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LOOKING AT ENGINEERING STUDENTS THROUGH A MOTIVATION/CONFIDENCE FRAMEWORK

Abstract

In this paper we compare groups of engineering students along two dimensions, intrinsic psychological motivation to study engineering and confidence in professional and interpersonal skills. We focus on these two measures because they have been shown to be directly related to seniors' future career plans and other aspects of the student experience[1].

Our sample included 103 students who participated in the NSF-sponsored Academic Pathways Study (APS) from 2003 to 2007 and who graduated with an engineering degree. The students completed the Persistence in Engineering (PIE) survey seven times during their four years of college. Scores of intrinsic motivation and professional and interpersonal confidence were created for each student using survey data from the end of their freshman year. Students were then categorized into four groups depending on whether their motivation and confidence scores were above or below the population mean. Scores on other variables related to the college experience were used to investigate the influence of engineering undergraduates' motivation and confidence levels as freshmen on the rest of their undergraduate careers.

We found no statistical differences in group demographics or professional persistence. However, students who were high in intrinsic motivation and professional and interpersonal confidence (M/C) also reported higher levels of perceived importance of professional and interpersonal skills, participation in non-engineering extracurricular activities, and exposure to the engineering profession than students who were low in both measures (m/c). We present case studies of two students, one M/C and the other m/c, to illustrate differences in their attitudes toward activities outside of the classroom and toward the importance of professional and interpersonal skills. While the M/C student felt that she best utilized her time by engaging in a number of non-engineering extracurricular activities and internship experiences, her m/c peer viewed such activities as encroaching on her limited time. We argue that a student's level of non-academic involvement is related to the importance she ascribes to professional and interpersonal skills in engineering. Implications for engineering educators and suggestions for further research are discussed.

Introduction

Findings from the recent Academic Pathways Study (APS) sponsored by the Center for Advancement of Engineering Education (CAEE) have shown that intrinsic psychological motivation to study engineering and confidence in professional and interpersonal skills are key predictors of engineering seniors' future plans[1]. Sheppard et al. (2010) have also shown that, when taken in combination, intrinsic motivation and professional and interpersonal confidence influence seniors' level of college involvement as well. Highly motivated and highly confident students report higher levels of non-academic participation (including co-op, internship, research, and non-engineering extracurricular activities), greater gains in engineering knowledge, and greater interaction with faculty than students with low motivation and low confidence[i]. Students with high motivation/low confidence and low motivation/high confidence report average levels of involvement which fall in between the two extremes[1].

Measures of intrinsic motivation and professional and interpersonal confidence have also been used to study changes in engineering students during their first two years of college. Otto et al. (2010) revealed that students who experience positive changes in motivation and/or confidence are distinct from those who experience negative or no changes in terms of persistence in the engineering profession, confidence in math and science skills, and perceived importance of math and science skills[2]. The current study uses the motivation/confidence framework to investigate engineering students' experiences over their entire four years of college.

Our sample consists of 103 engineering students who participated in the APS and who graduated with an engineering degree from one of four CAEE institutions in 2007[3]. Scores of intrinsic motivation, professional and interpersonal confidence, and other variables were created using data from the Persistence in Engineering (PIE) survey that students completed seven times during their four years on college. Students were then categorized into four groups depending on whether their motivation and confidence scores at the end of their freshman year were above or below the population mean. Scores on other variables were used to investigate students' experiences from freshman year through senior year. In this way, we consider the impact of engineering students' motivation and confidence levels as freshmen on their overall college experiences.

Background

This paper begins with background information pertinent to the current study. Further details about the motivation/confidence framework can be found in the work of Sheppard et al. (2010)[1] and Otto et al. (2010)[2].

The motivation/confidence framework used in this study was originally developed as part of the Academic Pathways of People Learning Engineering Survey (APPLES). Derived from the PIE survey, the APPLE survey was administered to 21 institutions nationwide in the spring of 2008[1]. In the APPLES study, differences were examined between seniors in each of the four groups defined in Table 1. Post-graduation career plans and level of college involvement were found to differ significantly among the groups.

Table 1. The Motivation/Confidence Groups Defined

Group Number	Group Label	Intrinsic Psychological Motivation (M)	Professional and Interpersonal Confidence (C)
1	M/C	At or above mean	At or above mean
2	M/c	At or above mean	Below mean
3	m/C	Below mean	At or above mean
4	m/c	Below mean	Below mean

[i] By "low" ("high"), we mean lower (higher) than average when compared to other students.

Definitions of the Motivation and Confidence Variables

The intrinsic psychological motivation variable measures students' interest in studying engineering for its own sake, i.e., for the pleasure and satisfaction that is inherent in the activity. Students who are intrinsically motivated engage in behaviors for the fun or challenge entailed rather than to obtain rewards or avoid sanctions. Alternatively, students who are extrinsically motivated engage in certain behaviors because they lead to separable outcomes, such as money or grades[4].

In the PIE and APPLES studies, the intrinsic psychological motivation variable is a modified version of the intrinsic motivation subscale of the Situational Motivation Scale (SIMS)[5] and is comprised of three items (questions)[ii]:

a) I feel good when I am doing engineering activities.
b) Majoring in engineering is fun.
c) I think engineering is interesting.

Students were asked to rate the extent to which they agreed that each of the items was a reason that they were currently majoring in or considering majoring in engineering, and the options for these items were "strongly disagree," "moderately disagree," "disagree," "unsure," "agree," "moderately agree," or "strongly agree."

The confidence in professional and interpersonal skills variable measures students' self-confidence in their business, teamwork, and communication proficiencies. Both ABET[6] and the National Academy of Engineering[7] have identified these proficiencies as crucial for all engineering graduates to possess. Confidence variables were included in the PIE and APPLE surveys to explore the relationship between confidence and persistence in engineering.

The professional and interpersonal confidence variable is comprised of five items (questions)[iii]:

a) Self confidence (social)
b) Leadership ability
c) Public speaking ability
d) Communication skills
e) Business ability

Students were asked to rate themselves on each of the above traits as compared to their classmates. The options for these items were "lowest 10%," "below average," "average," "above average," and "highest 10%."

[ii] The wording of the items given here is the same as that used in the PIE survey. The same three items comprised the variable in the APPLE survey but slightly different wording was used. The word "activities" was removed from part a) and the words "majoring in" in part b) were replaced with "I think"[1].

