

Interpreting Successes of a Community College-University Partnership in Retaining Underrepresented Engineering Students

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Abstract

Previous research points to both individual and institutional factors that impact recruitment and retention of women and minorities in STEM fields. Scholars exploring persistence rates among minorities have argued that academic preparedness, rather than socioeconomic status per se, is responsible for differences between minority and white students. In addition, a number of institutional factors are found within engineering and education literature to affect retention of women and URM students. These factors include gender and ethnic isolation, a lack of mentors and absence of peer support, low expectations and unsupportive attitudes of science and engineering faculty who are predominantly white and male (Campbell 1997). In light of these issues, the North West Engineering Talent Expansion Partnership (NW-ETEP), a statewide collaborative project among four community colleges and two universities, was undertaken in Washington State in 2004. The main goal of the project was to increase the number of students earning undergraduate engineering degrees statewide, with attention to URMs and females.

In this paper we use cross sectional data analysis of student survey responses collected over a four year period from NW-ETEP participants to address some of the key factors impacting recruitment and retention of women and minorities. We show that among NW-ETEP students, while there are no significant differences between under and overrepresented groups in terms of their feeling academically prepared, there are significant differences in student groups' academic self confidence over time. We also examine students' perceptions of institutional factors including climate and access to mentorship. Lastly, our analysis demonstrates differing concerns between men and women regarding the ability to balance work and life activities in STEM fields.

I. Introduction

Institutions of higher education have long recognized the need to retain students through graduation. The cost of losing a student has been estimated at thousands of dollars to the institution (DeBerard 2004). Not only is there an economic cost to attrition to the institution and local economy, there is a cost to society as certain populations of students appear to drop out at higher rates than others. Thus, the low enrollment and retention of underrepresented minority (URM) and female students in engineering is of national concern. In light of these issues, a statewide collaborative project among four community colleges and two universities was undertaken in Washington State in 2004. The main goal of the project was to increase the number of students earning undergraduate engineering degrees statewide by 10%, with special attention on URMs (100% increase) and females (20% increase). Participating schools

implemented a variety of strategies designed to provide academic support and to create a 'community' of (pre-) engineering students, specifically targeting women and URMs.

This paper uses program evaluation survey data to test whether elements of social and academic integration differentially impact the student experience of under-represented populations within an NSF-funded intervention to increase the numbers of undergraduate students graduating with engineering degrees. Institutional factors examined included gender and ethnic isolation, a lack of mentors and absence of peer support, low expectations and unsupportive attitudes of science and engineering faculty who are predominantly white and male (Campbell 1997).

II. Literature Review

Given the interest in student retention, models and theories abound and have been refined over the course of years to identify key factors influencing the persistence of students in higher education. Much of the research concerning student retention draws upon the theory of social and academic integration first articulated by Vincent Tinto (1975). Drawing on an earlier theory regarding why individuals commit suicide (Durkheim 1961), Tinto (1987; 1993) argued that the level of a student's integration into the social and academic structure of an institution of higher education, in addition to their pre-college preparation, experiences, and personal attributes has a direct impact on his/her successful retention at that institution. Many researchers have tested and found support for this theory, suggesting that lack of integration is a critical predictor of student persistence (Bers & Smith 1991; Braxton et al. 1988; Cabrera et al. 1992a; Cabrera et al. 1992b; Nora et al. 1990; Pascarella et al. 1986; Pascarella & Terenzini 1979; Pascarella et al. 1986; Stage 1989; Williamson & Creamer 1988). Modes of integration include course participation, classroom climate, advising, peer culture, campus social activities, study groups, and the development of close friends on campus. The degree to which the student "commits" to the institution or the rites of passage (Van Gennep 1960) has a direct impact on successful outcomes.

