2017 Pacific Southwest Section
Meeting: Tempe, Arizona Apr 20 Paper ID #20679

What Makes a Successful Engineering Student?

Dr. Ruth E. Davis, Santa Clara University

Ruth E. Davis is the Lee and Seymour Graff Professor and Associate Dean for Undergraduate Engineering at Santa Clara University. Her dissertation "Generating Correct Programs From Logic Specifications" won the 1979 ACM Doctoral Forum Award for Outstanding Ph.D. Thesis in Computer Science. Dr. Davis was named a Distinguished Scientist of the ACM in fall 2006. She has done research in formal methods in software engineering, but for the last ten to fifteen years has been more involved in several activities to increase the participation of underrepresented groups in engineering.

What Makes a Successful Engineering Student

Abstract

At Santa Clara University we have been collecting data from our engineering students for thirteen years. We have tracked the graduation rates and degrees earned by all students who started in engineering and compared these with their responses to the questionnaire they completed in the introduction to engineering class. We asked about learning styles, preferences for collaboration or individual work, and several psychosocial factors found to be important in an earlier study. Now we are investigating the correlations among demographics, academic preparation, motivation and commitment to engineering, to success in an engineering program. This paper reports on some of the results of this study. We examine the psychosocial factors of commitment to engineering, confidence in engineering abilities, motivation for studying engineering, and perceived social value of engineering, as well as preparation for engineering study, and look at correlations with achieving an engineering degree within five years, for both genders and multiple ethnicities.

Introduction

At Santa Clara University we have been working to improve the experience of undergraduate engineering students for a long time. We started with an NSF grant to support significant revision in the way we taught the Introduction to Engineering course, changing it from a "talking heads" tour through disciplines to active engagement in project work that demonstrated the interdisciplinary quality of most projects, while also showing how each discipline contributed its expertise.

We went from a one-unit lecture course to a one-unit laboratory course, and then, after a few years, added another unit so we could have a one-unit lecture and a one-unit lab each week. We tracked the student response to each of these changes, but in addition, we tracked the students' demographics, entering expectations, preparation and motivation for studying engineering, commitment and confidence of success.

We have been collecting data on our students for thirteen years. We have tracked the graduation rates and degrees earned by all students who started in engineering and compared these with their responses to the questionnaire they completed in the introduction to engineering class. We asked about learning styles, preferences for collaboration or individual work, and several psychosocial factors found to be important in an earlier study. Now we are investigating the correlations among demographics, academic preparation, motivation and commitment to engineering, to success in an engineering program. We tracked graduation rates, time to degree, changes of major within and outside of engineering, and grades achieved along the way.

This paper reports on some of the results of this study. We examine the psychosocial factors of commitment to engineering, confidence in engineering abilities, motivation for studying engineering, and perceived social value of engineering, as well as preparation for engineering study, and look at correlations with achieving an engineering degree within five years, for both genders and multiple ethnicities.

We hope to learn the most important factors predicting success so that we can provide useful advice and formative experiences to improve the development of students in some of these factors.

The Problem

"Every time an engineering problem is approached with a pale, male design team, it may be difficult to find the best solution, understand the design options, or know how to evaluate the constraints."[1]

Dr. Wm. A. Wulf, as President of the National Academy of Engineering, often spoke of the problem of lack of diversity in engineering. He pointed to the need for a diversity of perspective and experience in order to avoid the opportunity loss of designs not considered, constraints not understood, processes not invented, and products not built. At the time Dr. Wulf wrote the quote above (1998), the percentages of women and minorities enrolled in engineering programs was increasing (very slowly, but the trends were in the right direction).

Between 1998 and 2005, the trend was reversed; women's enrollment peaked in 1999 at 19.8% and steadily decreased to just 17.2% in 2005. Table 1 charts the engineering enrollment by gender in 1995 through 2005.