[iii] In the iterations of PIE after the first year and in the APPLE survey, an additional item, "Ability to perform in teams," was included in this variable. For consistency in this work, we are only using the five items shown.

Cronbach's alpha tests for internal consistency among the individual items which make up a variable. The Cronbach's alpha scores for both variables were higher than the minimum preferred value of 0.70[iv]. Within each variable, each item was equally weighted, and the students' scores for both variables were normalized on a scale of 0 to 1.

Methodology

Description of Data Sets

The main source of data in this study is the Persistence in Engineering (PIE) survey, a research component of the Academic Pathways Study (APS). This survey was administered seven times to a cohort of 40 students at each of the four institutions, from their matriculation in 2003 to the end of their fourth year of college in 2007. All of the students who participated in this study were either enrolled in an engineering program or intending to major in engineering. The sample discussed in this paper consists only of the 103 students who graduated with an engineering degree at end of their fourth year and who answered all of the survey items necessary to calculate the intrinsic motivation and professional and interpersonal confidence variables. Additionally, we only consider student responses to the PIE surveys administered in the spring of each school year. Further details on the development, administration, and results of the PIE survey can be found in Eris et al. (2005)[8] and Eris et al. (2010)[19].

This study also utilizes academic transcripts and interview data. Academic transcripts were used to compare students' cumulative grade point averages (GPA's) at the end of their senior year. The interview data come from ethnographic interviews that a subset of students at each school participated in, also as part of the APS. Interviews of two non-minority female students from a technical public university in the western United States were chosen from among the 103 students in this study to further demonstrate differences between high motivation/high confidence students and low motivation/low confidence students.

Motivation/Confidence Groupings

Intrinsic motivation and professional and interpersonal confidence scores were calculated for each student using data from the spring of the students' freshman year (i.e., Year 1). These scores represent the students' early college motivation and confidence levels. Next, the population means for the students' Year 1 motivation and confidence scores were calculated separately, and the students were assigned to one of the four groups according to whether their scores were above or below the mean. The means and standard deviations are given in Table 2.

Table 2. Means and Standard Deviations of Variable Scores at the End of Year 1

	Intrinsic Psychological Motivation [scale 0-1]	**Professional and Interpersonal Confidence [scale 0-1]**
Year 1 (Spring 2004)	0.757 ± 0.150	0.632 ± 0.165

[iv] The quoted Cronbach's alpha values in this paper are based on responses to the APPLE survey[1].

The distribution of students across groups is illustrated in Figure 1. Bolder circles represent instances in which two or more students had the same intrinsic motivation and professional and interpersonal confidence scores. The vertical and horizontal lines indicate the means for the intrinsic motivation and professional and interpersonal confidence scores, respectively. The upper right quadrant represents Group 1, with high motivation and high confidence (M/C). The lower right quadrant represents Group 2, with high motivation and low confidence (M/c). The upper left quadrant represents Group 3, with low motivation and high confidence (m/C). Lastly, the lower left quadrant represents Group 4, with low motivation and low confidence (m/c).

Figure 1: Distribution of Students Across Groups at the End of Year 2

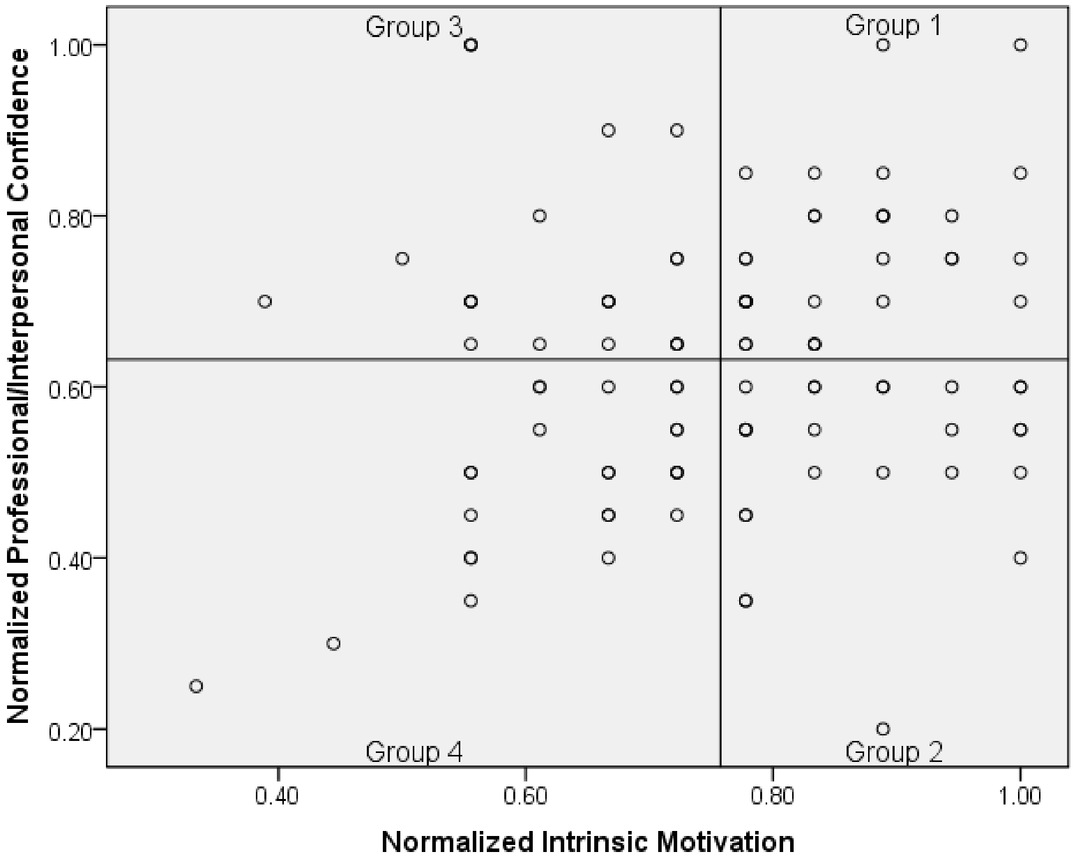


Table 3 lists the means for the intrinsic motivation and professional and interpersonal confidence scores, as well as the number of students, by group. As shown, the students were distributed fairly equally across groups. The distribution of students across groups was fairly equal in the APPLES study as well.

