Profiling the Successful First-Year Engineering Student

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Abstract **- Students' success in undergraduate engineering programs depends on more than their intelligence and prior academic experience. Beyond adapting to an increase in the difficulty of the material, students also need the ability to be self-directed learners. We designed this ongoing research to investigate the characteristics of successful engineering students, which we defined very broadly as those who made it to the second semester of their first year. Based on the principles of self-regulated learning, we employed three different existing, validated scales. We administered the *Revised Need for Cognition Scale*, the *Academic Attributional Style Questionnaire*, and the *Revised Academic Locus of Control Scale for College Students* to engineering students in an online survey, which also collected demographic information and details about the students' co- and extra-curricular activities. Students (*N*=96) completed the survey in the context of their first-year seminar, within a set of assignments for which they earned class credit. Analysis of the results will be focused on determining patterns of responses for the three individual difference scales, as well as investigating which additional components of the students' lives may be important factors in their success. In the fall, we will redeploy this survey to all incoming first-year students to compare to this year's baseline sample. Over time, we seek to create a profile of our successful engineering students.**

Index Terms - Individual differences, Persistence, Student success/development models

INTRODUCTION

Students' success in undergraduate engineering programs depends on personal qualities beyond their general intelligence and prior education in science, technology, engineering and math courses. Educators interested in retaining students through graduation might be able to intervene early in struggling students' education, if they can identify students likely to fail or otherwise leave the program. Faculty may hope or assume necessary skills and abilities are developed before the students come to college, but in fact, many of them arrive ill-prepared. So, what characteristics does the successful engineering student have, or need?

Based on the principles of self-regulated learning [1], students' success involves their ability to: monitor their thoughts and knowledge, that is, metacognition; plan and direct their motivation and effort; and employ effective study skills. Students' sense of responsibility for their own behavior and its consequences, and their beliefs about their own efficacy influence each aspect of self-regulation. Furthermore, individual differences, such as how much the student likes to think for the sake of thinking, or tackle difficult problems, factor into their ability to be self-directed learners [2]. Finally, transitioning from high school to college involves more than adapting to an increase in the difficulty of the material. College is more than courses; extra-curricular activities, outside and potentially competing responsibilities, and a marked change in independence and diversity also characterize higher education.

In recent years, diversity among incoming engineering students has increased. Unfortunately, this diversity has sometimes led to disconnects between student and faculty expectations and altered historical retention trends. The present research is designed to investigate some of the critical individual differences that characterize a successful engineering student, with the intention that such a profile could potentially help identify students needing assistance. Strategic, targeted intervention in the first year might identify and retain students who would otherwise leave engineering, and the purposeful use of time and resources benefits everyone.

METHOD

The present, ongoing study collected baseline data to establish a profile of a potentially successful undergraduate engineering student, which we broadly defined as one who has continued to the second semester.

Participants

Undergraduate engineering students participated in the context of their freshman seminar during the spring semester. The survey was an optional assignment within a set of assignments for which they earned class credit. The seminar is a pass/fail, zero credit-hour course, and is mandatory for all engineering students. Of the students who attempted the assignment (*N*=116 of 134 enrolled, or an 87% response rate), two were excluded from the sample because they responded to <10% of the items on the survey, and one

participant's redundant attempt was deleted. The last question on the survey allowed students to opt out of participating in this research by indicating that they wanted their responses excluded from analysis; 18 students (16% of the 116 completed surveys) chose to withdraw their data, leaving a final sample of 96. Students earned full credit for the assignment even if they left some items blank or opted out, and the course instructor did not see their responses.

Of the participants, 74% identified as men, 17% women, 2% preferred not to identify their gender, and 7% did not respond to this item. Participants' average age was 18.8 years (*SD* = 2.04). Students identified their majors as: mechanical engineering (43%), renewable energy (7%), ceramic (13%), materials science (8%), biomaterials (10%), glass (3%), and undecided (9%). Six participants (6%) declined to report a major. The vast majority reported only one major; a mere 5% were double majors and only 21% of the sample had declared a minor.

Materials and Procedure

The survey was one of several assignments that students could choose to earn participation credit in the course. The instructor of the freshman seminar announced the survey's availability online using a link posted in BlackBoard, the classroom management system, by email, and in class. The survey was available for nearly six weeks, after an extension of the deadline was granted to encourage more students to choose and complete the assignment. Students responded to the survey online via the eSurveysPro.com website, which is a secure, subscription-based surveying tool.