Personal or background factors affecting persistence may include preparation and achievement at pre-college levels, self confidence, self-efficacy, financial situation, and demographic characteristics. Also individual preferences for specific fields, perceptions of labor market prospects, sex role socialization and preferences about "helping" careers or well-paid professions are indicated in the literature as affecting persistence (Eccles and Hoffman 1984; Frehill 1997; Gianakos and Subich 1988; Lackland and De Lisi 2001; Maple and Stage 1991; Peterson and Roscoe 1983; Turner and Bowen 1999).

Additional research and anecdotal evidence of diverse student populations in science and engineering have noted issues faced by non-majority students which have been tested in various frameworks. Grandy (1994) found that women rated their study skills higher than did men, while the opposite was true in self-assessment of problem-solving skills and in self-image as future engineers. A survey of 400 undergraduate engineering students (Sax 1996) found no differences between men and women in their positive responses to treatment of faculty members as fair or in their comfort level in requesting help from instructors outside of class. However, twice as many women as men (30% vs. 15%) indicated significant discomfort about participating in class and concern with successful completion of their degree. Crawford and MacLeod (1990) report that low self-esteem inhibits the performance of women in all fields in higher education.

Rayman and Brett (1995) also found that women have lower self-confidence and perceived ability than men have, even though their grade point averages are equal to or higher.

Non-majority students may experience isolation and a chilly climate due to their minority status. A chilly climate is one in which individuals or groups experience isolation, invisibility, lack of respect, powerlessness, bias, and/or discrimination (Sandler 1996). In WEPAN's 1998 climate survey, females consistently reported a lower comfort level asking questions in class and using laboratory equipment than their male counterparts. For minority students, the greater the incongruence between the student's home culture and institutional culture contributes to the greater potential stress in adaptation (Tierney 1999).

Thus, institutions seeking to recruit and retain nontraditional populations may choose to direct their interventions by following suggestions of the basic Tinto model. The rise of student services programming targeting women and minorities is an attempt to develop sub-communities within the greater university setting in order to create a more welcoming environment for non-majority students.

This paper uses student survey data to examine which elements of the student experience contribute to student satisfaction at their institution. This survey instrument was based on the 1998 WEPAN survey. Differences noted by race/ethnicity and gender are identified in order to make suggestions on what changes can be made to improve student satisfaction and retention.

III. Project Description

Funded by a five-year grant from the National Science Foundation, the Northwest Engineering Talent Expansion Partnership (NW-EETEP) is a partnership among eight institutions of higher education in Washington State. Institutions include: Washington State University, University of Washington, Seattle Central Community College, Yakima Valley Community College, Highline Community College, and Columbia Basin College.

Since the start of programmatic interventions related to recruitment, retention, and transfer, the six participating NW-EETEP schools have registered over 3100 students. Twenty-six percent are females, and fifteen percent are from under-represented minorities (URMs include African-Americans, Hispanics, and Native Americans). As of the 2008-2009 academic year, 76 NW-EETEP students have transferred to the University of Washington or Washington State University.

Although interventions have largely been institution-specific, outreach to high schools and community colleges (speakers, open houses, and parental involvement), tutoring, mentoring, and advising are main components of the program. Some NW-EETEP sites have engaged students in hands-on activities (e.g Human Powered Paper Vehicle Competition), conferences, living-learning communities, and site visits to industry.

In terms of reaching the statewide goals of the grant, the data from WSU and UW suggest that goals 1 and 3 above may be achieved in the next two years. Baccalaureate engineering degrees granted over the grant period show that degrees granted overall and to URM students have increased by 3.5% and 54%, respectively while female degrees granted have declined by 20% at WSU and UW. Changes in upper division engineering enrollments yield very positive findings at UW and WSU. They have increased in total, for women, and for URM students throughout the five year grant

period by 15%, 21%, and 37%, respectively. Additionally, findings from the Student Experience Survey, administered annually for four years, reflect statistically significant improvements in student attitudes regarding perceptions of teaching quality, student services participation, and self-confidence in academic abilities over the grant period.