Table 1. Undergraduate enrollment in engineering programs by gender percent: 1995-2005.[2]

Year	All enrolled		Full-time, first year	
	Female	Male	Female	Male
1995	18.5	81.5	19.9	80.1
1996	19.0	81.0	19.9	80.1
1997	19.4	80.6	19.7	80.3
1998	19.7	80.3	19.6	80.4
1999	19.8	80.2	19.2	80.8
2000	19.5	80.5	18.9	81.1
2001	19.2	80.8	18.3	81.7
2002	18.5	81.5	17.2	82.8
2003	18.0	82.0	16.4	83.6
2004	17.7	82.3	16.3	83.7
2005	17.2	82.8	16.2	83.8

Table 2 presents the enrollment data from 2005 through 2015 as collected by the ASEE from IPEDS data, and combining Native American, and Pacific Islander. This shows that after bottoming out in 2006 at 17.2%, female enrollment started to climb again, reaching 20.9% in 2015. However, it also shows that we are not doing well with underrepresented minority students. Since the reporting changed in 2010, allowing designation of two or more ethnicities, it is difficult to tell how that may have impacted the other categories. Nevertheless, we see a disturbing downward trend in African American enrollment in engineering, while Hispanic participation has risen very slowly. The percentage of foreign undergraduate students has nearly doubled over this time period. (The total enrollment in undergraduate engineering has risen monotonically from 421,072 in 2005 to 704,818 in 2015.)

Table 2. Undergraduate enrollment in engineering programs by gender and ethnicity percent: 2005 – 2015 [3]

year	male	female	African Amer.	Asian Amer.	Hispanic	NatAm/ Pac Is	2+	foreign
2005	82.8	17.2	5.6	10.4	8.5	0.5	0.0	5.0
2006	82.8	17.2	5.4	10.2	8.7	0.6	0.0	5.1
2007	82.7	17.3	5.3	10.0	8.9	0.6	0.0	5.2
2008	82.2	17.8	5.3	10.2	9.4	0.6	0.0	5.5
2009	82.0	18.0	5.0	10.0	9.5	0.6	0.0	5.8
2010	81.7	18.3	5.0	9.7	9.6	0.6	1.2	6.5
2011	81.5	18.5	4.9	9.8	10.1	0.7	1.7	7.0
2012	81.1	18.9	4.8	9.9	10.4	0.6	2.2	8.2
2013	80.5	19.5	4.6	10.1	10.5	0.5	2.4	8.5
2014	79.7	20.3	4.5	10.7	11.0	0.6	2.9	9.1
2015	79.1	20.9	4.5	11.0	11.2	0.5	2.9	9.4

Certainly, an important part of the problem is recruitment. We have been unable to attract a sufficiently diverse population to engineering. However, another critical part of the problem, and the one on which we focus in this study, is retention of the engineering students we do enroll. An emerging body of research indicates that the problems in retention are based on psychosocial factors rather than differences in abilities.

In a report of a longitudinal study of chemical engineering students at North Carolina State University (1995) [4], the authors noted that, while the backgrounds and pre-engineering academic credentials of the women students indicated they would be more likely to succeed than the men, the percentage of women who dropped out of the major after the sophomore year was twice the percentage of men who dropped out. In spite of the fact that they were better prepared, the women entered engineering with greater anxiety and lower confidence in their preparation than did the men. The men consistently expressed higher self-assessments of their abilities, and this gender difference in self-assessed ability became more pronounced as students approached graduation. Women were more likely than men to attribute poor performance to their own lack of ability, while the men were more likely to blame a lack of hard work or being treated unfairly. On the other hand, men were more likely to attribute success to their abilities, while the women were more likely to attribute success to outside help.

Consistent with this finding, much of the research suggests that women's persistence in engineering is tied to their self-efficacy in the field. Self-efficacy "refers to beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments."[5] This includes dimensions of confidence in one's abilities, commitment to a chosen path, and positive feedback with respect to accomplishments. It is based on an individual's perception, not always in agreement with an objective assessment, of one's performance.

