

Understanding Student Confidence as It Relates to First Year Achievement ⁱ

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Abstract - *There has been considerable concern that entering female engineering students begin their studies with less confidence in their abilities than academically equivalent male students. Further, there is concern that this 'under-confidence' problem persists throughout the university experience. As a precursor to a larger cross-institutional studyⁱⁱ, we have investigated this issue at the University of Pittsburgh, University of Texas - El Paso and North Carolina State University. Using the Pittsburgh Freshman Engineering Attitudes Survey, we examined the differences between male and female students' self-assessed confidence (relative to five measures) when they began their engineering studies and after one or two semesters of study. In addition, we examined students' confidence and changes in confidence with respect to their entering SAT scores and first year performance. At all three institutions, female students entered with significantly lower confidence in their basic engineering knowledge and skills (one of the five measures) than did their male counterparts, but only continued to exhibit this low confidence at one institution during the freshman year. However, we did not find any consistent, significant relations for the other measures, nor did we find any relations with SAT and performance.*

Introduction

A student's initial level of confidence and subsequent changes, particularly during the important first year, may affect his/her motivation, performance, and quite possibly retention in engineering. Yet, not all engineering students begin their college education confident of their background knowledge and ability to achieve academic success. Researchers have established that female engineering students have lower confidence than their male counterparts [1,2,3,4,5]. We have found that initial poor perception of one's abilities to succeed in engineering is linked to subsequent attrition out of the program [6]. That study, conducted at only one institution, revealed that although gender differences existed in students' attitudes and confidence, male and female engineering students left in the same proportions. Yet to be examined is the extent to which female engineering students' low confidence is correlated with their performance and retention across multiple institutions.

In a pilot for a larger multi-institutional study involving more than 10 US engineering schools, we are investigating gender differences with respect to students' self-assessed confidence at three of these institutions. In conducting this study, we have three objectives. First, we want to better understand the differences between male and female freshman engineering students with respect to their self-assessed

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confidence. Second, we want to capture how their level of confidence changes following their first semester or academic year. Finally, we want to investigate these differences with respect to their incoming knowledge (as measured by SAT scores) and their success during the first year (GPA).

To investigate these differences we have used data obtained with our Pittsburgh Freshman Engineering Attitude Survey from the 1997-98 freshman engineering class at the University of Pittsburgh (Pitt), the University of Texas – El Paso (UTEP), and the North Carolina State University (NCSU). Specifically, we have compared pre-freshman year self-assessed confidence with SAT scores for male and female students. For University of Pittsburgh students, we have compared the same students’ self-assessed confidence at the end of their freshman year to their end-of-year grade point averages (GPAs). Attitude changes over the freshman year have also been examined and related to first year performance. For the University of Texas – El Paso and North Carolina State University, these comparisons were made at the end of the first semester

Pittsburgh Freshman Engineering Attitudes Survey

To determine students’ initial self-assessed confidence, we used the Pittsburgh Freshman Engineering Attitudes Instrument (PFEAS), a closed-form questionnaire developed and tested at the University of Pittsburgh to gather information about incoming engineering students’ initial attitudes and their changes as they experience their first year [7]. The questionnaire has been used since the fall 1993, first at Pitt and now at over 10 US institutions. Originally designed to evaluate innovative changes made to the freshman engineering curriculum at the University of Pittsburgh [8], the questionnaire has been effectively used by these other institutions to help evaluate their freshman engineering programs [9]. In addition, it is being used in a national cross-institutional study of freshman engineering attitudes [10].

The questionnaire measures several facets of student attitudes including opinions about the engineering profession and their reasons for studying engineering. Students also are asked to rate their self-assessed confidence in the pre-requisite background knowledge and skills, and in their perceived ability to succeed in engineering. Finally, students rate their study skills and their interest towards working in groups. The closed-form questionnaire contains 50 items that are rated on either a Likert scale or an ordinal-based self-assessed confidence scale. These 50 items have then been statistically clustered into 13 student attitude and self-assessment measures.