IV. Methodology

The Student Experience Survey (SES) was administered as an online survey and was open to all students registered with NW-ETEP at their institutions. This annual survey assessed student experiences at their institutions and in NW-ETEP programs. The SES asked questions to determine the effectiveness of the NW-ETEP intervention over time. The SES was developed to assist the institutions in learning what aspects of the services could be improved in order to improve the retention of all students, including NW-ETEP registrants. Table 1 below shows a summary comparison of each year's SES respondents and the total NW-ETEP registrants.

Table 1. Comparison of SES Respondents and All NW-ETEP Registrants

	SES 2005- 2006 (%)	SES 2006- 2007 (%)	SES 2007- 2008 (%)	SES 2008- 2009 (%)	All NW- ETEP Registrants
Female	36.0	37.2	35.2	30.8	25.9
URM	11.0	13.9	13.9	10.9	14.9
African American	4.0	4.0	4.7	4.2	5.1
Hispanic	6.6	6.6	6.7	5.9	8.2
Native American	0.4	3.3	2.5	0.8	1.6
Total Participants	227	151	360	122	3,124

The demographic composition of SES respondents closely mirrored that of the total NW-ETEP registrants, making us confident that SES respondents were a representative group of NW-ETEP participants. Women were slightly more represented among SES respondents, with more than one-third consistently responding to the SES while comprising only one-quarter of all registrants. In 2009, nearly 11% of SES respondents were underrepresented minorities, compared to 15% of total registrants. These similarities show that SES respondents were demographically representative of NW-ETEP registrants, suggesting that inferences about registrants as a whole can reasonably be made from the experiences of the SES respondents.

Previous research has found differences between female and minority students and white males in the level of academic and social integration into STEM disciplines. To test for these differences we examine SES data collected throughout the life of the NW-ETEP program, focusing on both differences between groups and trends over time. Differences between groups are measured using Pearson chi-square and two-tailed asymptotic significance tests. When statistical significance is indicated, adjusted standardized residuals are used to identify cells (or specific scale levels) in which significant difference lies. Significant changes over time are measured using Kruskal-Wallis one-way ANOVA, a nonparametric test. Adhering to social science convention, significance is determined by an alpha or p-value smaller than 0.05.

V. Findings

We begin our analysis of the NW-ETEP data by exploring students' perceptions of their academic preparedness coming into college and changes in their academic self-confidence over time. We show that while there are no significant differences between under and over-represented groups in terms of their feeling prepared for taking STEM courses, there are significant differences in student groups' academic self confidence over time. Next, we examine students' perceptions of institutional factors including climate and access to mentorship. Finally, our analysis demonstrates differing concerns between men and women regarding the ability to balance work and life activities in STEM fields.

A. Academic Preparedness & Confidence

When asked to rate on a five point scale how adequately their high school coursework prepared students to be successful in an engineering or science curriculum, respondents from underrepresented groups indicated the same degree of preparedness as their white or male counterparts, with no statistical difference in means across all four years the survey was administered.¹ In addition, women and URM respondents indicated equally high levels of confidence when asked about the likelihood of completing their intended majors as their white male counterparts. For example, in the last year of the survey, women reported a mean of 4.31 (out of 5) and URMs reported a mean of 4.36 (out of 5) when asked how confident they were regarding completing their degree.

A different trend emerges when analyzing academic self-confidence. According to the research literature, self-confidence levels during engineering study decrease over time for women and URMs (Seymour & Hewitt 1997; Brainard & Carlin 1998; Goodman & Cunningham 2002; CAWMSET 2000). Indeed for three years of the SES survey (2006, 2008, and 2009) men and women reported significantly different degrees of increase in confidence levels regarding overall academic ability, with men experiencing greater improvements in confidence (see Table 2).

