2011 WEPAN National Conference

Advancing Women: Transforming Engineering Education

June 21-23, 2011

Seattle, Washington

Why do Women Engineering and Computer Science Undergraduates Persist in their Major?

Kaitlyn J. Bunker, Raven R. Rebb, Laura E. Brown, Gretchen L. Hein, Nilufer Onder
Michigan Technological University

ABSTRACT

The completion of an undergraduate degree in engineering or computer science is challenging. Many students think about switching majors at some point during their undergraduate education. Previous research addresses general retention at the university level. In addition, researchers have focused on what helps underrepresented groups to be retained at universities. Many initiatives relate to intervention during the first and second years of study, but when do students, and women in particular, contemplate switching majors and what or who influences them to persist? To begin to answer this complex issue, engineering and computer science students were surveyed at Michigan Technological University. Some of the questions investigated through the survey were: (1) How do men and women students compare in relation to questioning their choice of major? Does one group question their choice of major more? Do women or men question their degree choice at different times? (2) What factors influence the two groups to persist within their degree program? and (3) Who influences the two groups to persist within their degree program? This paper discusses the results of the survey and ties the findings to other research.

INTRODUCTION

Students start engineering or computer science degree programs with varying expectations with respect to college life, academics, and job prospects. On one hand, incoming students hope to get their education in an area that interests them and that they feel confident in working. On the other hand, engineering and computer science degrees are usually academically challenging, lack diversity, and students may not adequately perceive the components of a successful career, aspects which may be overwhelming to any student and affect retention. Studies have been conducted to analyze factors that make students leave their major. However, few investigate why students choose to remain in their degree program even if they have thought about leaving. In this work, we explore the factors that contribute to students' choice of major, switching majors, and persistence in a major. Our instrument is an online survey given to current engineering or computer science majors at Michigan Technological University. We analyze the data collected from 436 students and based on these results present suggestions to improve persistence.

This data analysis focuses on determining gender differences in the responses. The data shows that women place importance on a variety of factors when selecting and persisting with their major, while men do to a lesser degree. Both women and men report that they persisted within their major generally because of the department environment, faculty and fellow students. For the students who had switched majors, men and women both state that the main reason for switching is a “new career path” and improved job prospects. The decision to switch is mainly reported as being based on self-reflection and no reasons are gender specific. This is also true for students who had thought about switching majors. All of the students were asked about perceptions of their confidence, their major and the university environment. Although there are gender differences, overall the students are confident in their abilities with respect to completing their degree and being successful in their career choice. They can relate to the faculty and their fellow students. These results are discussed in greater detail in the following sections.

BACKGROUND

It is well known that the need for engineering or computer science graduates is greater than the number of students entering the workforce in these fields. There are many factors that encourage students to choose engineering or computer science. Research shows that having a strong role model can be a major driving force in a female student’s decision (Zeng & Duncan 2007), whereas the lack of a strong role model can deter students from choosing or persisting in one of these fields (Malady et al. 2008). Other reasons to

choose these majors include a desire to improve the world in some way, and to have good employment opportunities available after graduation (Zeng and Duncan 2007). The fields of engineering and computer science provide a range of opportunities for satisfying those reasons (Zeng and Duncan 2007).

Once students have selected and started in a major, retention becomes a challenge. University of Pittsburgh faculty have analyzed the attrition data of computer science (CS) students, by the aggregate and by gender. They found that many of the successful students who left CS did so because they lost confidence in their ability to succeed. Some of this lost confidence was due to their required effort to succeed when compared to the perceived effort of their classmates. Other students left because the material no longer interested them. When successful students left the program, it was independent of gender (Katz et al. 2006). Ohland et al. (2009) studied longitudinal data of students at nine public universities in the southeastern United States. They found that women are less likely to persist to the eighth semester for the same six-year graduation rate and hypothesized that women might be leaving engineering early due to low self-efficacy. They also found that among those who persist to eight semesters, women are 1% to 13% more likely than men to graduate within six years.

Light et al. (2007) and Morozov et al. (2008) studied the relationships between self-confidence and performance. Surveys given to first year students show that men report higher self-confidence than women. However, men and women performed equally well in an engineering design related task given as part of the survey. This suggests that expectancy related constructs do not predict persistence. In fact, preliminary data suggest that women are more likely to persist than men after the first year. Morozov et al.'s studies also showed men reporting higher confidence levels, but they found that the gap diminishes significantly by the fourth year. Men and women were similar in their perception of the quantity of the design education that they are receiving. However, women perceived the quality of their design education to be lower when compared to men. Marra and Bogue (2008) looked at data on classroom learning environments in three engineering departments and did not find gender differences in how first year students view teaching and learning activities. They hypothesize that this is because the study looks at women who already entered their degree program and thus might have learned how to cope with the climate of an engineering classroom.

Marra et al. (2009) studied data collected from women engineering students at five U.S. institutions. They found that in two years, there was either an increase or a small drop in career expectations, engineering self-efficacy, coping self-efficacy, and math expectations. There was a statistically significant drop in feelings of inclusion. The negative change for 11 African American students was greater than other ethnic groups, but the difference was not statistically significant. Concannon and Barrow's (2009) findings were similar to Marra et al. in that there are no significant differences between genders with respect to engineering self-efficacy. The authors did find that women engineering students were less able to “manage stressful circumstances in an attempt to decrease internal stress”. In addition, they found that transfer students have lower self-efficacy beliefs. In general, the longer a student was in an engineering degree program, the higher their engineering self-efficacy was.

