THE ATTRITION OF ENGINEERING GRADUATES: AN EXPLORATORY STUDY ON INFLUENTIAL CAREER CHOICE FACTORS

by

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# Abstract

Margolis, James (M.S., Mechanical Engineering)

The Attrition of Engineering Graduates: An Exploratory Study on Influential Career Choice Factors

Thesis directed by Instructor Daria Kotys-Schwartz

This study investigates the post-graduation attrition of engineering students. Attrition issues with undergraduate engineering students are concerning but well-documented. However, little research has explored post-graduation attrition. The demand for engineers in the workforce and anecdotal evidence of post-graduation attrition motivated this research. Two *mixed model* surveys administered over the course of one year classified students based on their post-graduation plans and yielded evidence that post-graduation attrition might be a problem among CU mechanical engineering students. The results indicate five factors that may influence post-graduation attrition: 1) feeling prepared to pursue an engineering career, 2) internship experiences, 3) Senior Design course experiences, 4) satisfaction with the quality of instruction in the engineering program, and 5) career values related to financial rewards and co-workers. The implementation of an internship program, the continued implementation of improved pedagogy, and increased monitoring of the Senior Design course are suggested as methods to reduce post-graduation attrition.

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# Chapter 1:Introduction

## 1.1 Motivation and Research Questions

As of 2002, approximately 1.2 million people in the United States with engineering degrees were employed in engineering-related jobs. However, 2.2 million people in the workforce had a degree in engineering, meaning about 1 million people with engineering degrees do not actually practice engineering (1). As other countries like China, and India increasingly compete with the United States in the production of engineers (2) and enrollment in U.S. engineering programs continues to lag behind other four-year degrees (1), training a consistent number of quality engineers has become a critical issue for the American workforce.

Existing attrition problems with engineering as a major—nationwide, less than half of undergraduate college students who start in engineering complete the degree—are concerning but well-documented (3). The number of engineering students who choose engineering careers is often not well-recorded. Though the University of Colorado at Boulder (CU) College of Engineering and Applied Science (CEAS) administers a graduation survey, it reveals little about the intended career plans of many graduating students, and how those career plans are influenced by their educational experiences. Some anecdotal evidence in the CU Department of Mechanical Engineering suggests uncertainty among students about engineering as a career. The combination of these factors beg a question of interest to engineering schools, engineering educators, and U.S. business and industry leaders alike: Is there an attrition problem among graduating engineering students?

A wealth of research on career choice development exists, but little if any research has examined factors in the educational experience of engineering students and their effect on post-graduation attrition. Thus, this research was designed as an exploratory study to begin to answer the following questions:

- Is there a post-graduation attrition problem among mechanical engineering graduates at the University of Colorado at Boulder?[1]
- What factors, if any, influence post-graduation attrition? In other words, what factors affect an engineering student's choice to pursue an engineering or non-engineering career?
- What, if any, changes in the educational experience could decrease post-graduation attrition rates?

## 1.2 Background

The theoretical framework for this study is comprised of two specific areas within the fields of engineering education and psychology: attrition of engineering students and career choice theories. The section on attrition of engineering students will outline a common theoretical student attrition model and describe in detail the significant predictors of engineering student attrition reported in the literature. Leading career choice theories, including Holland's Career Typology, Schein's

[1] Since this study is focused only in the Department of Mechanical Engineering at the University of Colorado, phrases such as "student," "graduate," etc. are assumed to be preceded by "University of Colorado Department of Mechanical Engineering…"

Career Anchor Model, and Social Cognitive Career Theory, as well as relevant literature on the choice of engineering as a career and the phenomenon of career change will be discussed in terms of their significance to this research.

An analysis of the CEAS graduation survey and discussion of its focus will precede an important debate about the relevance of this research: If graduating students are deciding not to pursue engineering careers, is that really a problem? Why should the College of Engineering and Applied Science be concerned? This debate, the CEAS graduation survey analysis, and the review of attrition and career choice literature emphasizing a lack of post-graduation attrition research will frame the motivation for this study.

## 1.3 Methods

Chapter 3 will address engineering education research design, including classification of my research design, blending quantitative and qualitative research methods, survey development and delivery, and statistical analysis considerations.

Two independent surveys were conducted over the course of this one-year exploratory study. The surveys had a mixed model research design that included quantitative Likert-style questions, forced-choice categorical questions, and open-end qualitative questions. Career choice development, factors related to attrition of engineering students, and issues identified in informal interviews served as the theoretical background for the questionnaire design. The first survey, given to mechanical engineering students graduating in December 2007, which gathered significant useful data, also served partially as a pilot data collection instrument to improve the delivery of the second survey. The second survey was administered to the Fall 2007- Spring 2008 Mechanical Engineering Senior Design course. Response rates for both surveys surpassed 80 percent.

## 1.4 Results

The detailed analysis of the survey is presented in three major sections:

1. A demographical characterization of the survey samples including the categorization of respondents into Post-Graduation Plans Groups based on their short- and long-term career plans;
2. An analysis of the entire sample's response and Post-Graduation Plans Groups' response to quantitative survey items;
3. A qualitative analysis of the response to open-ended survey questions.

The analysis revealed issues with post-graduation attrition and attitudes towards engineering as a career that is at least of significant interest, if not some mild concern, to the Department of Mechanical Engineering. Three major factors that may influence identification with a particular Post-Graduation Plans Group and therefore post-graduation attrition were also identified:

1. Preparedness to pursue an engineering career
2. Internship experience
3. Senior Design Project course experience

In addition, two other factors are posited to play a lesser but still important role in post-graduation attrition:

4. Satisfaction with the quality of instruction in the engineering program
5. Different career values, specifically those related to financial rewards and co-workers

## 1.5 Discussion, Conclusions and Future Work Recommendations

In Chapter 5, the extent of the evidence behind the five post-graduation attrition factors is investigated in detail. Results are triangulated across the two surveys and within interrelated survey sections. Results are also discussed in the context of the relevant existing literature and the limitations of the study are addressed. Finally, future areas of related research are suggested. Recommendations include both in-depth investigations of specific issues identified in this research and broader questions stemming from interesting observations in the results.

# Chapter 2:Background

## 2.1 Attrition of Undergraduate Engineering Students

Research on the attrition of engineering students has a long history. The 1930 Wickenden Report documented a 28 percent graduation rate among U.S. engineering students (4). Studies in the 1980s from the Higher Education Research Institute at UCLA, the Cooperative Institutional Research Program, and the Engineering Dean's Council drew attention to declines in interest and persistence in math and science-based majors, reporting undergraduate attrition losses of over 50 percent (5). Notably, about half of this attrition occurs during the freshman year (6). These studies, among others, provided the framework for Helen Seymour and Nancy Hewitt's *Talking About Leaving: Why Undergraduates Leaves the Sciences*, the landmark modern study on why undergraduates leave science, math, and engineering (SME) majors.

In engineering specifically, attrition research has been driven by declining student enrollment (1), an increased demand for qualified engineers (2; 7), and shrinking budgets coupled with cost analyses that indicate student retention is less expensive than new student recruitment (4). Attrition research has generally focused on two areas: individual student attributes (intrinsic attrition-related factors) and students' academic experiences (extrinsic attrition-related factors). SAT scores, high school and university GPA, gender, ethnicity, attitudes toward and beliefs about engineering, reasons for choosing engineering as a major, self-efficacy, and personality types have been identified as individual attributes that tend to predict engineering student retention (3; 4; 5; 6; 8; 9). Research on students' academic experiences has shown inaccessible instructors, uninspiring teaching methods, inadequate student support networks and low student social capital are factors that contribute to attrition while active, cooperative, and problem-based teaching methods, first-year project courses, and industry co-operative employment programs seem to reduce attrition (4; 6; 10). This section of the background will review a leading theory of college student attrition; intrinsic attrition-related factors such as choice of engineering as a major and/or career, prior academic performance, gender and ethnicity, attitudes, and personality characteristics; and extrinsic attrition-related factors like institutional cultures, pedagogical techniques, and student social capital and support networks.

### 2.1.1 Tinto's Theory of Student Attrition

The most frequently cited theory of college student attrition is that of psychologist Vincent Tinto's, who suggests that "individual departure from institutions can be viewed as arising out of a longitudinal process of interactions between an individual with given attributes, skills, financial resources, prior educational experiences, and dispositions (intentions and commitments) and other members of the academic and social systems of the institution" (11). Intentions and commitments are constantly modified by intellectual (academic) and personal (social) integration. Positive, or integrative, experiences enhance intentions and commitments, including those to the institution, and thereby reinforce persistence. Negative, or malintegrative, experiences do just the opposite—weaken intentions and commitments, reducing the likelihood of persistence. External commitments, those regarding life outside of the academic institution, also serve to modify intentions and commitments towards the institution. Pre-entry attributes, such as family and community backgrounds, skills and abilities, financial resources, dispositions and prior schooling serve as part of the "initial conditions" that form the subsequent interactions between the individual and other members of the institution. Additionally, academic performance and faculty interactions affect academic integration, while extracurricular activities and peer group interactions influence social integration. Finally, academic and social integration modify intentions and commitments that results in the ultimate decisions to stay in or leave college (11).

Tinto modeled his theory on Durkheim's Theory of Suicide. He cites the analog that attrition and suicide "represent a form of voluntary withdrawal from local communities that is as much a reflection of the community as it is of the individual who withdraws." Tinto also adds that attrition "highlights the ways in which the social and intellectual communities that make up a college come to influence the willingness of students to stay at that college." Thus, Tinto's theory challenges previous theories that ignored external influences and attributed attrition to "a personal failure of the individual to measure up to the demands of college life" (11).

### 2.1.2 Intrinsic Attrition-Related Factors

#### 2.1.2.1 Choosing Engineering as a Major

Seymour and Hewitt found that a student's reasons for choosing a major play a limited but somewhat important role in whether or not the student persisted in a SME major. Indeed, choosing an SME major for 'the wrong reasons' was the second most common choice-related problem (at 82.5 percent of reasons) cited by those who left SME majors. For "switchers," the term used for those who left SME majors, the "active influence of others" was the most frequently given reason for originally choosing an SME major. Family members, especially parents who were paying for a child's education, seemed to have the most influence, but peers, high school teachers and counselors, college advisors, and other role models and mentors also played significant roles. The pressure often focused on the financially-rewarding and prestigious career that an SME major would ostensibly offer, and warnings about careers with low pay and low status to which choosing an non-SME major might lead (5).

In contrast, choosing an SME major out of "intrinsic interest" was the most often cited reason by non-switchers. Non-switchers claimed that a choice based on personal interest encouraged identification with the major, a sense of direction, and a determination to persist through difficult times. Though the "intrinsic interest" might have been influenced or encouraged by parents or teachers, a key difference between those who cited "intrinsic interest" over the "active influence of others" in choosing their major was that they felt the choice was their own. Qualitatively, it seems that interests which were refined and enhanced over time more often resulted in persistence than interests based on a "romantic fantasy" (5).

Switchers were also more likely to choose SME majors on the basis of "pragmatism/materialism," such as the financial rewards, prestige, and job security that associated occupations offer, and because they were "good at math and/or science in high school" and an SME major seemed like a logical extension of these skills. In the case of "pragmatism/materialism," the desire to persist died quickly if not accompanied by a strong interest in the major. The perceived future benefits did not seem to be worth the cost of not enjoying their school work in the present. Similarly, switchers who chose an SME major on the basis of being "good at math and/or science in high school" had confused good grades with a true interest in the subject matter (5).

#### 2.1.2.2 Academic Performance: High School Rank, Standardized Test Scores, and GPA as Predictors of Persistence

Academic performance has often been linked to persistence in engineering majors. Though university GPA is often cited, performance variables are not limited to the university level. High school class rank, SAT scores (math scores in particular), and high school GPA have been shown to correlate with university performance and thus persistence (4; 5; 9; 12). Although some of the aforementioned factors were identified as early as the 1970s (13) and these quantitative student characteristics received most of the early engineering education research attention (4), studies have shown that they may only explain up to 25 percent of the variability in persistence data (9; 14). This has likely, at least in part, motivated research on individual student attributes like self-efficacy, attitudes and beliefs about engineering, reasons for choosing engineering as a major and institutional variables like pedagogy, social capital[2], and university culture.

[2] Social capital is a tool used to analyze social systems. It has gained attention from its use in fields such as sociology and economics, though it has also been applied to engineering education. According to Brown, et al, "social capital broadly consists of social networks, social norms, and the value of these networks and norms for achieving mutual goals" (10).

#### 2.1.2.3 Gender and Ethnicity

Nationwide, the underrepresentation of women and ethnic minorities in engineering is perhaps one of the biggest challenges facing engineering education and the engineering profession. Women and three particular ethnic minorities—African-Americans, Latinos, and Native Americans—have been historically underrepresented in engineering majors and careers. The numbers of women and minorities graduating with degrees in engineering have been increasing since the 1990s, but the degrees granted to men and whites have increased at a greater rate, negating the relative gains made by women and minorities as percentage of the entire engineering field (15). Even more troubling is the observed attrition rates for women and minorities, which are significantly greater than those of men and whites. Some graduation rates are as low as 30 percent (4).

The problem is complex and cultural differences and pre-college experiences play an important role. For women, disparities in classroom learning experiences and different expectations from math and science teachers have often resulted in women exhibiting less confidence in their abilities than men. Women tend to have preferences for cooperative learning styles (which conflict with the hegemonic individual competitiveness of some science disciplines), different concepts of success and failure, and doubts about the value of their achievements. Though women generally outperform men academically, they seem to be more affected by traditional science pedagogy and experience more disinterest in science courses than men (5). Additionally, women often report lower self-efficacy beliefs than men, which are tied to interest in SME majors (16). The sum of these factors is that fewer women choosing and persisting in SME majors (5; 16).

The attrition of minority students from SME majors is the highest among any demographic group, ethnic or gender. Although large-scale efforts by organizations like the National Science Foundation have improved enrollment of minorities, attrition rates have stayed the same. Minority students tend to be less prepared for college than white students, have less access to information about science and technology careers, are more likely to develop negative attitudes towards math and sciences in junior high school and not see their relevance to everyday life. Nationwide, inequalities in pre-college education underlie all of these factors. Minority students face challenges unique to their minority status: differences in cultural values and socialization processes, internalization of performance and ability stereotypes, racism and isolation, and poor support networks. Minority students' reasons for leaving SME majors differ significantly from those of whites. Minority students tend to cite "inappropriate reasons for their choice of an SME major," "conceptual difficulty with one or more SME subjects," and "inadequate high school preparation in basic subjects and study skills," illustrating the tendency of minorities to blame themselves rather than institutional factors for most of their difficulties. As with women, minorities often have a loss of confidence in ability to perform in SME majors that preceded attrition (5).

#### 2.1.2.4 Attitudinal Persistence Factors: Beliefs about Engineering and Self-Efficacy

Due to the observation that measures of academic performance are only limited predictors of persistence in engineering, more recent engineering education research has focused on student attitudes towards engineering and about their own abilities. In fact, a major finding from Seymour and Hewitt was that those who left engineering were not academically different from those who stayed and that attitudes were a better predictor of persistence than academic performance measures (5; 17). Besterfield-Sacre, Atman, and Shuman measured student attitudes and found that those who left engineering started their degree with less interest in engineering and less appreciation for engineering as a profession. Those who left also tended to enjoy math and science less than those who stayed, and also had lower confidence in their ability to succeed in engineering (17).

Student beliefs about engineering are influenced by knowledge of engineering as a profession and negative stereotypes of engineering. Yurtseven reports that one national survey found forty-five percent of the general United States population was not very well informed about engineering as a profession or of engineers as practitioners. The number was similar in a general sample of college graduates (1). Codone, Lackey, and Grady found some evidence that engineering students do not have a full understanding of the daily work of an engineer (18). Negative stereotypes of engineering in society are also prevalent. Historically, the archetype of an engineer was someone like Leonardo Da Vinci, the Renaissance artist also known for his brilliance as an architect, scientist, and engineer. Da Vinci designed and built cathedrals, other public buildings, and water canals (based on his studies of the surface of Mars) in Italy and France, designed weapons, studied the formation of clouds and weather patterns, published findings on the fluid mechanics of flow in blood vessels, and even produced a design for a rudimentary helicopter. Da Vinci's broad talents and creativity contrast with today's *Dilbert*-like image of a narrow, specialized engineer wedged in the corporate ladder with socially inept co-workers (1).

"Self-efficacy," the strength of a student's belief that he or she can achieve certain goals (as opposed to the aforementioned factor of self-confidence, which is merely the belief in one's abilities), is also an important predictor of persistence. As part of his social cognitive theory that describes human learning as the interaction of personal factors, environmental influences and behavior, Albert Bandura defines four sources of self-efficacy: *mastery experiences, vicarious experiences, social persuasions,* and *physiological states* (16; 19). *Mastery experiences*, which occur when successes build a strong belief in one's own efficacy but can also be undermined by failures, are the most important source of high self-efficacy. *Vicarious experiences* can be a source of efficacy when an individual has no experience or is unsure of his or her abilities in a certain area but is encouraged by the outcomes of others who have performed similar tasks. *Social persuasions* are the verbal judgments of others and can be an important source of self-efficacy. The *physiological states* that people associates with their actions, such as stress, anxiety, and fatigue, are the final source of self-efficacy proposed in Bandura's theory. For women in traditionally male-dominated fields, it seems that vicarious experiences and social persuasions play the largest role in the development of efficacy beliefs (16; 19). For engineering students, self-efficacy beliefs may be measured in a variety of areas, including perceptions of: problem-solving abilities in certain subject areas, course performance, computing abilities, teamwork issues, personal motivation, and enjoyment of material. Self-efficacy beliefs have been linked to persistence in engineering—those with lower self-efficacy beliefs are more likely to leave—by several studies (3; 16)

#### 2.1.2.5 Personality Type and Persistence

The personality type of oft-stereotyped engineering students seems to play a role in predicting student attitudes, performance, and persistence. The most common measure of personality type is the Myers-Briggs Type Indicator (MBTI) derived from Jung's Theory of Psychological Types. People are measured by their preferences in four areas:

- *"introversion* (I) (interest flowing mainly to the inner world of concepts and ideas) or

  *extraversion* (E) (interest flowing mainly to the outer world of actions, objects, and persons);
- *sensing* (S) (tending to perceive immediate, real, practical facts of experience and life) or

  *intuition* (N) (tending to perceive possibilities, relationships, and meanings of experiences);

- *thinking* (T) (tending to make judgments or decisions objectively and impersonally) or

  *feeling* (F) (tending to make judgments subjectively and personally);
- *judging* (J) (tending to live in a planned and decisive way) or

  *perceiving* (P) (tending to live in a spontaneous and flexible way). (20)"

The literature shows that in general, introverts, intuitors, thinkers, and judgers tend to outperform—and thus are more likely to remain in engineering—classmates of the extraverted, sensing, feeling, and perceiving personality types (8; 20), contributing to the Dilbert stereotype.

### 2.1.3 Extrinsic Attrition-Related Factors

> *"Contrary to the common assumption that most switching is caused by the personal inadequacy in the face of academic challenge, one strong finding…is the high proportion of factors cited as significant in switching decisions that arise either from structural or cultural sources in institutions…*(4; 5)"

The above conclusion from Seymour and Hewitt sums up the impetus for the new body of engineering education research, one that challenged the "the attrition problem lies with the students" paradigm and began to focus on the drawbacks of SME culture (such as competitiveness and the "weed-out" tradition), pedagogy, curriculum and advising issues. This new body of research has also been backed by findings that relatively few students—one study showed only 8.5 percent—actually leave engineering because of academic difficulty (4). Some of the major factors—

competitive SME culture, uninspired pedagogy, poor curriculum design, and inadequate student support network are discussed in the following sections.

#### 2.1.3.1 SME Culture: "Cutthroat" Competition and the "Weed-Out" Tradition

The competitive culture in SME education has been cited as an important factor in the decision of some undergraduate students to leave SME majors. Students often did not see the competition as healthy or natural, but found it alienating and discouraging.  Complaints often centered on curve-grading, "cutthroat" attitudes towards other students, an unwillingness to help others that is more isolationist than independent, and that the competitive ethos in SME is contrary to the cooperative working styles often found in work organizations.  Though students reported a dramatic shift towards cooperative learning in the junior year, even those who stayed in SME majors claim the competitive culture had diminished their educational experience.  Issues with grades—students who felt like they did not understand the material at all but who received relatively high grades, and those who were used to making good grades and found themselves discouraged with relatively lower ones—played a role in the switching decisions of some students.

The lore of the "weed-out" tradition was also mentioned by many students, who felt that faculty and administrators have pre-determined attrition rates to identify the best students.  The weed-out tradition was observed to be strongest among majors that serve professions—medicine and engineering.  Students saw the "weed-out" system to have two major functions:

1. Restrict entry to the engineering professions, protecting salary levels by matching the number of graduates with the number of jobs
2. Identify students that were best fit to continue in the major, which students found preferable to a pre-college selection process that would conflict with the democratic ideal of open entry to higher education

Though few students claimed to like the “weed-out” system, most could tolerate it. Engineering students felt that the “profit-to-grief ratio” was acceptable because they would be able to command good jobs and salaries after graduating. However, the “weed-out” system was often viewed as counter-productive because it encouraged cheating, overwhelming course loads that did not lead to a true understanding of the material, and indifferent and unapproachable instructors (5).

### 2.1.3.2 The Influence of Pedagogy on Persistence

Pedagogical techniques have a significant impact on students’ decisions to leave SME majors and their persistence and performance in the major. Seymour and Hewitt identified poor teaching as the third most frequently cited reason for leaving an SME major at 36 percent of switching reasons. Perhaps more convincingly, over 90 percent of switchers and 70 percent of non-switchers mentioned poor teaching as a concern they had about their SME major. Poor teaching was mentioned with far more frequency than complaints about curriculum, course pacing and structure, assessment methods, or workload. “Bad teaching” was associated with faculty being primarily concerned with research, not wanting to teach or not seeing it as an important part of their professional role, a disregard for teaching evaluations, unapproachability, and indifferent or dismissive attitudes towards students' questions about material and whether the students learned the course material (5).

On the contrary, students associated "good teaching" with "openness, respect for students, encouragement of discussion, and the sense of discovering things together" (5). Indeed, student learning has been positively correlated with faculty ratings in evaluation questionnaires completed by students (21). The importance of "good" and "bad" teaching has given rise to research on the best way to educate engineering students of all learning styles and backgrounds. New pedagogical techniques have incorporated active, cooperative, and problem-based learning methods and project-based courses designed to help retain students and improve student retention of the course material.

In active learning, students are actively engaged in classroom activities through quizzes, solving example problems in groups, individual worksheets, brainstorming sessions, classroom discussions and debates, classroom response systems that provide immediate feedback on student comprehension of concepts, and in-class writing assignments (22; 23). In cooperative learning, students work in small groups and apply their knowledge and skills to projects and problems, designed to maximize individual and teammates' learning. Problem-based learning starts by posing a problem, identifying knowledge needed to solve the problem, learning what needs to be known, and then applying the knowledge to solve the problem. Project-based courses, sometimes part of modern curriculum reforms in the retention-critical first year of engineering programs, focus on hands-on design work in small teams. One course in particular, the Freshman Engineering Projects course at the University of Colorado at Boulder, also often emphasizes connecting theory and practice in engineering, and showing students that "engineering is a helping, people-oriented profession that underpins both our economy and our quality of life" (4).

Active, cooperative, and problem-based teaching methods contrast with the typical lecture format, in which students are told what they need to know by the lecturer and given an example to demonstrate the application of the knowledge, but with limited interaction between the lecturer and students (22). Active, cooperative and problem-based teaching techniques have been shown to improve both student performance and retention (22; 23; 24). Student participation in a first-year engineering projects course also has significant retention benefits (4).

#### 2.1.3.3 The Importance of Student Social Capital and Support Networks

Social capital is a tool used to analyze social systems and has gained attention from its use in fields such as sociology and economics, though it has also been applied to engineering education. According to Brown, et al, "social capital broadly consists of social networks, social norms, and the value of these networks and norms for achieving mutual goals" (10). Social norms are accepted behaviors given a specific social setting, and may include trust, respect, and reciprocity among community members. The network aspect of social capital refers to "relationships among social entities [formal and informal], and the patterns and implications of these relationships" (10). For engineering students, this refers to participation in engineering-related clubs and student groups, such as Engineers Without Borders or the American Society of Mechanical Engineers, as well project groups for courses, interactions with faculty and advisors, and student peer groups (10).

