Why Do Students Choose Engineering? Implications for First-Year Engineering Education

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***Abstract* – Developing first-year courses to include activities that align with student motivations for pursuing engineering may encourage retention. A study was completed to explore reasons that students choose to become engineers. Open-ended responses from civil engineers enrolled in a first-year course were classified according to a set of 10 common reasons for choosing engineering. The most prevalent categories cited by students were the drive to make/build something (*behavioral*), the desire to be *technically challenged*, and a general interest in the field (*psychological*). The least common motivations were *mentor influence*, *previous courses/experiences*, and *prestige*. No significant differences in retention were found based on reason for choosing engineering. Results from this work and others suggest the need to design first-year courses that are interactive, appropriately challenging, and appealing to a diverse group of students.**

Index Terms - Motivation, Retention, Civil Engineering

INTRODUCTION

A substantial engineering workforce is essential for ensuring a prosperous future for the United States (US). For instance, engineers will be key players in developing innovative strategies for solving emerging problems, such as climate change and dwindling petroleum reserves. However, numerous studies have highlighted the difficulties in sustaining recruitment and retention of engineering students [e.g., 1]. Developing first-year engineering courses to include content and activities that align with student motivations for pursuing engineering may serve to improve retention.

Several studies have investigated reasons that students choose to pursue engineering. For instance, the Academic Pathways of People Learning Engineering Survey (APPLES) was designed to capture student motivations for pursuing engineering [2]. The survey consists of six different motivation constructs: financial, parental influence, social good, mentor influence, intrinsic (psychological), and intrinsic (behavioral). The psychological category captures ideas related to enjoying or liking engineering, while the behavioral category captures the desire to *do* something, such as build, fix, or solve. In his popular first-year engineering textbook, Ray Landis also presents the top ten benefits of becoming an engineer: varied opportunities, challenging work, intellectual development, social impact, financial security, prestige, professional environment, understanding how things work, creative thinking, and self-esteem [3]. Other authors have confirmed the APPLES and Landis classifications, based on samples of chemical engineering [4], community college [5], civil engineering [6], and graduate [7] students.

Several authors have investigated the impacts of independent variables, such as gender and major, on motivation for choosing engineering. Overall, males were shown to be more *behaviorally* motivated than females [2]. By major, females in mechanical engineering are less *behaviorally* motivated than males and are more likely to have been influenced by a *mentor* [8]. Also, industrial engineers are less *behaviorally* motivated than mechanical or aerospace engineers [8]. Bielefeldt [9] also shows that *improving society* is a key motivational factor for female civil and environmental engineering students.

Fewer studies have examined the impact of student motivation on dependent factors, such as retention in engineering. Among students who chose to leave engineering, key factors initially attracting them to the field were being good at math/science, financial opportunities, and the desire to build/fix things [10]. Atman et al. [11, 12] found that non-persisters were more influenced by family members than persisters, while Anderson-Rowland [13] concluded that motivation had no impact on retention. Consequently, additional work is needed to characterize the impact of student motivation on persistence in engineering.

The goal of this study was to explore first-year students' motivations for pursing an engineering degree. The objectives were to: (1) classify students' reasons for enrolling in engineering and (2) quantify the impact of motivation on retention. Results will be used to provide insights for first-year engineering education, as well as directions for future work.

STUDY METHODS

A preliminary investigation was conducted to analyze students' reasons for majoring in engineering. At the beginning of the Fall 2013 and 2014 semesters, a survey was administered to first-year civil engineering students at a small, teaching-focused college in the southeastern US. In addition to answering 50 multiple choice questions, students also responded to the open-ended question: "Why did you choose to become an engineering major?" Of the 198 total

students, 97 surveys (49%) included responses to the open ended question, as well as a name (necessary to determine retention). Of the 97 participants, 91% were male.

One faculty examined student responses and evaluated the appropriateness of the APPLES motivation constructs [2] and Landis's list of top benefits of becoming an engineer [3]. Upon preliminary coding, the faculty evaluator identified nine different categories that were reflected in student responses (Table I). Also, *military*, *previous courses/experiences*, and *aptitude* categories were created to capture additional aspects of student responses.

TABLE I
PRELIMINARY CATEGORIES IDENTIFIED BY SINGLE FACULTY EVALUATOR

Category	Source
Aptitude[1]	Emerged from data
Behavioral/How things work	APPLES, Landis
Financial[2]	APPLES, Landis
Job Security[2]	Landis
Mentor Influence	APPLES
Military	Emerged from data
Parental/Familial	APPLES
Prestige	Landis
Previous Courses/Experiences	Emerged from data
Psychological	APPLES
Social Good	APPLES, Landis
Technical/Challenging[1]	Landis

[1,2]Later combined into single categories.