Upon following the link to the survey, students first encountered a page that described the survey and its purpose in general terms, gave instructions for completion, and asked them to indicate their intent to continue by typing in their full name. This step served as both the consent statement and as documentation for assignment credit.

The survey comprised three existing, validated scales from psychology and also collected demographic information and details about the students' co-curricular responsibilities and extra-curricular activities. The first psychological component was the Revised Need for Cognition Scale [2], which measures individuals' inclination to think about things for fun, to spend effort understanding situations, and frustration when their need is thwarted [3]. Participants responded to 18 statements such as, "I would prefer complex to simple problems," and "I really enjoy a task that involves coming up with new solutions to problems," by rating how characteristic each was of them, using a 9-point Likert-type scale ranging from -4 (*very strongly agree*) to 4 (*very strongly disagree*). After reverse-scoring the negatively phrased items, the total score for the scale was achieved by summing the ratings; scores can range from ±72, with higher, positive scores indicating a higher need for cognition.

The second component of the survey was the Revised Academic Locus of Control Scale for College Students [4], which measures students' beliefs about the cause of their behavior specifically concerning academic outcomes. People are generally characterized as having primarily internal locus of control beliefs, in which a person's own effort or ability determines the outcome, or primarily external locus of control beliefs, in which the influence of luck, task difficulty, or outside agents determines one's success or failure. Participants rated 21 statements such as, "I came to college because it was expected of me," and "I would never allow social activities to affect my studies," as either true or false of them. Negative items were reverse coded, and the total score was computed by summing the items rated true; scores can range from 0 to 21, and higher scores indicate a more external locus of control [4].

The third component of the survey was the Academic Attributional Style Questionnaire [5], which measures how students explain negative academic outcomes. People who have a dysfunctional attribution style tend to believe the causes of their own behavior and outcomes are not in their control and that the causes are stable across time or situation (e.g., "I am just not good at math"). Conversely, students who see the cause of their behavior as internally controllable and temporary (e.g., "I could try harder and possibly succeed") will have substantially healthier emotional and motivational reactions to negative academic outcomes [5]. Participants were given six negative scenarios, such as, "You fail an examination," and "You cannot get started writing a paper." For each scenario, participants first gave a free-response cause for the situation; then, they rated each cause on the same 12 semantic differential scales, with three apiece representing four primary dimensions on which the cause could vary: Locus, Personally Controllable, Stable, and Externally Controlled. Their ratings indicated where the cause lay between two endpoints such as, "This reflects an aspect of the situation <---> This reflects an aspect of you," and "Over which you have no power <---> Over which you have power." The questionnaire produces 12 continuous subscale scores by averaging the ratings for each dimension across the six scenarios. They are quantified by using 1 at the leftmost value and 9 at the opposite extreme. The scores were further condensed by collapsing the three conceptually related dimensions into an average score for each of the four primary dimensions. Higher averages indicated more internal locus, personally controllable, stable, and externally controlled attributions.

The last section of the survey collected demographic information from the participants, including: gender, age, engineering major, extra-curricular activities as categorical groups (e.g., "Student organizations or clubs"), average weekly hours of on- and off-campus employment, enrolled credit hours, and whether they were double majoring or had declared a minor. The final page of the survey thanked them for their participation in the survey, reiterated their rights as research participants, and gave them an opportunity to remove their data from the analysis for the study. Students who opted out were removed from the dataset before analysis, but still received full credit for completing the assignment. The dataset was anonymized before analysis.

TABLE I
ACADEMIC ATTRIBUTIONAL STYLE QUESTIONNAIRE (AASQ) DESCRIPTIVE RESULTS

	M (SD)	Range	Proportion of Categorized AASQ Scores (% and Interpretation)		
Locus	6.50 (1.26)	3.44 – 9.00	63.5% Internal	36.5% Intermediate	0% External
Personally Controllable	6.69 (1.28)	3.28 – 9.00	71.9% Personally controllable	28.1% Intermediate	0% Not personally controllable
Stability	3.38 (1.23)	1.11 – 7.67	40.6% Unstable	56.3% Intermediate	3.1% Stable
Externally Controlled	3.86 (1.45)	1.00 – 7.67	27.1% Not externally controlled	66.7% Intermediate	6.3% Externally controlled

Future Plans

The same method described above will be repeated using the incoming first-year engineering class in the fall semester (anticipated enrollment of 145 students). That sample, unlike the baseline, will include students who will leave either engineering or the university, and their data will be separated from those who remain enrolled for spring semester and compared to both their successful cohort-mates and the baseline.