Various studies have highlighted the importance of student social capital in engineering student retention. Students in one study reported positive interactions with peers, faculty and advisors as significant factors that resulted in retention, while competitive norms in engineering, negative or nonexistent interactions with faculty and advisors, and lack of community in engineering courses were reported as complaints (10). Seymour and Hewitt found that the "failure to find adequate advice, counseling, or tutorial help" for courses and careers and "lack of peer study support" were cited as significant factors in decisions to leave SME majors. Additionally, half of seniors who persisted in SME majors reported that "confusion and gaps in the provision of support" continued throughout their entire academic career (5).

## 2.2 Career Choice Theories and Engineering Careers

A student's choice to pursue a career in engineering is a longitudinal decision influenced by a multi-faceted web of often interrelated factors. Career choice theorists posit congruence between personality and occupational environment, dominance of "career anchors" formed by real-world experiences, and connections between self-efficacy, outcome expectations and personal goals as models to explain career choice development (25; 26). Studies have linked engineering career choice to a wide range of elements, including intrinsic work-related factors like perceived interest, a desire for challenge and creativity, self-image congruence and enjoyment of problem-solving; extrinsic work-related factors like job opportunities and salary;

perceived competence, such as self-efficacy or math and science aptitude; and people-oriented factors like the influence of mentors and family members (5; 27; 28; 29). This section of the background will provide an overview of the major career development theories and then review the pertinent literature on engineering-related career choice, career rejection and career change.

### 2.2.1 Major Career Choice Development Theories

#### 2.2.1.1 Holland's Career Typology

John Holland's career choice theory suggests that vocational choice can be predicted and understood by characterizing the personality types of people and modeling the environments in which they live, and then pairing the respective personality types and environments (30). In short, this means people are attracted to occupations that provide satisfaction and meet their personal needs, but through the interaction of personality types and model environments (25). Four assumptions form the heart of the theory:

1. *"In our culture, most persons can be categorized as one of six types:*
    1.1. *Realistic:* has a preference for activities that entail the explicit, ordered or systematic manipulation of objects, tools, machines, animals, and an aversion to education or therapeutic activities.
    1.2. *Investigative:* has a preference for activities that entail observational, symbolic, systematic, and creative investigation of physical, biological and cultural phenomena in order to understand and control such phenomena; and to an aversion to persuasive, social, and repetitive activities.

1.3. *Artistic:* has a preference for activities that entail the manipulation of physical, verbal, or human materials to create art forms or products, and to an aversion to explicit, systematic, and ordered activities.

1.4. *Social:* has a preference for activities that entail the manipulation of others to inform, train, develop, cure, or enlighten; and an aversion to explicit, ordered, systematic activities involving materials, tools, or machines.

1.5. *Enterprising:* has a preference for activities that entail the manipulation of other to attain organizational goals or economic gain; and an aversion to observational, symbolic, and systematic activities.

1.6. *Conventional:* has a preference for activities that entail the explicit, ordered or systematic manipulation of data, such as keeping records, filing materials, reproducing materials, organizing written and numerical data according to a prescribed plan, operating business machines and data processing machines to attain organizational or economic goals; and an aversion to ambiguous, free, exploratory, or unsystematized activities.

2. *There are six kinds of environments: realistic, investigative, artistic, social, enterprising, and conventional.* Each environment is dominated by a population of its corresponding personality types and the activities present in each environment are those which the various personality types have a preference for.

3. *People search for environments that will let them exercise their skills and abilities, express their attitudes and values, and take on agreeable problems and roles.*

4. *A person's behavior* [and therefore vocational choice behavior] *is determined by an interaction between his personality and the characteristics of his environment"* (30).

Though much research supports Holland's theory, it has been criticized for gender bias since most females seem to fall into the Artistic, Social, and Conventional personality types (25).

### 2.2.1.2 Schein's Career Anchor Model

Egdar Schein's career anchor model theorizes that an individual's abilities, needs, and values are refined through real-world experiences. This refinement leads to the development of a specific career identity or anchor, and this anchor will drive an individual's career behavior (26). Schein suggests that individuals have only one dominant career anchor (31). Schein's eight career anchors, taken directly from Feldman and Bolino's *Careers Within Careers* (26), are summarized below:

1. *"Technical/Functional Competence*: Primarily excited by the content of the work itself; prefers advancement only in his/her technical or functional area of competence; generally disdains and fears general management as too political.
2. *Managerial Competence*: Primarily excited by the opportunity to analyze and solve problems under conditions of incomplete information and uncertainty; likes harnessing people together to achieve common goals; stimulated (rather than exhausted) by crisis situations.

3. *Security and Stability*: Primarily motivated by job security and long-term attachment to one organization; willing to conform and to be fully socialized into an organization's values and norms; tends to dislike travel and relocation.
4. *Entrepreneurial Creativity*: Primarily motivated by the need to build or create something that is entirely their own project; easily bored and likes to move from project to project; more interested in initiating new enterprises than in managing established ones.
5. *Autonomy and Independence*: Primarily motivated to seek work situations which are maximally free of organizational constraints; wants to set own schedule and own pace of work; is willing to trade off opportunities for promotion to have more freedom.
6. *Service and Dedication to a Cause*: Primarily motivated to improve the world in some fashion; wants to align work activities with personal values about helping society; more concerned with finding jobs which meet their values than their skills.
7. *Pure Challenge*: Primarily motivated to overcome major obstacles, solve almost unsolvable problems, or win out over extremely tough opponents; define their careers in terms of daily combat or competition in which winning is everything; very single-minded and intolerant of those without comparable aspirations.
8. *Lifestyle*: Primarily motivated to balance career with lifestyle; highly concerned with such issues as paternity/maternity leaves, day-care options,

etc.; looks for organizations that have strong pro-family values and programs" (26).

### 2.2.1.3 Social Cognitive Career Theory

Robert Lent, Steven Brown, and Gail Hackett's Social Cognitive Career Theory, as explained by Lent, Brown, et al, in *Social Cognitive Predictors of Academic Interests and Goals in Engineering: Utility for Women and Students at Historically Black Universities*, is "concerned with the interplay between a variety of personal, environmental, and behavioral variables that are assumed to give rise to people's academic and career-related interests, choices, and performance outcomes. Among its predictions, the theory maintains that people's interests stem partly from their self-efficacy (beliefs about personal capabilities) and outcome expectations (beliefs about the outcomes of engaging in particular courses of action). Academic and career choice goals and actions are seen as being influenced largely by interests, self-efficacy, and outcome expectations, as well as by the environmental supports and barriers that people have experienced, or expect to experience, in relation to particular choice alternatives. Self-efficacy and outcome expectations, two key building blocks of academic/career choice and development, are hypothesized to derive from a variety of personal (e.g., subject matter mastery, affective state) and socially-mediated (e.g., modeling, encouragement) experiences" (32). The theory is partially based on Bandura's social cognitive theory and research on career and academic self-efficacy (32).

### 2.2.2 Factors Leading to the Choice of an Engineering Career

The factors that lead a student to choose engineering as a career can be broadly classified into four categories (mentioned in 2.2 Career Choice Theories and Engineering Careers): intrinsic work-related factors, extrinsic work-related factors, perceived competence, and people-oriented factors.[3] Intrinsic work-related factors are qualities innate in engineering jobs that attract individuals to a career in engineering. Surveys from the National Engineering Career Development Study established four elements that engineering students and employed engineers perceived to be present in engineering careers and were influential in engineering career choice: challenge, creativity, independence, and enjoyment of problem-solving (29). The role of perceived interest in the field, or interest congruence, has also been linked to being important in engineering career choice and is perhaps the most frequently cited reason for career choice (5; 28; 33)

Congruence between occupational image and self-image, another intrinsic work-related factor, has some conflicting evidence as a factor in determining career choice. Mclean and Kalin's study of Canadian university students found that individuals whose self-image matches their image of an engineering occupation will tend to gravitate toward engineering, a finding that supports Holland's career typology (34). However, Triplett, Husman, and Hong found evidence to support the concept that engineering students reject the idea of the "typical engineer"

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[3] This classification scheme is based on the logical combination of categories from two papers on engineering career choice: Morgan's *The Role of Interest in Understanding the Career Choices of Female and Male College Students* (28) and Jagacinski's *Factors Influencing the Choice of an Engineering Career* (29). Morgan suggests *interesting, people-oriented, extrinsic rewards* and *perceived competence*. Jagacinski uses *work-related factors, school-related factors, people-related factors,* and *hobby-related factors.*

(presumably based on negative stereotypes of engineering. Negative stereotypes were covered in 2.1.2.4 Attitudinal Persistence Factors: Beliefs about Engineering and Self-Efficacy) and that engineering students with engineering career goals had a greater difference between their actual and ideal self-concepts in comparison with education majors who became teachers (35). Such rejection has a parallel in findings from Seymour and Hewitt—a rejection of the stereotypes of the perceived career options offered by SME majors was a factor in nearly one-third of decisions to leave SME majors(5).

Among extrinsic work-related factors influencing engineering career choice, salary, career opportunities and career stability predominate. Seymour and Hewitt found that engineering majors in particular, as opposed to science and math majors, anticipated good material rewards in their careers and that this played a role in the choice of engineering as a career (5). Findings from ethnographic interviews by Stevens, Amos, et al also found support for the appeal of high salaries perceived to be offered by a career in engineering (36). Seymour and Hewitt also found that engineering students had a general belief that they could find a job, whereas science and math students were much less confident about their prospects (5). Stevens, Amos, et al and Jagacinski found a belief that engineering offered good career security (29; 36). However, these findings were not purely positive. Both Seymour and Hewitt and Stevens, Amos, et al found evidence that engineering students believed that good material rewards were due to them solely because of the hard work required to earn an engineering degree and that some students do not possess a true understanding of an engineering career and its role as "a meaningful craft" that can be used to help others (5; 36).

Self-efficacy is the most commonly linked factor to engineering career choice in the perceived competence category. Students whose educational experiences in engineering have led to success and mastery of skills are more likely to choose engineering as a career (33). The building of self-efficacy is not limited to the academic realm, however. Success in work and internship experiences has also been shown to play an important role in self-efficacy and engineering career choice (29; 6). Such observations offer support for the validity of social cognitive career theory. Additionally, math and science aptitude appear to be a less significant, but also important factor in developing the perceived competence that leads to choosing engineering as a career (28; 29).

The influence of family members or mentors, an expressed altruistic desire to help others or contribute to society, and interpersonal interactions and goals, make up people-oriented factors, the final category of elements related to engineering career choice. All of these factors have been found influential in career choice to varying degrees (28; 29). Interestingly, women more often cite altruistic motives than do men (28). Additionally, female role models are of significantly greater importance to women than men, which may be explained by engineering's history as a male-dominated occupation (29).

### 2.2.3 Factors Leading to the Rejection of an Engineering Career

Some research is available on the specifics of why graduating engineering students may reject engineering careers. Logically, low levels of interest, self-efficacy, and self- and occupational-image congruence, factors which are negatively correlated with engineering career choice, would predict a choice to reject an engineering career. Seymour and Hewitt found some other insights, but mostly among freshman and sophomore engineering students. Students often perceived that careers would not be fulfilling, purposeful or enjoyable, and that they would have low levels of responsibility and no time for other interests. Descriptions of the nature of engineering work given by engineering students were often characterized by "brain-numbing" work in "confined, sterile, prison-like surroundings" and nightmarish visions of entrapment. Engineers were portrayed as "dull, unsociable, and materialistic" people "who lacked a personal or social life and were unable to relate comfortably to non-engineers." They saw such stereotypes as very different from their own personalities and rejected the idea of an engineering career because it would force them to adopt such personas (5). Triplett, Husman, and Hong found similar evidence that engineering students reject the idea of the "typical engineer," whatever that may be to each student (35). Though not always well-founded, such reasons were often enough to make a student decide to change majors. The prevalence of these negative stereotypes was complicated by the fact that students often had very little idea of what engineers actually do. Internship experiences often played a decisive role in reinforcing decisions both to leave and stay (5).

### 2.2.4 Engineering-Related Career Change

The limited research on career change among employed engineers focuses on two main phenomena: socialization of newcomer engineers and aspirations to move into management positions. Socialization, in terms of a newly-hired engineer entering an organization, can be defined as "the process through which newcomers learn and identify organizational and unit values, expectations about job-related behaviors, and the social knowledge necessary to assume roles as productive members"(37). A study by Gundry suggests that newcomer engineers and managers have different perceptions of satisfaction, clarity, and consistency of work-related expectations and that newcomer engineers have a lower intention to remain in their organizations than engineering managers (37). Though this does not necessarily mean that newcomer engineers will leave engineering altogether (and there doesn't seem to be any research on the topic), the implications of poor socialization allow for such a possibility.

Surveys by Rynes on aspirations to manage reveal perhaps the most telling information about engineering career change, but they do not focus specifically on post-graduation attrition. One survey of undergraduate engineering students revealed that in 20 years, only 30 percent wanted to still be engineers—36 percent wanted to be managers, 17 percent entrepreneurs, and 17 percent academics or consultants. The analysis compared only two groups—the engineers and aspirant managers. Interesting differences were revealed, however. Those who intended to remain engineers—technical aspirants—had different reasons on going to engineering school. Technical aspirants cite problem-solving interest while managerial aspirants cite ease of finding a job and the opportunity to move into management. Technical aspirants had more favorable beliefs about engineering, such that engineering provides good working conditions, engineers are valuable to employers, and that they would find satisfaction with engineering as an occupation, than did managerial aspirants. Not surprisingly, managerial aspirants were more likely to get MBAs and technical aspirants were more likely to obtain graduate engineering degrees (38). The overarching finding of Rynes' surveys, which canvassed students and employed engineers, was that aspirations to manage were just as common among engineering students as graduated engineers (39). This gives credence to the relevance of studying post-graduation attrition from the engineering field at the undergraduate student level.

## 2.3 Study Motivation

A cursory look at data from the CEAS graduation survey would suggest no deficiency in meeting the identified need of engineers in the American workforce. [4] Indeed, 97 percent of mechanical engineering (MCEN) students who reported having job offers upon graduation were to be employed as engineers. But, only 44 percent of MCEN students whose primary post-graduation plan was employment (84 percent said employment was their primary plan) actually reported engineering-related jobs. (It is important to mention that 11 percent of graduating MCEN students reported plans for graduate school immediately after graduation and 88% of these respondents

[4] The College of Engineering and Applied Science has been collecting this survey data since May 2005. However, December 2006 was the first year that primary employments plans were specifically identified. Past surveys used a "check all that apply" method that complicates and may skew the interpretation of the results. As a result, the numbers cited here are from the May 2007 data only. The December 2006 was not examined in detail because of the small sample size (most students graduate in May).

reported plans for graduate school in engineering. Twenty-four percent of respondents reported plans for graduate school at some point in their future, with 28 percent planning engineering graduate school, 61% planning business graduate school, 6% planning medical school, and 6% planning law school). One percent reported non-engineering-related jobs and 55 percent of MCEN students had unconfirmed employment plans (40). Those who reported job offers listed their position and company, which provided a source for tabulating engineering-related jobs.

Until December of 2006, the survey made no distinction between engineering and non-engineering employment, so the intended career fields of a substantial number of engineering students are unknown. Additionally, the response rate of MCEN students is 71 percent and the potential for a response bias is significant—students who did not have a good experience in the College of Engineering and who are not confident about their employment prospects may ignore the survey. This possibility is openly mentioned by the Dean's Office, which administers the survey. Another confounding factor is that many students may not have secured jobs by the time that the CEAS graduation survey is administered in March, April and May. The CEAS alumni surveys, one administered 6-8 months after graduation and the other 3-5 years post-graduation, are also not very telling—they have response rates of 44 percent and less than 30 percent, respectively. These confounding factors have been mentioned by the CEAS Dean's Office, which produces and collects the survey (41). Furthermore, a primary focus of the CEAS Dean's Office is to ensure that the engineering programs in its college meet the program outcomes required for ABET accreditation. The CEAS graduation survey has, justifiably, a wholly different focus than the question of post-graduation attrition.

Anecdotal evidence and informal interviews with graduating students in the Department of Mechanical Engineering suggest uncertainty towards engineering as a career—students claim they do not want to be an engineer, have reservations about pursuing an engineering career, or do not see engineering as a long-term career. In light of this anecdotal evidence and the paucity of data on student's post-graduation plans, an obvious question is: "Are we getting the whole picture—is there an attrition problem among graduating engineering students?"

Immediately, one might dismiss this question as entirely irrelevant. Students ought to be able to apply their engineering degree any way they wish. Indeed, the educational objectives for CU's Mechanical Engineering program make no specific mention of an intention to produce only engineers:

> "The educational objective of the undergraduate program in Mechanical Engineering is to prepare graduates so that, within three years of graduation, they will have successfully established themselves in professional careers and/or obtained a graduate degree, and will have begun to generate new knowledge or exercise leadership in their positions to the benefit of society"(42).

As modern society becomes more technologically-centered, having individuals with technical backgrounds in various industries would certainly be a boon to the workforce.

However, such an argument neglects two obvious and important parallels in the undergraduate engineering student attrition and career choice literature. First, the paradigmatic shift in attrition research from a focus on student attributes and the view that the student alone is the reason for attrition to the influence of institutional variables like university culture and pedagogical techniques. Tinto's theory of student departure also highlights the importance of the student's interaction with institutional environments. Second, career choice theories show the importance of self-efficacy beliefs in influencing career choices. Self-efficacy is influenced by many factors, but success in academic coursework is an important one. Recall that academic performance and persistence in engineering is influenced by institutional variables like faculty, university culture, and social capital.

This leads back to the preeminent questions of relevance: If graduating students are deciding not to pursue engineering careers, is that really a problem? Why should the College of Engineering be concerned? The College of Engineering has a responsibility to produce (and ought to pride itself on producing) graduates motivated to contribute to society. The answer to the question of relevance truly depends upon why the graduates may leave—controllable attrition issues such as low self-efficacy, negative stereotypes of engineering careers fed by lack of information about engineering careers, or bad educational experiences should be a concern; a desire among students to creatively apply engineering skills to other fields should not be a concern. The lack of information on post-graduation attrition in both the literature and from the College of Engineering and Applied Science coupled with the aforementioned argument for the relevance for studying post-graduation attrition serve as the underlying motivations for this study.

# Chapter 3:Methods

## 3.1 Research Design: Mixed Model Questionnaire

Since this study investigates a question that does not have any direct answers in the research literature, an exploratory research model was used. *Exploratory research* has the objective of generating ideas about a subject. My research also has some explanatory objectives. *Explanatory research* has the objective of discovering causality in a phenomenon (43). In the context of my study, the objectives were to explore the post-graduation attrition of engineering students by identifying its existence, and then identify some factors that may relate to post-graduation attrition.

Additionally, this study was nonexperimental in nature, meaning no independent variables were manipulated. The phenomenon of post-graduation attrition was observed with two mixed model questionnaires, providing both quantitative and qualitative data. *Mixed model* research methods collect quantitative and qualitative data simultaneously in a single stage of a study, whereas *mixed methods* research utilizes both methods but in separate stages of a study (43). Quantitative data was collected in three ways:

1. Likert-style statements, where students reported their level of agreement with a particular statement on a 1 to 5 scale.

2. Rank order scales, where students ranked a list of factors in order of their importance to themselves
3. Closed-ended questions in which respondents selected a single, pre-established category that best answered the question

Qualitative data was collected through open-ended questions that allowed for brief written responses on the survey form.

## 3.2 Survey Administration

The survey was administered to two groups. The first was the December 2007 Mechanical Engineering graduates. A list of names and emails was obtained from Undergraduate Advisor Larry Monke. A gift card for food at a local restaurant was offered to entice the sample response. Students completed the survey on their own time between December 7, 2007 and December 14, 2007 in the Integrated Teaching and Learning Program Laboratory on the University of Colorado at Boulder campus. Gift cards were given after the completion of the survey. Some students on the December 2007 graduates list were identified by Professor Derek Reamon, who was teaching a course in which many December 2007 graduates were enrolled. These students were asked personally to fill out the survey in the “break out room” at a time of convenience to them.

The second survey was administered to the Fall 2007-Spring 2008 Mechanical Engineering Senior Design course during a class meeting on January 23, 2008. The Senior Design course is two-part capstone design experience course for senior mechanical engineering students. Though not all students in the course were graduating in May 2008, all will typically finish in the following two semesters. Permission to administer the second survey was given by course instructor Gary Pawlas. The survey was given alongside another survey designed by Professor Daria Kotys-Schwartz, who introduced her survey and then allowed me to introduce mine. Students were informed that all results were confidential. Professor Kotys-Schwartz left the administration site and I collected the surveys as they were completed.

## 3.3 Data Collection Methods: Survey Design

The research objectives of this study, identified in the form of questions in 1.1 Motivation and Research Questions, served as the basis for the survey design. The survey was divided into five main parts:

1. Demographic Information: name (for identification purposes only), gender, ethnicity, degree type, and cumulative GPA
2. Internship Information:
    a. How many engineering-related internships a student had, if any;
    b. A categorical description of the internship (design, testing, manufacturing, project management, sales, etc.);
    c. Likert-style statements that measured the internship experience in terms of enjoyment, challenge, and increasing understanding of engineering and a desire to pursue an engineering career;
    d. An open-ended question summarizing internship experiences
3. Educational Experience Information:

a. Likert-style statements measuring factors of interest in the Senior Design course experience, including enjoyment, challenge, and increasing a desire to pursue an engineering career. The Senior Design course was chosen as a survey topic because the course provides significant experience with engineering as a practice and a chance for students to work with employed engineers. The Senior Design experience could be a decisive experience, especially for students who never had engineering internships.

b. A Likert-style statement measuring the challenge of pursuing an engineering degree

c. Satisfaction with the quality of instruction and the accessibility of instructors

d. Perceived level of preparation to pursue an engineering career (closed-ended categorical question)

4. Career Values and Career Perception Information

a. A rank order question measuring the relative importance of specified career-related factors such as interest, salary, and prestige

b. Likert-style statements measuring the purpose of a career, as either to earn money or as something to be passionate about

c. Open-ended questions about why the respondent chose his or her cited career (whether engineering or non-engineering), if he or she had any reservations about engineering as a career (if engineering was chosen), and what could have made him or her choose engineering as a career (if engineering was not chosen)

5. Post-Graduation plans: Closed-ended questions on whether or not a respondent was planning an engineering career after graduation or in the future, if he or she planned to pursue other careers either immediately or in the future, and other post-graduation plans such as graduate school, medical school, law school, MBA program, etc.

The first survey, given to mechanical engineering students graduating in December 2007 gathered significant useful data. Additionally, it served as a pilot data collection instrument to improve the delivery of the second survey to the Fall 2007-Spring 2008 Mechanical Engineering Senior Design Course. Copies of the original surveys can be found in Appendix A.

## 3.4 Sample Groups: Demographics and Response Rates

The demographics of both surveys' respondents are summarized in Table 3.1. Both samples were predominantly white male bachelor's degree students. The Senior Design sample had a total of 132 respondents. Males made up 87 percent of the sample. Eighty-six percent of the respondents were white, with Hispanic, Chicano, and Mexican Americans, Asians or Pacific Islanders, and African-Americans making up five percent, four percent, and two percent of the sample, respectively. Other ethnicities composed the remaining two percent of the sample. Ninety-five percent of the Senior Design respondents were BS students; the other five percent were concurrent BS/MS students. The December Graduates survey contained only 37 respondents. Eighty-nine percent were male, and 97 percent were white. Asians or Pacific Islanders made up the remaining three percent. Seventy-eight percent of the December Graduates were BS students and 19 percent were concurrent BS/MS students. A lone MS student rounded out the sample.

**Table 3.1: Survey Demographics: Gender, Ethnicity, and Degree**

| | Senior Design | | December Graduates | |
|---|---|---|---|---|
| **Category** | *Number of Students* | *Percentage of Survey Sample* | *Number of Students* | *Percentage of Survey Sample* |
| *Gender* | | | | |
| Males | 115 | 87% | 33 | 89% |
| Females | 17 | 13% | 4 | 11% |
| *Ethnicity* | | | | |
| White | 113 | 86% | 36 | 97% |
| Hispanic, Chicano, Mexican American | 7 | 5% | 0 | 0% |
| Asian or Pacific Islander | 5 | 4% | 1 | 3% |
| Declined to Answer | 3 | 2% | 0 | 0% |
| African-American | 2 | 2% | 0 | 0% |
| Other | 2 | 2% | 0 | 0% |
| Native American | 0 | 0% | 0 | 0% |
| *Degree* | | | | |
| BS | 126 | 95% | 29 | 78% |
| BS/MS | 6 | 5% | 7 | 19% |
| MS | 0 | 0% | 1 | 3% |

The response rate for both surveys, shown in Table 3.2, surpassed 80 percent. Good response rates provide an important basis for deriving legitimate conclusions from the results.