For this study, we have focused our investigation on three of the thirteen measures and two statements from two other attitude measures, as given in Table 1. The self-assessed confidence measures being used are: ‘Confidence in Chemistry,’ ‘Confidence in Communication Skills,’ and ‘Confidence in Basic Engineering Knowledge.’ Students rate their confidence on the following scale: ‘not strongly confident’ to ‘neutral’ to ‘strongly confident.’ In addition,

we are using two statements from other attitude measures that specifically address the students’ confidence:

- “I am confident about my current study habits or routine” (Adequate Study Habits), and
- “I feel confident in my ability to succeed in engineering” (Engineering Abilities).

For these particular statements, students rate the degree of their agreement to the statement on a Likert scale: ‘strongly disagree’ to ‘neutral’ to ‘strongly agree’.

Table 1. Self-Assessed Confidence Measures and Statements Used in the Study

Self-Assessed Confidence Measure or Statement	Rating Value
Confidence in Chemistry <i>Self-assessed confidence in chemistry knowledge</i>	1 – has low confidence 5 – has high confidence
Confidence in Communication Skills <i>Self-assessed confidence in writing and speaking skills</i>	1 – has low confidence 5 – has high confidence
Confidence in Basic Engineering Knowledge and Skills <i>Self-assessed confidence in knowledge of physics, calculus, and engineering, and in computer skills</i>	1 – has low confidence 5 – has high confidence
Adequate Study Habits <i>“I am confident about my current study habits or routine”</i>	1 – strongly disagree 5 – strongly agree
Engineering Abilities <i>“I feel confident in my ability to succeed in engineering”</i>	1 – strongly disagree 5 – strongly agree

Methodology

At Pitt the pre-questionnaire was administered during the orientation sessions prior to the start of the freshman year. The post-questionnaire was given at the end of the freshman year. NCSU administered the pre-questionnaire during the first week of classes the post-questionnaire during the last week of first semester classes. At UTEP, the pre-questionnaire was given during orientation and the post-during the fall registration period in mid-November. Hence the time between pre- and post- is longest at Pitt (approximately eight months) and subsequently shorter at NCSU and UTEP (approximately three months). Table 2 provides a summary of the students by gender that began their first year engineering studies at each institution. Note that the percentage of female students ranged from 22 at UTEP to 26 percent at Pitt.

Table 2. Student Demographics

	Male	Female	Total
Pitt	273 (74%)	96 (26%)	369
UTEP	209 (78%)	59 (22%)	268
NCSU	799 (77%)	239 (23%)	1038

A conservative approach for analyzing the data was taken. For each school, Mann-Whitney non-parametric tests (analogous to the t-test) were conducted on the confidence measures and statements for both the pre- and post-questionnaires to determine if differences existed between male and female students. A Bonferroni protection for multiple comparisons was applied to a significance value of 0.05 resulting in an adjusted P-value of 0.01 for each school. To determine if significant changes in students' self-assessed confidence occurred between the pre and post questionnaire, Wilcoxon Signed Ranks non-parametric test was used (similar to the paired-t). This test was conducted for each gender resulting in a Bonferroni protection for multiple comparisons adjusted P-value of 0.005 for each school.

To determine if students' SAT scores were correlated with their initial level of confidence, non-parametric correlations (Kendall's tau-b) were computed. Similar correlations were computed between SAT scores and post-questionnaire confidence to determine if the SAT scores may possibly predict students' later confidence. Separate correlations were computed for both male and female students and for the math and verbal portions of the SATs.

To determine if relationships exist between students' post-questionnaire confidence and their performance in engineering as measured by GPAs (end-of-semester for UTEP and NCSU and end-of-year for PITT), non-parametric correlations were computed for both male and female students.

Finally, two-way analysis of variance tests (ANOVA) were conducted for each of the five self-assessed confidence measures to determine if significant interactions existed between gender and students' SAT scores and between gender and students' end-of-semester/year GPAs ($\alpha = 0.05$). To do this, the SAT scores were aggregated into either five levels of 100 each if the math or verbal scores were used separately (e.g., <400, 400-490, 500-590, etc.) or nine levels if the total score was used (e.g., <800, 800-890, 900-990, etc.). Similarly, the GPAs were separated into six levels: <1.49, 1.50-1.99, 2.00-2.49, 2.5-2.99, 3.0-3.49, and 3.50-4.00.