RESULTS AND DISCUSSION

Because the present research is in-progress, the preliminary results reported here are limited to descriptive statistics for our baseline cohort sample. Future analysis will compare successive cohorts and segregate the successful students from those who did not persist. We will also conduct deeper analysis of the samples' demographic characteristics to look for patterns of individual differences among sub-populations within and across first-year engineering student cohorts.

Participants scored slightly lower than the midpoint on the Need for Cognition Scale (M= -17.93, SD= 16.96), indicating an intermediate-level need for cognition [3]. Scores ranged from -61 to 23, which is skewed lower than might be expected of a university-based sample. People's need for cognition is typically correlated with their choice of profession; for example, people with low need for cognition are more likely to be employed in manual labor or low-skill professions, whereas people with a high need for cognition will be more represented in academia and business [3]. The first cohort's scores will be more informative when we are able to compare them to the students who are not successful in subsequent cohorts.

On the Academic Locus of Control (ALCS) [4], participants' average score was 7.45 (SD= 3.39, *Range* = 0-15). For this scale, higher scores mean a more external orientation, so this sample exhibited a more internal locus of control. This result is consistent with expectations of successful students; people with an internal locus of control are more likely to feel responsible for, and in control of, their own outcomes [4].

The Academic Attributional Style Questionnaire (AASQ) produces four subscale scores denoting the dimensions that comprise attributional style (see Table I). The baseline cohort exhibited the pattern of attributional style expected for successful students [5]; for the vast majority, they considered the causes of the negative scenarios to be internally controllable, unstable, and not externally controlled. These students consider themselves able to do something different to achieve a better outcome; they are neither stuck with a bad situation, nor at the mercy of fate nor powerful others. Contrary to occasionally pessimistic professors' perceptions, all students do not feel as though the teacher "gives" them a grade rather than them earning their own grades, and they are able to explain their behavior without relying solely on excuses.

Because the AASQ [5] includes a measure of locus of control and personal controllability, the scores from it should align with participants' scores on the ALCS, and we generally found that to be the case (Pearson's r = -.17, p = .10). First, the subscale scores from the AASQ's locus of control and personal controllability were combined as averages, and in that scale, high scores mean more internal and personally controllable attributions. On the ALCS [4], high scores indicate an external locus of control. Therefore, a negative correlation between AASQ and ALCS would indicate the participants' scores are generally consistent across measures. However, the fact that the resulting correlation is only marginally statistically significant is interesting, and will need to be explored when we are comparing our baseline results to future cohorts.

Finally, we collected information about other aspects of the participants' life, to discern responsibilities and interests potentially competing for time and energy (see Table II). As is often the case, the students' lives are very full. While most were not externally employed, a majority were involved in extra-curricular activities, with 12% involved in two or more. In the future, we will explore the correlations between these outside factors and the individual difference measures described above and compare across cohorts.

TABLE II
PARTICIPANT DEMOGRAPHIC INFORMATION AND EXTRA- AND CO-CURRICULAR RESPONSIBILITIES

Credit Hours Enrolled for Spring Semester:		M= 16.93, (SD=2.18)	*Range*= 12 to ≥21
On-Campus Employment:	68.8% not employed	20.8% work 1-10 hrs/wk	4.2% work >10 hrs/wk
Off-Campus Employment:	78.1% not employed	7.3% work 1-10 hrs/wk	7.3% work >10 hrs/wk
77.1% Involved in anything	35.4% Varsity Athletics	8.3% Performing Arts	36.5% Student Organizations

Implications

Universities are invested in increasing students' success and diversity in their undergraduate engineering programs. As stereotypes of the typical engineer diminish, recruiting efforts produce more variable cohorts. However, the variability accompanies a wider range of preparedness for the rigors of higher education in general, and engineering programs in particular. It is not unusual for a distressing proportion of students to depart from engineering or the university altogether. This attrition is harmful to the student, the field, and the university's bottom line. Everyone benefits by improving students' chances of success.

If we can create a profile of the successful engineering student by measuring individual differences known to influence students' motivation and academic outcomes, we can plan more effective retention solutions—within engineering or the university. Using such a profile, faculty and support staff could potentially identify students likely to need additional attention and resources and change those students' trajectories. This research, based on an unusual collaboration across disciplines, could substantially increase our understanding of the actions needed to educate and retain an increasingly diverse population of engineering students.

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