**Table 3.2: Survey Response Rates**

| | Senior Design | December Graduates |
|---|---|---|
| Total Respondents | 132 | 37 |
| Total Students | 166 | 46 |
| Response Rate | 80% | 80% |

## 3.5 Survey Analysis Methods

A variety of statistical tests were used to compare quantitative data from the survey. Quantitative data from each survey respondent was considered as independent data points, since there was no pairing of samples and knowing the values from one respondent does give a prediction for values from other respondents. Each internship was considered a separate and independent data point to allow for the consideration of students with multiple internships. The response values to the Likert-style statement for preparedness were considered to be ordinal data. The response values to the rest of the Likert-style statements—Internship Experience; Senior Design Experience; and Challenge, Career Perception, and Instruction—were considered to be scale data. SPSS 16.0 software was used for all statistical testing. An explanation of the tests and their use is given in the following sections.

### 3.5.1 Hypothesis Testing and P-values

Hypothesis testing is a branch of inferential statistics used to build evidence about relationships in populations. A population is the set of units that are studied—in this study, the populations were students from the December 2007 mechanical engineering graduates and the Fall 2007 - Spring 2008 Senior Design course students. Hypothesis testing is a way of determining when "sample data support a null hypothesis (that there is no relationship in the population) and when the null hypothesis can be rejected in favor of the alternative hypothesis (that there is a relationship in the population)" (43). The possible outcomes of hypothesis testing are summarized in Table 3.3.

**Table 3.3: Hypothesis Testing Outcomes (43)**

TABLE 16.5 The Four Possible Outcomes in Hypothesis Testing

| | | The True (but Unknown) Status of the Null Hypothesis | |
|---|---|---|---|
| | | The null hypothesis is true (It should not be rejected.) | The null hypothesis is false (It should be rejected.) |
| Your Decision* | Fail to reject the null hypothesis | Type A<br>Correct decision! | **Type II Error**<br>(false negative) |
| | Reject the null hypothesis | **Type I Error**<br>(false positive) | Type B<br>Correct decision! |

*Remember that if the null hypothesis is true, it should *not* be rejected, but if the null hypothesis is false, it *should* be rejected. The problem is that you will not know if the null hypothesis is true or false. You only have the probabilistic evidence obtained from your sample data.

The outcome of a statistical hypothesis test gives a probability, often called a p-value, of erroneously observing a result contradictory to the null hypothesis (it is assumed that the null hypothesis is true). If the p-value is below a specified significance level (α), then the probability of making a Type I error is sufficiently small that the null hypothesis can be rejected in favor of alternative hypothesis and a claim of statistical significance can be made. The most commonly used significance level and the one employed in this analysis are p-values less than or equal to .05. For this study, statistically interesting differences be considered for p-values greater than .05 and less than or equal to .10. Note that p-values for the Senior Design survey will be preceded by “SD” and p-values from the December Graduates survey will be preceded by “DG” when presented simultaneously in the text.

### 3.5.2 Tests for Comparing Means

#### 3.5.2.1 Levene's Test for Homogeneity of Variance

For many mean comparison tests, particularly t-tests and ANOVA, there are assumptions about equal variance in the sample data. Thus, it is important to measure the equality of variance in the sample data. This was done with a Levene's test, which is similar to an F-test but is designed for more than two samples. Levene's test computes a ratio of the group variances and then calculates a p-value related to the difference in the variances. For p-values less than or equal to .05, the variances are said to be unequal. The hypothesis and null hypothesis for the Levene's test are:

$H_o$: All group variances are equal

$H_a$: All group variances are not equal

Given a variable $Y$ with sample of size $N$ divided into $k$ subgroups, where $N_i$ is the sample size of the $i$th subgroup, the Levene's test statistic is defined as:

$$W = \frac{(N-k)}{(k-1)} \frac{\sum_{i=1}^{k} N_i (Z_{i\cdot} - Z_{\cdot\cdot})^2}{\sum_{i=1}^{k} \sum_{j=1}^{N_i} (Z_{ij} - Z_{i\cdot})^2}, \quad \textbf{Eq. (1)}$$

where

$Z_{ij} = |Y_{ij} - \bar{Y}_{i\cdot}|$ with $\bar{Y}_{i\cdot}$ the mean of group $i$,

$Z_{\cdot\cdot} = \frac{1}{N} \sum_{i=1}^{k} \sum_{j=1}^{N_i} Z_{ij}$ is the mean of all $Z_{ij}$,

$$Z_{i\cdot} = \frac{1}{N_i} \sum_{j=1}^{N_i} Z_{ij}$$ is the mean of the $Z_{ij}$ for group $i$

Levene's test rejects the hypothesis that the variances are equal ($H_o$) if:

$$W > F_{(\alpha,\, k-1,\, N-k)} \qquad \textbf{Eq. (2)}$$

where $F_{(\alpha,\, k-1,\, N-k)}$ is the upper critical value of the F-distribution with $k - 1$ and $N - k$ degrees of freedom at a significance level of α (44).

#### 3.5.2.2 Two Sample t-test

A two sample (or independent samples) t-test compares the means of two groups and determines if there is a statistically significant difference between the means. For each group pairing for the two-sample t-test, the hypothesis and null hypothesis are:

$H_o$: The group means are equal

$H_a$: The group means are not equal

There are two cases: one when the groups have equal variances and the other when the variances are unequal. For unequal variances, the test statistic, $t$, is given by:

$$t = \frac{Y_1 - Y_2}{\sqrt{\frac{(s_1)^2}{N_1} + \frac{(s_2)^2}{N_2}}} \qquad \textbf{Eq. (3)}$$

where $N_1$ and $N_2$ are the sample sizes, $Y_1$ and $Y_2$ are the sample means, and $s_1^2$ and $s_2^2$ are the sample variances.

If equal variances are assumed, then the formula reduces to:

$$t = \frac{Y_1 - Y_2}{s_p \sqrt{\frac{1}{N_1} + \frac{1}{N_2}}}$$ **Eq. (4)**

where

$$\left(s_p\right)^2 = \frac{\left(N_1 - 1\right)\cdot\left(s_1\right)^2 + \left(N_2 - 1\right)\cdot\left(s_2\right)^2}{N_1 + N_2 - 2}$$ **Eq. (5)**

The test rejects the null hypothesis if:

$$t < -t_{(\alpha/2,\, \nu)} \text{ or } t < t_{(\alpha/2,\, \nu)},$$

where $t_{(\alpha/2,\nu)}$ is the critical value of the $t$ distribution with ν degrees of freedom. where

### 3.5.2.3 One Sample t-test

A one sample t-test is used to compare a group mean to a specified value. In the context of this study, one sample t-tests were used to compare responses to Likert-style statements to the neutral response (a value of 3) to determine if the responses were significantly different from the neutral response. The hypothesis and null hypothesis for the one sample t-test was:

$H_o$: The statement mean is equal to 3

$H_a$: The statement mean is not equal to 3

The test is a one-sample $t$-test statistic is defined as:

$$t = \frac{\left(Y - \mu_0\right)}{\frac{s}{\sqrt{N}}}$$ **Eq. (8)**

where *Y* is the sample mean, *s* is the sample standard deviation, and *N* is the sample size.

The test rejects the null hypothesis if:

$$t < -t_{(\alpha/2,\ N-1)} \text{ or } t < t_{(\alpha/2,\ N-1)},$$

where $t_{(\alpha/2,\ N-1)}$ is the critical value of the *t* distribution associated with the significance level α and the sample size *N*.

### 3.5.2.4 Bonferroni Multiple Comparison Procedure

When multiple comparisons among groups (i.e. between more than two groups) are made with t-test, the family-wise Type I error ($\alpha_f$) propagates according to:

$$\boldsymbol{\alpha_f = 1 - (1-\alpha)^n \approx \alpha \cdot n}$$ **Eq. (9)**

where α = the original significance level and n = number of comparisons

The Bonferroni procedure is a way of reducing the family-wise Type I error. The new significance level, $\alpha_{adj}$, is given by:

$$\boldsymbol{\alpha_{adj} = \alpha_f / n}$$ **Eq. (10)**

where $\alpha_f$ = the overall family-wise significance level and n = number of comparisons (45). A Bonferroni is useful when an ANOVA cannot be used for multiple comparisons because the equal variance assumption is violated.

### 3.5.2.5 Single Factor Analysis of Variance (ANOVA)

A single factor ANOVA is used to compare the means of one factor across three or more groups. The factor is the variable of interest measured in the research. As implied above in the discussion of the Bonferroni procedure, an ANOVA is preferable to multiple t-tests because there is no Type I error propagation from multiple comparisons. ANOVA assumes equal variances in and normality of the sample data. The hypothesis and null hypothesis for the ANOVA are:

$H_o$: All group means are equal

$H_a$: At least one of group's means is not equal to the others

### 3.5.2.6 Tukey's HSD Post Hoc Test

An ANOVA only reveals if any of the group means are different, not which ones are different. Thus, it requires an accompanying *post hoc* test to determine which group means are different. A common *post hoc* test and the one used in this analysis is Tukey's HSD (Honestly Significant Difference) test. It operates similar to a two sample t-test, giving a p-value associated with the difference between a pair of means.

## 3.5.3 Nonparametric Comparison Tests: Mann-Whitney and Kruskal-Wallis Tests

Ordinal data, such as that from rank order questions, represent a special case when standard parametric comparisons (like t-test and ANOVA) cannot be used. The Mann-Whitney test, the nonparametric analog of the two sample t-tests, can be used to compare two groups. The Kruskal-Wallis test, the nonparametric analog of the single factor ANOVA, can be used to compare three or more groups. The tests operate in a manner similar to the t-test and ANOVA, but the test statistics and associated p-values are based on ranked data instead of the actual data. In this sense, the group distributions, instead of the group means, are being compared. The Mann-Whitney test is also used as a *post hoc* test for the Kruskal-Wallis test. The hypothesis and null hypothesis for the Kruskal-Wallis test are:

$H_o$: There are no differences in the distributions of the groups

$H_a$: There are differences in the distributions of the groups

The hypothesis and null hypothesis for the Mann-Whitney test are:

$H_o$: The two groups have the same distribution

$H_a$: The two groups do not have the same distribution

When the Mann-Whitney test is used as a *post hoc* test, it involves multiple comparisons. For this situation, the significance level is adjusted with the Bonferroni multiple comparison procedure.

### 3.5.4 Correlation Analysis: Spearman's Rho

The measure of association between two variables can be measured with Spearman's rho, also called Spearman's rank correlation. Essentially, it measures the strength of an increasing or decreasing relationship between two values on a scale from 1 (perfect positive correlation) to -1 (perfect negative correlation) (46). A p-value is also calculated for the relationship. P-values less than or equal to .05 indicate acceptable evidence that the slope of the linear regression line is different from zero. The hypothesis and null hypothesis for Spearman's rho are:

$H_o$: There is no monotonic relationship between the two variables

$H_a$: There is a monotonic relationship between the two variables

The simple linear regression line is given by:

$$\mathbf{y = mx + b + e} \qquad \textbf{Eq. (11)}$$

Where:
y = response (dependent) variable
m = slope
x = explanatory (independent) variable
b = y-intercept
e = residuals

### 3.5.5 Cross Tabulation Tables and the Chi-Square Test

A cross tabulation table is table containing observed frequencies of categorical variables. It can be used to compare the distribution of counts of a specific categorical variable (such having had an internship) among different groups (such as genders). To find statistical differences in the distributions, a chi-square test is used. The test statistic compares the given distribution to the chi-square distribution and computes an associated p-value, which indicates the level of difference in the distributions. The hypothesis and null hypothesis for chi-square are:

$H_o$: The distribution of the categorical variable is the same across the population

$H_a$: The distribution of the categorical variable differs across the population

# Chapter 4:Results

## 4.1 Characterizing the Survey Respondents: Senior Design Students and December 2007 Graduates

The two surveys collected in this research—the Senior Design survey and the December 2007 Graduates survey—are analyzed side-by side as separate populations in the following sections. Some questions were added to the Senior Design survey after the results from the December survey were initially obtained, so not all survey items were comparable. However, for the survey items that are comparable, a side-by-side analysis is an effective way of connecting corroborating or contradicting observations. Although the December Graduates survey was conducted first chronologically, the results from the Senior Design survey are presented first because its sample size was larger.

### 4.1.1 Categorizing the Survey Respondents

Survey respondents were classified into six groups:

- Pursuers (those pursuing an engineering career immediately after graduation without reservations or plans to leave the field in the future)
- Pursuers with Reservations Only (those pursuing an engineering career immediately after graduation who currently had reservations about their career choice)

- Future Leavers Only (those pursuing an engineering career immediately after graduation who planned to leave the field in the future)
- Pursuers with Reservations and Future Leavers (those pursuing an engineering career immediately after graduation who currently had reservations *and* planned to leave the field in the future)
- Returners (those *not* pursuing an engineering career immediately after graduation but with plans for an engineering career in the future)
- Leavers (those *not* pursuing an engineering career immediately after graduation with no plans for an engineering career in the future)

Students were first classified based on their answer to Survey Item 12, shown in Figure 4.1.

**12. Do you plan to pursue a career in engineering immediately after graduation?**

__ No
__ Yes, and I have job offers available or I have applied/will apply, and I think I will get at least one job offer
__ Yes, I would like to, but I don't think I will get a job offer

**Figure 4.1: Survey Item 12: Post-Graduation Plans**

The respondents' post-graduation plans allowed them to be categorized in the following two ways:

- Immediate Pursuers: Students who were pursuing an engineering career immediately after graduation

- Non-immediate Pursuers: Students who were *not* pursuing an engineering career immediately after graduation

The Immediate Pursuers were then directed to another part of the survey with two other questions, Survey Items 14 and 15, shown in Figure 4.2.

**14. Do you have any reservations about your choice?**
__ Yes __ No

**15. Do you see engineering as a long-term career for you?**
__ Yes __ No

**Figure 4.2: Survey Items 14 and 15: Reservations and Long-Term Plans**

This allowed the Immediate Pursuers to be classified in four ways:

- Pursuers
- Pursuers with Reservations Only
- Future Leavers Only
- Pursuers with Reservations and Future Leavers

Non-immediate Pursuers were directed to a part of the survey containing Survey Item 17, shown in Figure 4.3.

**17. Do you see yourself pursuing a career in engineering in the future?**
__ Yes __ No

**Figure 4.3: Survey Item 17: Plans for an Engineering Career in the Future**

Responses to Survey Item 17 allowed the Non-immediate Pursuers to be categorized in the following two ways:

- Returners
- Leavers

The numerical breakdown of the survey respondents based on their post-graduation plans—into Post-Graduation Plans Groups— for Senior Design and December Graduates, is shown in Figure 4.4 and Figure 4.5, respectively.

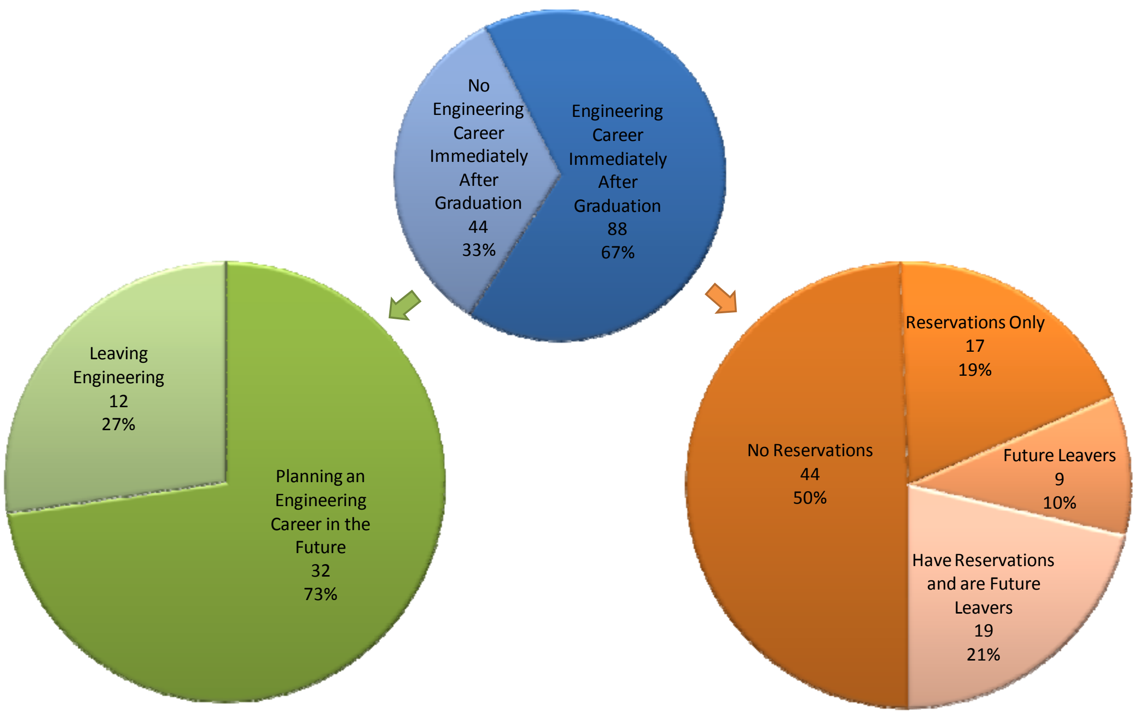


**Figure 4.1: Senior Design Survey: Group Separation based on Post-Graduation Plans**

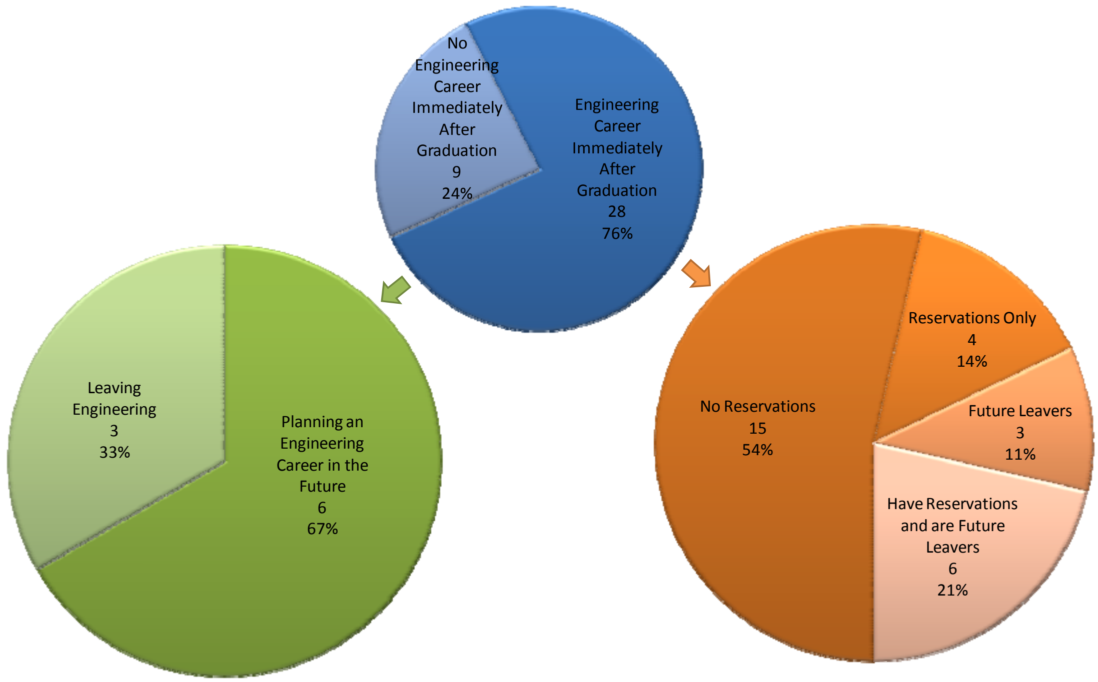


**Figure 4.5: December Graduates Survey: Group Separation based on Post-Graduation Plans**

Before performing any statistical analysis, the Pursuers with Reservations Only, Future Leavers Only, Pursuers with Reservations and Future Leavers were combined into a single group: Pursuers with Reservations. This decision was made due to the significant overlap between Pursuers with Reservations Only and Future Leavers Only and the logical consideration that a plan to leave the engineering field in the future is a form of a reservation about a career choice. It would not make sense to remove the Pursuers with Reservations and Future Leavers group from statistical analysis entirely since it is such a large portion of the sample, nor would it make sense to leave the groups separate because of sample size considerations. The statistical analysis grouping is shown in Table 4.1.

The group proportions were relatively consistent across both surveys. Immediate Pursuers outnumbered Non-immediate Pursuers in both samples. In the Senior Design survey, Pursuers with Reservations was the largest group, slightly outnumbering Pursuers. In the December Graduates survey, Pursuers were the largest group, slightly outnumbering Pursuers with Reservations. In both surveys, Returners were the third-largest group and Leavers were the smallest group. The high proportions of Pursuers with Reservations in both samples were interesting and somewhat surprising.

**Table 4.1: Post-Graduation Plan Groups: Grouping for Statistical Analysis**

| | Senior Design | | December Graduates | |
|---|---|---|---|---|
| **Group** | *Number of Students* | *Percentage of Sample* | *Number of Students* | *Percentage of Sample* |
| Pursuers | 44 | 33% | 15 | 41% |
| Returners | 31 | 23% | 6 | 16% |
| Pursuers with Reservations | 45 | 34% | 13 | 35% |
| Leavers | 12 | 9% | 3 | 8% |

### 4.1.2 Characterizing the Post-Graduation Plans Groups by Gender, Ethnicity, Degree Types, Internships, and GPA

A thorough analysis of the survey samples was undertaken to determine if any pre-existing differences would affect the sample analysis. First, cross tabulations with a Chi-Square statistic were performed to see if there were any differences in the distribution of gender, ethnicity, degree, or having had an internship among the Post-Graduation Plans Groups. The results are shown in Table 4.2 through Table 4.11.

There were no significant differences among the Post-Graduation Plans Groups between genders, although it is interesting to note that all Leavers in the Senior Design survey were male (Table 4.2) and two of the three Leavers in the December Graduates survey were also male (Table 4.3). In the Senior Design survey, 41 percent of females, compared to 33 percent of males, had reservations about engineering as a career (Table 4.2). In the December Graduates survey, 25 percent of females, compared to 33 percent of males, had reservations about engineering as a career (Table 4.3).

Ethnicity did not have a statistically significant effect on Post-Graduation Plans Group Identification in either survey (Table 4.4 and Table 4.5). Interestingly, all Leavers were white. It would be unreasonable to infer anything from this observation until more data is collected and sample size issues can be reasonably neglected, but the significance of the Leavers all being white will be discussed in 5.3 Future Work Recommendations.

**Table 4.2: Senior Design Survey: Cross Tabulation for Post-Graduation Plans Group and Gender**

**PGP_Group * Gender Crosstabulation**

| | | | Gender | | |
|---|---|---|---|---|---|
| | | | Male | Female | Total |
| PGP_Group | Pursuers | Count | 36 | 8 | 44 |
| | | Expected Count | 38.3 | 5.7 | 44.0 |
| | | % within PGP_Group | 81.8% | 18.2% | 100.0% |
| | | % within Gender | 31.3% | 47.1% | 33.3% |
| | | % of Total | 27.3% | 6.1% | 33.3% |
| | Returners | Count | 29 | 2 | 31 |
| | | Expected Count | 27.0 | 4.0 | 31.0 |
| | | % within PGP_Group | 93.5% | 6.5% | 100.0% |
| | | % within Gender | 25.2% | 11.8% | 23.5% |
| | | % of Total | 22.0% | 1.5% | 23.5% |
| | Pursuers With Reservations | Count | 38 | 7 | 45 |
| | | Expected Count | 39.2 | 5.8 | 45.0 |
| | | % within PGP_Group | 84.4% | 15.6% | 100.0% |
| | | % within Gender | 33.0% | 41.2% | 34.1% |
| | | % of Total | 28.8% | 5.3% | 34.1% |
| | Leavers | Count | 12 | | 12 |
| | | Expected Count | 10.5 | 1.5 | 12.0 |
| | | % within PGP_Group | 100.0% | .0% | 100.0% |
| | | % within Gender | 10.4% | .0% | 9.1% |
| | | % of Total | 9.1% | .0% | 9.1% |
| | Total | Count | 115 | 17 | 132 |
| | | Expected Count | 115.0 | 17.0 | 132.0 |
| | | % within PGP_Group | 87.1% | 12.9% | 100.0% |
| | | % within Gender | 100.0% | 100.0% | 100.0% |
| | | % of Total | 87.1% | 12.9% | 100.0% |

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 4.305[a] | 3 | .230 |
| Likelihood Ratio | 5.940 | 3 | .115 |
| Linear-by-Linear Association | 1.191 | 1 | .275 |
| N of Valid Cases | 132 | | |

a. 2 cells (25.0%) have expected count less than 5. The minimum expected count is 1.55.