Additional evidence for the importance of focusing on psychosocial factors appears in a study performed at the University of Southern California Viterbi School of Engineering. The researchers found that while the retention rate for women students in engineering was higher than that for men, the average GPA of women students leaving the field was higher than that of men students leaving. They felt this suggested that rather than focus on academic assistance, retention efforts should concentrate "on activities which help women develop self-enhancing attitudes."[6] (Of course, one might also interpret this to mean we should concentrate on the atmosphere of engineering, making it more attractive and palatable a place for women to study.)

There have been many studies that focus on retention from first year to second year of engineering study, and the reasons students leave and even models for predicting success [7, 8]. This is an important time as most students who leave engineering do so in the first two years. However, there is much to be learned by considering a longer period of time. There are more and more studies that have opted for longer-term tracking of cohorts, such as [9, 10, 11]. We chose to follow students who start in engineering to graduation, or to transfer out of engineering.

Several studies have also been focused on the factors that impact retention for specific groups, defined by gender and ethnicity. [12, 13, 14, 15]

Identifying Factors that Predict Success

As part of an earlier study [13], we developed a questionnaire to assess psychosocial factors that appeared to be related to the retention of women engineering undergraduates. Exploratory factor analyses and reliability analyses confirmed that the measure we developed reliably assessed seven factors that had been suggested as important for retention: commitment, confidence, the perceived value of engineering, interest/curiosity about engineering, family support, social perceptions, and perceptions of bias in the field of engineering. While that study was focused specifically on women students and interventions to impact those factors and increase retention of women, our numbers were too small to indicate any statistically significant results. We felt that much could be learned by tracking all of the students, and instead of trying to assess the impact of specific interventions on the factors identified, validate the correlations between some of these factors and success in engineering across gender and ethnicity identification.

Following on the example of the study in 1999, we identified several factors believed to affect student retention in engineering. For this study we devised a questionnaire that asked questions that could be classified into 8 factors: preparation, commitment, confidence, perceived value of engineering, interest/curiosity/internal motivators, outcome oriented/external motivators, influencers, and learning styles. After preliminary factor analysis and reliability analyses, we decided to focus on just the preparation, commitment, confidence, value, and internal motivator factors across a diversity of gender and ethnicity for this paper. (We had more difficulty in establishing reliable measures of learning styles, as students would not report their preferences consistently; and external motivators and influencers were confused. Some influences were viewed as supportive, others as pressure.)

Purpose and Hypotheses
The purpose of the current study is to identify correlations among preparation, commitment, confidence, motivation, and perceived social value, and successfully completing an engineering program of study. We developed a questionnaire to be used with all students taking the Introduction to Engineering course. Utilizing this instrument, we planned to determine whether the impact of these factors on success (i.e., whether students graduate with an engineering degree) were independent of gender and race identity.

The following hypotheses were posed:

1. High school preparation, the number of AP classes and exams in mathematics and science will be positively related to success in engineering programs.
2. Initial commitment to engineering will be positively related to success in engineering programs.
3. Confidence in one's abilities will be positively related to success in engineering programs.
4. Internal motivators, such as interest in engineering activities, will be positively related to success in engineering programs.
5. A higher perceived social value of engineering will be positively related to success in engineering programs.
6. Gender and ethnicity, when considered independently of the factors above will not be related to success in engineering.

Method
Participants
Cohorts 1 -- 7. These consist of all first year engineering students entering the program from the fall quarter of 2004 through fall 2010. These students would have a full six-year graduation rate available.

Cohort 8. This cohort contains all first year engineering students entering the program in the fall quarter of 2011. We cannot report six-year graduation rates on these students, but can report on five-year graduation rates, and retention for those who have not graduated.

Cohorts 9 – 13. These cohorts of students entered the university between fall 2012 and fall 2016. While we also have survey data for these students, we decided it was too early to include them in the study results for this paper.

