshman and sophomore female engineering students with female junior and senior level students for mentoring and academic tutoring.

For minority students, increased opportunities for the types of social and career networking and mentoring offered through programs like MEP designed to reach more students would be beneficial. Faculty development with respect to understanding learning styles and cultural norms of minority students would help to integrate these students more fully into the academic and social community of engineering.

Conclusion

Much of what was learned in this study supported the literature in that social and academic integration into an institution and, more specifically into a degree program profoundly affects students’ decisions to persist. While factors such as pre-college preparation, high school GPA, and the like, most certainly impact student persistence, experiences that students have once they enter an engineering degree program may be equally powerful in shaping decisions of whether to stay or leave. Interactions with faculty and peers, experiences in the classroom, and experiencing the engineering curriculum through the lenses of culture and gender all interweave to form the basis for which decisions related to persistence are made.

While this study was highly contextual in nature in that it was meant to examine sources of support and challenges to retention of underrepresented students at a single institution with the intent of improving and designing programs and activities to aid retention, several issues emerging in the study may indeed influence underrepresented student persistence in engineering programs at other institutions. In turn, implications for support programs designed to increase retention of underrepresented students in engineering degree programs are applicable to programs at other institutions faced with issues of retention of these students who are critical to ensuring increased diversity in the engineering work force.

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