Lasich and Sulzbach (2008) explain that being part of a campus-based organization has a positive influence on the retention of female students and study this in the context of the Society of Women Engineers (SWE) section at Colorado School of Mines. They show that focused changes that brought in a funded director position to the SWE section, defined a University reporting and funding structure, and emphasized a “community” for women engineering students, were vital to the University's improved climate. Kissinger et al. (2009) studied belonging and sense of community in electrical engineering, civil and environmental engineering, and computer science. Their results show that the averages for the sense of belonging and sense of community are similar for men and women when analyzed over the entire student population. However, junior and senior women reported a significantly higher sense of belonging compared to men at the same level. Tsang and Halderson (2008) show that learning communities contribute to improved retention of students.

Barker et al. (2009) studied the persistence of freshmen and sophomores who took an introductory CS course. They found that student-student interaction is a strong predictor of persistence for all students, not only for members of underrepresented groups. Malady et al. (2008) emphasize that

looking for possibly non-existent attributes that are present only for women might not be fruitful. They suggest that improvements made to the K-12 career preparation curricula and the undergraduate curricula will have positive impacts on both male and female students. Hartman and Hartman (2008) also support the view that many issues that are seen as problematic for women are also issues for men. In general, career-family conflicts, the length of preparation required, the perception of women as unfeminine, lack of confidence that they can handle the work, and lack of social encouragement to pursue engineering fields are problematic, but not to a degree to view women as significantly different. However, this changes in majors in which the women are less than the "critical mass" of 15%, and women are seen as more different. The study found that there were significant perception differences between the first-year and fourth-year students, regardless of gender. More first-year students perceived conflicts between their careers and personal life, length of time to attain degree as problematic, and a lack of information on the career as a deterrent than fourth-year students. The differences in the latter two items were attributed to more information on their selected major and more commitment to their career as the students' progress through their education. The family-career balance issue is interesting because the younger students are more concerned about it than the students who are closer to graduation. Zeng and Duncan (2007) performed interview-based, qualitative studies and classified the major forces affecting women engineering students. They recommended that the forces affecting each individual be understood thoroughly to increase the students' probability of success.

Jones et al. (2010) pointed out that those who persist within academia might not necessarily work in an engineering career after graduation and showed that expectancy-related (one's belief in the possibility of his or her success in engineering) constructs predict academic achievement whereas value-related (interest, attainment, utility, and identification) constructs predict career plans for men and women. The survey was given to 363 engineering students during the each semester of the first year. The results showed that while men reported higher levels in expectancy-related constructs, the value-related levels were similar for men and women. Further analyses showed that men and women have similar decreases between the two surveys over all constructs tested, indicating that the underlying reasons affect men and women similarly. Intercorrelations among the variables and predictors of GPA were similar across gender. Zeng and Duncan (2007) recommended a "force-based" analysis during school because even if women graduate from an engineering program, they may switch to alternative careers. Concannon and Barrow (2009) found that African Americans have significantly lower engineering career outcome expectations. In particular, they believed that they were less likely to be treated fairly on the job or feel part of the group they are working in.

METHOD

In the spring 2011 semester, a study was conducted at a public, Science, Technology, Engineering, and Mathematics (STEM)-intensive, Midwestern university. The undergraduate enrollment is approximately 5500 students with 60% enrolled in Engineering and Computer Science degree programs. The university is an ADVANCE university with 28.7% female enrollment. The percentage of female enrollment within the College of Engineering (COE) and Department of Computer Science (CS) (part of the College of Sciences and Arts) is 18.2%.

The survey was available as an anonymous, online survey that was developed using questions similar to other studies (Marra et al. 2009). All students within the COE and CS were forwarded an invitation to participate in the survey by the students' respective program advisors and Women in Science and Engineering (WISE) faculty email list. Invitations were also sent to members of the Society of Women Engineers (SWE) and Women in Computing Sciences (WiCS). The number of students who started the survey was 495 with 459 who completed the survey (92.7%). The survey respondents were asked to indicate their current major, from a list of COE and CS majors. There were 16 respondents who were graduate students and 7 students outside the COE and CS who were not considered further, bringing the total study population to 436 students.

In Table 1, each major (or grouping of majors) has the percentage of and number of female and male students who completed the survey reported. The same information is presented for each major

from university enrollment data. Additionally for each major, the total number of male and female students are reported along with the proportion of participants or enrollees within the COE and CS fields. Engr. – Other refers to Engineering (Bachelor of Science in Engineering, BSE), Geological Engineering, Materials Science and Engineering, and Undeclared – Engineering, which were grouped due to the small number of survey participants. The survey response rate was 25.4% among the female and 11.1% among the male COE and CS students. The higher response rate from female students could be due to repeated, directed invitations to student organizations such as SWE and WiCS as well as other faculty members.