Table 3: Means and Number of Students by Group

Group Number	Group Label	M Mean [1]	C Mean [2]	Number of Students [3]
1	M/C	0.860	0.760	31
2	M/c	0.878	0.514	25
3	m/C	0.621	0.757	22
4	m/c	0.629	0.482	25

[1] F (3, 99) = 64.5, p<0.001; Group 1,2 > Group 3,4
[2] F (3, 99) = 57.147, p<0.001; Group 1,3 > Group 2,4
[3] Chi-square (3, N = 103) = 1.6602, p>0.05

Looking at how group membership changed over time, we found that the students' confidence scores at the end of Year 1 were strongly correlated with their confidence scores at the end of Years 2 to 4. All correlations had a Pearson coefficient higher than 0.7 and were significant at the p<0.001 level. Similarly, the students' motivation scores at the end of Year 1 were strongly correlated with their motivation scores at the end of Year 2, r(103) = .642, p<0.001[v]. Thus, the data suggest that, while some students transitioned between groups, most students stayed within the group to which they were originally assigned.

Statistical Analysis

Next we explored the similarities and differences between the four groups. A summary of the steps we took are as follows:

1) Run chi-square contingency tests and analysis of variance (ANOVA) tests to compare group demographics and professional persistence.

2) Run repeated measures analysis of variance (RM-ANOVA) to compare group mean scores on variables related to the college experience at the end of their freshman, sophomore, junior, and senior years (i.e., Years 1 through 4). These tests provided information on the effect of group membership, the effect of administration (time), and any interaction effect for each variable.
    a. If the RM-ANOVA yielded a statistically significant group effect, it was followed by *post hoc* ANOVA tests to determine differences in groups at each time point.
    b. If the RM-ANOVA yielded a statistically significant administration effect, it was followed by *post hoc* RM-ANOVA tests to identify changes in each group over time.

It should be noted that RM-ANOVA can only be used on complete sets of data. For a student's score to be included in the analysis of a given variable, the students must have answered all of the items related to that variable on each survey. While a student may have answered all of the items for one variable, he or she may not have answered all of the items for another. For this reason, the exact number of students included in the analysis fluctuates with each variable. An alpha of p=0.05 was used to denote statistically significant differences between groups, and all tests were non-directional.

[v] The items comprising intrinsic psychological motivation were (unfortunately) not included in the PIE survey after the second year.

Case Study Analysis

Ethnographic interviews provided a means for exploring statistically significant differences between the two extremes, M/C and m/c, as identified in the quantitative analyses. As previously mentioned, a subset of students at each school was interviewed at the end of each academic year. Interviews for all M/C and m/c students participating in this part of the study were read specifically for content related to those variables on which the two groups differed, and data analysis was performed using the case study methods recommended by Miles and Huberman (1994)[10]. Finally, two case studies, one from the M/C group and the other from the m/c group, were chosen for presentation in this paper. These case studies illustrate the differences that we found between the M/C and m/c groups in our statistical analyses. Furthermore, not only are these two students very similar in terms of their demographics and intentions to persist in engineering, they are representative of the other students in their respective groups.

Results

Comparison of Group Demographics and Professional Persistence

We compared group demographics and professional persistence using PIE survey data and the student's academic transcripts. Table 4 shows the distribution of students across schools for each group, and Table 5 shows the distribution of students across majors for each group. Table 6 summarizes the gender, under-represented minority (URM) status[vi], socioeconomic status (SES)[vii], and grade point average (GPA) demographics of the four groups. Lastly, Table 7 shows the percentage of "professional persisters"[viii] in each group, where professional persistence refers to a student's intention to remain in engineering for at least three years after graduation.

Chi-square contingency tests were used to determine whether group membership was influenced by school membership or by membership in a particular major. As demonstrated in Table 4 and Table 5, neither case was true. The groups were not statistically different in their distribution across schools or majors.

[vi] URM students are those who marked one or more of the following underrepresented racial/ethnic categories on their survey: Black/African American, Hispanic/Latino, American Indian/Alaska Native, and Native Hawaiian/Pacific Islander. Non-URM students are those who marked Asian/Asian American, White, or both Asian/Asian American or White. Students who marked both URM and non-URM categories were considered neither URM nor non-URM and were excluded from the analysis of URM status[1]. Ethnicity was determined from PIE survey responses collected in the spring of Year 2.

[vii] SES is comprised of three items: self-reported family income level, mother's highest level of education, and father's highest level of education. For specific details about how SES was calculated, please see Donaldson et al. (2008)[11]. SES was determined from PIE survey responses collected in the spring of Year 4.

[viii] In the PIE study, a "professional persister" is defined as a student who answered "definitely yes" or "probably yes" to the question, "Do you intend to practice, conduct research in, or teach engineering for at least 3 years after graduation?" Conversely, a "non-persister" is one who answered "definitely not" or "probably not" to the same question. Students who answered "unsure" were considered neither a persister nor a non-persister[1]. Professional persistence was determined from PIE survey responses collected in the spring of Year 4.

Table 4: Distribution of Students Across Schools by Group

	Percentage of Students				
School [1]	**Group 1**	**Group 2**	**Group 3**	**Group 4**	***Total***
Technical Public University	8.7	3.9	8.7	4.9	*26.2*
Urban Private University	8.7	3.9	2.9	2.9	*18.4*
Suburban Private University	7.8	6.8	4.9	4.9	*24.3*
Large Public University	4.9	9.7	4.9	11.7	*31.1*

[1] Chi-square (9, N = 103) = 12.124, p>0.05
Percentages may not add up to 100% due to rounding.

Table 5: Distribution of Students Across Majors by Group

	Percentage of Students				
Major [1]	**Group 1**	**Group 2**	**Group 3**	**Group 4**	***Total***
Aeronautical Engineering	0	1.9	0	1.9	*3.8*
Chemical Engineering	3.9	1.0	6.8	3.9	*15.6*
Civil & Environmental Engineering	4.9	4.9	1.0	0	*10.8*
Computer Engineering & Science	3.9	6.8	1.0	7.8	*19.5*
Electrical Engineering	4.9	2.9	1.9	1.9	*11.6*
Industrial & Management Engineering	1.9	1.0	0	1.9	*4.8*
Material Engineering	1.0	1.0	1.0	1.9	*4.9*
Mechanical Engineering	7.8	2.9	3.9	2.9	*17.5*
Other Engineering	1.9	1.9	5.8	1.9	*11.5*

[1] Chi-square (24, N = 103) = 34.23, p>0.05.
Percentages may not add up to 100% due to rounding.