In order to treat all students the same we decided to define success as graduating with an engineering degree within five years of first enrollment. (Though we have data from students entering through Fall 2016, we also eliminated from consideration the later cohorts of students, since they have not had five years in which to complete a degree.) We considered only those students who were first year full time students, entering their first year as full time students in Fall 2004 through Fall 2011. We eliminated all transfer students from the study, as well as removing all students who were not in the engineering school at the time they entered the university. This produced a sample of 1346 students.

Questionnaires
The questionnaire was developed to assess a variety of factors that were believed to be important to success in completing math and engineering programs. Several factors were identified, although we report on just five of them in this paper:

1. Perceptions of the social value of engineering;
2. Interest and enjoyment in engineering-related activities;
3. Commitment to engineering study;
4. Confidence in the ability to complete an engineering degree;
5. Motivation: intrinsic and extrinsic;
6. Math/science/engineering preparation;
7. Family support and other influencers; and
8. Persistence and learning styles.

In fact, in doing a factor analysis, number 2, above, loaded as intrinsic motivation for engineering study. Extrinsic motivation appeared to be a combination of outside influences, and the prospect of getting jobs with high salaries. Factors 7 and 8 will need more work to discern, as learning styles were difficult to get students to report consistently, and "support" and "influence" did not necessarily go hand in hand.

Preparation. The level of preparation for engineering was approximated by nine items indicating the number of math and science Advanced Placement classes and exams the students completed, as well as the level of math achieved in high school. (We also noted the number of non-math or science AP exams each student completed, but did not include it in this factor.) The math/science preparation scale had excellent inter-item reliability, with Cronbach's alpha of 0.822.

Commitment. The level of students' commitment to engineering and to their current major was assessed using three items that asked how committed they were to each when they took the introduction to engineering course (their first year). The commitment scale had good inter-item reliability, with a Cronbach's alpha of 0.731.

Confidence. Four items were selected to assess students' level of confidence in their ability to complete an engineering degree. The confidence scale also had good inter-item reliability, with a Cronbach's alpha of 0.794.

Interest/intrinsic motivation. Five items were used to measure the students' level of intrinsic motivation and interest in engineering activities. This scale also had a good Cronbach's alpha of 0.772.

Perceived Social Value of engineering. Six items were used to measure the students' perception of the social value of engineering, with a Cronbach's alpha of 0.770.

Results
Preliminary analyses indicated that there was no significant difference in the answers provided by cohorts 1-8, therefore all cohorts were combined for the following analyses. A binary logistic

regression was done to determine the impact of each of the five factors on the dependent variable of success in engineering (GradInEngIn5). These results are presented in table 3.

Hypothesis 1: Preparation for engineering will be positively related to success in engineering programs.
The analysis presented in Table 3 shows that preparation was a significant factor in determining graduation in five years. This analysis included all students regardless of gender or ethnicity.

Table 3. Binary Logistic Regression showing impact of five factors on success in engineering.

	B	S.E.	Wald	df	Sig.	Exp(B)
Commitment	0.099	0.048	4.277	1	0.039	1.104
Confidence	0.014	0.048	0.083	1	0.773	1.014
MathSciPrep	0.060	0.021	8.507	1	0.004	1.062
Value	-0.019	0.020	0.874	1	0.350	0.982
InternalMotivation	-0.019	0.025	0.577	1	0.448	0.981
Constant	-0.376	0.796	0.223	1	0.637	0.687

Hypothesis 2: Initial commitment to engineering will be positively related to success in engineering programs.
Again, we can see in Table 3 that commitment was a significant factor in success in completing an engineering degree within five years.

Hypothesis 3: Confidence in one's abilities will be positively related to success in engineering programs.
Surprisingly, confidence was not a significant factor for the student population at large.