Next, an additional faculty was recruited to verify the categories. A sample of 16 student responses (not taken from the current sample) was coded by the two faculty according to the 12 pre-screened categories (Table I). Due to the overlap and vagueness of some student responses, it was concluded that *financial* and *job security* categories should be combined into a single category. For instance, one student wrote: "[engineering] is a solid career opportunity." It is unclear whether engineering is "solid" because there are many job opportunities and/or because there are high-paying jobs available. Similarly, *aptitude* and *technical/challenging* were condensed into a single category, since discussion of talent was related to technical and traditionally challenging subjects (e.g., "I am gifted with great math skills"). Overall, discussion among the faculty members resulted in 10 reasons why students choose to pursue engineering. Krippendorff's alpha for the practice session was 0.842, which is "adequately acceptable" [14].

After the practice session, student responses were coded by both faculty evaluators. Krippendorff's alpha for faculty's individual scores was 0.844, which is "adequately acceptable" [14]. Discrepancies in classifications were discussed, and a set of consensus classifications were reached. Fisher's exact test, which is appropriate for small and unequal sample sizes, was used to capture differences in student retention based on reason for choosing engineering. Retention was determined based on Spring 2015 enrollment.

RESULTS AND DISCUSSION

I. Classification of Student Responses

Consensus classifications revealed a variety of reasons why first-year students choose, at least initially, to pursue engineering (Table II, Figure I). *Behavioral* considerations, such as wanting to "build things" or have a "hands-on" job, were among the most common reasons for choosing engineering. Second, students were attracted to engineering because they wanted a *challenging/technical* career. Among the least prevalent reasons for choosing engineering were *mentor influences* and *previous courses or experiences*.

TABLE II
SAMPLE STUDENT RESPONSES AND CLASSIFICATIONS

Behavioral: "Because I like building things, and I want to know how stuff works."
Financial: "Job security is very strong." "Because of the great job opportunities that an engineering degree brings."
Mentor Influence: "It was suggested at a young age…"
Military: "I had to choose a technical engineering major after receiving an AFROTC scholarship."
Parental/Familial: "My father, grandfather…are engineers."
Prestige: "…prestigious [job]."
Previous Courses/Experiences: "…watched a show on green building…" "…took a few classes in high school…"
Psychological: "found it to be a fascinating field of study."
Social Good: "…I wanted to help improve society."
Technical/Challenging: "…I wanted more of a challenge." "I enjoy math and science…"

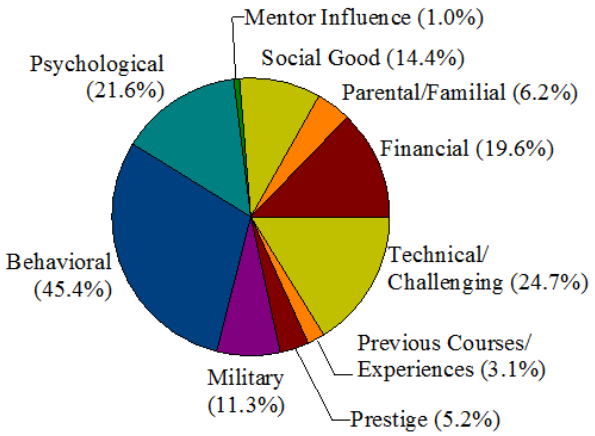

FIGURE I. STUDENTS (%) INDICATING EACH CATEGORY

II. Impact of Motivation on Student Retention

Impact of motivation on student retention was investigated (Table III). However, no significant differences in retention were found based on students' reasons for enrolling in engineering. Regardless of whether or not students persisted, they were most interested in *behavioral* and *technical* aspects of engineering. For persisters and non-persisters, mentor influence ranked as one of the least frequent motivations.

TABLE III
RETENTION BASED ON REASONS FOR PURSUING ENGINEERING

Reason for Choosing Engineering	Retained? Yes (%) (n = 69)	Retained? No (%) (n = 28)	Fisher's Exact p
Behavioral	47.8	39.9	0.504
Technical/Challenging	24.6	25.0	1.000
Psychological	21.7	21.4	1.000
Financial	20.3	17.9	1.000
Social Good	15.9	10.7	0.751
Military	11.6	10.7	1.000
Familial/Parental	7.2	3.6	0.669
Previous Experiences	4.3	0.0	0.554
Prestige	4.2	7.1	0.624
Mentor Influence	1.5	0.0	1.000

III. Implications for First-Year Engineering Education

Given that nearly half of all students indicated the desire to build, fix, and solve (*behavioral*), it is important that first-year classes be interactive. The positive impact of active pedagogies on student learning is well-documented, and leads to outcomes such as sharpened problem-solving skills [15]. Incorporating active activities into first-year courses may resonate with students' desires to be hands-on and encourage persistence in engineering.