Tests were also conducted to determine whether group membership was influenced by gender, URM status, SES, and GPA. Table 6 shows that the groups were not statistically different with regard to any of these demographic characteristics. However, we note that Group 1 has a relatively low percentage of women and relatively high percentage of URM students compared to the other groups[ix].

[ix] We also note that the percentages of women and URM students in each group are higher than those in the national population of engineering students. (These percentages are 19.5%[12] and 13.3%[13], respectively.) This difference is due to the fact that women and URM students were oversampled in the PIE study.

Table 6: Demographic Characteristics by Group

Group Number	Group Label	% Women [1]	% URM [2]	Mean SES [scale 0-1] [3]	Mean GPA[x] [scale 0-4] [4]
1	M/C	32.3	35.5	0.623	3.38
2	M/c	44.0	16.0	0.621	3.56
3	m/C	40.9	22.7	0.664	3.24
4	m/c	48.0	20.0	0.602	3.39

[1] Chi-square (3, N = 103) = 1.5794, p>0.05
[2] Chi-square (9, N = 103) = 7.782, p>0.05
[3] F (3, 88) = 0.2778, p>0.05
[4] F (3, 97) = 1.7934, p>0.05

Lastly, a chi-square contingency test was used to determine whether group membership had any effect on students' intentions to persist in engineering after graduation. There were no statistical differences among the proportion of professional persisters in each group (see Table 7). However, one of the shortcomings of this construct is that it only provides a glimpse of student's plans up to three years into the future. It does not capture the fine-grained complexities that often accompany career decision-making, e.g., the plan to use an engineering job as a stepping stone to a non-engineering job, or the decision to pursue a non-engineering job before eventually returning to engineering. The APPLE survey addressed this issue by asking participants how likely it was that they would do each of the following after graduation: work in an engineering job, working in a non-engineering job, go to graduate school in an engineering discipline, and go to graduate school in a non-engineering discipline[1].

Table 7: Professional Persistence by Group

Group Number	Group Label	% Professional Persisters [1]
1	M/C	70.0
2	M/c	72.0
3	m/C	80.0
4	m/c	74.4

[1] Chi-square (6, N = 96) = 5.221, p>0.05

Comparison of Group Mean Scores for Variables Related to the College Experience

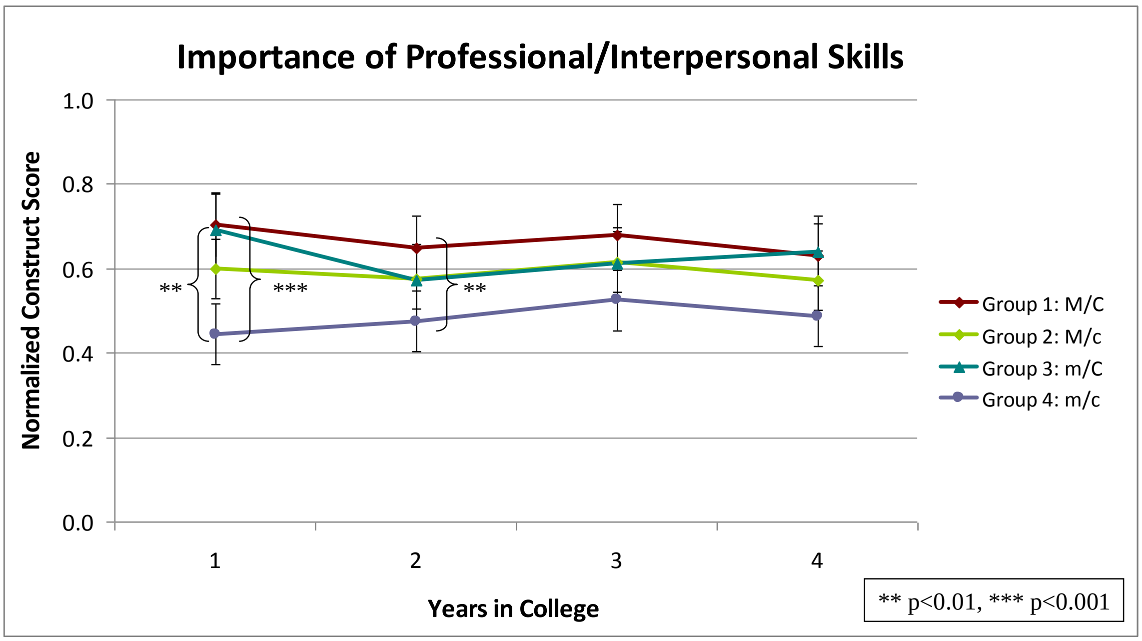
The PIE survey contains a number of variables related to motivation, confidence, and the college experience[10]. In this study, we looked at nine variables that showed statistically significant differences among engineering seniors in the APPLES study[1]. For confidence in math and science skills, importance of math and science skills, mentor influence motivation, and frequency of interaction with instructors, there were no differences among groups. However, RM-ANOVA did reveal significant group effects for the other five variables: perceived importance of professional and interpersonal skills, social good motivation, overall satisfaction with the college experience, frequency of non-engineering extracurricular activities, and exposure to the engineering profession.

[x] By 'GPA,' we mean the students' cumulative GPA at the end of their senior year.

Graphs of these variables are shown in Figures 2 through 6. The group mean scores, normalized on a scale from 0 to 1, are displayed on the y-axis, with error bars depicting the standard error of the mean. Table 8 summarizes the results of the statistical analyses performed for each variable. The table includes the results of the overall RM-ANOVA, as well as the individual ANOVA tests performed for each time points.

Figure 2 shows that, at every time point, the students in Groups 1 through 3 placed greater importance on professional and interpersonal skills in engineering than did the students in Group 4. The means of Groups 1 and 4 were significantly different at the end of Years 1 and 2, while the means of Groups 3 and 4 were significantly different at the end of Year 1 only. There was no administration effect, suggesting that perceived importance of professional and interpersonal skills for each group remained constant over time.