For all analyses described, SPSS for Windows (release 7.5.1) statistical software package was used.

Discussion of Results

Table 3 presents the averages and standard deviations (*in Italics*) by gender for SAT scores and GPAs for the three institutions. Mann-Whitney non-parametric tests revealed no differences between male and female GPAs for the three institutions.

While male SAT scores were greater than those for female students' at all three institutions, only at NCSU were female engineering students found to have significantly lower SAT math scores than males. (This is because the smaller variances for the NCSU students in combination with the larger sample sizes result in a statistically significant difference between men and women's scores.) This result is consistent with previous years at NCSU [11].

Table 3. Gender Differences in SAT scores and GPAs

SAT	Pitt		UTEP ^a		NCSU	
	Male n=197	Female n=80	Male n=94	Female n=38	Male n=591	Female n=161
Total	1210	1198	980	956	1235	1215
Math	179	239	231	262	127	141
	627	605	520	497	643	621
Verbal	92	119	132	141	71	76
	583	593	459	460	593	594
GPA ^b	100	131	108	125	77	81
	2.75	2.91	2.36	2.61	3.03	3.09
	.73	.62	1.12	1.14	.76	.70

* Significant at P-value 0.001
^a 131 out of 226 students took the SAT
^b End-of-year GPAs for Pitt; end-of-first semester GPAs for UTEP and NCSU

Pre-Questionnaire Results

Table 4 gives the averages and standard deviations calculated for the pre-questionnaire self-assessed confidence measures for the three institutions. At Pitt, 73% male students and 83% female students completed the questionnaire. Only two-thirds of the students at UTEP attended the engineering orientation, of which 61% male students and 68% female students completed the questionnaire. At NCSU, 74% of the male students and 67% of the female students completed the questionnaire. Although the practical differences between male and female average responses to specific items may not be large, consistent differences were found across the three institutions that require explanation.

Table 4. Pre-Questionnaire Gender Differences in Self-Assessed Confidence

	Pitt		UTEP		NCSU	
	Male n=198	Female n=80	Male n=127	Female n=40	Male N=591	Female n=161
<i>Confidence in Chemistry</i>	3.56	3.81	3.40	3.23	3.64	3.51
	.89	.86	1.02	1.09	0.85	.98
<i>Confidence in Communication Skills</i>	3.49	3.71	3.49	3.61	3.25	3.31
	.85	.86	.82	.85	.88	.90
<i>Confidence in Basic Engineering Knowledge and Skills</i>	3.75	3.43	3.69	3.33	3.83	3.48
	.56	.55	.65	.68	.58	.50
<i>"I am confident about my current study habits or routine"</i>	3.16	3.28	3.13	3.03	2.97	3.18
	.87	.89	1.07	.98	.92	.99
<i>"I feel confident in my ability to succeed in engineering"</i>	4.07	3.91	4.36	4.19	4.15	3.94
	.71	.80	.73	.91	.65	.66

*1 Significant at P-value 0.01
*2 P-value 0.02

For all three schools, female students entered their engineering studies with lower confidence in their basic engineering knowledge and skills (Pitt and NCSU, P-value 0.01; UTEP, P-value 0.02). This finding is consistent

with previous analyses at Pitt and NCSU. In addition, female students at NCSU rated their confidence to succeed in engineering significantly lower than did male engineering students. Though not significant, Pitt and UTEP female students also rated their confidence to succeed in engineering lower than male engineering freshman. At UTEP and NCSU, female engineering students rated their confidence in chemistry lower than did male students, though not significantly. Though not significant, female students at all three institutions began their engineering education with higher confidence in communication skills than did male students. Female students at NCSU also had significantly more confidence in their study skills than did their male colleagues.

To determine if these results were correlated with students' incoming ability, non-parametric correlations between math, verbal and total SAT scores were conducted on each of the students' self-assessed confidence measures. No to weak correlations (< 0.30) were found for each of the three schools. This suggests that there is no relationship between a student's actual background knowledge, as measured by their SAT scores and their self-assessed confidence.