Hypothesis 4: Internal motivators, such as interest in engineering activities, will be positively related to success in engineering programs.
As indicated in the table, internal motivation, defined mainly by interest in tinkering with, designing and building things, was not a significant predictor of success in engineering.

Hypothesis 5: A higher perceived social value of engineering will be positively related to success in engineering programs.
The perceived social value of engineering was not significant for the student population at large.

Hypothesis 6: Gender and ethnicity, when considered independently of commitment and confidence will not be related to success in engineering.

A logistic regression was performed to check the significance of each factor for women in determining whether or not they graduated in five years. Only the math and science preparation factor was found to be significant for women students succeeding in engineering. (See Table 4.) Commitment was significant for the population at large, but not so for women considered independently, with p value of 0.696. Women were slightly less likely than men to graduate within five years of entering engineering as first year full time students, with 73% of men succeeding, while 71% of the women earned an engineering degree in less than five years.

However, math and science preparation for engineering study was the most significant factor, followed by commitment. The women were significantly less committed than the men, and we believe that the slight difference in degree completion can be explained by that and the fact that the women students were slightly less prepared than the men, as explained in the discussion below.

Table 4. Binary Logistic Regression showing impact of five factors on success in engineering for women students.

	B	S.E.	Wald	df	Sig.	Exp(B)
Commitment	0.037	0.095	0.153	1	0.696	1.038
Confidence	-0.015	0.092	0.028	1	0.867	0.985
MathSciPrep	0.114	0.049	5.535	1	0.019	1.121
Value	-0.012	0.043	0.077	1	0.781	0.988
InternalMotivation	0.015	0.048	0.103	1	0.748	1.016
Constant	-0.214	1.502	0.020	1	0.886	0.807

The analysis was also run separately for underrepresented minority students (defined as African American, Hispanic, Native American, Alaskan Native, or Pacific Islander) to determine whether any of the factors predicted whether URM students graduated with a major in engineering within five years of initial matriculation. Unfortunately, with the addition of the category of "two or more" ethnicities, the university tracking of these students is lost. The university lumps all of the "two or more" in with those who were "not specified," so we are only able to track as underrepresented minorities those students who selected a single ethnicity. For the students so defined as URM, math and science preparation was again the most significant factor, with 0.032, followed by internal motivation with 0.042. None of the other factors were significant for underrepresented students. These p values were all less significant than for the entire student population. (See table 5.) URM students were slightly less likely than other students to graduate in five years, with a 70% success rate.

Table 5. Binary Logistic Regression showing impact of five factors on success in engineering for underrepresented students.

	B	S.E.	Wald	df	Sig.	Exp(B)
Commitment	0.037	0.122	0.092	1	0.761	1.038
Confidence	-0.016	0.123	0.017	1	0.896	0.984
MathSciPrep	0.135	0.063	4.572	1	0.032	1.145
Value	-0.057	0.063	0.832	1	0.362	0.945
InternalMotivation	0.152	0.075	4.151	1	0.042	1.165
Constant	-2.805	2.077	1.824	1	0.177	0.061

Discussion

Gender and Ethnicity Differences

Several one-way analysis of variance (ANOVA) tests were run to determine whether there were gender differences in math preparation, commitment, confidence, value, and internal motivation. (See Table 6.) These analyses were conducted to determine whether data in the current study are consistent with previous findings; that is, that men and women enter programs with similar preparation levels but with different levels of commitment and confidence.

Table 6. One-way analysis of variance comparing gender impact on each factor

Factor		Mean	SD	F	Sig.
Commitment				10.611	0.001
	Women	16.72	3.23		
	Men	17.36	2.94		
Confidence				25.163	0.000
	Women	23.47	3.47		
	Men	24.54	3.16		
MathSciPrep				3.824	0.051
	Women	8.13	3.72		
	Men	8.75	4.44		
Value				20.474	0.000
	Women	35.44	4.42		
	Men	33.73	4.80		
Internal Motivation				96.885	0.000
	Women	26.25	4.49		
	Men	29.22	4.17		

The differences in preparation were barely on the edge of significance, while each of the other factors indicated significant differences, indicating women were less confident in their abilities, less committed to completing a degree in engineering, less driven by internal motivators (many based on outside experiences), and considered that engineering had more social value than did the men.

