Pre-College Interactions, Early Expectations, and Perceived Barriers: Are There Differences for Underrepresented Engineering Students?

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Abstract

One of the most significant challenges facing engineering education is the chronic problem of inclusion and retention of underrepresented groups, including women, certain racial and ethnic groups, and students whose parents did not complete college. An exploratory comparative study was conducted to investigate how engineering-related interactions prior to college and perceived barriers during engineering studies may differ among entering engineering students based on membership in an underrepresented group (women, students of color, first-generation). The sample included 252 first-year engineering students who completed an online questionnaire during their first week of studies at a four-year urban research university. Statistically significant group differences were found for perceived likelihood of experiencing financial and social support barriers, as well as number of pre-college interactions with adults who recommended engineering as a college career. The findings are useful to engineering education professionals involved with first year orientation experiences, and further current understanding about pre-college experiences that are linked to engineering enrollment.

Introduction

One of the most significant challenges facing engineering education is the chronic problem of inclusion and retention of underrepresented minority (URM) groups, including women, certain racial and ethnic groups (African American, Latino, Native American) and students whose parents did not complete college (first generation college). In this paper, we present preliminary results from a project whose aim is study how formal and informal interactions with engineering agents may influence attitudes and intentions of URM students for enrollment and persistence. The purpose of the study is to investigate how engineering-related interactions prior to college, perceived barriers during engineering studies, and early expectations of interactions with faculty may differ among engineering students based on membership in an underrepresented group.

Previous research suggests that certain personal and academic factors are associated with student success in engineering, particularly for students from groups that are traditionally underrepresented in college engineering programs. In engineering, academic self-efficacy refers to a person's confidence in their abilities to complete all of the major engineering requirements of their program [1]. Studies have found a positive relationship between self-efficacy and GPA among engineering students [2,3]. Other academic factors associated with success in engineering include study habits and academic ability [e.g., 3,4].

Perceived support from family and peers are personal factors associated with success of underrepresented students in engineering. Family ties are important to students because of the emotional connection and attachment to financial support given by members of the family [5]. Students who feel supported by their peers and who engage in quality relationships with others tend to have higher grades and perform better academically [3,6,7].

Interactions with institutional agents such as faculty, staff, and administrators are strong predictors of student learning and are important connections for students so that they have the information and resources necessary to successfully maneuver through the college environment [8,9,10,11]. Faculty-student interactions are vital to academic success, especially for underrepresented students who are pursuing a science or engineering degree [12]. Research shows that faculty-student interaction is related to student success indicators including academic performance, persistence, institutional commitment, and intellectual development [13,14,15,16, 17,18,19,20,21]. Carini and colleagues [14] suggest that faculty mentorship may help mitigate the negative effects of low SAT scores on college grades. For underrepresented students of color (i.e., Black, Latino, Native American) in STEM disciplines, frequent interactions with faculty and support from faculty are associated with higher grades [6,22,23].

Considering the importance of personal and academic factors for the success of underrepresented students in engineering, we developed two guiding research questions for this study.

Among entering engineering students at a four-year urban research institution:

1. To what extent does perceived likelihood to experience financial, social, and academic barriers during engineering studies differ based on student membership in an underrepresented group related to gender, ethnicity, or parent education level?

2. To what extent does frequency of pre-college engineering related interactions with supportive adults differ based on student membership in an underrepresented group related to gender, ethnicity, or parent education level?

Methodology

This study utilizes an exploratory comparative approach to determine whether membership in an underrepresented group is associated with differing levels of pre-college interactions and perceived barriers to studying engineering among entering engineering students at a four-year urban research institution in the Southeast United States. The College of Engineering (COE) on this campus has an undergraduate enrollment of approximately 2,700 students in programs in civil and environmental engineering, electrical engineering, engineering (undesignated), computer engineering, mechanical engineering, systems engineering, and engineering technology. The institution is unique in the regard that it is one of a handful in the United States to offer four-year engineering technology programs. Additionally, the college has a high proportion of transfer students (nearly 50%) as well as first-generation college students (again, 50%). The primary programs for first year students include an orientation seminar, freshman learning community, and peer mentoring program.