Table 1. Majors of Survey Participants, University Enrollment

	Survey Participants, % (n)			University Enrollment, % (n)		
Major	Female	Male	Total	Female	Male	Total
Biomedical Engr.	46.2 (18)	53.8 (21)	8.9 (39)	40.8 (86)	59.2 (125)	6.5 (211)
CS, Comp.& Elect. Engr.	20.2 (20)	79.8 (79)	22.7 (99)	9.2 (75)	90.8 (744)	25.2 (819)
Chemical Engr.	39.5 (30)	60.5 (46)	17.4 (76)	26.9 (104)	73.1 (283)	11.9 (387)
Civil Engr.	33.8 (24)	66.2 (47)	16.3 (71)	17.9 (85)	82.1 (390)	14.6 (475)
Environ. Engr.	56.7 (17)	43.3 (13)	6.9 (30)	46.4 (65)	53.6 (75)	4.3 (140)
Mech. Engr.	17.7 (17)	82.3 (79)	22.0 (96)	9.6 (94)	90.4 (883)	30.1 (977)
Engr. – Other	44.0 (11)	56.0 (14)	5.7 (25)	33.6 (81)	66.4 (160)	7.4 (241)
CS and Engr.	31.4 (137)	68.6 (299)	100.0 (436)	18.2 (590)	81.8 (2660)	100.0 (3250)
Non CS and Engr.	71.4 (5)	28.6 (2)	--- (7)	44.2 (978)	55.8 (1234)	--- (2212)
Total				28.7 (1568)	71.3 (3894)	(5462)

The survey respondents consisted of 137 (31.4%) female students and 299 (68.6%) male students, where 3 students did not indicate their gender. The ethnicity of the survey sample has less than one percent of students identifying themselves as Hispanic or Latino (*n*=4 students). Students were allowed to select more than one race. The race of the students was mainly Caucasian (*n*=417, 95.6%) with a small percentage of American Indian (*n*=3, 0.7%), Asian (*n*=10, 2.3%), Black or African American (*n*=8, 1.8%) students and no students reporting as Native Hawaiian or other Pacific Islander. The survey respondents were approximately evenly distributed between first and fourth years with also a smaller percentage of fifth+ years reported. Table 2 shows this data.

Table 2. Survey Respondents' Distribution by Year of Study

	Survey Participants, %, (n)		
Year	Female	Male	Total
First Year	30.6 (30)	69.4 (68)	22.5 (98)
Second Year	36.6 (30)	63.4 (52)	18.8 (82)
Third Year	30.2 (29)	69.8 (67)	22 (96)
Fourth Year	28.4 (33)	71.6 (83)	26.6 (116)
Fifth+ Year	34.1 (15)	65.9 (29)	10.1 (44)
Total	31.4 (137)	68.8 (299)	100 (436)

ANALYSIS OF RESULTS

Tables 3 through 9 present the results for the survey questions. Each question had 7-11 items that were rated with a 5-point Likert scale. Multiple items had less than 5 respondents for a rating. Therefore, the ratings were condensed into three groups for presentation and statistical analysis as follows. For Tables 3, 4, and 9, responses of very unimportant/strongly disagree and unimportant/disagree were combined, responses of very important/strongly agree and important/agree were combined, and responses for neutral remained unchanged. For Tables 5, 6, 7, and 8, responses of no influence/importance remained alone, responses of some influence/importance and moderate influence/importance were combined, and responses of high importance/influence and extremely high importance/influence were combined.

For each question item, the tables present the percentage and number of respondents for each Likert rating separated by gender. The mean of each gender's responses and the mean of all responses

were calculated from the original 5-point Likert scale data where the responses are given interval values of 1-5. Finally, a χ^2 test was used to assess whether the responses were independent of gender (on the condensed data). Items with a *p*-value of less than 0.05 were assessed as rejecting the null hypothesis of independence.

Undergraduate students were asked why they selected their current major (Table 3). The mean responses were similar for men and women, with the female responses having a higher value. In general, the students reported that they selected their major because it interested them and they are good at math and science; this choice allowed them to find a job and be a force for positive change. It was surprising that income potential, although the mean value was higher than 3, was not rated as high as the student's inherent interests and job potential. The other factors, "a family member or close friend is in this career field" and "my parents/counselor recommended this career" were generally rated as unimportant. Looking at the mean values, the main differences between the male and female students lie in two categories. Female students ranked having an opportunity to make a difference in the world as important more often than males. Women reported at a higher rate than men that being good at math and science influenced their choice of major. When the results are further broken down, those female students that are not currently thinking of changing their major, regardless of whether they have changed majors in the past, ranked being good at math and science as more important than other survey respondents.

When students were asked why they persist in their current major, they responded positively with respect to liking their departments, faculty and fellow students. An analysis of Table 4 shows that enjoyment and job related factors "Overall, I like my major," "I think my major has good job opportunities," "I think my major will allow me to make a difference in the world" and "I think my major has good income potential," "I found a related career path that I can pursue with this degree" have high importance. The factors related to diversity and environment ("I am satisfied with the diversity within my major" and "I am satisfied with the environment within my major"), and current indicators of success ("I think I will complete this major without difficulty" and "I have a good GPA in my major") were moderately important. The factors related to other majors ("No other attractive majors available") and time spent in the degree program ("It's too late in my degree program to switch majors") were not as important.

Table 3. Results for "Why did you choose your current major?"