We also wanted to identify any differences for underrepresented minorities, so a similar table is provided in Table 7. The results of the one-way ANOVAs to check for differences in commitment, confidence, preparation, value, and internal motivation for underrepresented minorities found the most significant difference to be in commitment. Students who were members of an underrepresented minority (URM) were significantly more committed to completing a degree in engineering. Questionably significant was the internal motivation factor, which was slightly higher for underrepresented students. There were no significant differences in the math and science preparation, confidence in abilities, or the perceived social value of engineering.

Table 7. Comparing Underrepresented Minority students (URM) separately on each factor

Factor		Mean	SD	F	Sig.
Commitment				11.234	0.001
	URM	17.84	3.03		
	Majority	17.07	3.01		
Confidence				2.032	0.154
	URM	24.56	3.41		
	Majority	24.21	3.25		
MathSciPrep				11.707	0.089
	URM	7.49	4.01		
	Majority	8.80	4.28		
Value				2.147	0.143
	URM	34.70	4.83		
	Majority	34.05	4.75		
Internal Motivation				3.852	0.050
	URM	29.05	4.23		
	Majority	28.31	4.49		

To assist in understanding the results, we also look at the one-way analysis of variance comparing those who graduated in engineering within five years and those who didn't. Table 8 presents these results.

Of course table 8 gives us the impact of success on each of the factors, which is interesting to note simply because of the increased significance in the responses to commitment, confidence and preparation when comparing those who succeeded in engineering with those who did not. However, the binary logistic regression looking at the impact of all five factors on the success in engineering dependent variable (GradInEngIn5), provided in Table 3, above, showed that only MathSciPrep and Commitment were significant predictors of success.

Table 8. Comparing graduation with an engineering major within five years of initial matriculation separately on each factor

Factor		Mean	SD	F	Sig.
Commitment				14.810	0.000
	GradEngIn5	17.41	2.82		
	Others	16.67	3.46		
Confidence				10.895	0.001
	GradEngIn5	24.46	3.11		
	Others	23.77	3.64		
MathSciPrep				8.535	0.004
	GradEngIn5	8.83	4.22		
	Others	7.90	4.29		
Value				0.167	0.683
	GradEngIn5	34.11	4.88		
	Others	34.26	4.48		
Internal Motivation				0.736	0.391
	GradEngIn5	28.50	4.42		
	Others	28.24	4.54		

The men and women in this study began their engineering programs at close to the same level of ability (six of the nine individual items for preparation showed no significant gender differences). This finding is consistent with previous research. The underrepresented students were significantly less prepared on five of the nine items. The finding that only math and science preparation significantly predicted graduation in women contradicts previous research findings, which had found both confidence and commitment to be significant for women. For underrepresented students, math preparation was most significant, followed by intrinsic motivation for studying engineering. It is interesting that the intrinsic motivation became significant only for the underrepresented students.

We were surprised that the only factor significant for women was the preparation for study in engineering. Our earlier study had found that confidence and commitment were both significant, similar to results reported by several other studies. It was particularly surprising since there were quite significant differences in the factors by gender and by ethnicity; however, those differences did not apparently affect graduation in five years. Also, when comparing those women who left engineering with those who stayed, they were significantly lower in confidence and in commitment than the women who stayed, while there was a small but not significant difference in their level of preparation.

A note about intrinsic motivation: this factor relied heavily on prior exposure to engineering-like or related activities, so it is unsurprising that the women students score significantly lower on this factor. This may have not been the best choice of name for the factor. It is made up of items that indicate interest in investigating new gadgets, building things, fixing things, and designing things to help people.