Figure 2: Perceived Importance of Professional and Interpersonal Skills Over Time



The students in Groups 1 and 2 had higher levels of social good motivation[xi] than the students in Groups 3 and 4 at all four administrations (Figure 3). The means of Groups 1 and 4 differed significantly at the end of Year 1. Additionally, the mean of Group 2 was significantly higher than the means of Groups 3 and 4 at the end of Year 3. There was a significant overall administration effect ($p<0.001$) and a significant interaction effect ($p<0.05$). RM-ANOVA revealed non-linearity in Group 1 ($p<0.001$) and Group 3 ($p<0.01$) as well as a negative trend in Group 4 ($p<0.001$).

[xi] In the PIE and APPLES studies, social good motivation was defined as the motivation to study engineering due to the belief that engineers improve the welfare of society[1].

Figure 3: Social Good Motivation Over Time

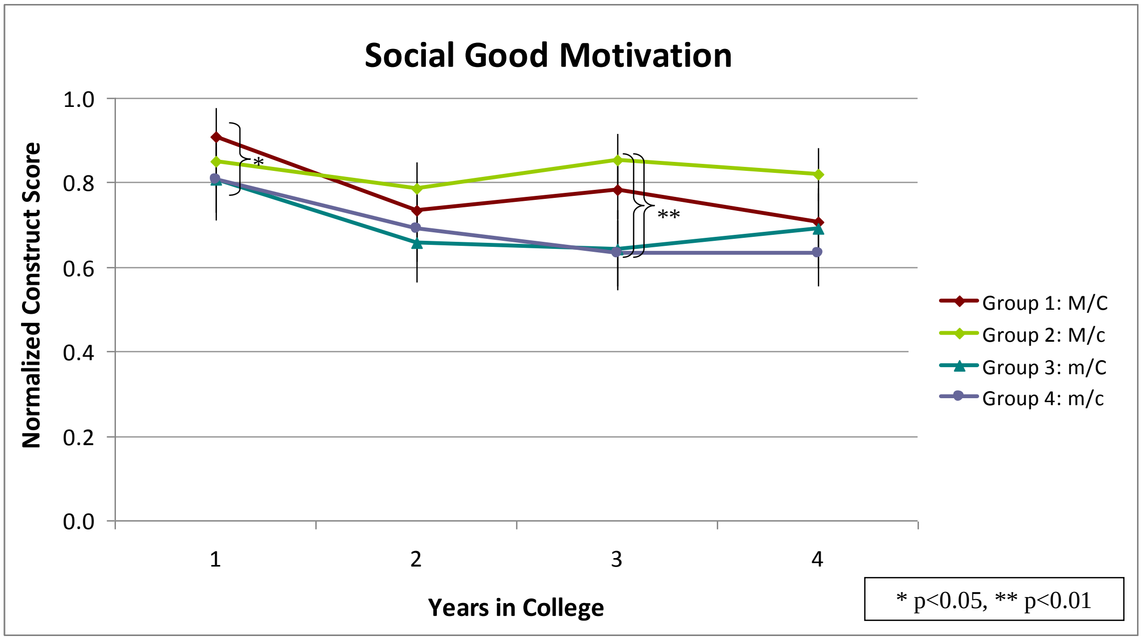
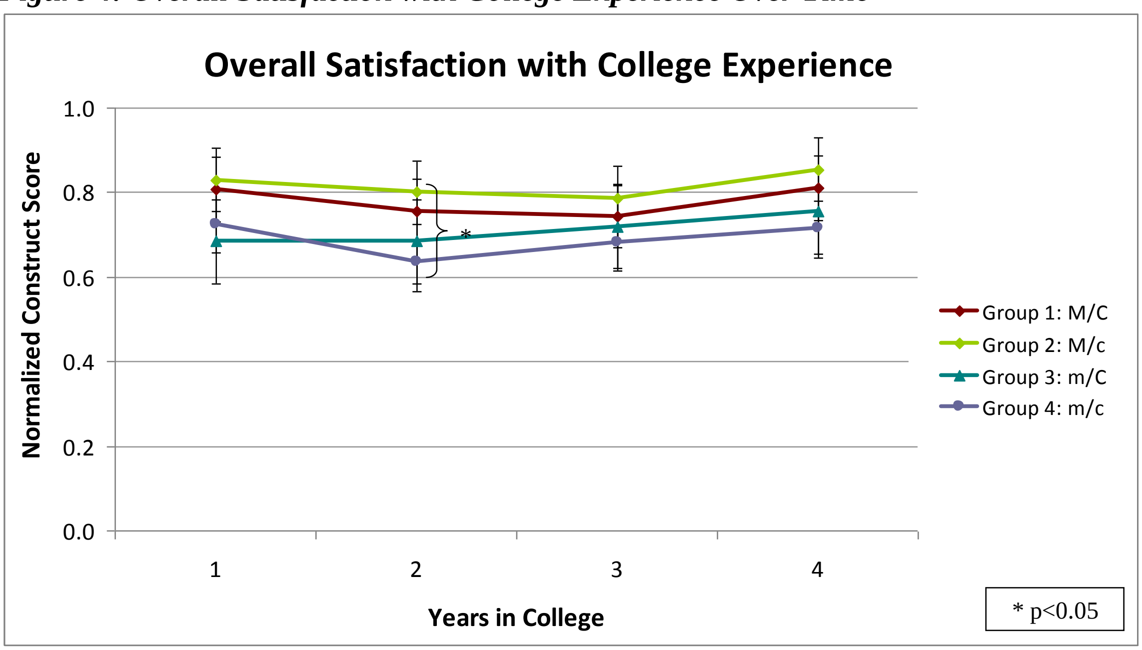


