An Analysis of Freshman Engineering Student Attitudes

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***Abstract* - This paper focuses on identifying attitudes of freshman students that come from varied backgrounds and preparation then determining the changes in those attitudes during their first semester. For this purpose, students in freshman engineering classes were given the Pittsburg Freshman Engineering Attitude Survey twice as an assignment during their first year; pre-survey at the beginning of fall semester and post-survey at the beginning of spring semester. Typical Freshman Engineering students, who are qualified to take Calculus I (on time) or Precalculus (one semester behind), enroll in Introduction to Engineering I in fall semester and Introduction to Engineering II in spring semester. Some of our students, who are qualified to take College Algebra (two semesters behind), enroll in Fundamentals of Success in Engineering Study in fall semester and move on to Introduction to Engineering I or II in spring semester. High-achieving honors students who are qualified to take Calculus II or beyond can enroll in Honors Research or Innovation Experience and Colloquium. The analysis of survey results showed that students' perception of engineering, persistence in engineering and their desire to be involved in campus all increased from fall semester to spring semester. Our analysis for differences among the students enrolled in different types of freshman engineering classes revealed that while the confidence levels in science and math differ, the persistence in engineering, perception of engineering, study and social skills did not show significant difference between students of varied backgrounds.**

Index Terms –Freshman attitudes, honors, math placement, PFEAS, retention.

INTRODUCTION

The Freshman Engineering Program (FEP) in the College of Engineering (CoE) at the University of Arkansas was established in 2007 to improve the retention of first-year engineering students to the sophomore year and ultimately support the CoE long-term goal of increasing graduation rates. Since the establishment of FEP, the second-year retention rate for the CoE has increased from 62% to 71%. Identifying the factors which influence retention and using the resultant information to improve the academic and student service support for freshman engineering students is critical to the continual success of our program. Towards this effort, we collect and analyze data in many areas.

One area we focused on in recent years is identifying freshman students' attitudes which are influenced by varied backgrounds and preparation then determining the changes in those attitudes during their first semester based on varied class experiences. Types of freshman engineering classes offered through our program are listed and described below. Researchers have shown that attitudes of freshman engineering students change over the course of their first academic year and suggested that these attitudes and how they change throughout a student's undergraduate education can provide insight into understanding students' decision to remain in engineering and their ability to perform well if retained [1-4]. An assessment of attitudes can also be used as a tool to evaluate and improve the educational process.

The Pittsburg Freshman Engineering Attitude Survey (PFEAS) has been developed to measure students' attitudes about engineering and their confidence in their abilities to achieve in engineering disciplines [1-3, 5, 6]. We administered PFEAS at the beginning of each semester in all types of freshman engineering classes since Fall 2015. We included the descriptions below for each type of course offered in FEP in order to better explain our student population.

Our long-term goal is to gain an understanding of the attitudes of our students, create assessment tools, and determine any intervention for creating student success in engineering.

I. Course Descriptions

All FEP students are required to participate in the FEP peer mentoring program and in the weekly drill sessions which include information about the different engineering majors and departments on campus as well as topics related to professional development. In addition to these components, we strive to provide our students with appropriate level of instruction of engineering content which allows remediation of under prepared students and unique opportunities for students who enter with advanced standing. This is why we offer several different types of Freshman Engineering courses (GNEG). The key factor in determining which GNEG courses a student is allowed to take is their initial math placement.

- **GNEG 1201 Fundamentals of Success in Engineering Study:** GNEG 1201 was developed for students who are behind in the engineering eight semester degree plans with regards to their math placement (i.e, enrolled in college algebra during first fall semester or pre-calculus during the first spring semester). Because these students

may not have the math skills needed to begin developing fundamental engineering skills, we developed this course to focus on study skills so that students will be successful when they begin taking their engineering courses.