Table 2. Means, Student Reporting on Overall Academic Self Confidence Since Entering College

	2006	2007	2008	2009
Women	2.88	3.24	2.94	3.47
Men	3.62	3.63	3.69	3.88
Significance level (p)	.000	.111	.000	.040

**Scale: 1=Greatly Decreased 2=Decreased 3=Stayed the Same 4=Increased 5=Greatly Increased*

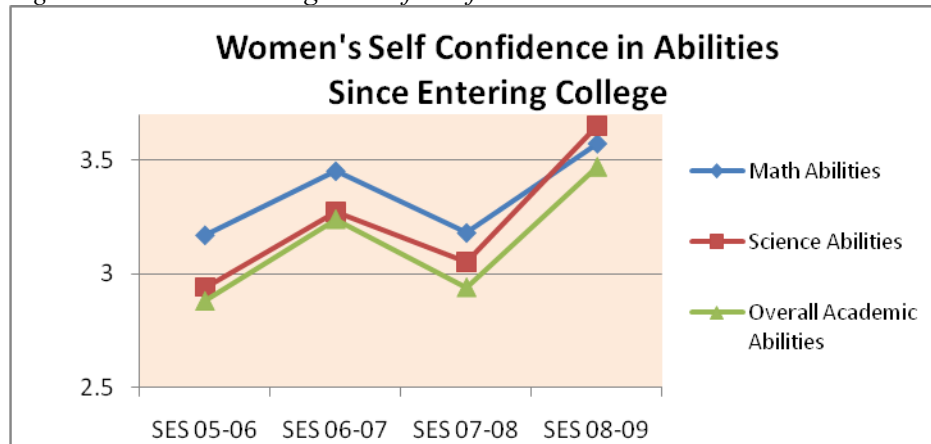
Interestingly, this difference between the two groups lessened over time. For example, during the first year of the survey (2006), only 11% of those reporting that their overall academic confidence levels 'greatly increased' were women compared to 32% in the fourth year of the survey (2009). In fact, women's confidence levels in their science and overall academic abilities show a significant improvement over time.² That is, over the course of the NW-ETEP program, fewer women reported decreases in their confidence, and more reported experiencing increases in confidence. Figure 1 displays the mean ratings of women's confidence in math, science, and overall academic abilities over the four years of the SES survey. The first year of the survey, the mean rating for women's self confidence either stayed the same or had actually decreased since

¹ For example, in the 2008 survey, the mean response to this question for women was 3.19 compared to men's mean response of 3.14; URMs gave a mean response of 3.10 compared to non-URMs' response of 3.18.

² The relevant survey questions are worded: "Since you entered college, has your self-confidence in []: 1=Greatly Decreased, 2= Decreased, 3=Stayed the Same, 4= Increased, 5= Greatly Increased.

entering college. By year four of the survey, the mean ratings of all three measures of self-confidence are above ‘stayed the same’ and approach ‘increased.’ Although the change in women’s confidence in their math abilities is not statistically significant, there is a similar trend.

Figure 1. Women’s Change in Self Confidence in Academic Abilities Over Time



Scale: 1=Greatly Decreased 2=Decreased 3=Stayed the Same 4=Increased 5=Greatly Increased
 *Changes over time in math abilities confidence not statistically significant

Academic self-confidence also followed a positive trend for URM students, but without a statistically significant increase over time. However, when compared to nonURMs, there is some evidence of difference: in two years of the survey (2005 and 2007) URM students reported statistically significantly lower increases in confidence than non-URMs.

B. Campus Climate

Research also shows that a climate of discrimination and prejudice on campus or in the classroom is a key factor in differences in social and academic integration between minority and non minority students (Cabrera et al. 1999). Scholars argue that a climate of discrimination discourages minority students from interacting with faculty, nonminority students, and campus organizations (Solorzano, Ceja & Yosso 2000; Zeldin & Pajares 2000), and consequently, the “low involvement with the different campus communities...impinges on the minority student’s cognitive and affective development as well as his or her decisions to persist in college” (Cabrera et al. 1999: 136). Climate factors of competition and lack of support from faculty and peers are cited as reasons for leaving in a large-scale study of undergraduates (Goodman et al 2002).