ANOVAs were conducted for each of the five self-assessed confidence measures to determine if significant interactions existed between gender and students' SAT scores. No interactions were found to be significant at the Bonferroni adjustment P-value of 0.01.

Post-Questionnaire Results

Table 5 gives the averages calculated for the post-questionnaire self-assessed confidence measures for the three institutions. Again there were only a few significant gender differences for the confidence measures. Student self-assessed confidence in their basic engineering knowledge and skills remained different between male and female students at NCSU. Though not significant, Pitt and UTEP female engineering students continued to rate their basic knowledge and skills lower than that of the male students. Although these results show some gender differences in student confidence, there were no significant differences in GPAs between male and female students. (As given in Table 3, female students' GPAs are notably higher across the three schools.)

In addition, NCSU female engineering students continued to rate their confidence in their abilities to succeed in engineering lower than did male students. This was not the case for Pitt nor UTEP female students where confidence levels were similar for male and female students. Further, although there were initially gender differences in confidence in study habits for students at NCSU, the post-questionnaire revealed that these differences disappeared by the end of the semester due to females' confidence decreasing while males' confidence remained the same for this measure.

At Pitt, male students entered their engineering studies with lower confidence in their communication skills than their female counterparts. This confidence difference in

communications skills became more magnified and significant at the end of the first year, as female students' confidence levels increased while male students' decreased.

Table 5. Post-Questionnaire Gender Differences in Self-Assessed Confidence

	Pitt		UTEP		NCSU	
	Male n=103	Female n=41	Male n=99	Female n=24	Male N=59	Female n=161
<i>Confidence in Chemistry</i>	2.84	2.93	3.29	3.00	3.65	3.52
	.86	.85	.92	.98	1.05	1.12
<i>Confidence in Communication Skills</i>	3.41	3.78	*1 3.65	3.65	3.49	3.53
	.65	.58	.94	.76	.86	.96
<i>Confidence in Basic Engineering Knowledge and Skills</i>	3.31	3.15	*2 3.57	3.43	3.89	3.58
	.42	.41	.68	.59	.63	.63
<i>"I am confident about my current study habits or routine"</i>	3.17	3.29	2.75	2.75	2.97	3.07
	1.34	1.17	1.01	1.36	1.02	1.01
<i>"I feel confident in my ability to succeed in engineering"</i>	3.35	3.37	4.04	4.04	4.00	3.84
	1.01	.99	.95	.75	.78	.84
*1 Significant at P-value	0.01					
*2 P-value	0.04					

Again non-parametric correlations between GPA and each of the students' self-assessed confidence measures revealed only weak (< 0.34) to no correlations for each of the three schools, with one exception. At UTEP, female students' confidence in study skills was moderately correlated with GPA ($= 0.578$) meaning that the more confident students also achieved higher GPAs.

ANOVAs conducted on each of the five self-assessed confidence measures to determine if significant interactions existed between gender and students' GPA scores yielded no significant interactions for Pitt and UTEP, but there were two significant interactions found for NCSU. Specifically, there was a significant interaction between gender and GPA for confidence in chemistry (P-value = 0.017) and communication skills (P-value = 0.015). Upon closer examination, male students' confidence in chemistry steadily increased as their GPA increased. However, female students' confidence increased as GPA increased for low GPA students, but decreased with increasing GPA for high GPA students (i.e., 3.0). For confidence in communication skills, male students' confidence did not change as GPA increased; but female students' confidence was very high for the GPA range 1.5 – 1.99 in comparison to male students. Thereafter it was relatively consistent with the male students. More investigation is required to understand why female students with low GPAs have higher confidence than females with higher GPAs for these particular confidence measures. It may be that these students lack the maturity to properly assess their confidence.

Attitudinal Changes During the First Year/Semester

Table 6 shows the attitudinal changes that occurred during the first year (as in the case of Pitt) and during the first semester (as in the case of UTEP and NCSU).

No significant gender differences were found for each of the three institutions; that is, in no case did one gender group change significantly more than the other did. However, there were several significant changes within each gender type worth noting.