		Likert Scale Data, % (*n*)					
		Unimportant	Neutral	Important	Mean		
Statement	Gender	1-2	3	4-5	Gender	Total	*p*-value†
I am good at math and science	Female	5.9 (8)	11.0 (15)	83.1 (113)	4.15	3.98	0.016
	Male	5.7 (17)	22.6 (67)	71.6 (212)	3.90		
I am interested in this major/field	Female	3.6 (5)	2.9 (4)	93.4 (128)	4.48	4.53	0.019
	Male	0.7 (2)	7.1 (21)	92.3 (274)	4.55		
A family member of close friend	Female	60.7 (65)	16.8 (18)	22.4 (24)	2.34	2.34	0.727
is in this career field	Male	57.0 (135)	20.3 (48)	22.8 (54)	2.34		
My parents/counselor	Female	51.2 (62)	26.4 (32)	22.3 (27)	2.55	2.43	0.519
recommended this career	Male	54.4 (141)	28.2 (73)	17.4 (45)	2.37		
This field provides opportunities	Female	6.7 (9)	14.8 (20)	78.5 (106)	4.17	3.82	0.000
to make a difference in the world	Male	14.3 (42)	26.6 (78)	59.0 (173)	3.65		
There are many job opportunities	Female	2.9 (4)	14.0 (19)	83.1 (113)	4.20	4.10	0.195
	Male	4.7 (14)	19.9 (59)	75.3 (223)	4.06		
There is high income potential	Female	13.5 (18)	24.1 (32)	62.4 (83)	3.66	3.70	0.899
	Male	12.0 (35)	25.0 (73)	63.0 (184)	3.72		

† *p*-values were calculated using a chi-squared test, with a null hypothesis of independence of gender

Table 4. Results for "What made you persist with your major?"

		Likert Scale Data, % (*n*)					
		Unimportant	Neutral	Important	Mean		
Statement	Gender	(1-2)	(3)	(4-5)	Gender	Total	*p*-value†
Overall, I like my major	Female	2.2 (3)	3.6 (5)	94.2 (129)	4.51	4.34	0.024
	Male	3.0 (9)	11.5 (34)	85.5 (253)	4.27		
I think I will complete this major without difficulty	Female	24.1 (33)	38.7 (53)	37.2 (51)	3.20	3.16	0.270
	Male	28.6 (84)	31.0 (91)	40.5 (119)	3.14		
I have a good GPA in my major	Female	18.2 (25)	36.5 (50)	45.3 (62)	3.39	3.30	0.049
	Male	27.0 (80)	26.7 (79)	46.3 (137)	3.26		
No other attractive majors available	Female	51.8 (71)	24.1 (33)	24.1 (33)	2.52	2.49	0.540
	Male	57.3 (169)	20.3 (60)	22.4 (66)	2.48		
It's too late in my degree program to switch majors	Female	46.0 (63)	19.7 (27)	34.3 (47)	2.69	2.72	0.615
	Male	49.3 (145)	16.0 (47)	34.7 (102)	2.73		
I am satisfied with the diversity within my major	Female	26.3 (36)	32.8 (45)	40.9 (56)	3.11	2.86	0.015
	Male	40.5 (119)	28.2 (83)	31.3 (92)	2.74		
I am satisfied with the environment within my major	Female	15.3 (21)	24.1 (33)	60.6 (83)	3.62	3.36	0.010
	Male	25.3 (75)	29.1 (86)	45.6 (135)	3.23		
I think my major will allow me to make a difference in the world	Female	8.8 (12)	15.3 (21)	75.9 (104)	3.96	3.55	0.000
	Male	23.1 (68)	24.1 (71)	52.9 (156)	3.36		
I think my major has good income potential	Female	5.1 (7)	21.2 (29)	73.7 (101)	3.90	3.72	0.045
	Male	12.5 (37)	22.6 (67)	64.9 (192)	3.64		
I think my major has good job opportunities	Female	5.1 (7)	10.3 (14)	84.6 (115)	4.10	4.00	0.016
	Male	5.1 (15)	21.7 (64)	73.2 (216)	3.95		
I found a related career path that I can pursue with this degree	Female	11.0 (15)	23.5 (32)	65.4 (89)	3.79	3.56	0.025
	Male	21.1 (62)	24.8 (73)	54.1 (159)	3.45		

† *p*-values were calculated using a chi-squared test, with a null hypothesis of independence of gender

Female students cited more factors than male students as being important to persisting in their major. Women ranked "making a difference in the world" higher than men as influencing their persistence in their major. This was consistent with Table 3, where women ranked this statement as important when selecting their major. The women surveyed considered diversity issues and the departmental environment as more important to their decision than men.

Students were asked if they had already switched majors, and if so when and how many times they had switched. The number of women and men switching majors is about the same in terms of the study respondents: 23.4% of the women (32/137) and 20.1% of the men (60/299) reported switching majors. Approximately 60% of these students switched majors during their first year. This rapidly declined to 30% during their second year, and a few after that. Of those students who switched their major, most switched only one time, with isolated cases up to 5 times reported.

Those students who reported changing their major were asked what factors influenced their decision (Table 5). There were relatively no differences between the reasons reported by males and females. The highest rated factor was interest in a "new career path", followed by "better job prospects". Looking at the mean values, the diversity and environment of the major had low importance in why a student switched majors. Perceived difficulty of major and individual student performance were also of low importance when deciding to switch majors. One difference in the responses of men and women is with respect to income potential. More women responded that potential earnings were a consideration when they switched majors than men.