Importantly, NW-EETP students reported very low levels of feeling judged on the basis of race, with no statistical difference between URM students and non-URMs (on a scale of 1-5, URM mean= 1.75, non-URM mean= 1.38.) Likewise, there was no difference between these groups in feeling called upon to speak on behalf of their race/ethnicity, that they were treated with respect, their comments were taken seriously by peers, or their comments were taken seriously by faculty.

Feelings of isolation and discrimination have also been shown to affect women’s persistence in STEM (Goodman & Cunningham 2002; McIlwee & Robinson 1992). Women participating in NW-EETP reported no difference from men in feeling treated with respect or being taken seriously by peers and faculty. However, women were more likely to feel judged on the basis of

their gender and called upon to speak on behalf of their gender. Table 3 below shows mean responses for all years of the survey, with significant differences for three of those years.

Table 3. Means, Student Reporting on Extent of Being Judged on the Basis of Gender

	2006	2007	2008	2009
Women	2.15	2.30	2.25	2.03
Men	1.44	1.29	1.41	1.65
Significance level (p)	.000	.000	.000	.183

**Scale: 1=Not At All 2=A Little 3=Somewhat 4=Quite A Bit 5=Very Much*

While the survey did not probe whether, for example, being called upon to speak on behalf of women has a negative impact on female engineering students' experiences, this finding highlights female student awareness of their underrepresented status in STEM fields.

C. Mentorship

Mentorship has been shown to be an additional factor in STEM retention, particularly for women (Chesler, Boyle Single, & Mikic 2003; Frestedt 1995; Brainard & Ailes-Sengers, 1994). In all four years the survey was administered, significantly larger percentages of women reported having mentors than men. Over the duration of NW-ETEP program, between one-third and one-half of women reported having a mentor among the STEM faculty; whereas the proportion of men reporting having a mentor ranged from 18% to 33%. Percentages for each year of the survey and the significance level of differences are shown in Table 4.

Table 4. Percentages, Students Reporting to have a Mentor (Informal or Formal) Among the Faculty

	2006	2007	2008	2009
Women	36 %	40 %	35 %	49 %
Men	18 %	20 %	23 %	33 %
Significance level (p)	.003	.007	.024	.152

Large proportions of underrepresented minorities also reported having a mentor. However, the difference between URM and nonminority students was statistically significant only during the first year of the program. Somewhat troubling is the apparent trend in mentorship for URM students over the course of NW-ETEP program. As shown in Table 5, the proportion of URM students reporting having a mentor decreased over time; however, this is not a statistically significant change over time ($p=0.245$). The opposite trend holds for non-minority students: an increasing proportion claim to have a mentor among STEM faculty. The increase over time for non-minority students is a statistically significant one ($p=0.006$).

Table 5. Percentages, Students Reporting to have a Mentor (Informal or Formal) Among the Faculty

	2006	2007	2008	2009
URMs	52 %	25 %	35 %	31 %
Non-URMs	21 %	27 %	26 %	40 %
Significance level (p)	.001	.824	.159	.529

D. Balancing Work & Life Issues

Another finding consistent with research literature is that women are more concerned about balancing work and family obligations. Women have been found to be more likely to perceive work-life balance conflicts and anticipate career problems associated with certain careers (Hawks and Spade 1998), a concern which may be more prevalent in a male-dominated field such as engineering. This concern may prompt women to select what they perceive to be a less demanding career path. When asked about the extent of the following in shaping their professional plans, in at least three years of the survey, significantly larger percentages of women were concerned about their ability to maintain family and community ties, worried about parental (maternal/paternal) leave benefits, and were concerned about their ability to balance work and family. Each year of the program roughly one-half of female students reported anticipating conflicts in balancing work and family, compared to about one-third of male students (Table 6).