- **GNEG 1111 Introduction to Engineering I:** GNEG 1111 is the most common first course taken by FEP students, and students who qualify to take Precalculus or a higher math may enroll in this course. In GNEG 1111, students master basic skills needed to be successful in sophomore-level engineering courses, as well as, gain experience working on hands-on, group projects.
- **GNEG 1111H Honors Introduction to Engineering I:** GNEG 1111H is for students who qualify for GNEG 1111 but also are a part of the honors college. Requirements to join the Honors college are a 28 ACT (or SAT equivalent) and a High School GPA of 3.5 or higher. The course is taught concurrently with GNEG 1111 and requires some extra work on assignments for honors credit.
- **GNEG 1121 Introduction to Engineering II:** GNEG 1121 is the most common second course taken by FEP students, and students who have completed GNEG 1111 and qualify to take calculus I or higher math may enroll in this course. In GNEG 1121, students continue to master basic skills needed to be successful in sophomore-level engineering courses and gain experience working on hands-on, group projects.
- **GNEG 1121H Honors Introduction to Engineering I:** GNEG 1121H is for students who qualify for GNEG 1121 but also are a part of the honors college. The course is taught concurrently with GNEG 1121 and requires some extra work on assignments for honors credit.
- **GNEG 1301H Honors Research Colloquium (Fall 1st 8-week):** GNEG 1301H is offered as an alternative to GNEG 1111H for students who are in the honors college, initially qualify to take Calculus II or higher math, and are looking to gain skills beyond engineering fundamentals. GNEG 1301H outlines basics of research in the CoE and gives students the unique opportunity to begin research as a freshman. Students who elect to take this course must still exhibit mastery of the fundamental skills taught in GNEG 1111H.
- **GNEG 1311H Honors Research Experience I (Fall 2nd 8-week):** Students who take GNEG 1301H continue with GNEG 1311H during the second eight weeks. In this course, students begin research with CoE faculty member. The continue this research in GNEG 1322H in the spring concluding with Honors Research Symposium.

In Fall 2016, an alternate version of the GNEG 1301H/1311H/1322H course sequence was created for "Innovation" experience rather than "Research". This sequence outlines basics of innovation and entrepreneurship and gives students the unique opportunity to develop an innovative design project as a freshman. Since the collection of this data, the Innovation courses have been relabeled GNEG 1401H/1411H/1422H. For the results section of this paper, we labeled all the fall sections of Honors Research Experience and Honors Innovation courses as "GNEG 1301H".

RESULTS AND DISCUSSION

The Attitude Survey was administered online to all Freshman Engineering students through our learning management system during the first two weeks of the semester. Students were expected to complete the survey as an assignment for their respective GNEG course. Results were downloaded then combined or separated based on necessary groupings.

The Attitude Survey was too long (i.e., 70 questions) to discuss each question; therefore, a group of 16 questions that we identified to be most relevant to our program and our students were selected for analysis. These questions represent a cross section of attitudes that are a concern in Fall and those expected to be influenced by their first semester in FEP.

TABLE I
QUESTIONS SELECTED FROM PITTSBURG FRESHMAN ENGINEERING ATTITUDES SURVEY.

Q	Question
6	The future benefits of studying engineering are worth the effort.
8	I have no desire to change to another major (ex. biology, English, chemistry, art, history, etc.).
17	My parent(s) are making me study engineering.
24	An engineering degree will guarantee me a job when I graduate.
32	Engineers need good communication and writing skills.
34	Anyone who starts off as an engineering major has the ability to graduate in engineering.
36	I would rate my confidence in Chemistry as:
37	I would rate my confidence in Physics as:
38	I would rate my confidence in Calculus as:
42	I would rate my confidence in Computer Skills as:
43	I feel I know what an engineer does.
46	I need to spend more time studying than I currently do.
47	I have strong problem solving skills.
58	I am confident that I will succeed in engineering study.
63	I tend to procrastinate, putting off the things I need to do
70	I plan to join a student engineering organization.

For purposes of discussion, the questions were further grouped by categories:

- Persistence in Engineering (questions 6, 8, 17, 24, 34, & 58),
- Perceptions of Engineers (questions 32 & 43),
- Confidence in Skills (questions 36, 37, 38, 42, & 47), and
- Study & Social habits (questions 46, 63, & 70).

We conducted two sets of analysis. The first set of analysis was to see how typical students' attitudes changed from Fall to Spring. A typical FEP student is enrolled in GNEG 1111/1111H Introduction to Engineering I in fall semester, and enrolled in the sequence course GNEG 1121/1121H in spring semester. For this analysis, we used the combined results of Fall GNEG 1111/1111H from 2015 and 2016 and compared it to the combined results of Spring GNEG 1121/1121H from 2015 and 2016. A paired t-test was

done to examine differences from spring to fall with a 95% confidence interval. 1070 students took the survey in fall and 915 students took the survey in spring. The descriptive statistics results and P-values for each question are shown in Table II.