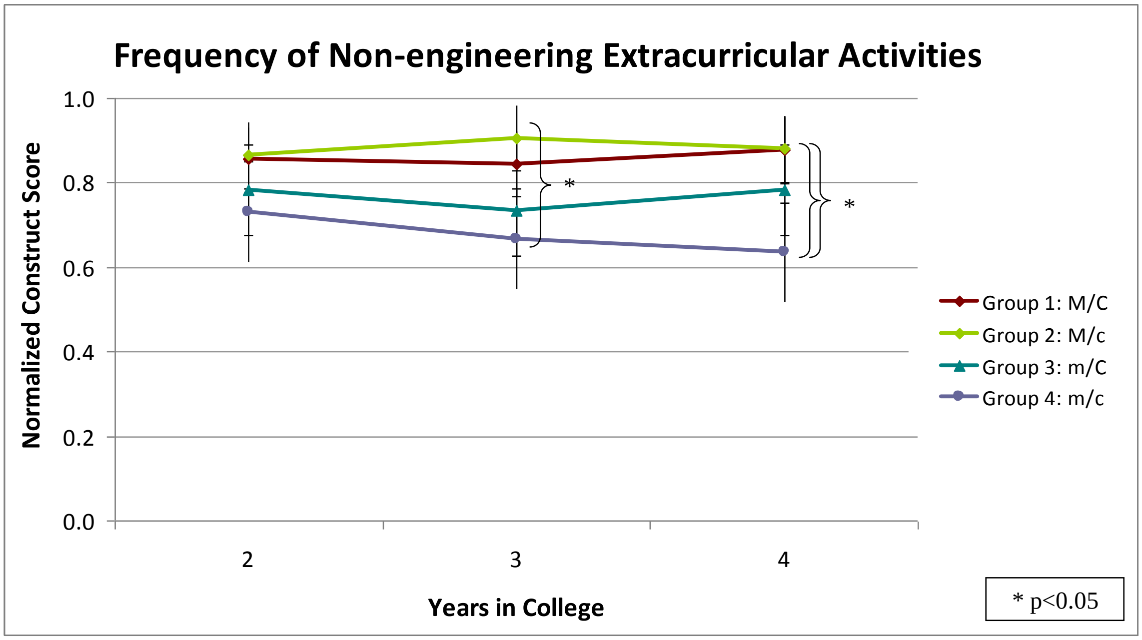
Figure 4 shows that the Group 2 students were most satisfied with their college experience over the four years. The means of Groups 2 and 4 were significantly different at the end of Year 2. RM-ANOVA revealed a significant administration effect for Group 4 ($p<0.05$). The trend appears to be a dip in satisfaction during sophomore year, followed by an increase in the junior and senior years.

Figure 4: Overall Satisfaction with College Experience Over Time



The students were also asked about their level of involvement in non-engineering extracurricular activities and their level of exposure to the engineering profession beginning in Year 2. Over the course of their education, the students in Groups 1 and 2 were more involved in non-engineering extracurricular activities than the students in Groups 3 and 4 (see Figure 5). The means of Group 1 and Group 4 were significantly different at the end of Year 4, and the means of Groups 2 and 4 were significantly different at the end of Years 3 and 4. There was no administration effect.

Figure 5: Frequency of Non-engineering Extracurricular Activities Over Time



Finally, Figure 6 shows that Group 1 students consistently reported greater exposure to the engineering profession through co-ops and internships than did Group 4 students. Their means were significantly different at all three time points. Despite these differences, RM-ANOVA revealed a positive increase in exposure for all four groups over time ($p<0.001$ for Groups 1 through 3; $p<0.01$ for Group 4).

Figure 6: Exposure to the Engineering Profession Over Time

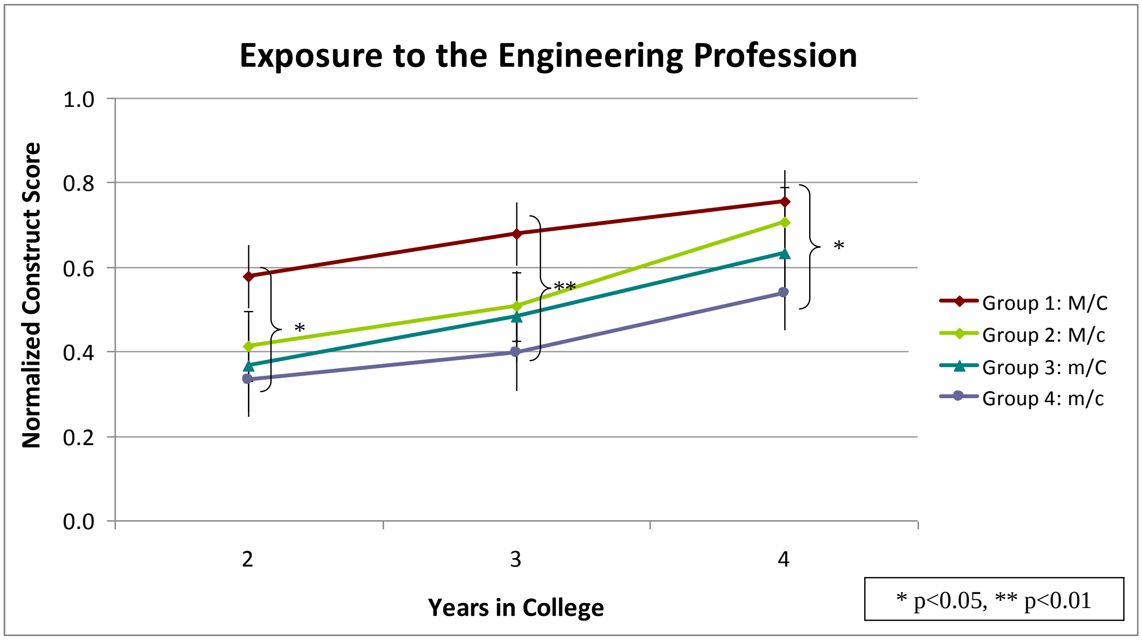


Table 8: Variables with Statistically Significant Differences Between Group Means

	Years in College			
Variable	**1**	**2**	**3**	**4**
Importance of Professional/ Interpersonal Skills [1]	Gr. 1 > 4 (***) Gr. 3 > 4 (**)	Gr. 1 > 4 (**)	ns	ns
Social Good Motivation [2]	Gr. 1 > 3 (*)	ns	Gr. 2 > 3,4 (**)	ns
Overall Satisfaction with College Experience [3]	ns	Gr. 2 > 4 (*)	ns	ns
Frequency of Non-engineering Extracurricular Activities [4]	ns	ns	Gr. 2 > 4 (*)	Gr. 1 > 4 (*) Gr. 2 > 4 (*)
Exposure to the Engineering Profession [5]	ns	Gr. 1 > 4 (*)	Gr. 1 > 4 (**)	Gr. 1 > 4 (*)