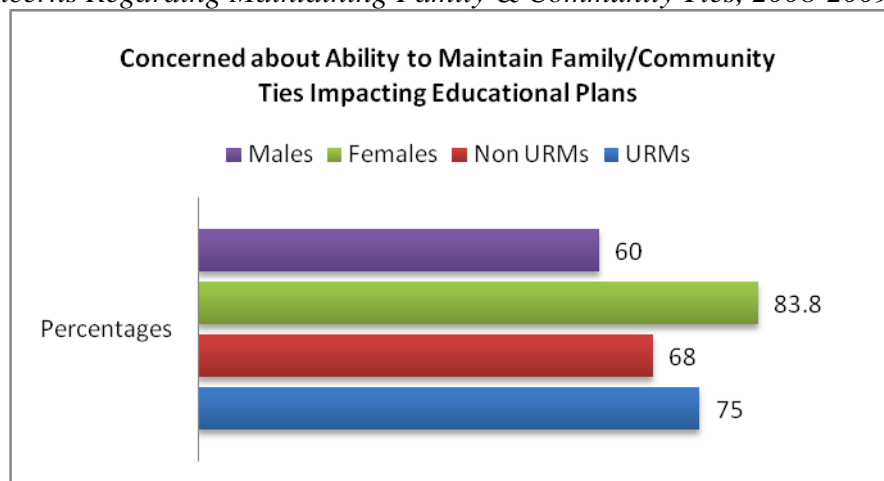
Table 6. Percentages, Extent to which Students are Concerned about Balancing Work & Family

	2006	2007	2008	2009
Women	48.8 %	55.6 %	53.7 %	54.3 %
Men	36.0 %	34.1 %	34.1 %	42.5 %
Significance level (p)	.054	.012	.000	.243

**Scale: 1=Not At All 2=A Little 3=Somewhat 4=Quite A Bit 5=Very Much*

Women were also significantly more likely to be concerned that their ability to maintain family and community ties would have an impact on their educational and professional plans (statistical differences between men and women were found in 2006, 2008, and 2009.) For example, in 2009, 83.8% of female students reported to be at least somewhat concerned about their ability to maintain family and community ties impacting their educational plans, compared to 60% of men. Higher percentages of minority than non-minority students also expressed this concern, but the differences were not statistically significant. (See Figure 3).

Figure 3. Concerns Regarding Maintaining Family & Community Ties, 2008-2009 Survey



**Difference between URM and non-URM is not statistically significant*

VI. Discussion

Overall, these survey findings may offer some insight into the outcomes of the NW-ETEP partnership. The degrees granted goals for women of a 20% increase had not been achieved by the end of the program, while the URM goal of a 100% increase was reached. Although the interventions were institution-specific, all partner institutions implemented a variety of programs and workshops such as tutoring, mentoring, advising, conferences, competitions, and site visits specifically aimed at recruiting and retaining underrepresented students. Our survey findings of little or no differences between URMs and non-URMs in terms of participating in mentorship programs, low feelings of discrimination and prejudice, and the ability to balance work and life obligations suggest that NW-ETEP may have succeeded in closing some of the gaps traditionally experienced between minority and non-minority students. While the survey data do not provide direct evidence of this link, it is plausible that the intervention programs successfully mitigated some of the factors that hinder social and academic integration (Clewell et al 2005; Patton et al 2006), and contributed to the doubling of URMs receiving engineering degrees at UW and WSU.

In contrast, the findings for women point to significant differences between academic self-confidence, participation in mentoring, experience of campus climate, and concerns with work-like balance in comparison to their male counterparts. The Student Experience Survey showed that females have lower self-confidence levels in comparison to their male peers, despite reports that they felt equally academically prepared. While we see that women's academic self-confidence did not increase to the same degree as men's, it is difficult to draw clear conclusions about how this impacts their likelihood of persistence. Previous studies have found that women's academic self-confidence vary depending on class level, particularly that women's self-confidence dips in the first two years and then increases (Brainard and Carlin 1998). As our samples are not large enough to disaggregate by class, we are unable to test for distinct patterns or trends at various grade levels.