**Table 4.3: December Graduates Survey: Cross Tabulation for Post-Graduation Plans Group and Gender**

**PGP_Group * Gender Crosstab**

| | | | Gender | | |
|---|---|---|---|---|---|
| | | | Male | Female | Total |
| PGP_Group | Pursuers | Count | 15 | 1 | 16 |
| | | Expected Count | 14.3 | 1.7 | 16.0 |
| | | % within PGP_Group | 93.8% | 6.3% | 100.0% |
| | | % within Gender | 45.5% | 25.0% | 43.2% |
| | | % of Total | 40.5% | 2.7% | 43.2% |
| | Returners | Count | 5 | 1 | 6 |
| | | Expected Count | 5.4 | .6 | 6.0 |
| | | % within PGP_Group | 83.3% | 16.7% | 100.0% |
| | | % within Gender | 15.2% | 25.0% | 16.2% |
| | | % of Total | 13.5% | 2.7% | 16.2% |
| | Pursuers with Reservations | Count | 11 | 1 | 12 |
| | | Expected Count | 10.7 | 1.3 | 12.0 |
| | | % within PGP_Group | 91.7% | 8.3% | 100.0% |
| | | % within Gender | 33.3% | 25.0% | 32.4% |
| | | % of Total | 29.7% | 2.7% | 32.4% |
| | Leavers | Count | 2 | 1 | 3 |
| | | Expected Count | 2.7 | .3 | 3.0 |
| | | % within PGP_Group | 66.7% | 33.3% | 100.0% |
| | | % within Gender | 6.1% | 25.0% | 8.1% |
| | | % of Total | 5.4% | 2.7% | 8.1% |
| | Total | Count | 33 | 4 | 37 |
| | | Expected Count | 33.0 | 4.0 | 37.0 |
| | | % within PGP_Group | 89.2% | 10.8% | 100.0% |
| | | % within Gender | 100.0% | 100.0% | 100.0% |
| | | % of Total | 89.2% | 10.8% | 100.0% |

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 2.213[a] | 3 | .529 |
| Likelihood Ratio | 1.757 | 3 | .624 |
| Linear-by-Linear Association | .805 | 1 | .370 |
| N of Valid Cases | 37 | | |

a. 5 cells (62.5%) have expected count less than 5. The minimum expected count is .32.

**Table 4.4: Senior Design Survey: Cross Tabulation for Post-Graduation Plans Group and Ethnicity**

**PGP_Group * Ethnicity Crosstabulation**

| | | | Ethnicity | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | White | African-American | Asian or Pacific Islander | Hispanic, Chicano, Mexican-American | Declined to Answer | Other | Total |
| PGP_Group | Pursuers | Count | 38 | 1 | 1 | 2 | 1 | 1 | 44 |
| | | Expected Count | 37.7 | .7 | 1.7 | 2.3 | 1.0 | .7 | 44.0 |
| | | % within PGP_Group | 86.4% | 2.3% | 2.3% | 4.5% | 2.3% | 2.3% | 100.0% |
| | | % within Ethnicity | 33.6% | 50.0% | 20.0% | 28.6% | 33.3% | 50.0% | 33.3% |
| | | % of Total | 28.8% | .8% | .8% | 1.5% | .8% | .8% | 33.3% |
| | Returners | Count | 27 | | 2 | 2 | | | 31 |
| | | Expected Count | 26.5 | .5 | 1.2 | 1.6 | .7 | .5 | 31.0 |
| | | % within PGP_Group | 87.1% | .0% | 6.5% | 6.5% | .0% | .0% | 100.0% |
| | | % within Ethnicity | 23.9% | .0% | 40.0% | 28.6% | .0% | .0% | 23.5% |
| | | % of Total | 20.5% | .0% | 1.5% | 1.5% | .0% | .0% | 23.5% |
| | Pursuers With Reservations | Count | 36 | 1 | 2 | 3 | 2 | 1 | 45 |
| | | Expected Count | 38.5 | .7 | 1.7 | 2.4 | 1.0 | .7 | 45.0 |
| | | % within PGP_Group | 80.0% | 2.2% | 4.4% | 6.7% | 4.4% | 2.2% | 100.0% |
| | | % within Ethnicity | 31.9% | 50.0% | 40.0% | 42.9% | 66.7% | 50.0% | 34.1% |
| | | % of Total | 27.3% | .8% | 1.5% | 2.3% | 1.5% | .8% | 34.1% |
| | Leavers | Count | 12 | | | | | | 12 |
| | | Expected Count | 10.3 | .2 | .5 | .6 | .3 | .2 | 12.0 |
| | | % within PGP_Group | 100.0% | .0% | .0% | .0% | .0% | .0% | 100.0% |
| | | % within Ethnicity | 10.6% | .0% | .0% | .0% | .0% | .0% | 9.1% |
| | | % of Total | 9.1% | .0% | .0% | .0% | .0% | .0% | 9.1% |
| Total | | Count | 113 | 2 | 5 | 7 | 3 | 2 | 132 |
| | | Expected Count | 113.0 | 2.0 | 5.0 | 7.0 | 3.0 | 2.0 | 132.0 |
| | | % within PGP_Group | 85.6% | 1.5% | 3.8% | 5.3% | 2.3% | 1.5% | 100.0% |
| | | % within Ethnicity | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 85.6% | 1.5% | 3.8% | 5.3% | 2.3% | 1.5% | 100.0% |

**Table 4.4 (Continued): Senior Design Survey: Cross Tabulation for Post-Graduation Plans Group and Ethnicity**

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 6.583[a] | 15 | .968 |
| Likelihood Ratio | 9.580 | 15 | .845 |
| Linear-by-Linear Association | .007 | 1 | .935 |
| N of Valid Cases | 132 | | |

a. 20 cells (83.3%) have expected count less than 5. The minimum expected count is .18.

A statistically interesting (p=.089) difference was observed in the Senior Design sample when the Post-Graduation Plans Groups were cross-tabulated on internship participation. As a group, Leavers had fewer internships than any of the other groups (Table 4.6). This will cause the internship-related data for Leavers to be especially non-normal, which may limit some comparisons between Leavers and other groups when internship-related data is analyzed. Concerns will be addressed when they surface in the actual analysis. Internship participation was not significantly different among the Post-Graduation Plans Groups in the December Graduates survey (Table 4.7). Notably, all Leavers in the December Graduates survey had internships.

One significant difference (p=.005) was found in the cross tabulations by degree type (Table 4.8 and Table 4.9). The Leavers in the December Graduates survey were all either BS/MS or MS students (Table 4.9). Due to the small sample size for the December Graduates survey—there were only three Leavers—it seems that this is observation is more of statistical anomaly and not a concern that would require changes in the data analysis.

**Table 4.5: December Graduates Survey: Cross Tabulation for Post-Graduation Plans Group and Ethnicity**

**PGP_Group * Ethnicity Crosstab**

| | | | Ethnicity | | |
|---|---|---|---|---|---|
| | | | White | Asian or Pacific Islander | Total |
| PGP_Group | Pursuers | Count | 16 | | 16 |
| | | Expected Count | 15.6 | .4 | 16.0 |
| | | % within PGP_Group | 100.0% | .0% | 100.0% |
| | | % within Ethnicity | 44.4% | .0% | 43.2% |
| | | % of Total | 43.2% | .0% | 43.2% |
| | Returners | Count | 6 | | 6 |
| | | Expected Count | 5.8 | .2 | 6.0 |
| | | % within PGP_Group | 100.0% | .0% | 100.0% |
| | | % within Ethnicity | 16.7% | .0% | 16.2% |
| | | % of Total | 16.2% | .0% | 16.2% |
| | Pursuers with Reservations | Count | 11 | 1 | 12 |
| | | Expected Count | 11.7 | .3 | 12.0 |
| | | % within PGP_Group | 91.7% | 8.3% | 100.0% |
| | | % within Ethnicity | 30.6% | 100.0% | 32.4% |
| | | % of Total | 29.7% | 2.7% | 32.4% |
| | Leavers | Count | 3 | | 3 |
| | | Expected Count | 2.9 | .1 | 3.0 |
| | | % within PGP_Group | 100.0% | .0% | 100.0% |
| | | % within Ethnicity | 8.3% | .0% | 8.1% |
| | | % of Total | 8.1% | .0% | 8.1% |
| | Total | Count | 36 | 1 | 37 |
| | | Expected Count | 36.0 | 1.0 | 37.0 |
| | | % within PGP_Group | 97.3% | 2.7% | 100.0% |
| | | % within Ethnicity | 100.0% | 100.0% | 100.0% |
| | | % of Total | 97.3% | 2.7% | 100.0% |

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 2.141[a] | 3 | .544 |
| Likelihood Ratio | 2.310 | 3 | .511 |
| Linear-by-Linear Association | .830 | 1 | .362 |
| N of Valid Cases | 37 | | |

a. 5 cells (62.5%) have expected count less than 5. The minimum expected count is .08.

**Table 4.6: Senior Design Survey: Cross Tabulation for Post-Graduation Plans Group and Internship**

**PGP_Group * Internship Crosstabulation**

| | | | Internship | | |
|---|---|---|---|---|---|
| | | | Yes | No | Total |
| PGP_Group | Pursuers | Count | 24 | 20 | 44 |
| | | Expected Count | 21.7 | 22.3 | 44.0 |
| | | % within PGP_Group | 54.5% | 45.5% | 100.0% |
| | | % within Internship | 36.9% | 29.9% | 33.3% |
| | | % of Total | 18.2% | 15.2% | 33.3% |
| | Returners | Count | 14 | 17 | 31 |
| | | Expected Count | 15.3 | 15.7 | 31.0 |
| | | % within PGP_Group | 45.2% | 54.8% | 100.0% |
| | | % within Internship | 21.5% | 25.4% | 23.5% |
| | | % of Total | 10.6% | 12.9% | 23.5% |
| | Pursuers With Reservations | Count | 25 | 20 | 45 |
| | | Expected Count | 22.2 | 22.8 | 45.0 |
| | | % within PGP_Group | 55.6% | 44.4% | 100.0% |
| | | % within Internship | 38.5% | 29.9% | 34.1% |
| | | % of Total | 18.9% | 15.2% | 34.1% |
| | Leavers | Count | 2 | 10 | 12 |
| | | Expected Count | 5.9 | 6.1 | 12.0 |
| | | % within PGP_Group | 16.7% | 83.3% | 100.0% |
| | | % within Internship | 3.1% | 14.9% | 9.1% |
| | | % of Total | 1.5% | 7.6% | 9.1% |
| | Total | Count | 65 | 67 | 132 |
| | | Expected Count | 65.0 | 67.0 | 132.0 |
| | | % within PGP_Group | 49.2% | 50.8% | 100.0% |
| | | % within Internship | 100.0% | 100.0% | 100.0% |
| | | % of Total | 49.2% | 50.8% | 100.0% |

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 6.514[a] | 3 | **0.089*** |
| Likelihood Ratio | 7.003 | 3 | .072 |
| Linear-by-Linear Association | 1.604 | 1 | .205 |
| N of Valid Cases | 132 | | |

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 5.91.

*** Indicates statistically interesting p-value (.05 < p ≤ .10)**

**Table 4.7: December Graduates Survey: Cross Tabulation for Post-Graduation Plans Group and Internship**

**PGP_Group * Internship Crosstab**

| | | | Internship | | |
|---|---|---|---|---|---|
| | | | Yes | No | Total |
| PGP_Group | Pursuers | Count | 12 | 4 | 16 |
| | | Expected Count | 12.1 | 3.9 | 16.0 |
| | | % within PGP_Group | 75.0% | 25.0% | 100.0% |
| | | % within Internship | 42.9% | 44.4% | 43.2% |
| | | % of Total | 32.4% | 10.8% | 43.2% |
| | Returners | Count | 4 | 2 | 6 |
| | | Expected Count | 4.5 | 1.5 | 6.0 |
| | | % within PGP_Group | 66.7% | 33.3% | 100.0% |
| | | % within Internship | 14.3% | 22.2% | 16.2% |
| | | % of Total | 10.8% | 5.4% | 16.2% |
| | Pursuers with Reservations | Count | 9 | 3 | 12 |
| | | Expected Count | 9.1 | 2.9 | 12.0 |
| | | % within PGP_Group | 75.0% | 25.0% | 100.0% |
| | | % within Internship | 32.1% | 33.3% | 32.4% |
| | | % of Total | 24.3% | 8.1% | 32.4% |
| | Leavers | Count | 3 | | 3 |
| | | Expected Count | 2.3 | .7 | 3.0 |
| | | % within PGP_Group | 100.0% | .0% | 100.0% |
| | | % within Internship | 10.7% | .0% | 8.1% |
| | | % of Total | 8.1% | .0% | 8.1% |
| | Total | Count | 28 | 9 | 37 |
| | | Expected Count | 28.0 | 9.0 | 37.0 |
| | | % within PGP_Group | 75.7% | 24.3% | 100.0% |
| | | % within Internship | 100.0% | 100.0% | 100.0% |
| | | % of Total | 75.7% | 24.3% | 100.0% |

**Chi-Square Tests**

| | Value | Df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 1.236[a] | 3 | .744 |
| Likelihood Ratio | 1.925 | 3 | .588 |
| Linear-by-Linear Association | .293 | 1 | .588 |
| N of Valid Cases | 37 | | |

a. 6 cells (75.0%) have expected count less than 5. The minimum expected count is .73.

**Table 4.8: Senior Design Survey: Cross Tabulation for Post-Graduation Plans Group and Degree**

**PGP_Group * Degree Crosstabulation**

| | | | Degree | | |
|---|---|---|---|---|---|
| | | | BS | BS/MS | Total |
| PGP_Group | Pursuers | Count | 41 | 3 | 44 |
| | | Expected Count | 42.0 | 2.0 | 44.0 |
| | | % within PGP_Group | 93.2% | 6.8% | 100.0% |
| | | % within Degree | 32.5% | 50.0% | 33.3% |
| | | % of Total | 31.1% | 2.3% | 33.3% |
| | Returners | Count | 30 | 1 | 31 |
| | | Expected Count | 29.6 | 1.4 | 31.0 |
| | | % within PGP_Group | 96.8% | 3.2% | 100.0% |
| | | % within Degree | 23.8% | 16.7% | 23.5% |
| | | % of Total | 22.7% | .8% | 23.5% |
| | Pursuers With Reservations | Count | 44 | 1 | 45 |
| | | Expected Count | 43.0 | 2.0 | 45.0 |
| | | % within PGP_Group | 97.8% | 2.2% | 100.0% |
| | | % within Degree | 34.9% | 16.7% | 34.1% |
| | | % of Total | 33.3% | .8% | 34.1% |
| | Leavers | Count | 11 | 1 | 12 |
| | | Expected Count | 11.5 | .5 | 12.0 |
| | | % within PGP_Group | 91.7% | 8.3% | 100.0% |
| | | % within Degree | 8.7% | 16.7% | 9.1% |
| | | % of Total | 8.3% | .8% | 9.1% |
| | Total | Count | 126 | 6 | 132 |
| | | Expected Count | 126.0 | 6.0 | 132.0 |
| | | % within PGP_Group | 95.5% | 4.5% | 100.0% |
| | | % within Degree | 100.0% | 100.0% | 100.0% |
| | | % of Total | 95.5% | 4.5% | 100.0% |

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 1.605[a] | 3 | .658 |
| Likelihood Ratio | 1.601 | 3 | .659 |
| Linear-by-Linear Association | .223 | 1 | .637 |
| N of Valid Cases | 132 | | |

a. 4 cells (50.0%) have expected count less than 5. The minimum expected count is .55.

**Table 4.9: December Graduates Survey: Cross Tabulation for Post-Graduation Plans Group and Degree**

**PGP_Group * Degree Crosstab**

| | | | Degree | | | |
|---|---|---|---|---|---|---|
| | | | BS | BS/MS | MS | Total |
| PGP_Group | Pursuers | Count | 13 | 3 | | 16 |
| | | Expected Count | 12.5 | 3.0 | .4 | 16.0 |
| | | % within PGP_Group | 81.3% | 18.8% | .0% | 100.0% |
| | | % within Degree | 44.8% | 42.9% | .0% | 43.2% |
| | | % of Total | 35.1% | 8.1% | .0% | 43.2% |
| | Returners | Count | 5 | 1 | | 6 |
| | | Expected Count | 4.7 | 1.1 | .2 | 6.0 |
| | | % within PGP_Group | 83.3% | 16.7% | .0% | 100.0% |
| | | % within Degree | 17.2% | 14.3% | .0% | 16.2% |
| | | % of Total | 13.5% | 2.7% | .0% | 16.2% |
| | Pursuers with Reservations | Count | 11 | 1 | | 12 |
| | | Expected Count | 9.4 | 2.3 | .3 | 12.0 |
| | | % within PGP_Group | 91.7% | 8.3% | .0% | 100.0% |
| | | % within Degree | 37.9% | 14.3% | .0% | 32.4% |
| | | % of Total | 29.7% | 2.7% | .0% | 32.4% |
| | Leavers | Count | | 2 | 1 | 3 |
| | | Expected Count | 2.4 | .6 | .1 | 3.0 |
| | | % within PGP_Group | .0% | 66.7% | 33.3% | 100.0% |
| | | % within Degree | .0% | 28.6% | 100.0% | 8.1% |
| | | % of Total | .0% | 5.4% | 2.7% | 8.1% |
| | Total | Count | 29 | 7 | 1 | 37 |
| | | Expected Count | 29.0 | 7.0 | 1.0 | 37.0 |
| | | % within PGP_Group | 78.4% | 18.9% | 2.7% | 100.0% |
| | | % within Degree | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 78.4% | 18.9% | 2.7% | 100.0% |

**Chi-Square Tests**

| | Value | Df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 18.333[a] | 6 | **0.005**** |
| Likelihood Ratio | 13.110 | 6 | .041 |
| Linear-by-Linear Association | 3.114 | 1 | .078 |
| N of Valid Cases | 37 | | |

a. 10 cells (83.3%) have expected count less than 5. The minimum expected count is .08.

**** Indicates a statistically significant p-value ($p \leq .05$)**

**Table 4.10: Senior Design Survey: Layered Cross Tabulation for Post-Graduation Plans Group, Gender, and Internship**

**PGP_Group * Gender * Internship Crosstabulation**

| Internship | | | | Gender: Male | Female | Total |
|---|---|---|---|---|---|---|
| Yes | PGP_Group | Pursuers | Count | 20 | 4 | 24 |
| | | | Expected Count | 19.9 | 4.1 | 24.0 |
| | | | % within PGP_Group | 83.3% | 16.7% | 100.0% |
| | | | % within Gender | 37.0% | 36.4% | 36.9% |
| | | | % of Total | 30.8% | 6.2% | 36.9% |
| | | Returners | Count | 12 | 2 | 14 |
| | | | Expected Count | 11.6 | 2.4 | 14.0 |
| | | | % within PGP_Group | 85.7% | 14.3% | 100.0% |
| | | | % within Gender | 22.2% | 18.2% | 21.5% |
| | | | % of Total | 18.5% | 3.1% | 21.5% |
| | | Pursuers With Reservations | Count | 20 | 5 | 25 |
| | | | Expected Count | 20.8 | 4.2 | 25.0 |
| | | | % within PGP_Group | 80.0% | 20.0% | 100.0% |
| | | | % within Gender | 37.0% | 45.5% | 38.5% |
| | | | % of Total | 30.8% | 7.7% | 38.5% |
| | | Leavers | Count | 2 | | 2 |
| | | | Expected Count | 1.7 | .3 | 2.0 |
| | | | % within PGP_Group | 100.0% | .0% | 100.0% |
| | | | % within Gender | 3.7% | .0% | 3.1% |
| | | | % of Total | 3.1% | .0% | 3.1% |
| | | Total | Count | 54 | 11 | 65 |
| | | | Expected Count | 54.0 | 11.0 | 65.0 |
| | | | % within PGP_Group | 83.1% | 16.9% | 100.0% |
| | | | % within Gender | 100.0% | 100.0% | 100.0% |
| | | | % of Total | 83.1% | 16.9% | 100.0% |

**Table 4.10 (Continued): Senior Design Survey: Layered Cross Tabulation for Post-Graduation Plans Group, Gender, and Internship**

| Internship | | | | Gender: Male | Gender: Female | Total |
|---|---|---|---|---|---|---|
| No | PGP_Group | Pursuers | Count | 16 | 4 | 20 |
| | | | Expected Count | 18.2 | 1.8 | 20.0 |
| | | | % within PGP_Group | 80.0% | 20.0% | 100.0% |
| | | | % within Gender | 26.2% | 66.7% | 29.9% |
| | | | % of Total | 23.9% | 6.0% | 29.9% |
| | | Returners | Count | 17 | | 17 |
| | | | Expected Count | 15.5 | 1.5 | 17.0 |
| | | | % within PGP_Group | 100.0% | .0% | 100.0% |
| | | | % within Gender | 27.9% | .0% | 25.4% |
| | | | % of Total | 25.4% | .0% | 25.4% |
| | | Pursuers With Reservations | Count | 18 | 2 | 20 |
| | | | Expected Count | 18.2 | 1.8 | 20.0 |
| | | | % within PGP_Group | 90.0% | 10.0% | 100.0% |
| | | | % within Gender | 29.5% | 33.3% | 29.9% |
| | | | % of Total | 26.9% | 3.0% | 29.9% |
| | | Leavers | Count | 10 | | 10 |
| | | | Expected Count | 9.1 | .9 | 10.0 |
| | | | % within PGP_Group | 100.0% | .0% | 100.0% |
| | | | % within Gender | 16.4% | .0% | 14.9% |
| | | | % of Total | 14.9% | .0% | 14.9% |
| | | Total | Count | 61 | 6 | 67 |
| | | | Expected Count | 61.0 | 6.0 | 67.0 |
| | | | % within PGP_Group | 91.0% | 9.0% | 100.0% |
| | | | % within Gender | 100.0% | 100.0% | 100.0% |
| | | | % of Total | 91.0% | 9.0% | 100.0% |

**Table 4.10 (Continued): Senior Design Survey: Layered Cross Tabulation for Post-Graduation Plans Group, Gender, and Internship**

**Chi-Square Tests**

| Internship | | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|---|
| Yes | Pearson Chi-Square | .646[a] | 3 | .886 |
| | Likelihood Ratio | .976 | 3 | .807 |
| | Linear-by-Linear Association | .003 | 1 | .957 |
| | N of Valid Cases | 65 | | |
| No | Pearson Chi-Square | 5.675[b] | 3 | .129 |
| | Likelihood Ratio | 7.382 | 3 | .061 |
| | Linear-by-Linear Association | 2.346 | 1 | .126 |
| | N of Valid Cases | 67 | | |

a. 5 cells (62.5%) have expected count less than 5. The minimum expected count is .34.

b. 4 cells (50.0%) have expected count less than 5. The minimum expected count is .90.

The final cross tabulation compared gender and internship participation among the Post-Graduation Plans Groups (Table 4.10 and Table 4.11). In the Senior Design survey, 45 percent of females had reservations about an engineering career after having an internship, while only 33 percent of females who did not have an internship had reservations. Thirty-seven percent of males who had an internship had reservations about an engineering career, while 29 percent of males without an internship expressed reservations (Table 4.10). All females in the December Graduates survey had internships (Table 4.11). Among those females (N=4), 25 percent had reservations about an engineering career. Males in the December Graduates survey were equally likely to express reservations (33 percent) regardless of internship participation (Table 4.11).