Table 6. Attitudinal Changes During the First Year/Semester

	Pitt		UTEP ^a		NCSU	
	Male n=85	Female n=38	Male n=50	Female n=10	Male n=591	Female n=161
Confidence in Chemistry	-0.72 ^{*1}	-0.89 ^{*1}	0.88	0.74	1.04	1.08
Confidence in Communication Skills	-0.16	0.22	-0.28 ^{*2}	-0.13	0.23 ^{*1}	0.22 [*]
Confidence in Basic Engineering Knowledge and Skills	-0.47 ^{*1}	-0.45 ^{*1}	-0.03	0.05	0.06 ^{*1}	0.10 [*]
"I am confident about my current study habits or routine"	0.00	-0.32	-0.43 ^{*2}	0.25	0.00	-0.11
"I feel confident in my ability to succeed in engineering"	-0.85 ^{*1}	-0.63 ^{*1}	-0.13	0.13	-0.15 ^{*1}	-0.10

*1 Significant at P-value 0.005
*2 P-value 0.05
^a Because there were only 10 matched pre-to-post pairs (by social security numbers), an analysis was not performed for the female students.

Pitt engineering students showed similar and significant changes in two confidence measures and one attitude statement: Confidence in Chemistry, Confidence in Basic Engineering Knowledge and Skills, and "I feel confident in my ability to succeed in engineering" (respectively). Both male and female students indicated a decrease in their self-assessed confidence in these three areas. Historically, at Pitt both male and female students have rated their confidence on the post-survey lower than the pre- for these areas. This is particularly true for chemistry, which is also the students' least liked freshman engineering course. The school of engineering is currently working with the chemistry department to isolate the factors behind this result and better improve the chemistry education delivered to engineering students. For Confidence in Basic Engineering Knowledge and Skills, we have traditionally found female students' confidence increase over the course of the year and males' confidence remain the same [12,13]. As this past years' results indicates that further investigation is needed to determine why students confidence decreased.

Male and female engineering students at NCSU also indicated significant changes in their self-assessed confidence for three measures. Both male and female students exhibited a pre-to-post increase in their self-assessed confidence in communication skills and confidence in basic engineering knowledge and skills. These increases may be attributed to an innovative introductory engineering course that included engineering projects that had students working in teams. The problems were chosen such that they necessitated communication between students and focused on students' skills in math, physics, and computer skills. In contrast, both male and female students' confidence decreased for the attitude statement: "I feel confident in my ability to succeed in engineering" between the pre- and post- surveys. However, the decrease in confidence for females was not significant.

At UTEP, there were no significant changes in male students' self assessed confidence between the pre- and post-questionnaire when the Bonferroni adjustment for multiple comparisons is used. However it should be noted that UTEP male students' confidence decreased for all five measures, in particular the measure confidence in communication skills and the attitude statement "I am confident about my current study habits or routine." These issues are currently being investigated at UTEP to determine if they are correlated with aspects of the first semester program.

Conclusions

The results from this pilot study do not suggest any clear trends, but rather point out avenues for further investigation. First, of the five measures of confidence studied, we found that for only one – "basic engineering knowledge and skills" - did female students from all three schools *begin* their college experience less confident than their male counterparts. However, in examining the post-survey results, we found that only at NCSU did female students display *significantly* lower confidence than their male counterparts (using the conservative Bonferroni adjustment). The post-survey results at Pitt and UTEP indicated that there was no significant difference between male and female students for this particular attitude measure. The extent to which these results are due to the smaller sample sizes at Pitt and UTEP compared to NCSU is not evident. Also not evident is the degree to which the 'confidence gap' between the two gender groups closed from the time of the pre-survey to that of the post-survey.

Second, at NCSU students of both genders exhibited significant *increases* in their confidence in communication skills and in basic engineering knowledge and skills. These positive changes occurred after only one semester of college. On the other hand, Pitt students of both genders displayed significant *decreases* in their confidence in chemistry, basic engineering knowledge and skills, and in their abilities to succeed in engineering. These negative trends are reflective of the entire first year of engineering. It is difficult to draw firm conclusions from these results. It may be that the

educational experience at NCSU has provided students with the confidence they need for their engineering education. Yet to be determined is the extent to which such an effect dissipates once students receive their first semester grades. Further does the “grind” of the freshman year finally reduce confidence for all students to the extent that statistically significant differences due to gender are no longer found (as in the case of Pitt)? These are issues that we plan to examine in our more definitive study.