Students were also asked if they are currently thinking of changing their major. The number of respondents who have thought of switching major totals 170 students (51 female and 119 male). Students who reported having thought about switching their major were also asked what factors would influence their decision (Table 6).

Table 5. Results for "Why did you switch majors?"

		Likert Scale Data, % (*n*)					
		No Importance	Some Importance	High Importance	Mean		
Statement	Gender	1	2-3	4-5	Gender	Total	*p*-value†
Did not understand what prior major was until I took some courses	Female	60.0 (18)	20.0 (6)	20.0 (6)	2.10	2.19	0.147
	Male	41.7 (25)	40.0 (24)	18.3 (11)	2.23		
Prior major was too difficult	Female	73.3 (22)	16.7 (5)	10.0 (3)	1.53	1.73	0.543
	Male	61.7 (37)	25.0 (15)	13.3 (8)	1.83		
GPA in prior major was low	Female	76.7 (23)	16.7 (5)	6.7 (2)	1.43	1.55	0.444
	Male	64.4 (38)	28.8 (17)	6.8 (4)	1.61		
Prior major had higher fees/costs	Female	76.7 (23)	23.3 (7)	0.0 (0)	1.27	1.37	0.590
	Male	72.9 (43)	23.7 (14)	3.4 (2)	1.42		
Prior major lacked diversity	Female	66.7 (20)	26.7 (8)	6.7 (2)	1.63	1.61	0.918
	Male	68.3 (41)	23.3 (14)	8.3 (5)	1.60		
Prior major lacked a supportive environment	Female	63.3 (19)	26.7 (8)	10.0 (3)	1.77	1.96	0.567
	Male	55.0 (33)	26.7 (16)	18.3 (11)	2.05		
Prior major did not provide opportunities to make a difference in the world	Female	50.0 (15)	33.3 (10)	16.7 (5)	2.10	1.87	0.364
	Male	63.3 (38)	28.3 (17)	8.3 (5)	1.75		
I was interested in different career path	Female	6.7 (2)	16.7 (5)	76.7 (23)	4.00	3.99	0.646
	Male	11.7 (7)	11.7 (7)	76.7 (46)	3.98		
New major has better income potential	Female	31.0 (9)	31.0 (9)	37.9 (11)	2.83	2.46	0.085
	Male	40.0 (24)	43.3 (26)	16.7 (10)	2.28		
New major has better job prospects	Female	20.7 (6)	20.7 (6)	58.6 (17)	3.24	2.98	0.253
	Male	31.7 (19)	28.3 (17)	40.0 (24)	2.85		

† *p*-values were calculated using a chi-squared test, with a null hypothesis of independence of gender

Table 6. Results for "What factors may influence your decision to switch majors?"

		Likert Scale Data, % (*n*)					
		No Influence	Some Influence	High Influence	Mean		
Statement	Gender	1	2-3	4-5	Gender	Total	*p*-value†
Did not understand what current major was until I took some courses	Female	25.5 (13)	45.1 (23)	29.4 (15)	2.65	2.57	0.861
	Male	29.3 (34)	41.4 (48)	29.3 (34)	2.54		
Current major is too difficult	Female	27.5 (14)	41.2 (21)	31.4 (16)	2.55	2.46	0.608
	Male	35.0 (41)	38.5 (45)	26.5 (31)	2.42		
GPA in current major is low	Female	41.2 (21)	37.3 (19)	21.6 (11)	2.31	2.19	0.690
	Male	48.3 (56)	31.9 (37)	19.8 (23)	2.13		
Current major has high fees/costs	Female	51.0 (26)	39.2 (20)	9.8 (5)	1.92	1.88	0.919
	Male	53.8 (63)	35.9 (42)	10.3 (12)	1.85		
Current major lacks diversity	Female	49.0 (25)	49.0 (25)	2.0 (1)	1.73	1.72	0.027
	Male	60.7 (71)	29.9 (35)	9.4 (11)	1.72		
Current major lacks a supportive environment	Female	51.0 (26)	33.3 (17)	15.7 (8)	2.04	2.14	0.401
	Male	41.9 (49)	44.4 (52)	13.7 (16)	2.18		
Other majors have better opportunities to make a difference in the world	Female	37.3 (19)	43.1 (22)	19.6 (10)	2.25	2.31	0.626
	Male	41.4 (48)	35.3 (41)	23.3 (27)	2.33		
I am interested in different career path	Female	6.0 (3)	40.0 (20)	54.0 (27)	3.50	3.29	0.398
	Male	12.0 (14)	42.7 (50)	45.3 (53)	3.21		
Other majors have better income potential	Female	50.0 (25)	48.0 (24)	2.0 (1)	1.72	1.86	0.150
	Male	46.2 (54)	42.7 (50)	11.1 (13)	1.91		
Other majors have better job prospects	Female	39.2 (20)	45.1 (23)	15.7 (8)	2.27	2.29	0.537
	Male	37.6 (44)	39.3 (46)	23.1 (27)	2.30		

† *p*-values were calculated using a chi-squared test, with a null hypothesis of independence of gender

For both men and women, interest in a different career path would be most influential in their decision to change majors, followed by their perceptions of their degree program and their performance in their current major. The factors ranked of lowest importance were lack of diversity within the current major, and income potential of other majors. For this question, there was a gender difference on the influence of "lack of diversity". The difference is most evident in that 61% of men compared to 49% of women rank this statement of "no influence".