**Table 4.11: December Graduates Survey: Layered Cross Tabulation for Post-Graduation Plans Group, Gender, and Internship**

**PGP_Group * Gender * Internship Crosstabulation**

| Internship | | | | Gender: Male | Gender: Female | Total |
|---|---|---|---|---|---|---|
| Yes | PGP_Group | Pursuers | Count | 11 | 1 | 12 |
| | | | Expected Count | 10.3 | 1.7 | 12.0 |
| | | | % within PGP_Group | 91.7% | 8.3% | 100.0% |
| | | | % within Gender | 45.8% | 25.0% | 42.9% |
| | | | % of Total | 39.3% | 3.6% | 42.9% |
| | | Returners | Count | 3 | 1 | 4 |
| | | | Expected Count | 3.4 | .6 | 4.0 |
| | | | % within PGP_Group | 75.0% | 25.0% | 100.0% |
| | | | % within Gender | 12.5% | 25.0% | 14.3% |
| | | | % of Total | 10.7% | 3.6% | 14.3% |
| | | Pursuers with Reservations | Count | 8 | 1 | 9 |
| | | | Expected Count | 7.7 | 1.3 | 9.0 |
| | | | % within PGP_Group | 88.9% | 11.1% | 100.0% |
| | | | % within Gender | 33.3% | 25.0% | 32.1% |
| | | | % of Total | 28.6% | 3.6% | 32.1% |
| | | Leavers | Count | 2 | 1 | 3 |
| | | | Expected Count | 2.6 | .4 | 3.0 |
| | | | % within PGP_Group | 66.7% | 33.3% | 100.0% |
| | | | % within Gender | 8.3% | 25.0% | 10.7% |
| | | | % of Total | 7.1% | 3.6% | 10.7% |
| | | Total | Count | 24 | 4 | 28 |
| | | | Expected Count | 24.0 | 4.0 | 28.0 |
| | | | % within PGP_Group | 85.7% | 14.3% | 100.0% |
| | | | % within Gender | 100.0% | 100.0% | 100.0% |
| | | | % of Total | 85.7% | 14.3% | 100.0% |

**Table 4.11 (Continued): December Graduates Survey: Layered Cross Tabulation for Post-Graduation Plans Group, Gender, and Internship**

| Internship | | | | Gender: Male | Gender: Female | Total |
|---|---|---|---|---|---|---|
| No | PGP_Group | Pursuers | Count | 4 | | 4 |
| | | | Expected Count | 4.0 | | 4.0 |
| | | | % within PGP_Group | 100.0% | | 100.0% |
| | | | % within Gender | 44.4% | | 44.4% |
| | | | % of Total | 44.4% | | 44.4% |
| | | Returners | Count | 2 | | 2 |
| | | | Expected Count | 2.0 | | 2.0 |
| | | | % within PGP_Group | 100.0% | | 100.0% |
| | | | % within Gender | 22.2% | | 22.2% |
| | | | % of Total | 22.2% | | 22.2% |
| | | Pursuers with Reservations | Count | 3 | | 3 |
| | | | Expected Count | 3.0 | | 3.0 |
| | | | % within PGP_Group | 100.0% | | 100.0% |
| | | | % within Gender | 33.3% | | 33.3% |
| | | | % of Total | 33.3% | | 33.3% |
| | | Total | Count | 9 | | 9 |
| | | | Expected Count | 9.0 | | 9.0 |
| | | | % within PGP_Group | 100.0% | | 100.0% |
| | | | % within Gender | 100.0% | | 100.0% |
| | | | % of Total | 100.0% | | 100.0% |

**Chi-Square Tests**

| Internship | | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|---|
| Yes | Pearson Chi-Square | 1.685[a] | 3 | .640 |
| | Likelihood Ratio | 1.486 | 3 | .686 |
| | Linear-by-Linear Association | .595 | 1 | .440 |
| | N of Valid Cases | 28 | | |
| No | Pearson Chi-Square | .[b] | | |
| | N of Valid Cases | 9 | | |

a. 6 cells (75.0%) have expected count less than 5. The minimum expected count is .43.

b. No statistics are computed because Gender is a constant.

#### 4.1.2.1 Comparing Mean GPA among Post-Graduation Plans Groups

To further understand the sample, the mean GPA among Post-Graduation Plans Groups, genders, ethnicities, and degree types were compared. The column plot of mean GPA by group is shown in Figure 4.6. Returners had the highest mean GPA and Pursuers with Reservations had the lowest. The Pursuers' mean GPA was only slightly higher (.05 points) than the mean GPA of Pursuers with Reservations. Leavers had a higher GPA than both Pursuers and Pursuers with Reservations. Only one difference was statistically significant: Returners had a significantly higher GPA than Pursuers with Reservations (p=.025, Table 4.12). There was a statistically interesting difference between Returners and Pursuers—the Returners had a higher mean GPA (p=.099, Table 4.12).

No statistical differences were observed in the December Graduates survey. Leavers had the highest mean GPA, but the fact that all Leavers were BS/MS or MS students in the December Graduates survey may be a confounding factor. Pursuers with Reservations had the lowest mean GPA (Figure 4.6). These results indicate that there are no meaningful differences in GPA between the Post-Graduation Plans Groups, which corroborates with an important finding from Seymour and Hewitt: switchers and non-switchers were not academically different(5). The significance of this result will be discussed further in Chapter 5: Discussion of Results, Conclusions, and Future Work Recommendations.

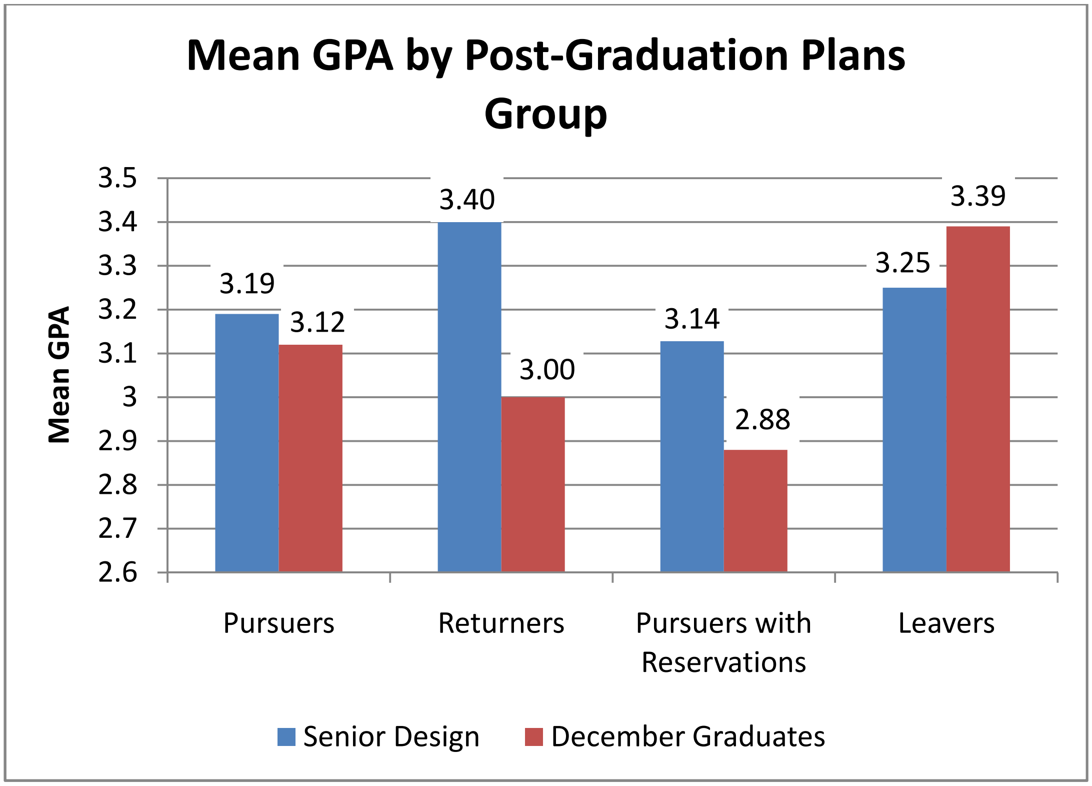


**Figure 4.6: Mean GPA by Post-Graduation Plans Group**

**Table 4.12: ANOVA and Post Hoc Test Results: GPA versus Post-Graduation Plans Group**

| | p-value | |
|---|---|---|
| **Variable** | **Homogeneity of Variance Test** | **ANOVA** |
| GPA | .419 | **.037**** |

** Indicates a statistically significant p-value ($p \le .05$)

Tukey HSD

| (I) Group | (J) Group | Mean Difference (I-J) | Std. Error | Sig. |
|---|---|---|---|---|
| Pursuers | Returners | -0.2111 | 0.09101 | **0.099*** |
| | Pursuers With Reservations | 0.04786 | 0.08037 | 0.933 |
| | Leavers | -0.05979 | 0.12236 | 0.962 |
| Returners | Pursuers | 0.2111 | 0.09101 | **0.099*** |
| | Pursuers With Reservations | .25896* | 0.09061 | **0.025**** |
| | Leavers | 0.15131 | 0.12932 | 0.647 |
| Pursuers With Reservations | Pursuers | -0.04786 | 0.08037 | 0.933 |
| | Returners | -.25896* | 0.09061 | **0.025**** |
| | Leavers | -0.10765 | 0.12206 | 0.814 |
| Leavers | Pursuers | 0.05979 | 0.12236 | 0.962 |
| | Returners | -0.15131 | 0.12932 | 0.647 |
| | Pursuers With Reservations | 0.10765 | 0.12206 | 0.814 |

** Indicates a statistically significant p-value ($p \le .05$)

* Indicates a statistically interesting p-value ($.05 < p \le .10$)

No significant differences between genders and ethnicities were observed. In both surveys, BS/MS students had significantly higher mean GPAs (SD: $p < .001$; DG: $p=.009$). It is not surprising that BS/MS students would have a higher GPA than BS students because there is minimum GPA requirement to enter the BS/MS program. Indeed, BS/MS students may have different attitudes towards engineering as a career. The distribution of degree type was different for the December Graduates survey but not for the Senior Design survey, so evidence for considering them as different populations or removing them from the sample seems inconclusive. Further data collection may show differences, but for the purposes of this exploratory study, BS/MS students will be treated the same as BS students.

## 4.2 Quantitative Survey Analysis: Responses to Likert-style Statements

The Senior Design Survey (Appendix A) contained a total of 17 Likert-style statements distributed among four survey items. The statements were intended to measure several factors hypothesized to be related to attrition and reservations:

1. Preparedness, expressed in terms of how well prepared the respondent felt he or she was to pursue an engineering career
2. Internship Experience
3. Senior Design Project experience
4. Challenge, Career Perception, and Instruction
    a. The importance of a need for being challenged by work and school
    b. The perception of a career, either as way to earn income or as something to be passionate about
    c. Perception of the quality of instruction and accessibility of professors

The actual questions from the survey are listed in Figure 4.7 through Figure 4.10.

1. **How well prepared do you feel to pursue a career in engineering?** (check one)
   __ not at all prepared
   __ slightly prepared
   __ prepared
   __ well prepared
   __ highly prepared

**Figure 4.7: Survey Item 6: Preparedness**

**Please rate your agreement with the following statements using the scale below:**
*(1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree)*

| | Internship #1 | Internship #2 | Internship #3 | Internship #4 |
|---|---|---|---|---|
| I enjoyed this internship experience overall | | | | |
| I enjoyed the people I worked with | | | | |
| I enjoyed the work | | | | |
| I found the work challenging | | | | |
| This internship increased my understanding of what it is like to have a career in engineering | | | | |
| This internship increased my desire to pursue an engineering career | | | | |

**Figure 4.8: Survey Item 7: Internship Experience**

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| I enjoyed working with the people on my senior design team | 1 | 2 | 3 | 4 | 5 |
| I enjoyed the work I did on my senior design project | 1 | 2 | 3 | 4 | 5 |
| I found the work challenging | 1 | 2 | 3 | 4 | 5 |
| My senior design project increased my desire to pursue an engineering career | 1 | 2 | 3 | 4 | 5 |

**Figure 4.9: Survey Item 9: Senior Design Experience**

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| Pursuing an engineering degree has challenged me | 1 | 2 | 3 | 4 | 5 |
| I need to be challenged in my career to feel satisfied | 1 | 2 | 3 | 4 | 5 |
| A career is a way earn income so that I can pursue my passions in my own time | 1 | 2 | 3 | 4 | 5 |
| A career should be something I am truly passionate about | 1 | 2 | 3 | 4 | 5 |
| I am satisfied with the quality of instruction in CU's engineering program | 1 | 2 | 3 | 4 | 5 |
| I am satisfied with the accessibility of my instructors | 1 | 2 | 3 | 4 | 5 |

**Figure 4.10: Survey Item 10: Challenge, Career Perception, and Instruction**

Each statement has a corresponding abbreviation code for simplicity in data coding and graphing. The codes are shown in Table 4.13.

**Table 4.13: Senior Design Survey: Survey Item Abbreviation Codes**

| Survey Item | Likert-style Statement | Abbrevation Code |
|---|---|---|
| 6 | How well prepared do you feel to pursue a career in engineering? | Prepared |
| 7 | I enjoyed this internship experience overall | Overall |
| 7 | I enjoyed the people I worked with | EnjPeop |
| 7 | I enjoyed the work | EnjWork |
| 7 | I found the work challenging | Challenge |
| 7 | This internship increased my understanding of what it is like to have a career in engineering | IncUnd |
| 7 | This internship increased my desire to pursue an engineering career | IncDesire |
| 9 | I enjoyed working with the people on my senior design team | SDEnjPeop |
| 9 | I enjoyed the work I did on my senior design project | SDEnjWork |
| 9 | I found the work challenging | SDChall |
| 9 | My senior design project increased my desire to pursue an engineering career | SDIncDes |
| 10 | Pursuing an engineering degree has challenged me | EngChall |
| 10 | I need to be challenged in my career to feel satisfied | NeedChall |
| 10 | A career is a way earn income so that I can pursue my passions in my own time | CareerIncome |
| 10 | A career should be something I am truly passionate about | CareerPassion |
| 10 | I am satisfied with the quality of instruction in CU's engineering program | Instruction |
| 10 | I am satisfied with the accessibility of my instructors | Accessibility |

The December Graduates survey (Appendix B) contained only nine Likert-style statements, all of which were also included in the Senior Design survey. They are shown below in Table 4.14. Abbreviation codes for survey items contained in both surveys are the same.

**Table 4.14: December Graduates Survey: Likert-style Statements**

| Survey Item | Likert-style Statement | Abbrevation Code |
|---|---|---|
| 5 | How well prepared do you feel to pursue a career in engineering? | Prepared |
| 6 | I enjoyed this internship experience overall | Overall |
| 6 | I enjoyed the people I worked with | EnjPeop |
| 6 | I enjoyed the work | EnjWork |
| 6 | This internship increased my understanding of what it is like to have a career in engineering | IncUnd |
| 6 | This internship increased my desire to pursue an engineering career | IncDesire |
| 8 | I enjoyed working with the people on my senior design team | SDEnjPeop |
| 8 | I enjoyed the work I did on my senior design project | SDEnjWork |
| 8 | My senior design project increased my desire to pursue an engineering career | SDIncDes |

#### 4.2.1.1 Response to Likert-style Statements from Entire Sample

Before comparing the Likert-style statement response by Post-Graduation Plans Group, the combined means of all the statements were examined. A histogram of the preparedness response for both groups is shown in Figure 4.11. The December Graduates' preparedness distribution is skewed farther to the right than the Senior Design distribution, implying that the December Graduates tended to feel more prepared for an engineering career on the whole.

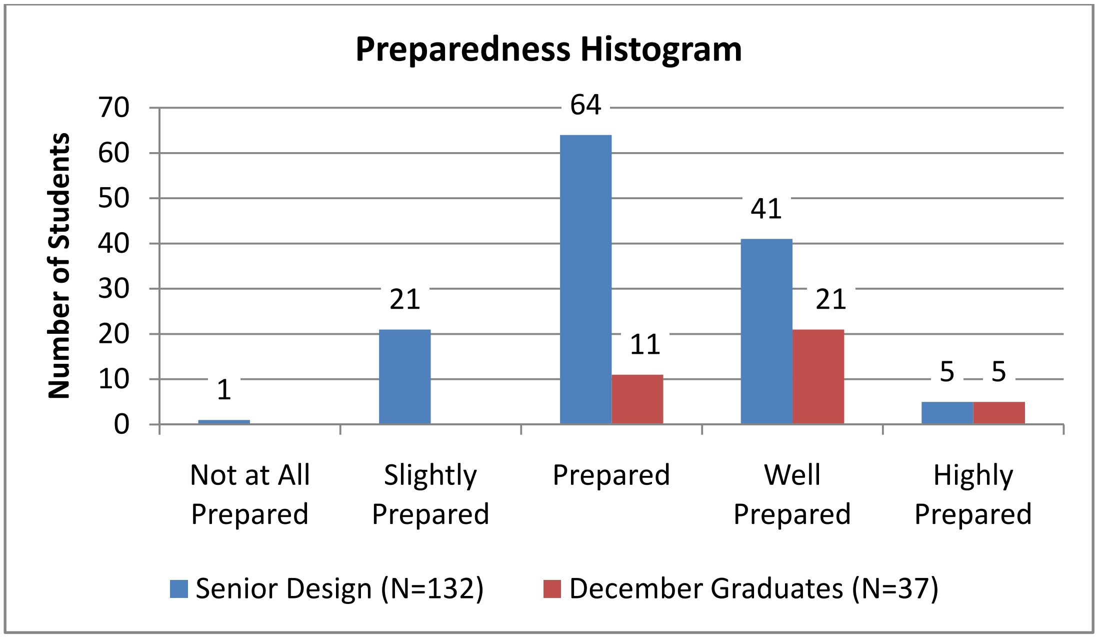


**Figure 4.11: Histogram of "How well prepared do you feel to pursue a career in engineering?"**

The mean responses to Internship Experience (both surveys); Senior Design Experience (both surveys); and Challenge, Career Perception, and Instruction (Senior Design Only) are shown in Figure 4.12 through Figure 4.14.

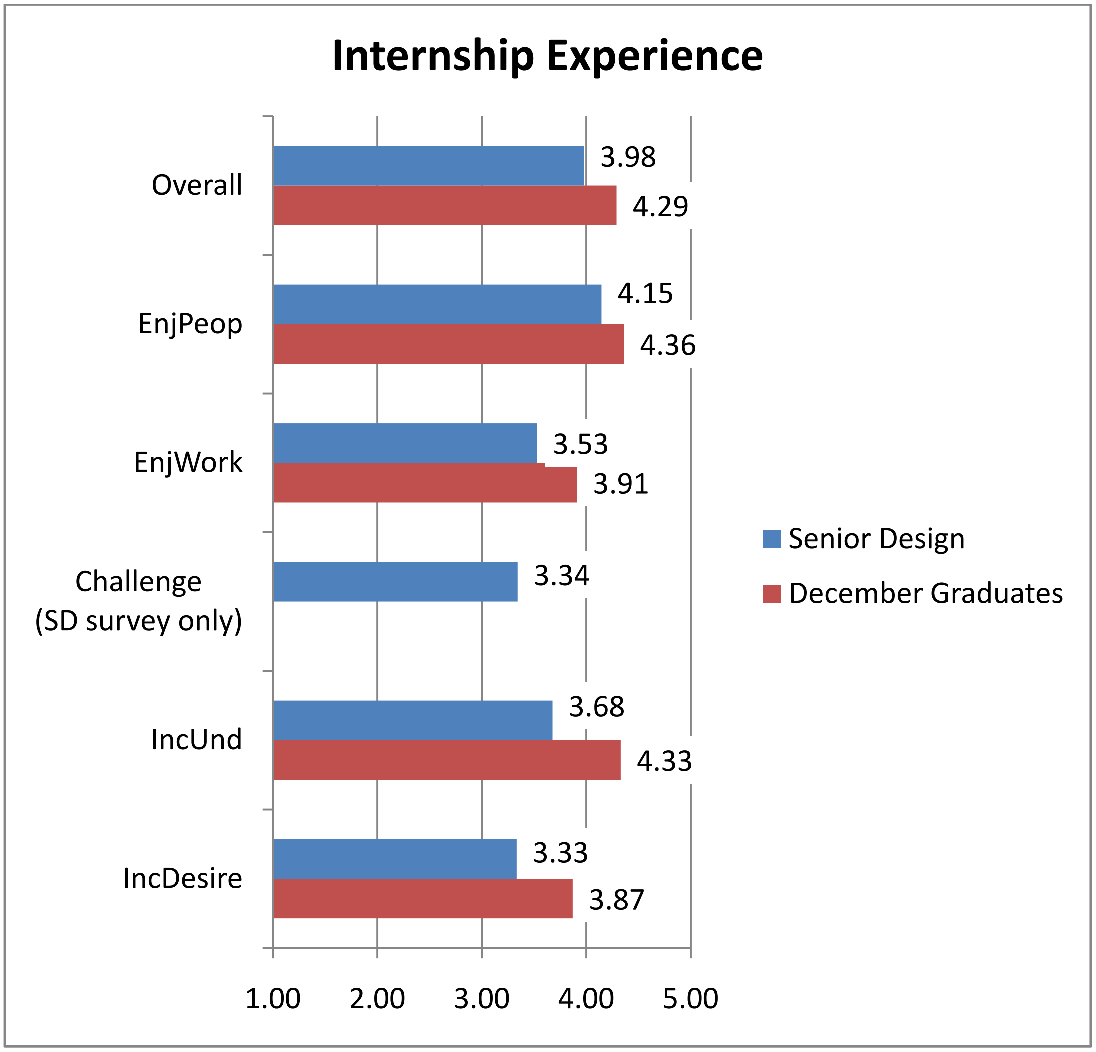


**Figure 4.12: Internship Experience: Mean Values by Statement**

In Internship Experience statements (Figure 4.12), respondents in both surveys rated "I enjoyed the people I worked" the highest (SD: EnjPeop mean=4.15; DG: EnjPeop mean=4.36) and "This internship increased my desire to pursue an engineering career" the lowest (SD: IncDesire mean=3.33; DG: IncDesire mean =3.87). In general, respondents from the December Graduates survey rated all

Internship Experience Likert-style statements higher than Senior Design survey respondents.