TABLE II
ATTITUDE CHANGE OVER TIME FOR THE TYPICAL FEP STUDENT. SAMPLE SIZE (N) = 1070 FOR FALL, N = 915 FOR SPRING. μ: MEAN, SD: STANDARD DEVIATION, DIFFERENCE Δ: $\mu_{SPRING} - \mu_{FALL}$. FOR CHANGES, "NS" STANDS FOR "NOT SIGNIFICANT", "+" IS CHANGE, "++" IS SIGNIFICANT CHANGE.

Q	μ_{fall}	μ_{spring}	SD_{fall}	SD_{spring}	Δ	P-value	Change
6	4.66	4.65	0.539	0.517	-0.010	0.689	Ns
8	3.83	4.00	1.01	1.01	0.170	0.000	++
17	1.60	1.72	0.748	0.823	0.121	0.001	++
24	3.42	3.48	0.977	0.972	0.064	0.142	Ns
32	4.09	4.18	0.765	0.723	0.096	0.004	+
34	3.30	3.25	1.20	1.24	-0.049	0.377	Ns
36	3.49	3.60	0.842	1.02	0.107	0.012	++
37	3.45	3.70	0.912	0.852	0.250	0.000	++
38	3.73	3.89	0.937	0.811	0.163	0.000	++
42	3.60	3.68	0.941	0.894	0.076	0.067	Ns
43	3.71	3.93	0.766	0.713	0.221	0.000	++
46	3.76	3.81	0.889	0.910	0.051	0.212	Ns
47	4.00	4.09	0.820	0.754	0.085	0.017	+
58	4.22	4.30	0.619	0.589	0.074	0.006	+
63	3.37	3.55	1.02	1.02	0.178	0.000	++
70	3.48	3.75	0.877	0.946	0.275	0.000	++

Question 8 essentially asks their likelihood of persisting in engineering. As expected, there is an increase because those that may have strongly considered changing their major did so between semesters. The questions related to why they persist in engineering mostly do not change from fall to spring. One that does have an increase is question 17 "parents are making me". This is not encouraging, but can be explained by those that are not being forced to stay in engineering have moved while those that are forced stay perhaps to their detriment. What is encouraging is the increase in question 58 "confidence to succeed in engineering".

Question 43 "I know what an engineer does" saw a large increase which makes sense based on the drill time given to each department as we help students decide which engineering degree best suits them. The small increase in question 32 (the expectations of communication skills) can also be attributed to emphasis in class, but as the fall mean was 4.09, it seems students already had those expectations.

The questions relating to confidence in other subjects (question 36 question Chemistry, question 37 Physics, and question 38 Calculus) mostly showed an increase. This can be explained in two ways. The more encouraging view would be that students learned well in the fall and feel more confident in spring. The more cynical view would be that the students who lacked confidence were no longer in engineering courses in spring. Confidence in computer skills showed an insignificant increase because they are not taking courses directly based on this. Problem solving skills showed a small increase which is another one of the goals of GNEG 1111/1111H.

As for the questions relating to study skills, students do not feel like they need more study time than they are putting in. The better follow-up question in spring might have been to rate "I spend more time studying than I expected." Since the survey was unaltered, what the results show is students basically feel they are studying the right amount whenever they take the survey. Question 63 shows that unfortunately procrastination increases. This is likely due to students not realizing their work load at the start of the year. They lack time management skills, but that was never a problem in high school. During their first semester, many struggle to stay on task, but we have at least made them aware of the issue by spring. Question 70 regarding a student organization has a large increase due to emphasis in our class by our peer mentors, departments, and our career services coordinators. Joining some organization (engineering or otherwise) is advertised as a must to promote a feeling of community, provide leadership opportunities, and establish employment connections.

After looking at our conclusions, we realized that we had left ourselves open to the possibility of some error in results due to the small population of students who left our program at the end of fall semester. Therefore, we conducted another paired t-test that only included students who stayed with the program. In order to increase the power of our t-test, we looked at samples with the same size, and we also paired the data for students who completed the survey during both fall and spring semesters. These results are shown in Table III.