Instrumentation for the study included a questionnaire developed by the researchers as well as demographic information from student institutional records. The questionnaire items were developed by the researchers by adapting existing instruments on perceived barriers to education [24] and engineering-related interactions [25]. The items were included on a standard questionnaire administered to the engineering freshman seminar students at the institution under study. Seven items on likelihood to experience certain barriers (e.g., negative faculty attitudes, coursework difficulties) were rated from 1=strongly agree to 5=strongly disagree. For seven items on pre-

college engineering-related interactions (e.g., visiting an engineering workplace), students indicate all of the adults with whom they interacted from five possible options: parent, family friend, K-12 educator, college professor, or other adult mentor. Item scores were created to indicate the number of adults providing each type of interaction support (range 0 to 5). Additional demographic questions included whether the student's parent had attained a four-year degree, to determine first-generation status. Gender and race/ethnicity were obtained as reported in the institution's student records database.

The sample includes 252 students who participated in an online questionnaire during the first week of class in Fall 2013, representing about 47% of the entering class. Among the participants, 35% were first-generation college; 15% were women; and 20% were students of color (4% African American; <1% American Indian; 6% Asian & Pacific Islander; 7% Hispanic/Latino; 2% two or more races). The sample is roughly representative of the student population in terms of students of color (about 19% of the population), however, women are overrepresented (about 9% of the population). Nearly 1 in 5 (19%) reported having an engineer parent.

Each questionnaire item was examined separately for group differences in the data analyses. Thus, three t-tests were conducted for each of the fourteen items, to compare groups based on gender (men vs. women); race/ethnicity (white vs. students of color); and parent education level (first-generation college vs. continuing generation college). Considering the number of tests (42) and the unbalanced group sizes, significance levels greater than $p=.001$ should be interpreted with caution. However, given the exploratory nature of the study, all results significant at the $p<.05$ level or greater are denoted and discussed as potentially significant and worthy of further study.

Results

Differences in perceived likelihood to experience barriers while studying engineering

Likelihood to experience barriers was rated on an agreement scale from 1 to 5, with higher mean scores indicating greater perceived likelihood to experience the barrier. The barriers with greatest perceived likelihood during engineering studies were financial problems, difficulties in science coursework (physics, chemistry), and difficulties in engineering coursework; however, none of these mean scores reached 4.0. Students reported lowest perceived likelihood to experience barriers related to family support and negative faculty attitudes. Item means and standard deviations for each subgroup are shown in Table 1.

Among the group comparisons (Table 1), membership in an underrepresented group was associated with significantly greater perceived likelihood of financial barriers (women, first-generation), lack of support from family (first-generation, students of color) and negative attitudes from faculty (first-generation). There were no significant differences in perceived likelihood to experience problems with coursework or fitting in with peers.

Table 1: Group differences in perceived likelihood to experience barriers while studying engineering

Barrier Mean (SD)	Group Mean (SD) 5=strongly agree, 1=strongly disagree						
	Women (W) n=37	Men (M) n=213	First- Generation (FG) n=88	Continuing Generation (CG) n=162	White/ Caucasian (Wh) n=186	Students of Color (SC) n=51	Significant Differences (t-test)
Financial problems	3.78 (1.21)	3.23 (1.28)	3.81 (1.13)	3.05 (1.28)	3.25 (1.28)	3.51 (1.27)	W>M** FG>CG***
Lack of support from family	1.76 (1.09)	1.64 (0.94)	1.95 (1.17)	1.50 (0.79)	1.55 (0.85)	1.92 (1.16)	FG>CG*** SC>Wh*
Negative attitudes from faculty	2.11(1.05)	2.06 (0.99)	2.32 (1.11)	1.93 (0.91)	1.96 (0.91)	2.24 (1.11)	FG>CG**
Not fitting in with peers	2.51 (1.07)	2.32 (1.05)	2.42 (1.10)	2.31 (1.02)	2.26 (1.02)	2.55 (1.06)	
Difficulties in math coursework	2.73 (1.26)	2.84 (1.22)	2.86 (1.12)	2.80 (1.28)	2.81 (1.24)	2.84 (1.19)	
Difficulties in science coursework	3.22 (1.25)	3.06 (1.08)	3.08 (1.02)	3.09 (1.15)	3.05 (1.12)	3.16 (1.08)	
Difficulties in engineering coursework	3.11 (1.10)	3.04 (1.06)	3.09 (0.98)	3.03 (1.11)	3.04 (1.09)	3.02 (0.99)	