The responses in Table 5 were then compared to those in Table 6. The two groups being compared are those who switched majors and cited their reasons retrospectively, and those considering switching majors who are citing their possible reasons. The mean responses are similar for both tables. A common important factor was interest in a different career path. Students who have switched majors indicate a lower importance of "did not understand major", "difficult major" and "low GPA" than those who are considering switching. The opposite occurred for "better income potential" and "better job prospects", with students who have switched majors indicating a higher importance than those who are considering switching.

Those students who reported changing their major were asked who influenced their decision (Table 7). Most students reported that their personal thoughts and feelings were the primary influence. This was followed by family and friends, as well as faculty and academic advisors. Campus services, colleagues, and organizations were not of high influence for either group when deciding to switch majors. Gender differences occurred with the influence of faculty and career services. Male students ranked the influence of faculty as slightly more important than female students did, and no females reported being highly influenced by career services.

Table 7. Results for "Who influenced your decision to switch majors?"

		Likert Scale Data, % (*n*)					
		No Influence	Some Influence	High Influence	Mean		
Statement	Gender	1	2-3	4-5	Gender	Total	*p*-value†
Self	Female	0.0 (0)	3.2 (1)	96.8 (30)	4.81	4.84	0.631
	Male	0.0 (0)	1.7 (1)	98.3 (59)	4.85		
Family	Female	26.7 (8)	46.7 (14)	26.7 (8)	2.65	2.21	0.189
	Male	43.9 (25)	42.1 (24)	14.0 (8)	1.98		
Friends	Female	35.7 (10)	46.4 (13)	17.9 (5)	2.13	2.08	0.597
	Male	42.1 (24)	35.1 (20)	22.8 (13)	2.05		
Significant Other	Female	66.7 (18)	29.6 (8)	3.7 (1)	1.35	1.22	0.355
	Male	81.1 (43)	17.0 (9)	1.9 (1)	1.15		
Colleague (internship/co-op)	Female	65.4 (17)	30.8 (8)	3.8 (1)	1.29	1.37	0.322
	Male	75.9 (41)	16.7 (9)	7.4 (4)	1.42		
Academic Advisor	Female	46.7 (14)	43.3 (13)	10.0 (3)	1.81	1.75	0.386
	Male	58.9 (33)	28.6 (16)	12.5 (7)	1.72		
Faculty	Female	41.4 (12)	48.3 (14)	10.3 (3)	1.90	1.87	0.038
	Male	60.7 (34)	21.4 (12)	17.9 (10)	1.85		
Career Services	Female	52.0 (13)	48.0 (12)	0.0 (0)	1.32	1.36	0.006
	Male	76.8 (43)	16.1 (9)	7.1 (4)	1.38		
Counseling Services	Female	75.0 (18)	25.0 (6)	0.0 (0)	1.03	1.08	0.232
	Male	87.3 (48)	10.9 (6)	1.8 (1)	1.10		
University Organization	Female	73.1 (19)	19.2 (5)	7.7 (2)	1.26	1.19	0.424
	Male	85.2 (46)	11.1 (6)	3.7 (2)	1.15		
Professional Organization	Female	68.0 (17)	28.0 (7)	4.0 (1)	1.30	1.19	0.178
	Male	84.9 (45)	11.3 (6)	3.8 (2)	1.14		

† *p*-values were calculated using a chi-squared test, with a null hypothesis of independence of gender

Students who reported having thought about switching their major were also asked who would influence their decision (Table 8). When students think about switching majors, their personal thoughts

and feelings are the primary factors, followed by family, friends, academic advisors and faculty. The factors with the lowest importance to student decisions were university services and organizations. A gender difference occurred with respect to the influence of a significant other.

The responses in Table 7 were then compared to those in Table 8. In both tables "self" is the most important influence with a mean value of around 4.80. In both tables, "family" and "friends" are shown to have moderate influence. It is interesting that the mean value for all of the other human influences increased from those who switched to those who are thinking about switching.

Table 8. Results for "Who may influence your decision to switch majors?"