One of the issues that may skew these results is that the number of male students is substantially greater than the number of women students, and the number of underrepresented minority students is substantially smaller than the number of others. Thus, we may have had problems getting significance when analyzing the smaller groups of students. There is a great deal more analysis possible with the data we have gathered, and we will be cognizant of this complicating factor as we move forward to analyze the additional items that did not fit neatly into factors.

End Notes

[1] This work was supported by National Science Foundation grants 0737110 and 0431975 and the SCU School of Engineering.

References

[1] Wulf, W. A. "Diversity in Engineering," *The Bridge*, National Academy of Engineering,Volume 28, Number 4 - Winter 1998.

[2] National Science Foundation, Division of Science Resources Statistics, National Science Foundation, Arlington, VA., 2006. (Source: Engineering Workforce Commission, *Engineering & Technology Enrollments: Fall 2005*)

[3] American Society for Engineering Education, Engineering Data Management System, tables created from IPEDS enrollment data, downloaded January 25, 2017.

[4] Felder, Richard M., Gary N. Felder, Meredith Mauney, Charles E. Hamrin, Jr., and E. Jacquelin Dietz, "A Longitudinal Study of Engineering Student Performance and Retention. III. Gender Differences in Student Performance and Attitudes," *Journal of Engineering Education*, Vol 84, April, 1995, pp. 151-163.

[5] Bandura, Albert. *Self-Efficacy: The Exercise of Control.* New York, N.Y. W.H. Freeman and Company. 1997.

[6] Jenkins, Maura, and Robert G. Keim, "Gender Trends in Engineering Retention," in Proceeedings of the 34th ASEE/IEEE Frontiers in Education Conference, Savannah, Georgia, October, 2004.

[7] Ting, S.R. "Predicting Academic Success of First-Year Engineering Students from Standardized Test Scores and Psychosocil Variables." *International Journal of Engineering Education,* Vol 17, No.1, 2001, pp. 75 – 80.

[8] Jin, Q., Imbrie, P. K., Lin, J.J. J., and Chen, X. C., "A Multi-Outcome Hybrid Model for Predicting Student Success in Engineering.", *Proceedings of the 2011 ASEE Annual Conference & Exposition,* Vancouver, British Columbia, June, 2011.

[9] Brainard, S. G., and Carlin, L., “A six-year longitudinal study of undergraduate women in engineering and science.” *Journal of Engineering Education*, 87(4), 1998, pp. 369 –375.

[10] Briller, V., Deess, E.P., Calluori, R., and Joshi, K., “Predicting Engineering Student Retention.” *Proceedings of the 2004 ASEE Annual Conference & Exposition,* Salt Lake City, Utah, June, 2004.

[11] Ohland, M. W., Sheppard, S. D., Lichtenstein, G., Eris, O., Chachra, D., and Layton, R. A., “Persistence, Engagement, and Migration in Engineering Programs.” *Journal of Engineering Education,* 97(3), 2008, pp. 259 – 278.

[12] May, G. S. and Chubin, D. E., “A Retrospective on Undergraduate Engineering Success for Underrepresented Minority Students.” *Journal of Engineering education,* 92(1), 2003, pp. 27 – 40.

[13] SULLIVAN, Kieran, with Ruth Davis, “Increasing Retention of Women Engineering Students," Proceedings of the 2007 ASEE Annual Conference and Exposition, Honolulu, HI, June, 2007.

[14] Frizell, S. and Nave, F., “A Preliminary analysis of factors affecting the persistence of African-American females in engineering degree programs.” *Proceedings of 2008 ASEE Annual Conference and Exhibition*, Pittsburgh, PA.

[15] Davis, R, and Arndt, A. “Retaining Women in Computing,” Proceedings of 11th Annual International Conference on Frontiers in Education: Computer Science and Computer Engineering (FECS ’15), Las Vegas, Nevada, July 2015, pp. 244-249.