Second, the technical rigor of first-year courses should be strategically set. On one hand, the *technical/challenging* aspect of engineering is one of the top reasons why students choose the field. Perhaps incorporating examples of emerging solutions for salient challenges would heighten student interest. Conversely, developing a first-year course laden with technical material may overload first-year students who are struggling through challenging math and science courses.

Third, it is important to design a course with a variety of activities and topics that resonate with the full spectrum of student motivations. Specifically, although not highlighted in this study, females may choose engineering for the purpose of promoting *social good*. Although the desire to improve society may not be one of the most prevalent reasons for choosing engineering, highlighting this aspect of the profession may be a successful strategy for retaining underrepresented groups.

CONCLUSIONS AND FUTURE WORK

A study was conducted to explore student motivations for pursuing engineering. First-year students enrolled in a first-year civil engineering course responded to an open-ended survey question, and two faculty evaluators classified responses according to a set of 10 categories. The following conclusions were made based on the results.

1. The most common reasons for choosing engineering were the desire to build/fix/do something (*behavioral*), the need to be *challenged*, and a general interest in the field (*psychological*).
2. The least common reasons for choosing engineering were *mentor influence*, *previous courses/experiences*, and *prestige*.
3. Reasons for choosing engineering had no significant impact on student retention.

Overall, it is suggested that first-year engineering courses be interactive, appropriately challenging, and appeal to a wide variety of interests. Future work will include investigating the impacts of several variables, such as gender and major, or student motivation and retention.

REFERENCES

1. Pierrakos, O., T.K. Beam, J. Constantz, A. Johri, and R. Anderson. "On the development of a professional identity: Engineering persisters vs engineering switchers", in *Frontiers in Education Conference, 2009*.
2. Kilgore, D., S. Sheppard, C.J. Atman, and D. Chachra. "Motivation makes a difference, but is there a difference in motivation? What inspires women and men to study engineering?", in *American Society for Engineering Education Annual Conference*. 2011. Vancouver, BC.
3. Landis, R.B., *Studying Engineering: A Road Map to a Rewarding Career*. 2007, Burbank, CA: Discovery Press.
4. Brawner, C.E., S.M. Lord, and M.W. Ohland. "Undergraduate women in chemical engineering: Exploring why they come", in *American Society for Engineering Education Annual Conference*. 2011. Vancouver, BC.
5. Anderson-Rowland, M.R., A.A. Rodriguez, and A. Grierson. "Why some community college students choose engineering and some don't", in *American Society for Engineering Education Annual Conference*. 2013. Atlanta, GA.
6. Ngambeki, I., O. Dalrymple, and D. Evangelou. "Decision-making in first-year engineering: Exploring how students decide about future studies and career pathways", in *American Society for Engineering Education Annual Conference*. 2008. Pittsburgh, PA.
7. Mattei, N.J. "Retention of women and minority engineering educators: Is this important to the profession?", in *American Society for Engineering Education Annual Conference*. 2002. Montreal, Canada.
8. Parikh, S., H. Chen, K. Donaldson, and S. Sheppard. "Does major matter? A look at what motivates engineering students in different majors", in *American Society for Engineering Education Annual Conference*. 2009. Austin, TX.
9. Bielefeldt, A.R. "Does engineering attract or repel female students who passionately want to help people?", in *American Society for Engineering Education Annual Conference*. 2014. Indianapolis, IN.
10. Marra, R., B. Bogue, D. Shen, and K. Rodgers. "Those that leave engineering - Assessing why students leave engineering", in *American Society for Engineering Education Annual Conference*. 2007. Honolulu, HI.
11. Atman, C., S. Sheppard, L. Fleming, R. Miller, K. Smith, R. Stevens, R. Streveler, C. Loneks_Jaret, and D. Lund. "Moving from pipeline thinking to understanding pathways: Findings from the academic pathways study of engineering undergraduates", in *American Society for Engineering Education Annual Conference*. 2008. Pittsburgh, PA.
12. Eris, O., D. Chachra, H. Chen, C. Rosea, L. Ludlow, S. Sheppard, and K. Donaldson. "A preliminary analysis of correlates of engineering persistence: Results from a longitudinal study", in *American Society for Engineering Education Annual Conference*. 2007. Honolulu, HI.
13. Anderson-Rowland, M.R. "Understanding freshmen engineering student retention through a survey", in *American Society for Engineering Education Annual Conference*. 1997. Milwaukee, WI.
14. Krippendorff, K., *Content Analysis: An Introduction to its Methodology*. 1nd ed. 2004, Thousand Oaks, CA: Sage Publications Inc.
15. Hassan, S.H.S., K. Mohd-Yusof, M.S. Abu, and S. Mohammad. "An instrument to assess students ' engineering problem solving ability", in *American Society for Engineering Education Annual Conference*. 2011. Vancouver, BC.