		Likert Scale Data, % (*n*)					
		No Influence	Some Influence	High Influence	Mean		
Statement	Gender	1	2-3	4-5	Gender	Total	*p*-value†
Self	Female	0.0 (0)	2.0 (1)	98.0 (50)	4.82	4.73	0.200
	Male	0.0 (0)	6.8 (8)	93.2 (110)	4.69		
Family	Female	17.6 (9)	41.2 (21)	41.2 (21)	3.08	2.78	0.454
	Male	23.9 (27)	44.2 (50)	31.9 (36)	2.65		
Friends	Female	25.5 (13)	43.1 (22)	31.4 (16)	2.65	2.54	0.206
	Male	19.6 (22)	58.0 (65)	22.3 (25)	2.50		
Significant Other	Female	41.3 (19)	28.3 (13)	30.4 (14)	2.06	1.89	0.045
	Male	45.1 (46)	41.2 (42)	13.7 (14)	1.81		
Colleague (internship/co-op)	Female	32.7 (16)	28.6 (14)	38.8 (19)	2.55	2.41	0.297
	Male	31.8 (35)	40.0 (44)	28.2 (31)	2.35		
Academic Advisor	Female	29.4 (15)	37.3 (19)	33.3 (17)	2.69	2.49	0.596
	Male	33.6 (38)	40.7 (46)	25.7 (29)	2.41		
Faculty	Female	24.0 (12)	46.0 (23)	30.0 (15)	2.73	2.57	0.707
	Male	30.1 (34)	40.7 (46)	29.2 (33)	2.50		
Career Services	Female	34.7 (17)	46.9 (23)	18.4 (9)	2.31	2.13	0.489
	Male	44.1 (49)	37.8 (42)	18.0 (20)	2.05		
Counseling Services	Female	40.4 (19)	44.7 (21)	14.9 (7)	2.08	1.92	0.621
	Male	48.6 (54)	39.6 (44)	11.7 (13)	1.85		
University Organization	Female	42.9 (21)	49.0 (24)	8.2 (4)	1.92	1.86	0.652
	Male	47.7 (53)	41.4 (46)	10.8 (12)	1.84		
Professional Organization	Female	39.6 (19)	43.8 (21)	16.7 (8)	2.10	1.95	0.552
	Male	48.1 (52)	39.8 (43)	12.0 (13)	1.88		

† *p*-values were calculated using a chi-squared test, with a null hypothesis of independence of gender

All students surveyed were asked to assess statements related to their self-confidence, perceptions of their major and the university environment; see Table 9. The responses were mostly positive. Students reported being confident that they can "complete their degree" and succeed in their career choice. They also reported that they can relate to the faculty and students within their degree program. There are differences between genders for four statements. Female students cited more often than male students that they can succeed in their major while still participating in other activities. Women stated that they can relate to other students in their classes, as well as to faculty more often than men. More women than men expressed confidence that they will be enrolled in an Engineering or CS major next year.

DISCUSSION AND CONCLUSIONS

At the end of the day, what matters is to find ways to address the underrepresentation of women in engineering and computer science professions. This work and prior studies suggest that solutions that are gender specific are helpful but their impact is not as great as one would hope for. Consequently, while it is important to continue with gender specific strategies, it is also important to develop strategies that reveal the matches between students' career goals and their personality and skills. Below, we present some suggestions based on our results.

Table 9. Results for "Assess the following statements in how they apply to you"

		Likert Scale Data, % (*n*)					
		Disagree	Neutral	Agree	Mean		
Statement	Gender	1-2	3	4-5	Gender	Total	*p*-value†
I can succeed in engineering or computer science curriculum	Female	1.5 (2)	8.0 (11)	90.5 (124)	4.39	4.38	0.594
	Male	2.4 (7)	10.4 (31)	87.2 (259)	4.37		
I can succeed in engr./cs program and still participate in other activities	Female	2.9 (4)	14.6 (20)	82.5 (113)	4.18	4.04	0.026
	Male	10.4 (31)	15.1 (45)	74.5 (222)	3.97		
I can relate to the students around me in my classes	Female	2.9 (4)	14.6 (20)	82.5 (113)	4.10	3.87	0.002
	Male	10.7 (32)	21.5 (64)	67.8 (202)	3.77		
I can relate to the faculty in my classes	Female	7.3 (10)	24.8 (34)	67.9 (93)	3.75	3.58	0.005
	Male	17.5 (52)	29.0 (86)	53.5 (159)	3.50		
I am confident that I will be enrolled in a cs or engr. Major next year	Female	4.4 (6)	5.1 (7)	90.4 (123)	4.51	4.31	0.027
	Male	9.5 (28)	10.5 (31)	80.1 (237)	4.23		
I am confident that my degree will be in my current field of study	Female	2.9 (4)	8.0 (11)	89.1 (122)	4.50	4.46	0.895
	Male	3.0 (9)	9.4 (28)	87.6 (261)	4.44		
I am confident I will graduate with a comp. sci. or engr degree	Female	2.9 (4)	4.4 (6)	92.7 (127)	4.62	4.60	0.704
	Male	2.7 (8)	6.4 (19)	90.9 (271)	4.58		
I am confident I will earn a degree at this university	Female	0.7 (1)	4.4 (6)	94.9 (130)	4.74	4.62	0.113
	Male	4.0 (12)	6.4 (19)	89.6 (267)	4.56		

† *p*-values were calculated using a chi-squared test, with a null hypothesis of independence of gender

In response to why students persist in their major, (Table 4), female students reported more factors than male students as being important to their persistence. Furthermore, students who are considering switching majors (Table 8) reported that almost all people or services listed will have some or high influence on their decision. This suggests that students will consult many sources before making a decision. Therefore, campus faculty and services must be well prepared to address student concerns regarding changing majors. Faculty, academic advisors, and university services must be familiar with a wide variety of literature and be trained on how to guide students towards making informed career decisions. The training should include guidance on how to be sensitive to gender specific issues. This also ties into the responsibility of the university, faculty and organizations, to provide career guidance grounded in the current practices and research.