[1] $F(3, 85) = 5.679$, $p<0.01$
[2] $F(3, 91) = 5.490$, $p<0.01$
[3] $F(3, 91) = 3.726$, $p<0.05$
[4] $F(3, 92) = 4.355$, $p<0.01$
[5] $F(3, 92) = 5.601$, $p<0.01$
* $p<0.05$, ** $p<0.01$, *** $p<0.001$, ns=not significant

For three of the five variables shown in Table 8, the main differences occurred between the two extremes, Groups 1 and 4. These two groups differed significantly in perceived importance of professional and interpersonal skills at the end of Years 1 and 2, in frequency of non-engineering extracurricular activities at the end of Year 4, and in exposure to the engineering profession at the end of Years 2 through 4. Group 1 means were also consistently higher than the Group 4 means for every one of these variables.

Based on these findings, we conclude that Group 1 students had higher levels of perceived importance of professional and interpersonal skills, participation in non-engineering extracurricular activities, and exposure to the engineering profession than did Group 4 students. Our conclusions complement those found in the APPLES technical report[1]. In the APPLES study confidence in professional and interpersonal skills was determined to be positively correlated with perceived importance of professional and interpersonal skills ($p<0.001$). Additionally, involvement in non-engineering extracurricular activities ($p<0.001$) and exposure to the engineering profession ($p<0.001$) were strong predictors of confidence in professional and interpersonal skills.

Case Studies of Students at the Extremes

One limitation of the APPLES study was that it lacked a qualitative component to help better understand how students from Groups 1 and 4 differed in their attitudes toward non-engineering extracurricular activities and internships. To answer this question, we present a short comparative study based on our ethnographic interview data of two students from the APS, whom we call "Hillary" and "Marie"[xii]. Hillary rated herself as high in intrinsic psychological motivation and professional and interpersonal confidence at the end of her freshman year, while Marie rated herself as low in both measures. Before discussing the individual students, we note that they were in many ways similar to one another. Both students were Caucasian females at a technical public university in the western United States. Both came from a high socioeconomic background, with at least one parent holding a graduate degree. Both pursued an engineering major in addition to two non-engineering minors, and both were strong students based on their GPA's. At the end of their senior year, they were separated by only 0.03 points on a four point scale. They both also reported moderate levels of curricular overload on their PIE surveys and, finally, both students planned to persist in engineering after graduation.

Hillary: High Motivation/High Confidence

Based on her interviews, Hillary was very academically and socially engaged in school. In addition to her busy class schedule, she was a member of a competitive swim team for all four years of college. Her teammates, many of whom she had classes with, made up her core group of friends.

> We do a lot of stuff during the season. We do all our dinners and things, especially for the freshmen because you can't always get what you need at the cafe for swimming. But, yeah, we'll do lots of parties … And then the other freshmen and I are pretty tight because we're all in the same classes, so we study together.

Hillary frequently acknowledged that competitive swimming was a major time commitment, but she contended that it helped her with time management and stress relief.

> I think [swim team] helps me be better in school because if I have practice in the afternoon, I know I have to get it done… I have to do it then and there.

[xii] The names of the two students are study pseudonyms used to protect the students' real identities.

> I tend to work out harder and more often on the hard weeks… My friends say, "Wait. You have no time so you're gonna go make more time to work out?,", which is backwards for a lot of people. But athletics is totally my stress release. Just gotta get through it and take it one day at a time.

An on-campus resident, Hillary also participated in non-competitive sports, several clubs, an honor society, and her local church. In her sophomore and junior years, she accepted a leadership position on her school's student athletic advisory committee. She resigned from this post in her senior year, but only so that she could devote more time to tutoring at a local elementary school. When the interviewer observed that she had a very rigorous non-academic life, she responded that she wanted to have a well-rounded college experience.

> I think that helps. I mean, you can get too focused on academics and kinda lose what college is all about. Like, college is not just academics.

Hillary had several internships as an undergraduate, with the first occurring the summer after her freshman year. These internships helped her secure a full-time position in her field after graduation. In her senior year, she named the ability to communicate effectively as an important skill for engineers to have. She also expressed her belief that all engineering students should be trained to be good communicators.

> I: Any other qualities that you can think of … that would be good qualities?
>
> R: Being in the right communiqué, especially in simple terms, taking something very complicated and mathematical and reducing it down to the bottom line. Because, in the engineering world, you're dealing with all sorts of people who aren't engineers, you know, the politicians and businessmen and bankers. And, they don't want the equations. They want, is the building gonna stand and how much is it gonna cost me.

> And I think so many people at this school think [liberal arts] classes are a joke, which they are at this school. I mean, it's a total joke. But I think I would toughen up that part of the curriculum because, while we're engineers and we need good technical degrees, we also have to be able to function in society and interface with society and explain our engineering fast to people that have no technical training.

In summary, Hillary was highly socially integrated with her school. She also had a significant amount of internship experience. While these non-academic activities required a major time commitment on her part, she viewed them as utilizing her time well and preparing her for engineering work.

Marie: Low Motivation/Low Confidence

In contrast to Hillary, Marie was not very socially engaged in campus. She had a small group of friends with whom she lived in an apartment off campus. She met these friends in her classes and claimed not have any friends outside of her major or minor departments. She often worried about keeping up with her coursework and felt like she did not have enough time for non-academic activities such as joining clubs, meeting people, and socializing. On more than one occasion, she admitted that she regularly sacrificed these activities for need of sleep.

> Choosing more hours of sleep versus getting to bond with other people is usually not something that I want. But it's just a choice that I make more frequently.
>
> I haven't been very outgoing and so I haven't gathered a large group of friends, and once in a while I get insecure about it and I'm like, "Oh, nobody likes me" … I haven't done very well with the friend-making but I haven't tried very hard.

In her freshman year, Marie talked about getting involved in more activities to help her better manage her time. Yet, in her second year, she took on several on-campus and off-campus jobs as a means to fill up her time instead.