$*p<.05, **p<.01, ***p<.001$

Differences in pre-college engineering related interactions with supportive adults

Students were asked to indicate if they had engineering-related interactions with different supportive adults prior to the student enrolling in engineering. For each type of interaction, a summed score was created for number of adults, ranging from 0 to 5. In addition, a total interaction and supports score was created across the seven items, with a possible range from 0 to 35. On average, students reported interacting with at least one adult for each of the engineering-related interactions except for visiting an engineering workplace. Overall, students reported the highest mean number of interactions with adults recommending that they study engineering in college, and adults providing information about engineering work. Lowest mean interaction across all groups was for visiting an engineering workplace. The means and standard deviations for number of adults reported for each engineering-related interaction are shown in Table 2.

Several significant differences were noted in the comparisons of mean number of adults providing engineering-related interactions (Table 2). Women reported significantly fewer supportive adults than men for providing engineering toys and equipment, providing information about engineering work, and recommending that they study engineering in college. Similarly, students of color indicated fewer supportive interactions than White students for information about engineering work and recommendations to study engineering in college. Comparisons based on parent education level showed the greatest number of significant differences, favoring continuing education students for providing toys and equipment, visiting an engineering workplace, telling about own work as engineer, recommending that they study engineering in college, and discussing engineering coursework and requirements. Finally, students in underrepresented groups reported less total engineering-related interaction and support than their counterparts.

Discussion and implications

This study examined early perceptions and pre-college interactions of first year engineering students at an urban research institution. As anticipated, women, students of color, and first-generation students in engineering were more likely to perceive certain barriers and to report fewer number of engineering-related interactions with supportive adults prior to enrolling in engineering. Differences in perceived likelihood to experience barriers were found for financial and social supports, but not for academic coursework. For different engineering-related interactions with supportive adults, there were significant differences between student groups for all except showing engineering experiments or research.

Notable across the analyses were the comparisons between first-generation and continuing generation students, with first-generation students expressing greater perceived likelihood to experience barriers; particularly related to finances and family support; and fewer pre-college engineering-related interactions than their counterparts whose parents had earned a four year degree. First-generation college students may have to work to pay their way through college [26] and are more likely to have student loans [27]. Parental support is important for first-generation college student success [7], and these students may experience cultural shift when "breaking away" from the familiar non-college-oriented home life [28].

Table 2: Group differences in number of engineering-related interactions with supportive adults

Interaction Mean (SD)	Group Mean (SD)						Significant Differences (t-test)
	Women (W) n=38	Men (M) n=214	First-Generation (FG) n=89	Continuing Generation (CG) n=163	White/ Caucasian (Wh) n=187	Students of Color (SC) n=52	
Provide engineering related toys or equipment	1.11 (1.23)	1.71 (1.12)	1.37 (1.16)	1.76 (1.13)	1.72 (1.08)	1.44 (1.36)	M>W** CG>FG*
Show engineering experiments or research	1.18 (1.01)	1.24 (1.02)	1.12 (0.96)	1.29 (1.04)	1.29 (1.05)	1.15 (0.94)	
Provide information about engineering work	1.42 (1.06)	1.89 (1.17)	1.63 (1.20)	1.93 (1.14)	1.91 (1.22)	1.52 (0.90)	M>W* Wh>SC*
Take to engineering workplace	0.55 (0.76)	0.63 (0.79)	0.45 (0.74)	0.71 (0.79)	0.65 (0.80)	0.52 (0.75)	CG>FG*
Tell about own work as an engineer	1.08 (0.88)	1.19 (0.95)	0.97 (1.01)	1.28 (0.88)	1.21 (0.94)	0.98 (0.90)	CG>FG*
Recommend study engineering in college	1.47 (1.22)	2.03 (1.49)	1.55 (1.30)	2.17 (1.51)	2.12 (1.51)	1.46 (1.24)	M>W* CG>FG** Wh>SC**
Discuss engineering coursework and requirements	1.03 (0.94)	1.33 (1.20)	1.02 (1.01)	1.43 (1.23)	1.37 (1.20)	1.06 (1.06)	CG>FG**
Total interactions and supports (0-35)	7.84 (5.10)	10.03 (5.33)	8.11 (5.35)	10.57 (5.16)	10.28 (5.47)	8.13 (4.90)	M>W* CG>FG*** Wh>SC*