In Table 8, 30% of the female students as compared to only 14% of the male students reported their "significant other" as having a high level influence on their decision to switch majors. This may suggest that the university student support structure should be extended to include those who support the women students (significant others, family members, or friends). Also, 42% of the female and 48% of the male students reported that university organizations will have no influence on their decision to switch majors. This suggests that university organizations should become proactive in supporting career choices and assist students in learning about and encourage participation in the professional organizations related to their major. Table 8 also shows that students switched majors due to a change in their career path rather than issues with degree program or individual performance.

The scope of the study is limited to students' perceptions with respect to their past and future decisions regarding their major, and the real reasons are probably more complex. It is limited to a single institution and is a one-time survey with a small sample size. The data are completely anonymous and self-reported. The responses are not tied to any university specific data on academic performance or retention. The findings were consistent with prior research which shows that there are no major gender differences with respect to why students persist.

This survey serves as a pilot study investigating the effects of gender on persistence. Future work will focus on deepening the understanding of why students persist within their major and investigating the effect of the environment on the student's choice of major. To accomplish this, the survey will be repeated in the following academic year to see how responses change over time. In this next phase, students will be asked to report personal information so that their persistence can be formally tracked.

REFERENCES

Barker, L. J., C. McDowell, and K. Kalahar. 2009. Exploring factors that influence computer science introductory course students to persist in the major. *ACM SIGCSE Bulletin*, 41(2):282–286.

Concannon, J. P. and L. H. Barrow. 2009. A cross-sectional study of engineering students' self-efficacy by gender, ethnicity, year, and transfer status. *Journal of Science Education and Technology*, 18:163–172.

Hartman, H. and M. Hartman. 2008. How undergraduate engineering students perceive women's (and men's) problems in science, math, and engineering. *Sex Roles*, 58:251–265.

Jones, B. D., M. C. Pareti, S.F. Hein, and T.W. Knott. 2010. An analysis of motivation constructs with first-year engineering students: Relationships among expectancies, values, achievement, and career plans. *Journal of Engineering Education*, 99:319–335.

Katz, S., D. Allbritton, J. Aronis, C. Wilson, and M. L. Soffa. 2006. Gender, achievement, and persistence in an undergraduate computer science program. *The DATA BASE for Advances in Information Systems*, 37(4):42–57.

Kissinger, J., R. C. Campbell, A. Lombrozo, and D. Wilson. 2009. The role of gender in belonging and sense of community. In *Proceedings of the 39th ASEE/IEEE Frontiers in Education Conference*, CD-ROM, Session M3G.

Lasich, D. and C. Sulzbach. 2008. The role of institutional commitment in the utilization of collegiate SWE sections as a recruitment and retention strategy. In P*roceedings of the 115th Annual American Society for Engineering (ASEE) Conference*, AC2008-1689.

Light, J., R. Korte, K. Yasuhara, and D. Kilgore. 2007. Exploring the relationships among performance on engineering tasks, confidence, gender and first year persistence. In *Proceedings of the 114th Annual American Society for Engineering (ASEE) Conference*, AC2007-1515.

Malady, A., W. Bopp, A. Jones, B. McNair, K. Norris, and A. Bell. 2008. From our perspective: Undergraduate and faculty women in electrical and computer engineering programs on recruitment, retention, and what really works. In *Proceedings of the 115th Annual American Society for Engineering (ASEE) Conference*, AC2008-857.

Marra, R. and B. Bogue. 2008. Engineering classroom environments: Examining differences by gender and departments. In *Proceedings of the 115th Annual American Society for Engineering (ASEE) Conference*, AC2008-232.

Marra, R. M., K.A. Rodgers, D. Shen, and B. Bogue. 2009. Women engineering students and self-efficacy: A multi-year, multi-institution study of women engineering student self-efficacy. *Journal of Engineering Education*, 98:27–38.

Morozov, A., D. Kilgore, K. Yasuhara, and C. Atman. 2008. Same course, different outcomes? Variations in confidence, experience, and preparation in engineering design. In *Proceedings of the 115th Annual American Society for Engineering (ASEE) Conference*, AC2008-768.

Ohland, M., M. Camacho, R. Layton, R. Long, and S. Lord. 2009. How we measure success makes a difference: Eight-semester persistence and graduation rates for female and male engineering students. In *Proceedings of the 116th Annual American Society for Engineering (ASEE) Conference*, AC2009-705.

Tsang, E. and C. Halderson. 2008. Create learning communities to enhance success for students with diverse academic preparation background. In P*roceedings of the 38th ASEE/IEEE Frontiers in Education Conference*, CD-ROM, Session S1D, Paper 1771.

Zeng, Y. and J.R. Duncan. 2007. Women: Support factors and persistence in engineering. In *Proceedings of the 114th Annual American Society for Engineering (ASEE) Conference*, AC 2007-2377.

ACKNOWLEGDEMENTS

The authors thank the College of Engineering and Computer Science students who took the time to complete the survey. The guidance and input from Dr. William Kennedy, Director of the MTU Center for Teaching, Learning, and Faculty Development, and Dr. Rocio Garcia-Retamero, University of Granada, were greatly appreciated. This material is based upon work supported by the National Science Foundation (NSF CCLI DUE-0836861). Ms. Kaitlyn Bunker, doctoral student in the MTU Department of Electrical and Computer Engineering appreciated the support from the NSF Graduate Research Fellowship Program (NSF DGE-1051031).

.