For the other four confidence measures – “chemistry,” “communications skills,” “study habits,” and “ability to succeed in engineering,” no consistent, significant differences were observed. In particular, female students did not consistently begin the year with lower confidence levels, and in a few cases began with higher confidence than male students. Yet decreases were mostly slight (but insignificant) over the first semester, and more pronounced over the year, especially for “chemistry” and “ability to succeed in engineering.” There were also a few cases of confidence increasing for both male and female students.

Finally in examining data from all three institutions, no relationships were found between confidence levels and students’ GPAs or SATs. Pending further analysis, this suggests that students’ perceptions of their abilities are independent of actual performance.

Although there were some consistencies across institutions, we suspect that many of these gender differences may be institution specific. For one of the three schools, we found significant interaction effects among gender, students’ confidence and GPA for two of the five measures. As data from more schools are obtained, we will be able to better understand these interactions, and further learn how confidence affects students’ performance and retention in engineering. This will enable us to develop better intervention strategies, which should facilitate student learning, retention and satisfaction.

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References

- 1 Seymour, E., and N. Hewitt, *Talking About Leaving – Factors Contributing to High Attrition Rates Among Science, Mathematics and Engineering Undergraduate Majors*, A Final Report to the Alfred P. Sloan Foundation on an Ethnographic Inquiry at Seven Institutions, Bureau of Sociological Research, University of Colorado: Boulder, April 1994.
- 2 Felder, R.M., G.N. Felder, M. Mauney, C.E. Hamrin, and E.J. Dietz, “A Longitudinal Study of Engineering Student Performance and Retention. Part III – Gender Differences in Student Performance and Attitude,” *Journal of Engineering Education*. 1995.
- 3 Besterfield-Sacre, M., C.J. Atman, and L.J. Shuman, “How Freshman Attitudes Change in the First Year,” *1995 ASEE Annual Conference Proceedings*, Anaheim CA, June 1995.
- 4 Fuller, H., S.C. Grant, K.C. Lawyer, R.L. Porter, and S.A. Rajala, “Attitude About Engineering Survey, Fall 1995 and 1996: A Study of Confidence by Gender,” *1997 ASEE Conference Proceedings*, Milwaukee, WI, June 1997.
- 5 Brainard, S.G. and L. Carlin, “A Longitudinal Study of Undergraduate Women in Engineering and Science,” *Journal of Engineering Education*, Oct. 1998, Vol. 87, No. 3.
- 6 Besterfield-Sacre, M., Atman, C.J., and L.J. Shuman, “Characteristics of Freshman Engineering Students: Models for Determining Student Attrition and Success in Engineering.” *Journal of Engineering Education*, April 1997, Vol 86. No. 2, pp. 139-149.
- 7 Besterfield-Sacre, M.E. and C.J. Atman, “Survey Design Methodology: Measuring Freshman Attitudes About Engineering,” *American Society for Engineering Education Conference Proceedings*, June 1994, pp. 236-242.
- 8 Besterfield-Sacre, M.E., C.J. Atman, and L.J. Shuman, “How Freshman Attitudes Change During the First Year,” *American Society for Engineering Education Conference Proceedings*, June 1995, pp. 157-163.
- 9 Besterfield-Sacre, M.E, L.J. Shuman, C.J. Atman, R.L. Porter, R.M. Felder, and H. Fuller, “Changes in Freshman Engineers’ Attitudes - A Cross Institutional Comparison. What Makes a Difference?” *Frontiers in Education Conference*, November 1996 (CD ROM).
- 10 Besterfield-Sacre, M.E. “A Cross Institutional Study of Freshman Engineering Attitudes,” *Success 101 Newsletter*, Fall 1997.
- 11 See reference 4.
- 12 See reference 8.
- 13 See reference 9.