$*p<.05, **p<.01, ***p<.001$

It is important to reiterate that the students in the study sample are enrolled first year engineering students. Thus, despite experiencing fewer interactions and encouragements, the underrepresented students in the study decided to enter engineering. Martin and colleagues [25] suggest that even single instances and interactions may be important for facilitating access to engineering among underrepresented students. We note that all student groups had, on average, at least one adult who provided an interaction or experience related to engineering. Perhaps most importantly, all groups of students indicated that at least one adult had encouraged them to study engineering in college.

The findings of this study provide a snapshot of engineering students' perceived barriers and pre-college experiences within the first few weeks of beginning engineering studies. The institution at which our study was conducted has relatively high proportions of groups that are considered underserved in engineering (i.e., first-generation and transfer students), along with multiple structures at the engineering college and institutional levels to support success for students from underserved groups (e.g., Black students, Latino students, veterans, transfer students). We suggest that institutions need to take a multi-pronged approach to supporting underrepresented engineering students both pre- and post-college entry, including institutional-level academic and student services that consider the needs of underrepresented students in general, along with extended orientation, peer mentoring, and cocurricular clubs and activities within the engineering college led by students and professionals that understand engineering education. Not all interventions need to be time and resource intensive - a recent study suggests that a short, targeted intervention of only an hour can be effective in increasing first-generation students' academic performance and use of campus services [29]. Our future research includes understanding how first year engineering students' perceptions of potential barriers changes over the first semester, as well as how Black and Latino engineering students negotiate barriers and interact with faculty members in their junior and senior years of engineering.

References

[1] Hackett, G., Betz, N. E., Casas, J. M., & Rocha-Singh, I. A. (1992). Gender, ethnicity, and social cognitive factors predicting the academic achievement of students in engineering. *Journal of Counseling Psychology 39*(4): 527–38.

[2] Concannon, J. P. & Barrow, L. H. (2010) Men's and women's intentions to persist in undergraduate engineering degree programs. *Journal of Science, Education, and Technology, 19*(2), 133–145.

[3] Sharkness, J., Eagan Jr, M. K., Hurtado, S., Figueroa, T., & Chang, M. J. (2010*). Academic achievement among STEM aspirants: why do Black and Latino students earn lower grades than their White and Asian counterparts?* Paper presented at Annual Meeting of the Association for Institutional Research, Toronto, CA.

[4] Credé, M., & Kuncel, N. R. (2008). Study habits, skills, and attitudes: The third pillar supporting collegiate academic performance. *Perspectives on Psychological Science, 3*(6), 425-453.

[5] Palmer, R., Davis, R. & Hilton, A. (2009). Exploring challenges that threaten to impede the academic success of academically underprepared Black males at an HBCU. *Journal of College Student Development, 50*(4), 429-445.

[6] Cole, D. (2008). Constructive criticism: The role of student-faculty interactions on African American and Hispanic students' educational gains. *Journal of College Student Development, 49*(6), 587-605.

[7] Dennis, J. M., Phinney, J. S., & Chauteco, L. I. (2005). The role of motivation, parental support, and peer support in the academic success of ethnic minority first-generation college students. *Journal of College Student Development, 46*(3), 223-236.

[8] Kuh, G. D. & Hu, S. (2001). The effects of student-faculty interaction in the 1990s. *The Review of Higher Education*, *24*, 309-332.