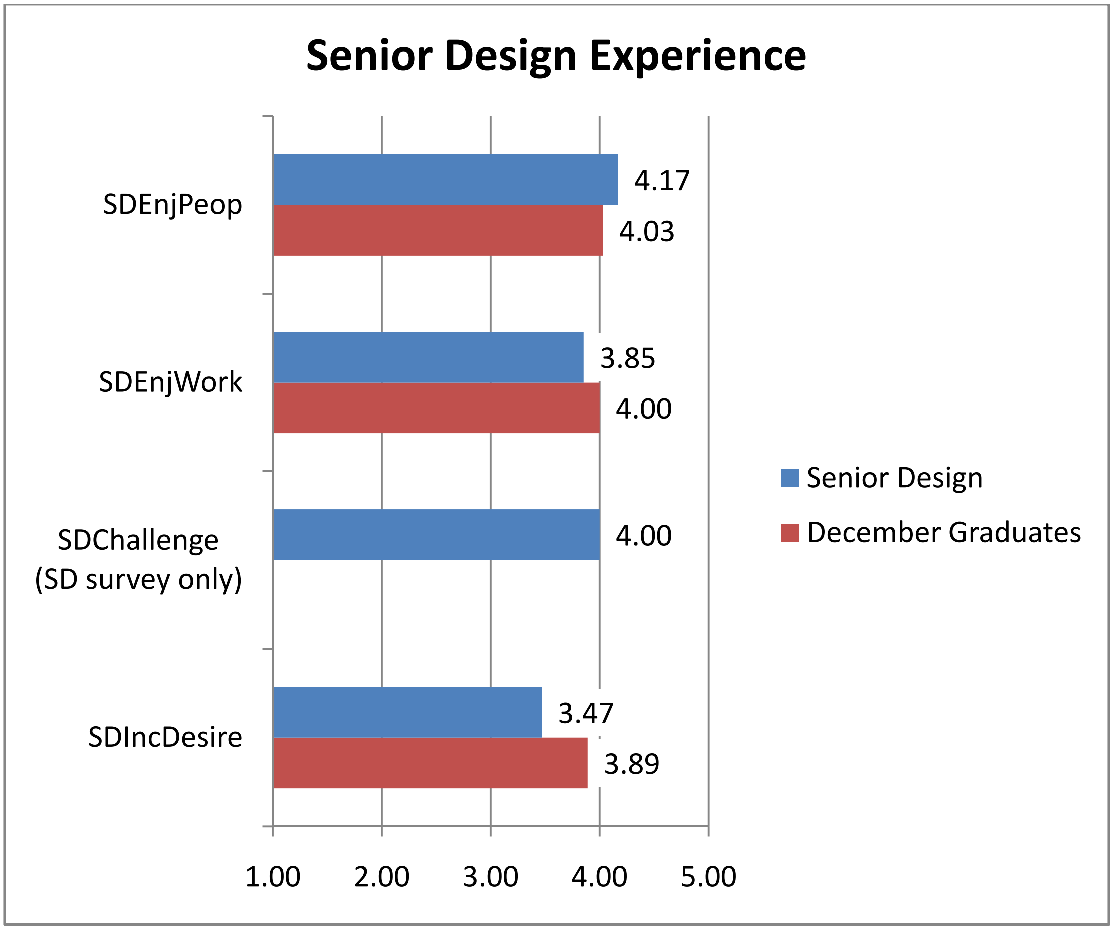


**Figure 4.13: Senior Design Experience: Mean Values by Statement**

In Senior Design Experience statements (Figure 4.13)., respondents in both surveys again rated "I enjoyed the people I worked with on my Senior Design team" the highest (SD: SDEnjPeop mean=4.17; DG: SDEnjPeop mean=4.03) and "My Senior Design project increased my desire to pursue an engineering career" the lowest (SD: SDIncDesire mean=3.47; DG: SDIncDesire mean =3.89). Senior Design survey respondents rated "I enjoyed the people I worked with on my Senior Design team" higher than December Graduates, but rated "My Senior Design project increased my desire to pursue an engineering career" lower than December Graduates

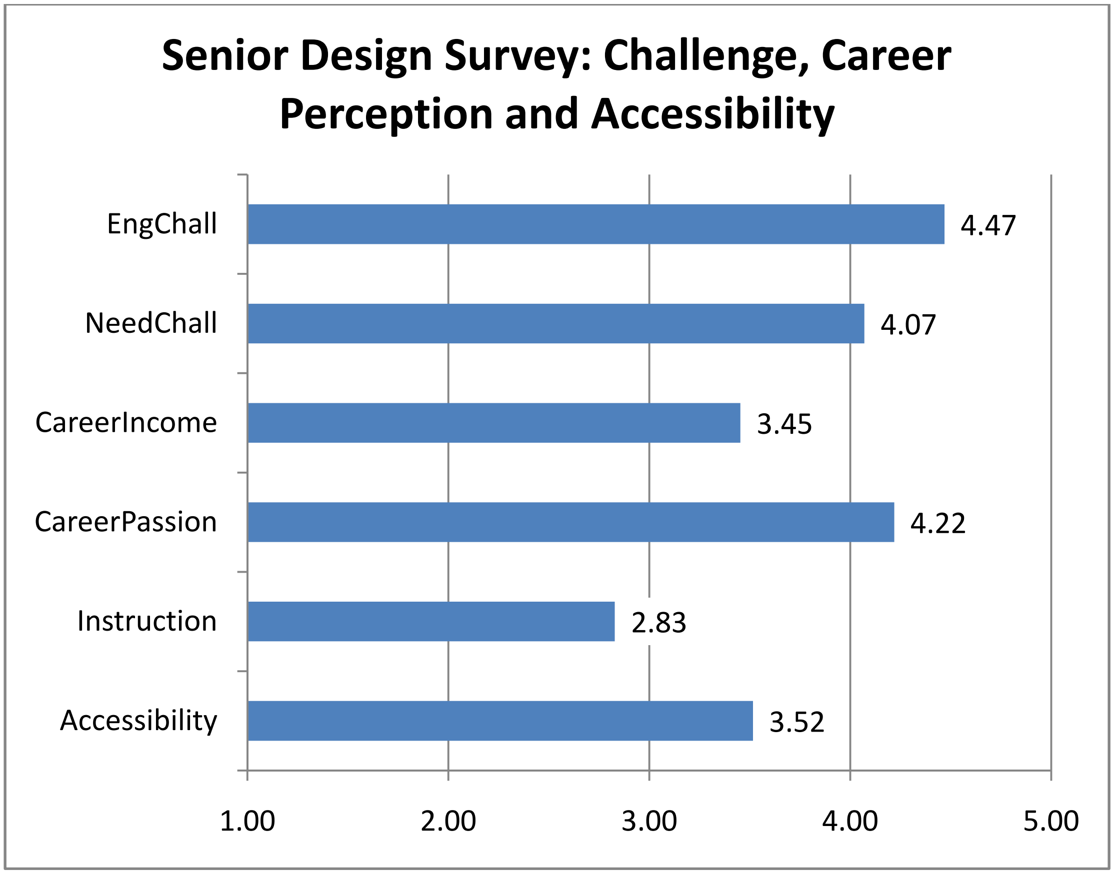


**Figure 4.14: Senior Design Survey: Challenge, Career Perception, and Instruction: Mean Values by Statement (Senior Design survey only)**

Among Challenge, Career Perception, and Instruction statements (Figure 4.14), students rated "Pursuing an engineering degree has challenged me" highest (mean = 4.47) and "I am satisfied with the quality of instruction in CU's engineering program" (mean = 2.83). Interestingly, the "Instruction" mean was the only Likert-style response mean below the neutral response of three in either survey sample.

Students tended to be more satisfied with the accessibility of their instructors than the quality of the instruction.

### 4.2.1.2 Statistical Analysis of Total Sample Responses

The mean for each Likert-style statement was compared to the neutral response of three with a one-sample t-test to determine statistical difference. It can be observed in Table 4.15 that the means for all Likert-style statements in both surveys were statistically different from the neutral response.

**Table 4.15: One Sample t-test Results: Likert-style statements**

| Statement Code | Senior Design | December Graduates |
|---|---|---|
| *Internship Experience* | | |
| Overall | .000** | .000** |
| EnjPeop | .000** | .000** |
| EnjWork | .000** | .000** |
| Challenge | .007** | (SD only) |
| IncUnd | .000** | .000** |
| IncDesire | .001** | .000** |
| *Senior Design Experience* | | |
| SDEnjPeop | .000** | .000** |
| SDEnjWork | .000** | .000** |
| SDChallenge | .000** | (SD only) |
| SDIncDesire | .000** | .000** |
| *Challenge, Career Perception, and Instruction* | | |
| EngChall | .000** | (SD only) |
| NeedChall | .000** | (SD only) |
| CareerIncome | .000** | (SD only) |
| CareerPassion | .000** | (SD only) |
| Instruction | .028** | (SD only) |
| Accessibility | .000** | (SD only) |
| ** Indicates a statistically significant p-value ($p \leq .05$) | | |

### 4.2.2 Response to Likert-style Statements by Post-Graduation Plans Group: Comparison of Means

In order to begin determining what factors may influence a respondent's identification as a Pursuer, Returner, Pursuer with Reservations, or Leaver, the mean response to each Likert-style statements were compared by Post-Graduation Plans Group. Since the preparedness data was ordinal in nature—the question contained check boxes for "Not at all prepared," "Slightly prepared," "Prepared," "Well Prepared," and "Highly Prepared," as opposed to a one through five scale—it was analyzed with a Kruskal-Wallis test. A Mann-Whitney test, with an adjusted significance level for multiple comparisons, was used as the *post hoc* test. The Kruskal-Wallis and Mann-Whitney test statistics are based on the ranks of the data instead of the actual values themselves. Therefore, for the preparedness survey item, a lower mean rank implies feeling relatively less prepared. All Likert-style statements other than "Prepared" were scale data and were therefore analyzed with a one factor ANOVA to see if any of the means were statistically different than the others.

#### 4.2.2.1 Preparedness Survey Item Analysis

The distribution of preparedness by Post-Graduation Plans Group is shown in Figure 4.15 and Figure 4.16 for the Senior Design and December Graduates surveys, respectively. In the Senior Design sample (Figure 4.15), Pursuers reported themselves in the "Well Prepared" and "Highly Prepared" categories (52 percent) more frequently than did Returners (29 percent), Pursuers with Reservations (26%), and Leavers (17%). For Pursuers, the category with the greatest number of respondents was “Well Prepared” (N=20, 45 percent). However, “Prepared” was the category with the highest count for Returners (N=20, 65 percent), Pursuers with Reservations (N=23, 51 percent), and Leavers (N=6, 50 percent). Leavers were the only group without a respondent in the “Highly Prepared” category.

**Figure 4.15: Senior Design Survey: Prepared Distribution by Post-Graduation Plans Group (Total N=132)**

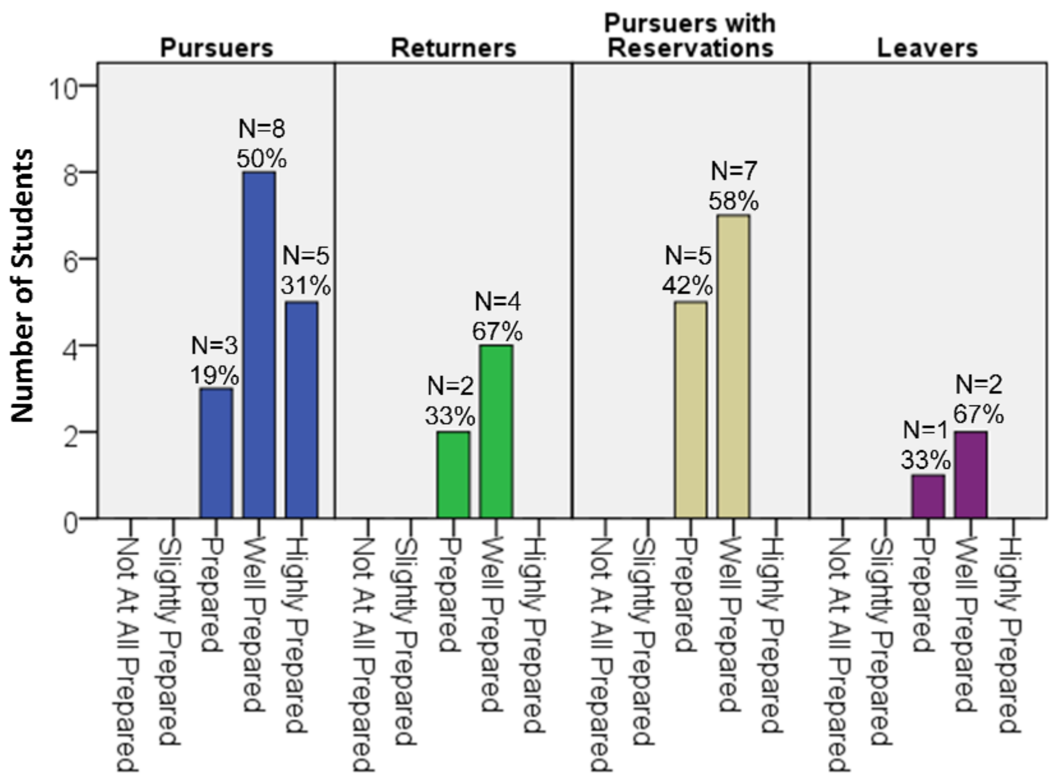


**Figure 4.16: December Graduates Survey: Prepared Distribution by Post-Graduation Plans Group (Total N=37)**

Due to the relatively small sample size in the December Graduates survey, trends in the data are more difficult to identify. From Figure 4.16, it can be seen that the category with the highest count for every group was "Well Prepared." Half of Pursuers (N=8), 67 percent of Returners (N=4), 58% of Pursuers with Reservations (N=7), and 67 percent of Leavers (N=2) reported themselves as "Well Prepared" for an engineering career. Interestingly, all respondents who reported being "Highly Prepared" were Pursuers.

The results of the statistical comparisons for both surveys can be found in Table 4.16. For the Senior Design sample, Pursuers had a higher mean rank (77.72) than Returners (67.74), Pursuers with Reservations (59.57), and Leavers (48.17). In the December Graduates survey, the trend was similar. Pursuers had the highest mean rank (23.06), followed by Returners (16.67), Leavers (16.67), and Pursuers with Reservations (15.33). A statistical difference between the preparedness distributions of Post-Graduation Plans Groups was observed in the Senior Design sample (p=.024) but not in the December Graduates sample (p=.162). A Mann-Whitney *post hoc* test (Table 4.17) with an adjusted significance level for the six total comparisons among four groups ($p\_adj \leq .0083$ for statistically significant; $.0083 < p\_adj \leq .017$ for statistically interesting) revealed only one statistically interesting result. Pursuers felt more prepared than Leavers (p=.017).

**Table 4.16: Kruskal-Wallis Test on "Prepared"**

| | Senior Design | | December Graduates | |
|---|---|---|---|---|
| **Group** | **N** | **Mean Rank** | **N** | **Mean Rank** |
| Pursuers | 44 | 77.72 | 16 | 23.06 |
| Returners | 31 | 67.74 | 6 | 16.67 |
| Pursuers with Reservations | 45 | 59.57 | 12 | 15.33 |
| Leavers | 12 | 48.17 | 3 | 16.67 |
| | | | | |
| Asymp. Sig. | **.024**** | | 0.162 | |

**** Indicates a statistically significant p-value (p ≤ .05)**
**At least one group distribution is different**

**Table 4.17: Senior Design Survey: Mann-Whitney "Prepared" Post Hoc Test: Between Group Comparison p-values**

| Group | Pursuers | Returners | Pursuers with Reservations | Leavers |
|---|---|---|---|---|
| Pursuers | - | | | |
| Returners | .176 | - | | |
| Pursuers with Reservations | .020 | .261 | - | |
| Leavers | **.017*** | .114 | .297 | - |

*** Indicates a statistically interesting p-value (.0083 < p_adj ≤ .017)**

#### 4.2.2.2 Post Graduation Plans Group Comparison: Internship Experience

A comparison of the Post-Graduations Plans Groups' responses to the Likert-style statements about internship experiences can be found in Figure 4.17 and Figure 4.18, for the Senior Design and December Graduates surveys, respectively. In the Senior Design survey (Figure 4.17), Pursuers ("Overall" mean= 4.08) and Returners ("Overall" mean= 4.17) tended to rate their overall internship experience higher than Pursuers with Reservations ("Overall" mean= 3.67) or Leavers ("Overall" mean= 4.00). Pursuers ("IncUnd" mean = 3.78, "IncDesire" mean=3.64) and Returners ("IncUnd" mean = 3.91, "IncDesire" mean=3.57) also seemed to have internship experiences that increased both their understanding of and desire to pursue an engineering career to a greater extent than Pursuers with Reservations ("IncUnd" mean = 3.57, "IncDesire" mean=3.05) and Leavers ("IncUnd" mean = 3.50, "IncDesire" mean=3.00). However, Pursuers with Reservations and Leavers did not tend to rate all statements lower than Pursuers and Returners. For example, Leavers ("EnjPeop" mean = 4.50) reported enjoying the people they worked with in their internship more than any other group.

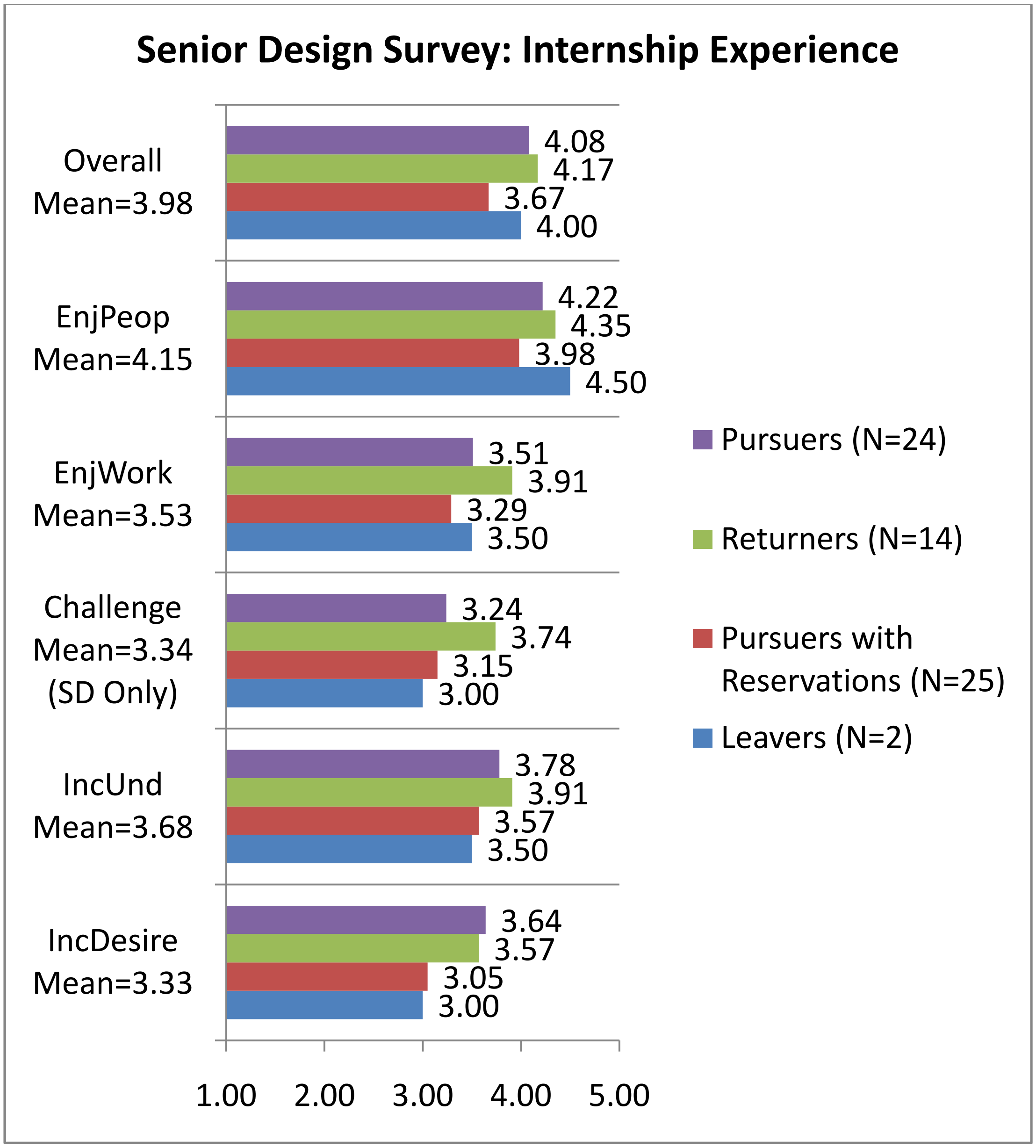


**Figure 4.17: Senior Design Survey: Internship Experience by Post-Graduation Plans Group**

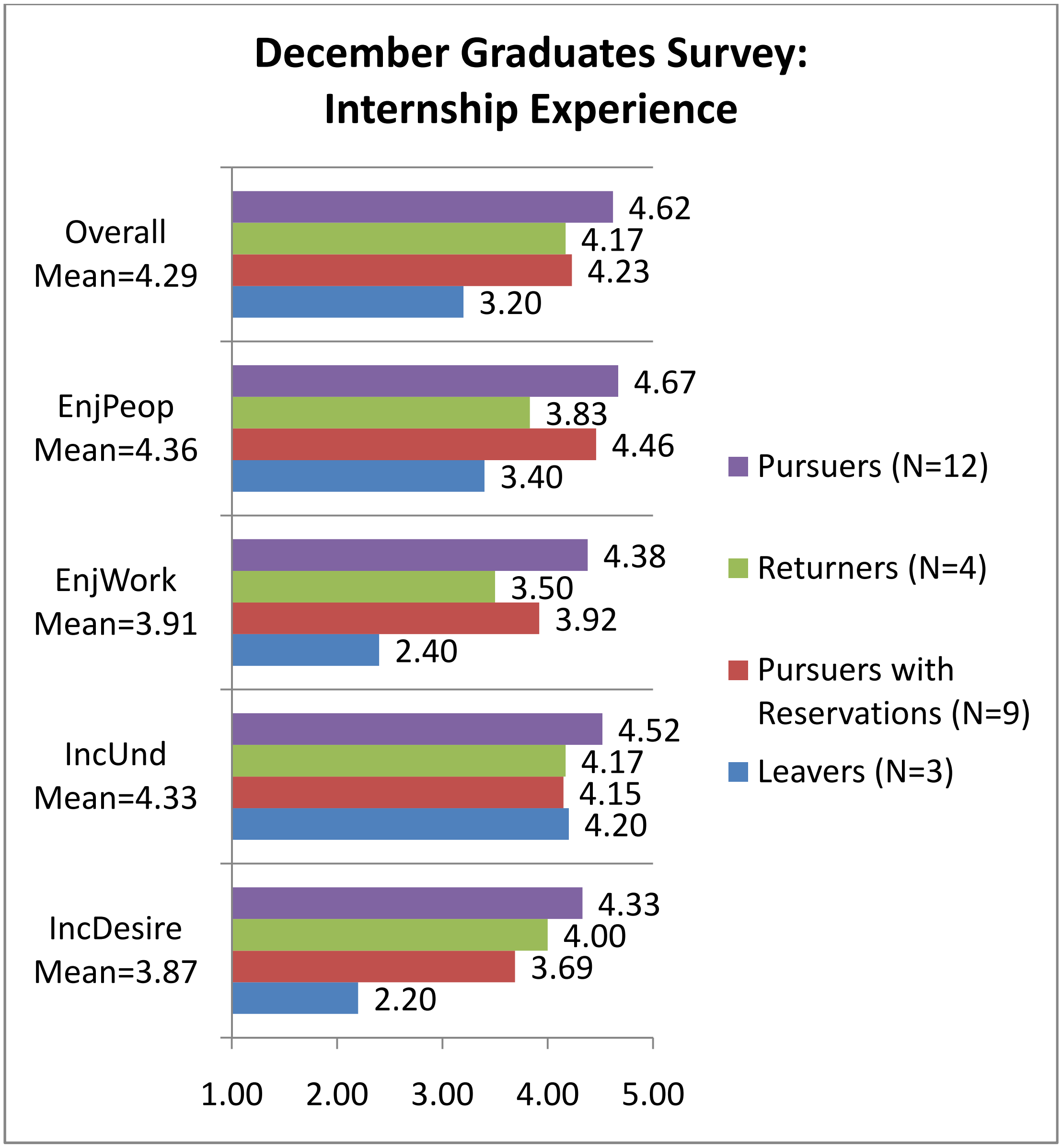


**Figure 4.18: December Graduates Survey: Internship Experience by Post-Graduation Plans Group**

The trends in the December Graduates survey (Figure 4.18) were somewhat inconsistent. One trend that did match the Senior Design survey was on the statement relating to an increased desire to pursue an engineering career. Pursuers ("IncDesire" mean=4.33) and Returners ("IncDesire" mean=4.00) reported internship experiences that increased their desire to pursue an engineering career to a greater extent than Pursuers with Reservations ("IncDesire" mean=3.69) and Leavers ("IncDesire" mean=2.20). With the exception of the statement related to gaining an increased understanding of an engineering career, Leavers tended to rate the statements much lower than the other groups. Leavers' mean responses to the statements "I enjoyed the people I worked with" (mean=2.40) and "This internship increased my desire to pursue an engineering career" (mean=2.20) were below the neutral response of three.

Since only two Leavers in the Senior Design sample had internships, the data did not meet the sample size assumptions of an ANOVA. A two-sample t-test between the Pursuers and Pursuers with Reservations (who had similar samples sizes that met the assumptions of a two sample *t*-test) revealed that internships increased Pursuers' desire to pursue an engineering career to a significantly greater extent than Pursuers with Reservations and Leavers (p=.025, Table 4.18).

**Table 4.18: Senior Design Survey: Internship Experience "IncDesire" t-test: Pursuers and Pursuers with Reservations**

| | "IncDesire" Statement | | |
|---|---|---|---|
| **Group** | N[†] | Mean | p-value |
| Pursuers | 36 | 3.64 | **.025**** |
| Pursuers With Reservations | 42 | 3.05 | |

**** Indicates a statistically significant p-value (p ≤ .05)**

[†] This N is the number of internships, not students

Though sample sizes issues may also have affected the December Graduates survey, significant differences were observed in the ANOVA (Table 4.19) between groups on the statements "Overall" (p=.011), "EnjPeop" (p=.009), "EnjWork" (p=.007), and "IncDesire" (p=.001).

**Table 4.19: December Graduates Survey: Internship Experience ANOVA**

| | p-value | |
|---|---|---|
| Statement | Homogeneity of Variance Test | ANOVA |
| Overall | .883 | **.011**** |
| EnjPeop | .571 | **.009**** |
| EnjWork | .690 | **.007**** |
| IncUnd | .582 | .565 |
| IncDesire | .674 | **.001**** |

**** Indicates a statistically significant p-value (p ≤ .05)**

Post Hoc tests (Table 4.20) showed the following significant differences:

- Pursuers enjoyed the overall internship experience more than Leavers (p=.006)
- Pursuers enjoyed the people they worked with in their internship to a greater extent than Leavers (p=.014)
- Pursuers enjoyed the work they performed in their internship to a greater extent than Leavers (p=.005)
- Pursuers (p=.001), Returners (p=.023), and Pursuers with Reservations (p=.032) found that their internship experiences increased their desire to pursue an engineering career to a greater extent than Leavers

The small sample sizes in the December Graduates survey (sample sizes for the groups are given in Figure 4.18) do not meet the assumptions for an ANOVA. Small sample sizes skew the ANOVA in a way that makes Type I error more likely. Putting too much emphasis on the statistical differences between groups would be erroneous, but the trends in the data—Pursuers with Reservations and Leavers tending to rate some statements lower than Pursuers and Returners—are still important.