TABLE III
ATTITUDE CHANGE OVER TIME FOR THE TYPICAL FEP STUDENT WHO COMPLETED THE SURVEY IN BOTH FALL AND SPRING SEMESTERS. SAMPLE SIZE (N) = 760 FOR FALL AND SPRING. μ: MEAN, SD: STANDARD DEVIATION, DIFFERENCE Δ: $\mu_{SPRING} - \mu_{FALL}$. FOR CHANGES, "NS" STANDS FOR "NOT SIGNIFICANT", "+" IS CHANGE, "++" IS SIGNIFICANT CHANGE.

Q	μ_{fall}	μ_{spring}	SD_{fall}	SD_{spring}	Δ	P-value	Change
6	4.68	4.66	0.508	0.520	-0.021	0.323	Ns
8	3.89	4.00	0.99	1.01	0.106	0.013	++
17	1.60	1.70	0.752	0.814	0.098	0.001	+
24	3.39	3.45	0.974	0.980	0.057	0.100	Ns
32	4.09	4.20	0.758	0.717	0.101	0.000	++
34	3.30	3.24	1.221	1.260	-0.058	0.197	Ns
36	3.53	3.64	0.840	1.011	0.108	0.001	++
37	3.47	3.69	0.900	0.866	0.219	0.000	++
38	3.82	3.92	0.885	0.813	0.102	0.001	++
42	3.62	3.66	0.915	0.895	0.041	0.131	Ns
43	3.72	3.92	0.746	0.722	0.205	0.000	++
46	3.73	3.80	0.883	0.905	0.068	0.047	Ns
47	4.01	4.11	0.829	0.733	0.095	0.002	+
58	4.23	4.30	0.598	0.591	0.066	0.004	+
63	3.35	3.54	1.032	1.020	0.186	0.000	++
70	3.52	3.78	0.881	0.948	0.260	0.000	++

Table III displays very similar results to Table II; therefore, we conclude that there are no significant changes in the analysis due to the students leaving engineering at the end of fall semester. However, these new set of data helps us to revise our conclusion on student's likelihood of persisting in engineering. We had thought the students leaving the program played a role in the increase in likelihood of persistence, but this increase is most likely due to the increase in student's confidence to succeed in engineering after a semester of getting used to the college life and classes.

The second set of analysis was to see if there were differences among our students depending on their fall GNEG course of study. We had four classifications: GNEG 1201 students (behind in math), GNEG 1111 students (on-time with math, typical student), GNEG 1111H students (on-time with math, typical student, in honors college) and GNEG 1301H students (ahead in math, in honors college, and enrolled in Research Experience or Innovation classes.) There are no GNEG 1311H results because those students took the survey during 1301H. The results from ANOVA analysis are shown in Table IV. The "Groups" column shows combinations in which the 95% confidence intervals overlap.

TABLE IV
ANOVA BETWEEN DIFFERENT CLASS TYPES FOR FALL SEMESTER 2015-16. GNEG 1201 (N = 184), GNEG 1111 (N = 694), GNEG 1111H (N = 381), GNEG 1301H (N =122).