> I wish I was more scheduled. I need to get involved in more activities that schedule my daily life a bit more so I'm not free in the evening from whenever I get off of class til two in the morning… I want… for my daily life to [be] a little more scheduled and regimented and more things to do.
>
> It's not really money most of the time. It's because I could put it on the resume, and it would be neat experience, and I could get exposure, and I could know such and such and so and so better in this department. I know I had a tendency in high school to do it too. If I had a block of time, then I was just like, I could fit a job in there. Yeah, just sort of a mentality I've developed. I take on more than I need to.

Marie said that her jobs left little time for her to do anything but "eat, work, [and] sleep". For example, in her second year, she said, "I don't have time to spend a Saturday making friends." Yet, she continually mentioned her regret at not having gotten involved in more activities on campus. She thought that being more engaged would have helped her feel less socially isolated.

> I would've gotten more involved first semester because I think that was a big source of my isolation.... I should've gotten more involved in, I'm not sure what. But I can see now how the kids that did get involved in student government or Greek organizations or things like that have a lot more to do and lot less social concerns.

Marie did not have an internship during her first two years of college because she lacked time to look for a job that she was qualified for. Instead she spent these summers doing custodial work while living at home in state. In the summer before her senior year, she had a formal internship in a research setting which inspired her to pursue a doctorate in her field after graduation. In her senior year, she named cleverness and determination (intrapersonal skills) as important for an engineer to have.

In summary, Marie demonstrated a low level of social integration with campus. She experienced difficulty balancing her school requirements with non-academic activities. While she regretted not getting more involved on campus, she seemed to prefer working at a job over socializing. However, her exposure to the engineering profession was limited to a single internship.

Discussion and Conclusions

In this paper, we categorized engineering students according to their scores for intrinsic psychological motivation to study engineering and professional and interpersonal confidence at the end of their freshman year. We divided the students into four groups according to whether they fell above or below the mean for these variables. We then compared the groups in terms of demographics and professional persistence and found no statistical differences between them. We did find group differences, however, in other variables related to the college experience. Particularly noteworthy were the differences between the groups at the two extremes, i.e., Group 1 with high motivation and high confidence and Group 4 with low motivation and low confidence. In general, Group 1 students had higher levels of professional and interpersonal skills, frequency of non-engineering extracurricular activities, and exposure to the engineering profession than did their Group 4 peers. These findings were similar to those found in the APPLES study.

Case studies from our ethnographic interview data demonstrated differences in the way that two students from Groups 1 and 4 thought about non-academic activities. In terms of demographics, academics, and professional persistence, Hillary and Marie were very nearly identical to one another. However, Hillary was very engaged in non-engineering extracurricular activities such as competitive swimming. She also had several internship experiences in her field, beginning as early as her first year of college. While these activities required a lot of time, Hillary felt that they actually contributed to her academic success and well-being. We also found evidence that these activities helped her better understand the importance of professional and interpersonal skills to engineering work. Marie, on the other hand, was not very engaged in non-engineering extracurricular activities or internships while in college. She felt that her schoolwork and work responsibilities left little time to do anything else. Based on her interviews, she seemed to ascribe little importance to professional and interpersonal skills.

We note that, while we chose to focus on Hillary and Marie, their attitudes and behaviors were representative of other students in their respective groups (as determined by interviews with these students). Like Hillary, other students in Group 1 were more likely to be involved in non-engineering extracurricular activities and to assume leadership roles in these clubs and organizations. They were also more likely to have several co-ops and internships as undergraduates. Like Marie, other students in Group 4 were more likely to say no to non-engineering extracurricular activities or to otherwise limit their participation as school and work demanded more of their time. They were also less likely to have co-ops and internships.

Implications and Future Work

Our findings indicate that intrinsic psychological motivation and professional and interpersonal confidence at the freshman level are positively linked to involvement outside of the classroom, i.e., non-engineering extracurricular activities and co-op/internship experiences, throughout college. However, we do not know whether high motivation and confidence levels drive Group 1 students to be very involved, or whether involvement in these activities reinforces their motivation and confidence. There could also be a third set of variables that were not studied that constitute the real cause. More work is needed to better understand this relationship.

We are also troubled by our findings regarding students with low motivation and low confidence. After four years in an engineering program, Group 4 students still ascribe relatively low importance to professional and interpersonal skills, even though these skills are critical to successful engineering practice. Again, we do not know how confidence and perceived importance are related. One possible explanation could be that Group 4 students downplay the importance of skills in which they lack confidence. In any case, we worry that students who ascribe low importance to professional and interpersonal skills may experience difficulty in their workplaces as these skills have not been sufficiently cultivated. A longitudinal study focused on the college-to-career transition of engineering students could allow us to address this question.

In terms of raising Group 4 students' appreciation of professional and interpersonal skills, Hillary's story tells us that non-academic involvement is crucial. Thus, faculty and student affairs professionals are encouraged to introduce as many of Kuh's "high-impact practices"[14] to their campuses as possible, including first-year seminars, common intellectual experiences, learning communities, writing-intensive courses, collaborative assignments and projects, undergraduate research, diversity experiences, study abroad, service learning, co-op/internships, and senior capstone courses. In addition to emphasizing the importance of professional and interpersonal skills, research from the National Survey of Student Engagement (NSSE) has shown that engagement in these practices is highly correlated with other student outcomes such as depth of learning, retention, and achievement[14].

We note that various approaches and interventions have been carried out to address students' intrinsic motivation and professional and interpersonal confidence as well. For example, project-based learning[15], cooperative learning[16], and laboratory design experiences[17] have been shown to increase students' intrinsic motivation to study and persist in engineering. There is also evidence that first-year engineering projects[18], capstone courses[19], multidisciplinary courses[20], peer-led learning workshops[21], K-12 outreach[22], active learning and problem-based learning[23] enhance students' confidence in various professional and interpersonal skills. We offer these examples as additional ways in which engineering educators can facilitate the m/c students' development.

Yet, as we have shown, it can be difficult to reach out specifically to Group 4 students because they are demographically and academically similar to their more involved peers. As such, another possible avenue for research might be to explore whether there are additional distinguishing characteristics of Group 4 students that can help us identify who they are. We also recommend future work examining the motivation and confidence levels of engineering students who do not persist in their majors. If a significant number of these students fall into the m/c category, addressing systematic issues contributing to their low motivation and confidence levels might help to improve retention.

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