**Table 4.20: December Graduates Survey: Internship Experience Post Hoc Tests**

## Post Hoc Tests

**Multiple Comparisons**

Tukey HSD

| Dependent Variable | (I) Group | (J) Group | Mean Difference (I-J) | Sig. |
|---|---|---|---|---|
| Overall | Pursuers | Returners | .45238 | .626 |
| | | Pursuer with Reservations | .38828 | .532 |
| | | Leavers | 1.41905* | **.006**** |
| | Returners | Pursuers | -.45238 | .626 |
| | | Pursuer with Reservations | -.06410 | .999 |
| | | Leavers | .96667 | .216 |
| | Pursuer with Reservations | Pursuers | -.38828 | .532 |
| | | Returners | .06410 | .999 |
| | | Leavers | 1.03077 | **.089*** |
| | Leavers | Pursuers | -1.41905* | **.006**** |
| | | Returners | -.96667 | .216 |
| | | Pursuer with Reservations | -1.03077 | **.089*** |
| EnjPeop | Pursuers | Returners | .83333 | .124 |
| | | Pursuer with Reservations | .20513 | .884 |
| | | Leavers | 1.26667* | **.014**** |
| | Returners | Pursuers | -.83333 | .124 |
| | | Pursuer with Reservations | -.62821 | .390 |
| | | Leavers | .43333 | .805 |
| | Pursuer with Reservations | Pursuers | -.20513 | .884 |
| | | Returners | .62821 | .390 |
| | | Leavers | 1.06154 | **.069*** |
| | Leavers | Pursuers | -1.26667* | **.014**** |
| | | Returners | -.43333 | .805 |
| | | Pursuer with Reservations | -1.06154 | **.069*** |

**** Indicates a statistically significant p-value ($p \le .05$)**

*** Indicates a statistically interesting p-value ($.05 < p \le .10$)**

## Post Hoc Tests (continued)

| Dependent Variable | (I) Group | (J) Group | Mean Difference (I-J) | Sig. |
|---|---|---|---|---|
| EnjWork | Pursuers | Returners | .88095 | .330 |
| | | Pursuer with Reservations | .45788 | .650 |
| | | Leavers | 1.98095* | **.005**** |
| | Returners | Pursuers | -.88095 | .330 |
| | | Pursuer with Reservations | -.42308 | .867 |
| | | Leavers | 1.10000 | .371 |
| | Pursuer with Reservations | Pursuers | -.45788 | .650 |
| | | Returners | .42308 | .867 |
| | | Leavers | 1.52308 | **.059*** |
| | Leavers | Pursuers | -1.98095* | **.005**** |
| | | Returners | -1.10000 | .371 |
| | | Pursuer with Reservations | -1.52308 | **.059*** |
| IncUnd | Pursuers | Returners | .35714 | .792 |
| | | Pursuer with Reservations | .36996 | .596 |
| | | Leavers | .32381 | .863 |
| | Returners | Pursuers | -.35714 | .792 |
| | | Pursuer with Reservations | .01282 | 1.000 |
| | | Leavers | -.03333 | 1.000 |
| | Pursuer with Reservations | Pursuers | -.36996 | .596 |
| | | Returners | -.01282 | 1.000 |
| | | Leavers | -.04615 | 1.000 |
| | Leavers | Pursuers | -.32381 | .863 |
| | | Returners | .03333 | 1.000 |
| | | Pursuer with Reservations | .04615 | 1.000 |
| IncDesire | Pursuers | Returners | .33333 | .886 |
| | | Pursuer with Reservations | .64103 | .273 |
| | | Leavers | 2.13333* | **.001**** |
| | Returners | Pursuers | -.33333 | .886 |
| | | Pursuer with Reservations | .30769 | .922 |
| | | Leavers | 1.80000* | **.023**** |
| | Pursuer with Reservations | Pursuers | -.64103 | .273 |
| | | Returners | -.30769 | .922 |
| | | Leavers | 1.49231* | **.032**** |
| | Leavers | Pursuers | -2.13333* | **.001**** |
| | | Returners | -1.80000* | **.023**** |
| | | Pursuer with Reservations | -1.49231* | **.032**** |

**** Indicates a statistically significant p-value ($p \leq .05$)**
*** Indicates a statistically interesting p-value ($.05 < p \leq .10$)**

#### 4.2.2.3 The Effect of Having an Internship on Preparedness

Cross tabulations in Section 4.1.2 Characterizing the Post-Graduation Plans Groups by Gender, Ethnicity, Degree Types, Internships, and GPA showed that whether or not a respondent had an internship had no significant effect on the identification of a respondent with a particular Post-Graduation Plans Group. However, since preparedness seems to be important to Post-Graduation Plans Group identification, the effect having an internship on preparedness was investigated (Figure 4.19).

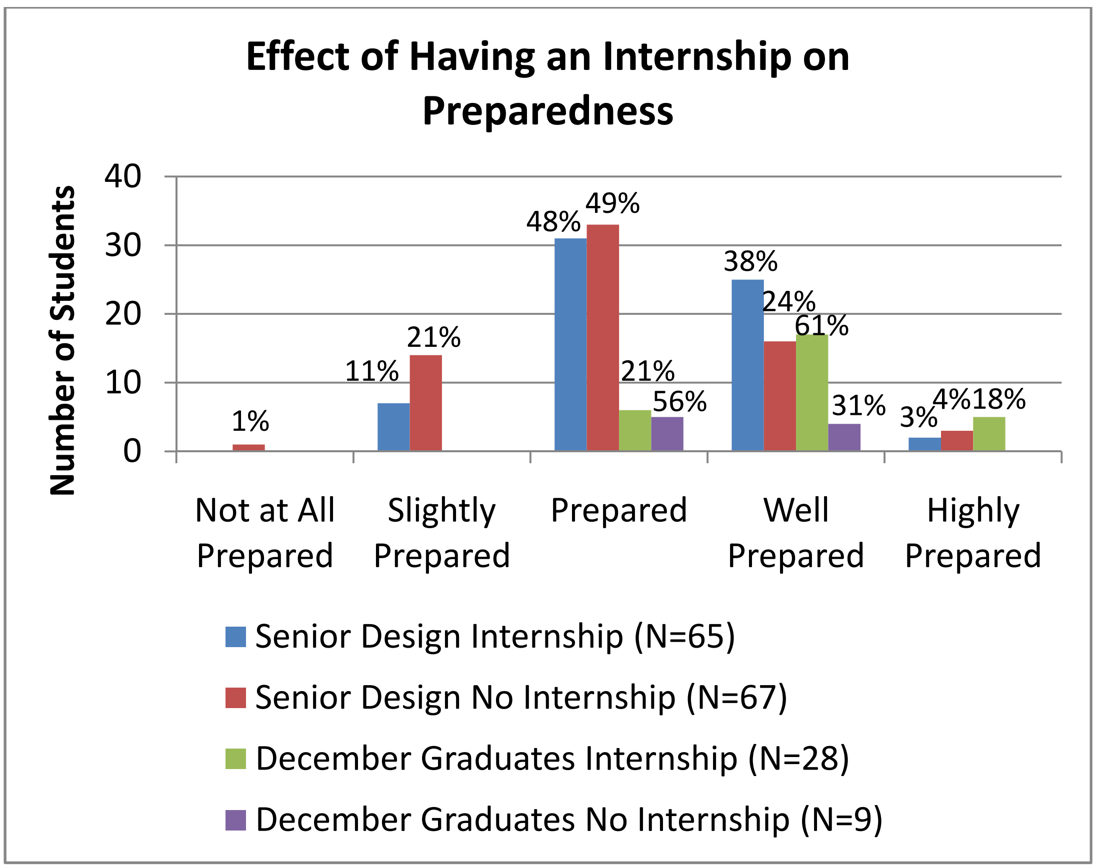


**Figure 4.19: Preparedness Distribution by Internship**

The preparedness distributions for both survey samples were compared with a Mann-Whitney test, shown in Table 4.21. A higher mean rank implies feeling more prepared for a career in engineering.

**Table 4.21: Mann-Whitney Test: Preparedness by Internship**

| | Internship | N | Mean Rank | p-value |
|---|---|---|---|---|
| Senior Design | Internship | 65 | 72.44 | .057* |
| | No Internship | 67 | 60.74 | |
| December Graduates | Internship | 28 | 20.89 | .062* |
| | No Internship | 9 | 13.11 | |

* Indicates a statistically interesting p-value (.05 < p ≤ .10)

In both surveys, students who had internships (SD: mean rank=72.44, DG: mean rank=20.89) reported feeling more prepared for an engineering career than students without internships (SD: mean rank=60.74, DG: mean rank=13.11). The difference between the distributions were statistically interesting (SD: p=.057, DG: p=.062). Though these results are not conclusive, the intuitive supposition that internship experiences might influence a respondent's identification with a particular Post-Graduation Plans Group has some evidence and warrants further investigation.

### 4.2.2.4 Post Graduation Plans Group Comparison: Senior Design Experience

For both surveys, the Senior Design Project experience seemed to have an influence on a respondent's identification with a certain Post-Graduation Plans Group. The mean response broken down by Post-Graduation Plans Group to Likert-style statements related to the Senior Design experience is found in Figure 4.20 and Figure 4.21 for the Senior Design and December Graduate survey, respectively.

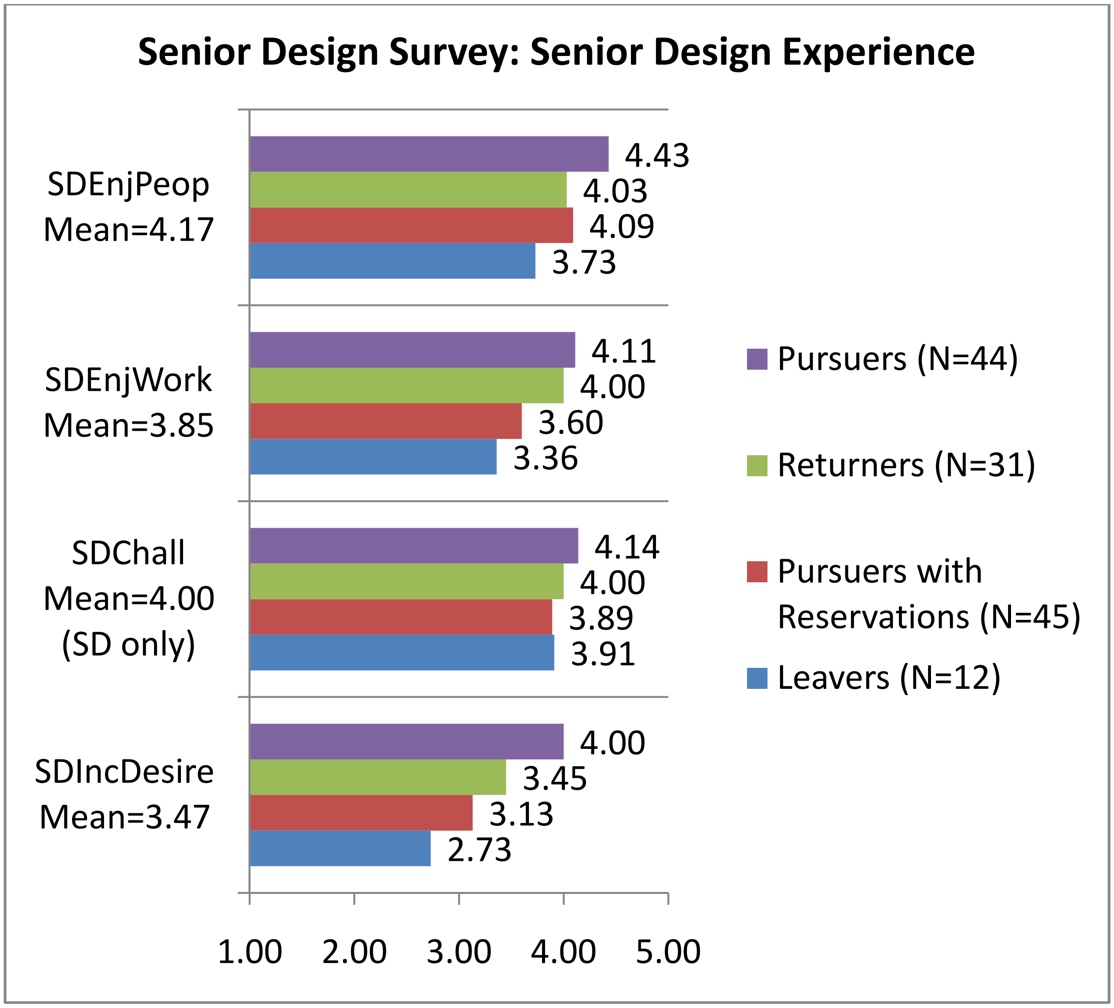


**Figure 4.20: Senior Design Survey: Senior Design Experience by Post-Graduation Plans Group**

In both surveys, the Pursuers rated every statement higher than all other groups. Pursuers tended to enjoy the people on their team (SD: "SDEnjPeop" mean=4.43, DG: "SDEnjPeop" mean=4.03), enjoy the work they did for the project (SD: "SDEnjWork" mean=4.11, DG: "SDEnjWork" mean=4.25), find the work challenging (SD only: "SDChall" mean=4.00) and have an experience that increased their desire to pursue an engineering career to a greater extent (SD: "SDIncDesire" mean =4.00, DG: "SDIncDesire" mean=4.38) than Returners, Pursuers with

Reservations, and Leavers. In both surveys, the Leavers' mean response to the "SDIncDesire" statement was below the neutral response of three (SD: "SDIncDesire" mean =2.73, DG: "SDIncDesire" mean=2.67).

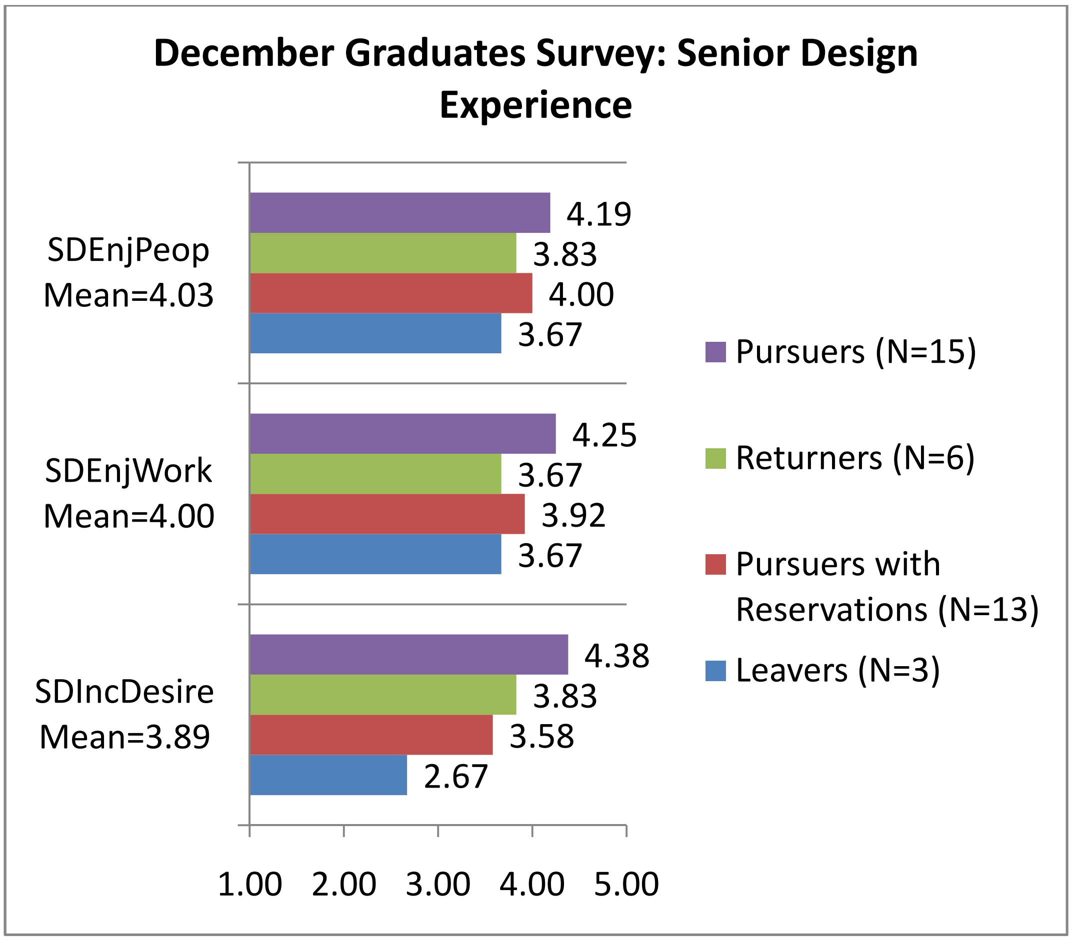


**Figure 4.21: December Graduates Survey: Senior Design Experience by Post-Graduation Plans Group**

A one-factor ANOVA was used to compare the group means for both surveys (Table 4.22). Only the Senior Design survey had significant ANOVA outcomes that did not fail a homogeneity of variance test. Post hoc test results are shown in Table 4.23.

The "SDEnjWork" statement failed the homogeneity of variance test in the Senior Design survey, so it was analyzed with a two-sample t-test (Table 4.24). In the December Graduates survey, the "SDIncDesire" statement also failed the homogeneity of variance test and was analyzed with a two-sample t-test (Table 4.25). To maintain a family-wise significance level of .05 for the six comparisons in the two-sample t-tests, the p-value was adjusted with the Bonferroni multiple comparison procedure. For adjusted p-values less than .008, the differences in the means were considered statistically significant. For adjusted p-values below .017, the differences in the means were considered statistically interesting.

**Table 4.22: Senior Design Survey: Senior Design Experience ANOVA Results**

| | Senior Design Survey | | December Graduates Survey | |
|---|---|---|---|---|
| | p-value | | | |
| **Statement** | **Homogeneity of Variance Test** | **ANOVA** | **Homogeneity of Variance Test** | **ANOVA** |
| SDEnjPeop | .787 | **.018**** | .348 | .785 |
| SDEnjWork | **.041**** | **.012**** | .512 | .492 |
| SDChall (SD only) | .267 | .648 | - | - |
| SDIncDesire | .774 | **.000**** | **.025**** | **.028**** |

** Indicates a statistically significant p-value ($p \leq .05$)

**Table 4.23: Senior Design Survey: Post Hoc Test Results: Senior Design Experience**

Tukey HSD

| Dependent Variable | (I) Group | (J) Group | Mean Difference (I-J) | Sig. |
|---|---|---|---|---|
| SDEnjPeop | Pursuers | Returners | .39956 | .119 |
| | | Pursuers With Reservations | .34293 | .151 |
| | | Leavers | .70455* | **.034**** |
| | Returners | Pursuers | -.39956 | .119 |
| | | Pursuers With Reservations | -.05663 | .989 |
| | | Leavers | .30499 | .665 |
| | Pursuers With Reservations | Pursuers | -.34293 | .151 |
| | | Returners | .05663 | .989 |
| | | Leavers | .36162 | .494 |
| | Leavers | Pursuers | -.70455* | **.034**** |
| | | Returners | -.30499 | .665 |
| | | Pursuers With Reservations | -.36162 | .494 |
| SDEnjWork | Pursuers | Returners | .11364 | .949 |
| | | Pursuers With Reservations | .51364* | **.038**** |
| | | Leavers | .75000 | **.067*** |
| | Returners | Pursuers | -.11364 | .949 |
| | | Pursuers With Reservations | .40000 | .227 |
| | | Leavers | .63636 | .184 |
| | Pursuers With Reservations | Pursuers | -.51364* | **.038**** |
| | | Returners | -.40000 | .227 |
| | | Leavers | .23636 | .861 |
| | Leavers | Pursuers | -.75000 | **.067*** |
| | | Returners | -.63636 | .184 |
| | | Pursuers With Reservations | -.23636 | .861 |
| SDIncDesire | Pursuers | Returners | .54839 | **.103*** |
| | | Pursuers With Reservations | .86667* | **.001**** |
| | | Leavers | 1.27273* | **.002**** |
| | Returners | Pursuers | -.54839 | **.103*** |
| | | Pursuers With Reservations | .31828 | .538 |
| | | Leavers | .72434 | .182 |
| | Pursuers With Reservations | Pursuers | -.86667* | **.001**** |
| | | Returners | -.31828 | .538 |
| | | Leavers | .40606 | .635 |
| | Leavers | Pursuers | -1.27273* | **.002**** |
| | | Returners | -.72434 | .182 |
| | | Pursuers With Reservations | -.40606 | .635 |

**** Indicates a statistically significant p-value (p ≤ .05)**

*** Indicates a statistically interesting p-value (.05 < p ≤ .10)**

**Table 4.24: Senior Design Survey: SDEnjWork t-test Results**

| Group | Pursuers | Returners | Pursuers with Reservations | Leavers |
|---|---|---|---|---|
| Pursuers | - | | | |
| Returners | .569 | - | | |
| Pursuers with Reservations | **.014*** | .040 | - | |
| Leavers | **.016*** | **.015*** | .465 | - |

*** Indicates a statistically interesting p-value (.0083 < p_adj ≤ .017)**

**Table 4.25: December Graduates Survey: SDIncDesire t-test Results**

| Group | Pursuers | Returners | Pursuers with Reservations | Leavers |
|---|---|---|---|---|
| Pursuers | - | | | |
| Returners | .169 | - | | |
| Pursuers with Reservations | .070 | .604 | - | |
| Leavers | **.003**** | .052 | .244 | - |

**** Indicates a statistically significant p-value (p_adj ≤ .0083)**

The results of the group mean comparisons imply that a student's experience the Senior Design Project course can play an important role in determining his or her identification as a Pursuer, Returner, Pursuer with Reservations, or Leaver. A summary of the statistically significant and interesting results follows:

- Senior Design Survey
    - Pursuers enjoyed working with the people on their Senior Design team ("SDEnjPeop" mean=4.43) significantly more than Leavers ("SDEnjPeop" mean=3.73, p=.034).
    - Pursuers enjoyed the work they did on their Senior Design project ("SDEnjPeop" mean=4.11) more than Leavers ("SDEnjPeop" mean=3.36, p=.067).

- The Senior Design project increased Pursuers' ("SDIncDesire" mean=4.00) desire to pursue an engineering career to a significantly greater extent than Pursuers with Reservations ("SDIncDesire" mean=3.13, p=.001) and Leavers ("SDIncDesire" mean=2.73, p=.002)

- December Graduates Survey
  - The Senior Design project increased Pursuers' ("SDIncDesire" mean=4.19) desire to pursue an engineering career to a significantly greater extent than Leavers ("SDIncDesire" mean=2.67, p_adj=.003)

#### 4.2.2.5 Post Graduation Plans Group Comparison: Challenge, Career Perception, and Instruction

The Senior Design survey contained a set of six Likert-style statements not present in the December Graduates survey. They were designed to measure how students valued the need for challenge in work and school, their perception of the purpose of a career, and their attitudes towards the quality of instruction and the accessibility of their professors. See Table 4.13 for the statements given in the survey. The mean response to each statement by Post-Graduation Plans Group is shown in Figure 4.22.

Response means by group tended to be very similar for the statements "Pursuing an engineering degree has challenged me," "I need challenge in my career to feel satisfied," and "A career should be something I am truly passionate about." The statement "A career is a way to earn income so that I can pursue my passions in my own time was rated higher by Pursuers with Reservations ("CareerIncome" mean=3.76) and Leavers (“CareerIncome” mean=3.58) than Pursuers

(“CareerIncome” mean=3.45) and Returners (“CareerIncome” mean=2.87).