Also constrained by data limitations are the findings regarding mentorship and institutional climate, the interpretation of which present somewhat of a puzzle. Our findings that women are more likely to have an informal or formal mentor among STEM faculty reflect, in part, the efforts undertaken by NW-ETEP site coordinators at each institution to pair underrepresented students with mentors. Unfortunately, the SES survey results do not indicate whether students felt their mentors were good matches, or how student-teacher mentor relationships developed. Several studies suggest that "matching" mentors based on ascriptive (i.e. women with women, minorities with minorities) measures are often fruitful for a successful relationship (Hassoun and Bana 2001). Having a more in-depth understanding of these mentoring relationships might shed light on why, despite the majority having faculty mentors and therefore being more integrated into the culture of academic engineering, women still felt judged according to and asked to speak on behalf of their gender. It is important to note that women did not report higher levels of being discriminated against or that their peers or faculty did not respect their comments and views. The question remains then, does the difference women feel negatively impact their decisions to persist in engineering or does it simply reflect a heightened awareness of their minority status?

Women also expressed concerns about work-life balance. A significantly larger proportion of women than men reported anticipating problems or conflicts in balancing work and family in their future. Our findings that women were much more worried, specifically, that maintaining family and community ties, and having adequate parental leave benefits would impact their educational or professional plans, reflects women's concerns not just at these institutions, but in

the field of engineering more broadly (Gatta and Roos 2002). Again, it is unclear from these data whether this concern will be strong enough to discourage women from persisting, but such prevalence also leads us to ask if it deters women from entering the engineering pipeline.

VII. Conclusion & Recommendations

We have already mentioned several of the data limitations of this study. To summarize, we have only benchmark and outcomes data on enrollments and degrees granted and do not have pre and post intervention measures to isolate impacts of specific aspects of the NW-ETEP program (i.e., tutoring, mentoring, workshops, etc.) In addition, our cross sectional samples are not large enough to disaggregate by gender within race, or within class level; nor do we have the statistical power needed to examine individual racial groups. Most importantly, these data do not track individuals as they moved through the program.

Despite these limitations, a number of programmatic recommendations can be drawn from our findings. First, our data suggest that the implementation of STEM-focused advising, academic support, and community building programs targeting underrepresented minorities can assist these students to more thoroughly integrate socially and academically into their institutions. Second, our data suggest that it may not be sufficient to simply fold services targeting women into those offered to minorities under the umbrella of serving “underrepresented” students. Instead, it may be more fruitful to implement separate services aimed more directly at recruiting and retaining women. Broadly, programmatic activities should emphasize building self-confidence, reducing isolation, and addressing concerns regarding family and work conflict. Suggestions include:

- Develop a WISE/WIE-specific programming. If already present on campus, WISE/WIE programs should consider developing their own hands-on activities for females to provide outside of the classroom learning experiences to boost self-confidence and comfort with engineering concepts, particularly in the first two years of engineering study.
- Incorporate “matching” into existing mentoring programs. Train mentors to be sensitive to the key issues that concern female students (institution-specific issues and workforce).
- Invite diverse engineering professionals to talk about their work-life balance experiences.

Addressing concerns regarding balancing work and life is particularly important not just for retention, but also recruitment, of women in engineering. If the nation is concerned with shortages of engineering students, these challenges cannot simply be perceived as female issues. However, changes in this area require some degree of institutional change, not interventions to the individual. Structuring institutions to be more parent-friendly increases the number of female students recruited and retained by engineering programs (Hassoun & Bana 2001; Shirley 1999).

To test the success of these recommendations and further tease apart the impact of interventions such as those undertaken in the NW-ETEP project, further research is needed in this area. Our analysis points to the potential benefits of including comparison groups in the data collection and analysis plan in order to more clearly delineate the impact of an intervention. Comparing student experiences before and after the intervention, as well as comparing program participants to non-participants would allow us to identify stronger linkages between the intervention and outcomes. There is also ample room for qualitative studies to probe findings such as women feeling equally prepared as men but having lower academic self-confidence.

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