Q	Class Type	μ	SD	95% Confidence Interval	Groups			
8	1201	3.70	1.02	(3.55, 3.84)			C	
	1111	3.92	0.99	(3.85, 3.99)	A			
	1111H	3.67	1.04	(3.57, 3.77)		B	C	
	1301H	3.93	1.01	(3.75, 4.11)	A	B	C	
17	1201	1.57	0.74	(1.46, 1.68)	A	B		
	1111	1.64	0.78	(1.59, 1.70)	A			
	1111H	1.51	0.67	(1.44, 1.59		B		
	1301H	1.48	0.72	(1.35, 1.62)	A	B		
32	1201	4.16	0.80	(4.05, 4.27)	A	B		
	1111	4.09	0.78	(4.03, 4.14)		B		
	1111H	4.09	0.75	(4.01, 4.17)		B		
	1301H	4.37	0.62	(4.23, 4.50)	A			
34	1201	3.53	1.21	(3.35, 3.70)	A			
	1111	3.37	1.19	(3.28, 3.46)	A	B		
	1111H	3.17	1.22	(3.05, 3.29)		B		
	1301H	3.18	1.27	(2.97, 3.39)	A	B		
36	1201	3.23	0.86	(3.11, 3.35)			C	
	1111	3.43	0.82	(3.36, 3.49)		B		
	1111H	3.61	0.86	(3.53, 3.69)	A			
	1301H	3.81	0.75	(3.66, 3.96)	A			
37	1201	3.39	0.87	(3.26, 3.52)	A	B		
	1111	3.40	0.93	(3.34, 3.47)		B		
	1111H	3.53	0.88	(3.44, 3.63)	A	B		
	1301H	3.66	0.98	(3.49, 3.82)	A			
38	1201	3.06	0.87	(2.93, 3.19)				D
	1111	3.64	0.96	(3.57, 3.71)			C	
	1111H	3.90	0.87	(3.81, 3.99)		B		
	1301H	4.36	0.77	(4.20, 4.52)	A			
42	1201	3.81	0.90	(3.67, 3.95)	A			
	1111	3.63	0.93	(3.56, 3.70)	A	B		
	1111H	3.55	0.96	(3.46, 3.65)		B	C	
	1301H	3.36	1.05	(3.19, 3.53)			C	
46	1201	4.14	0.81	(4.01, 4.26)	A			
	1111	3.82	0.85	(3.75, 3.88)		B		
	1111H	3.65	0.94	(3.56, 3.74)			C	
	1301H	3.65	0.96	(3.49, 3.81)		B	C	
58	1201	4.22	0.67	(4.12, 4.31)	A			
	1111	4.22	0.62	(4.17, 4.27)	A			
	1111H	4.24	0.62	(4.17, 4.30)	A			
	1301H	4.36	0.67	(4.25, 4.47)	A			
63	1201	3.49	0.99	(3.34, 3.64)	A			
	1111	3.37	0.99	(3.30, 3.45)	A	B		
	1111H	3.38	1.07	(3.28, 3.48)	A	B		
	1301H	3.18	1.06	(3.00, 3.36)		B		

The obvious questions we expect to see differences are those relating to confidence in their skills. Question 38 relating to confidence in Calculus is the only question with four distinct groups and results follow along what we would expect that confidence increases as math placement increases. Confidence in chemistry (Question 36) follows a similar pattern with 1301H not completely distinguished from 1111H. Confidence in physics (Question 37) is not as distinguished and the interesting result on that is the 1201 students have confidence matching higher placed students even though they will not be able to take physics until they reach Calculus I. Confidence in computer skills (Question 42) trends opposite to placement. Some of this skew may be due to the number of students choosing computer science where the perception is less math is needed for the degree. The reality is that while computer science does not continue to Calculus III or Differential equations, they actually take more math courses.

As for persistence, there are many overlapping groups. The distinction that is interesting in question 8 (not considering other majors) is that GNEG 1111 & 1301H can be distinguished as higher than GNEG 1201 & 1111H. There is an expectation that GNEG 1201 students might be considering alternatives once shown the long road ahead of them, but why GNEG 1111H students would be likewise low may be that they see more options to be successful and are not ready to commit to engineering. There are not significant differences in those feeling forced by parents (question 17) or in their belief they can succeed in engineering study (question 58). Similarly, GNEG 1201 students rate higher the idea that anyone can graduate in engineering (question 34). GNEG 1201course emphasizes that idea and may have been an influence as early as this first week of classes.

On the topic of procrastination (question 63), there is little surprise that the ones at the far end of the spectrum can be slightly different. The high achieving students procrastinate slightly less than the group as a whole and the ones at the bottom end of placement may procrastinate more. The encouraging counter to this is that GNEG 1201 students ranked higher on recognizing the need to study (question 46) while honors students rated it lower.

CONCLUSION

We conducted two sets of analysis on a selected set of questions from The Pittsburg Freshman Engineering Attitude Survey. Our first set of analysis, where we explored the changes in the attitudes of our typical engineering students from the beginning of fall semester to the beginning of spring semester, has revealed encouraging results that support our objectives in FEP. The students' perception of engineering, persistence in engineering, and their desire to be involved in campus all increased significantly, which are concepts we emphasize in our classes. The results also revealed that one area we can improve is to help our engineering students develop better study habits and time management skills.

The second analysis showed that students at all placement levels seem to mostly share common attitudes as

they enter our program. While the confidence levels in science and math differ, the persistence in engineering, perception of engineering, and study and social skills showed significance overlap.

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