[9] Stanton-Salazar, R. (1997). A social capital framework for understanding the socialization of racial minority children and youth. *Harvard Educational Review, 67*(1), 1‑40.

[10] Stanton-Salazar, R. D. (2001). *Manufacturing hope and despair: The school and kin support networks of U.S.-Mexican youth*. New York, NY: Teachers College.

[11] Trenor, J., Yu, S. L., Waight, C. L., Zerda, K. S., & Ting Ling, S. (2008). The relations of ethnicity to female engineering students' educational experiences and college and career plans in an ethnically diverse learning environment. *Journal of Engineering Education, 97* (4), 449-465.

[12] Leslie, L., McClure, G., & Oaxaca, R. (1998). Women and minorities in science and engineering: A life sequence analysis. *Journal of Higher Education, 69*, 239-276.

[13] Astin, A. W. (1993). *What matters in college? Four critical years revisited*. San Francisco, CA: Jossey-Bass.

[14] Carini, R., Kuh, G., & Klein, S. (2006). Student engagement and student learning: Testing the linkages. *Research in Higher Education*, *47*(1), 1-32.

[15] Cole, D. (2010). The effects of student-faculty interactions on minority students' college grades: Differences between aggregated and disaggregated data. *Journal of the Professoriate, 3*(2), 137-160.

[16] Eimers, M. T. (2001). The impact of student experiences on progress in college: An examination of minority and nonminority differences. *NASPA Journal, 38*(3), 386-409.

[17] Hurtado, S., Cabrera, N. L., Lin, M. H., Arellano, L., & Espinosa, L. L. (2009). Diversifying science: Underrepresented student experiences in structured research programs. *Research in Higher Education, 50*(2), 189-214.

[18] Kim, Y. K., & Sax, L. J. (2009). Student-faculty interaction in research universities: Differences by student gender, race, social class, and first-generation status. *Research in Higher Education, 50*, 437-459.

[19] Pascarella, E. T., & Terenzini, P. T. (2005). *How college affects students: A third decade of research (vol. 2)*. San Francisco, CA: Jossey-Bass.

[20] Tinto, V. (1993). *Leaving College: Rethinking the Causes and Cures of Student Attrition.* Chicago, Illinois: University of Chicago.

[21] Vogt, C. M. (2008). Faculty as a critical juncture in student retention and performance in engineering programs. *Journal of Engineering Education, 97*(1), 27–36.

[22] Cole, D., & Espinoza, A. (2008). Examining the academic success of Latino students in science technology engineering and mathematics (STEM) Majors. *Journal of College Student Development, 49*(4), 285-300.

[23] Torres, J., & Solberg, V. (2001). Role of self-efficacy, stress, social integration, and family support in Latino college student persistence and health. *Journal of Vocational Behavior, 59* (1), 53-63.

[24] McWhirter, E. H., Hackett, G., & Bandalos, D. L. (1998). A causal model of the educational plans and career expectations of Mexican-American high school girls. *Journal of Counseling Psychology, 45*(2), 166-181.

[25] Martin, J. P., Simmons, D. R., & Yu, S. L. (2013). The role of social capital in the experiences of Hispanic women engineering majors. *Journal of Engineering Education, 102*, 227-243.

[26] York-Anderson, D. C., & Bowman, S. L. (1991). Assessing the college knowledge of first-generation and second-generation college students. *Journal of College Student Development, 32*(2), 116-122.

[27] Martínez, J. A., Sher, K. J., Krull, J. L., & Wood, P. J. (2009). Blue-collar scholars?: Mediators and moderators of university attrition in first-generation college students. *Journal of College Student Development, 50*(1), 87-103.

[28] London, H. B. (1989). Breaking away: A study of first-generation college students and their families. *American Journal of Education, 97*(1), 144-170.

[29] Stephens, N. M., Hamedani, M. G., & Destin, M. (2014). Closing the social-class achievement gap: A difference-education intervention improves first-generation students' academic performance and all students' college transition. *Psychological Science, 25* (2), (online first).