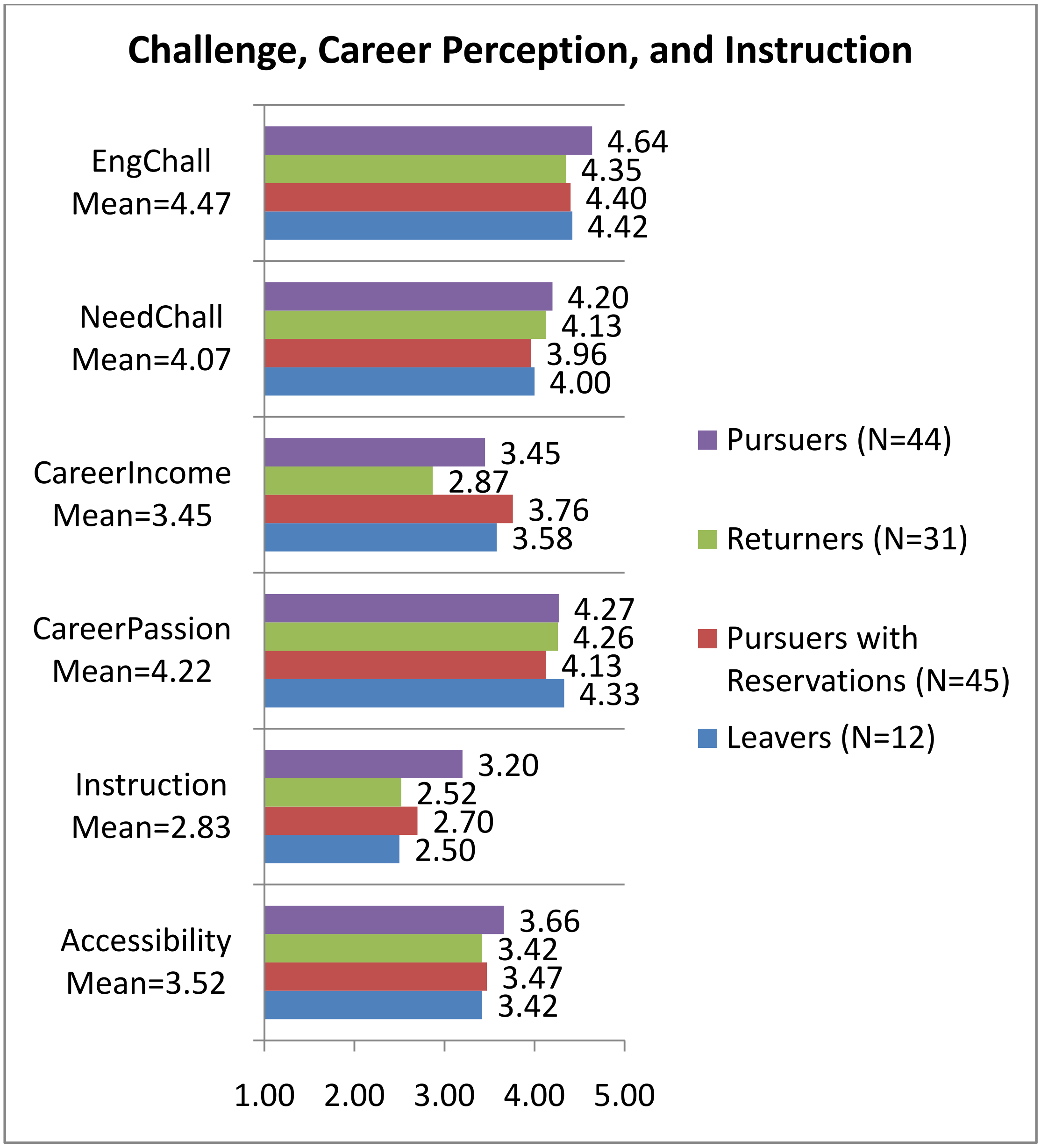


**Figure 4.22: Senior Design Survey: Challenge, Career Perception, and Instruction by Post-Graduation Plans Group**

The statements relating to satisfaction with instruction ("Instruction") and professors' accessibility ("Accessibility) were rated higher by Pursuers ("Instruction" mean=3.20, "Accessibility" mean=3.66) than Returners ("Instruction" mean=2.52, "Accessibility" mean=3.42), Pursuers with Reservations ("Instruction" mean=2.70, "Accessibility" mean=3.47), and Leavers ("Instruction" mean=2.50, "Accessibility" mean=3.42). The mean for Pursuers on the "Instruction" statement ("Instruction" mean=3.20) was the only group mean above the neutral response of three.

The group means were compared with a one-factor ANOVA (Table 4.26). Post hoc tests are found in Table 4.27. Only the statistically significant results are reported.

**Table 4.26: Senior Design Survey: Challenge, Career Perception, and Instruction ANOVA Results**

| | p-value | |
|---|---|---|
| **Statement** | **Homogeneity of Variance Test** | **ANOVA** |
| EngChall | .293 | .228 |
| NeedChall | .869 | .361 |
| CareerIncome | .436 | **.007**** |
| CareerPassion | **.015**** | .676 |
| Instruction | .765 | **.009**** |
| Accessibility | .215 | .529 |

**** Indicates a statistically significant p-value (p ≤ .05)**

**Table 4.27: Senior Design Survey: Post Hoc Test Results: Challenge, Career Perception, and Instruction**

## Post Hoc Tests

**Multiple Comparisons**

Tukey HSD

| Dependent Variable | (I) Group | (J) Group | Mean Difference (I-J) | Sig. |
|---|---|---|---|---|
| CareerIncome | Pursuers | Returners | .58358 | **0.103*** |
| | | Pursuers With Reservations | -.30101 | .556 |
| | | Leavers | -.12879 | .983 |
| | Returners | Pursuers | -.58358 | **0.103*** |
| | | Pursuers With Reservations | -.88459* | **0.003**** |
| | | Leavers | -.71237 | .217 |
| | Pursuers With Reservations | Pursuers | .30101 | .556 |
| | | Returners | .88459* | **0.003**** |
| | | Leavers | .17222 | .961 |
| | Leavers | Pursuers | .12879 | .983 |
| | | Returners | .71237 | .217 |
| | | Pursuer With Reservations | -.17222 | .961 |
| Instruction | Pursuers | Returners | .68842* | **0.015**** |
| | | Pursuers With Reservations | .50455 | **0.071*** |
| | | Leavers | .70455 | .119 |
| | Returners | Pursuers | -.68842* | **0.015**** |
| | | Pursuers With Reservations | -.18387 | .847 |
| | | Leavers | .01613 | 1.000 |
| | Pursuers With Reservations | Pursuers | -.50455 | **0.071*** |
| | | Returners | .18387 | .847 |
| | | Leavers | .20000 | .920 |
| | Leavers | Pursuers | -.70455 | .119 |
| | | Returners | -.01613 | 1.000 |
| | | Pursuers With Reservations | -.20000 | .920 |

**** Indicates a statistically significant p-value ($p \le .05$)**

*** Indicates a statistically interesting p-value ($.05 < p \le .10$)**

Two statistically significant and two statistically interesting differences were observed:

- Pursuers with Reservations saw careers as a way to just earn income to a greater extent than Returners ($p < .01$)
    - Pursuers also saw careers as a way to just earn income to a greater extent than Returners, but the difference was only statistically interesting ($p=.10$)
- Pursuers were more satisfied with the quality of instruction than Returners ($p < .05$).
    - Pursuers were also more satisfied with the quality of instruction than Pursuers with Reservations and Leavers, but the differences were only statistically interesting ($p=.07$ and $p=.10$, respectively)

These results are certainly less conclusive than the Senior Design experience results. However, there is some evidence here that begs further investigation: The purpose of a career—in other words, career values or anchors—may be different among the groups. Also, the satisfaction with the instruction in the engineering program may influence student attitudes towards engineering careers.

### 4.2.3 Post-Graduation Plans Group Comparison of Likert-style Statement Means: Summary of Results

Comparing the Likert-style statement means between the Post-Graduation Plans Groups elucidated several factors that may influence a student's identification as a Pursuer, Returner, Pursuer with Reservations, or Leaver—in other words, possible reasons why an engineering student may or may not choose to purse an engineering career. Collectively, these factors will be referred to as Group Identification Predictors, where Group is short for Post-Graduation Plans Group.

- Preparedness, measured in the form of how well prepared one feels to pursue an engineering career
- Internship experiences
- Senior Design Project experiences
- Satisfaction with the quality of instruction
- Career values related to salary

## 4.3 Correlations among Group Identification Predictors

To further understand what factors influence the Group Identification Predictors, correlations among GPA, Preparedness, Internship Experience, Senior Design Experience, and Challenge, Career Values, and Instruction (Senior Design survey only) were performed. The correlations were done in two distinct groups because the Internship Experience data was considered independent for each internship (some respondents had multiple internships), whereas all other data was considered independent for each respondent. The correlations for non-internship-related factors included GPA, Preparedness, Senior Design Experience and GPA, Preparedness, Challenge, Career Values, and Instruction (Senior Design survey only); the correlations for internship-related factors included GPA, Preparedness, and Internship Experience. Spearman's rho was used as the correlation coefficient.

The strength of the correlations was classified qualitatively with the following scheme:

- Weak: Spearman's rho between .2 and .3
- Mild: Spearman's rho between .3 and .4
- Moderate: Spearman's rho between .4 and .5
- Strong: Spearman's rho above .5

The correlation matrices showed many significant correlations, but only those related to the Group Identification Predictors will be discussed here. Selected scatter plots of interest fit with simple linear regression lines will also be shown. Regression lines were not fitted to scatter plots with Prepared as either the independent or dependent variable because it is an ordinal variable. The Spearman rho coefficient and associated p-value are reported in the figure captions. The label "DG" will precede a Spearman rho and p-value that comes from the December Graduates survey.

### 4.3.1 Correlations among Non-Internship Related Factors

The correlation matrices for non-internship related factors for both surveys are shown in Table 4.28 through Table 4.30.

**Table 4.28: Senior Design Survey: Correlation Matrix: Non-Internship-Related Factors: GPA, Prepared, and Senior Design Experience**

**Correlations**

| | | | GPA | Prepared | SDEnjPeop | SDEnjWork | SDChallenge | SDIncDesire |
|---|---|---|---|---|---|---|---|---|
| Spearman's rho | GPA | Correlation Coefficient | 1.000 | | | | | |
| | | Sig. (2-tailed) | . | | | | | |
| | Prepared | Correlation Coefficient | .142 | 1.000 | | | | |
| | | Sig. (2-tailed) | .110 | . | | | | |
| | SDEnjPeop | Correlation Coefficient | -.055 | .268 | 1.000 | | | |
| | | Sig. (2-tailed) | .543 | **.002**** | . | | | |
| | SDEnjWork | Correlation Coefficient | -.064 | .288 | .527 | 1.000 | | |
| | | Sig. (2-tailed) | .474 | **.001**** | **.000**** | . | | |
| | SDChallenge | Correlation Coefficient | -.023 | .005 | .309 | .486 | 1.000 | |
| | | Sig. (2-tailed) | .797 | .954 | **.000**** | **.000**** | . | |
| | SDIncDesire | Correlation Coefficient | -.215 | .340 | .522 | .705 | .406 | 1.000 |
| | | Sig. (2-tailed) | **.016**** | **.000**** | **.000**** | **.000**** | **.000**** | . |

**** Indicates a statistically significant p-value ($p \leq .05$)**

*** Indicates a statistically interesting p-value ($.05 < p \leq .10$)**

**Table 4.29: Senior Design Survey: Correlation Matrix: Non-Internship-Related Factors: GPA, Prepared, Challenge, Career Perception, and Instruction**

**Correlations**

| | | | GPA | Prepared | EngChall | NeedChall | CareerIncome | CareerPassion | Instruction | Accessibility |
|---|---|---|---|---|---|---|---|---|---|---|
| Spearman's rho | GPA | Correlation Coefficient | 1.000 | | | | | | | |
| | | Sig. (2-tailed) | . | | | | | | | |
| | Prepared | Correlation Coefficient | .142 | 1.000 | | | | | | |
| | | Sig. (2-tailed) | .110 | . | | | | | | |
| | EngChall | Correlation Coefficient | -.138 | .218 | 1.000 | | | | | |
| | | Sig. (2-tailed) | .123 | **.012**** | . | | | | | |
| | NeedChall | Correlation Coefficient | -.034 | .308 | -.022 | 1.000 | | | | |
| | | Sig. (2-tailed) | .702 | **.000**** | .801 | . | | | | |
| | CareerIncome | Correlation Coefficient | -.257 | -.023 | .089 | .020 | 1.000 | | | |
| | | Sig. (2-tailed) | **.004**** | .792 | .310 | .820 | . | | | |
| | CareerPassion | Correlation Coefficient | .096 | .085 | .040 | .166 | -.303 | 1.000 | | |
| | | Sig. (2-tailed) | .282 | .330 | .645 | **.057*** | **.000**** | . | | |
| | Instruction | Correlation Coefficient | -.048 | .297 | .087 | .049 | .065 | .029 | 1.000 | |
| | | Sig. (2-tailed) | .594 | **.001**** | .321 | .574 | .459 | .740 | . | |
| | Accessibility | Correlation Coefficient | .079 | .274 | .099 | .176 | -.095 | .159 | .406 | 1.000 |
| | | Sig. (2-tailed) | .374 | **.001**** | .260 | **.043**** | .281 | **.068*** | **.000**** | . |

**** Indicates a statistically significant p-value ($p \leq .05$)**

*** Indicates a statistically interesting p-value ($.05 < p \leq .10$)**

**Table 4.30: December Graduates Survey: Correlation Matrix: Non-Internship-Related Factors: GPA, Prepared, and Senior Design Experience**

**Correlations**

| | | | GPA | Prepared | SDEnjPeop | SDEnjWork | SDIncDesire |
|---|---|---|---|---|---|---|---|
| Spearman's rho | GPA | Correlation Coefficient | 1.000 | | | | |
| | | Sig. (2-tailed) | . | | | | |
| | Prepared | Correlation Coefficient | .430 | 1.000 | | | |
| | | Sig. (2-tailed) | **.009**** | . | | | |
| | SDEnjPeop | Correlation Coefficient | .086 | .354 | 1.000 | | |
| | | Sig. (2-tailed) | .618 | .032 | . | | |
| | SDEnjWork | Correlation Coefficient | .075 | .271 | .484 | 1.000 | |
| | | Sig. (2-tailed) | .665 | .105 | **.002**** | . | |
| | SDIncDesire | Correlation Coefficient | -.081 | .211 | .542 | .746 | 1.000 |
| | | Sig. (2-tailed) | .637 | .210 | **.001**** | **.000**** | . |

**** Indicates a statistically significant p-value ($p \leq .05$)**

The three strong correlations centered on the Senior Design course experience. Enjoying the work in Senior Design had a strong positive correlation with a Senior Design experience that resulted in an increased desire to pursue an engineering career (rho=.705, $p < .001$, Table 4.28; DG: rho =.746, $p < .001$, Table 4.30). Enjoying the people worked with in Senior Design had strong positive correlations with enjoying the work (rho=.527, $p < .001$, Table 4.28) and a Senior Design experience that resulted in an increased desire to pursue an engineering career (rho=.522, $p < .001$, Figure 4.23 and Table 4.28; DG: rho =.542, $p < .01$, Table 4.30).

Finding the work in Senior Design challenging resulted in moderate positive correlations with enjoying the work in Senior Design (rho=.486, $p < .001$, Table 4.28) and a Senior Design experience that resulted in an increased desire to pursue an engineering career (rho=.406, $p < .001$, Table 4.28). In the December Graduates survey, enjoying the people worked with in Senior Design had a moderate positive correlation with enjoying the work (DG: rho = .484, $p < .01$, Table 4.30). This correlation was strong for the Senior Design survey (Table 4.28). Additionally, the accessibility of instructors had a moderate positive correlation with the satisfaction with the instruction (rho=.406, $p<.001$, Figure 4.24 and Table 4.29).

A mild positive correlation was observed between a Senior Design experience that resulted in an increased desire to pursue an engineering career and feeling more prepared to pursue a career in engineering (rho=.340, $p < .001$, Table 4.28). In the December Graduates survey, enjoying the people worked with in Senior Design had a moderate positive correlation with feeling more prepared to pursue an engineering career (DG: rho = .354, p < .01, Table 4.30). This correlation was weak for the Senior Design survey (Table 4.28).

Weak correlations centered on preparedness. Enjoying the people in Senior Design (rho=.268, p=.002, Table 4.28), enjoying the work in Senior Design (rho=.288, p=.001, Table 4.28) satisfaction with the instruction (rho=.297, p=.001, Table 4.29), and satisfaction with the accessibility of instructors (rho=.274, p=.001, Table 4.29) were weakly correlated with higher preparedness.

The correlation between GPA and preparedness was inconclusive. In the Senior Design survey, a very weak positive correlation was observed (rho=.142, Table 4.28), but it was only statistically interesting (p=.10). However, the December Graduates survey showed a moderate positive correlation between feeling more prepared and having a higher GPA (DG: rho=.430, p < .01, Table 4.30).

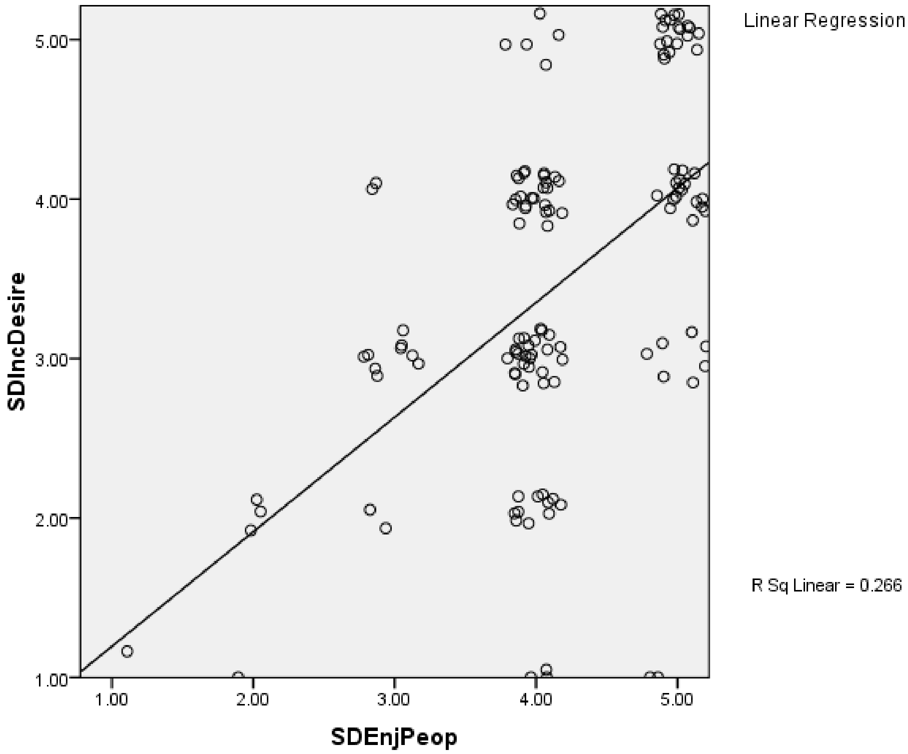


**Figure 4.23: Senior Design Survey: SDIncDesire vs. SDEnjPeop Correlation: Spearman's rho = .522, p < .001.**

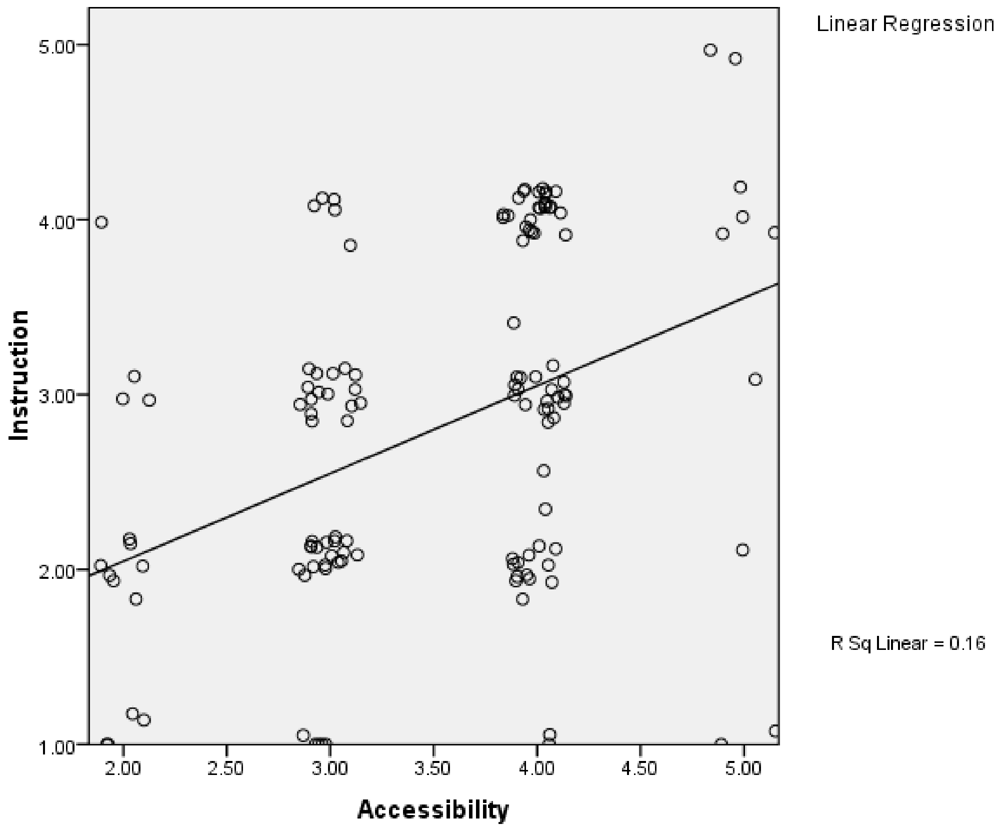


**Figure 4.24: Senior Design Survey: Instruction vs. Accessibility Correlation: Spearman's rho = .406, p < .001**

## 4.3.2 Correlations among Internship-Related Factors

The correlation matrices for non-internship related factors for both surveys are shown in Table 4.31 and Table 4.32.

**Table 4.31: Senior Design Survey: Correlation Matrix: Internship-Related Factors**

**Correlations**

| | | | GPA | Prepared | Overall | EnjPeop | EnjWork | Challenge | IncUnd | IncDesire |
|---|---|---|---|---|---|---|---|---|---|---|
| Spearman's rho | GPA | Correlation Coefficient | 1.000 | | | | | | | |
| | | Sig. (2-tailed) | . | | | | | | | |
| | Prepared | Correlation Coefficient | .172 | 1.000 | | | | | | |
| | | Sig. (2-tailed) | **.086*** | . | | | | | | |
| | Overall | Correlation Coefficient | -.061 | .304 | 1.000 | | | | | |
| | | Sig. (2-tailed) | .545 | **.002**** | . | | | | | |
| | EnjPeop | Correlation Coefficient | -.005 | .288 | .616 | 1.000 | | | | |
| | | Sig. (2-tailed) | .961 | **.003**** | **.000**** | . | | | | |
| | EnjWork | Correlation Coefficient | -.093 | .160 | .727 | .521 | 1.000 | | | |
| | | Sig. (2-tailed) | .359 | .107 | **.000**** | **.000**** | . | | | |
| | Challenge | Correlation Coefficient | .091 | .108 | .476 | .397 | .554 | 1.000 | | |
| | | Sig. (2-tailed) | .368 | .280 | **.000**** | **.000**** | **.000**** | . | | |
| | IncUnd | Correlation Coefficient | -.033 | .125 | .299 | .281 | .224 | .367 | 1.000 | |
| | | Sig. (2-tailed) | .743 | .209 | **.002**** | **.004**** | **0.023**** | **.000**** | . | |
| | IncDesire | Correlation Coefficient | -.170 | .160 | .520 | .458 | .504 | .448 | .620 | 1.000 |
| | | Sig. (2-tailed) | .090 | .106 | **.000**** | **.000**** | **.000**** | **.000**** | **.000**** | . |

**** Indicates a statistically significant p-value ($p \le .05$)**

*** Indicates a statistically interesting p-value ($.05 < p \le .10$)**

**Table 4.32: December Graduates Survey: Correlation Matrix: Internship-Related Factors**

**Correlations**

| | | | GPA | Prepared | Overall | EnjPeop | EnjWork | IncUnd | IncDesire |
|---|---|---|---|---|---|---|---|---|---|
| Spearman's rho | GPA | Correlation Coefficient | 1.000 | | | | | | |
| | | Sig. (2-tailed) | . | | | | | | |
| | Prepared | Correlation Coefficient | .354 | 1.000 | | | | | |
| | | Sig. (2-tailed) | **.017**** | . | | | | | |
| | Overall | Correlation Coefficient | -.073 | .151 | 1.000 | | | | |
| | | Sig. (2-tailed) | .632 | .323 | . | | | | |
| | EnjPeop | Correlation Coefficient | -.038 | .311 | .587 | 1.000 | | | |
| | | Sig. (2-tailed) | .807 | **.038**** | **.000**** | . | | | |
| | EnjWork | Correlation Coefficient | -.068 | .316 | .698 | .585 | 1.000 | | |
| | | Sig. (2-tailed) | .657 | **.034**** | **.000**** | **.000**** | . | | |
| | IncUnd | Correlation Coefficient | .209 | .013 | .610 | .383 | .448 | 1.000 | |
| | | Sig. (2-tailed) | .168 | .934 | **.000**** | **.009**** | **.002**** | . | |
| | IncDesire | Correlation Coefficient | -.065 | .082 | .732 | .345 | .736 | .476 | 1.000 |
| | | Sig. (2-tailed) | .674 | .592 | **.000**** | **.020**** | **.000**** | **.001**** | . |

**** Indicates a statistically significant p-value ($p \leq .05$)**

*** Indicates a statistically interesting p-value ($.05 < p \leq .10$)**

There were many strong correlations that interrelated enjoying the people, finding the work challenging, enjoying the experience overall and having an increased desire to pursue an engineering career. Enjoying the people had a strong positive correlation with enjoying the work (rho=.521, $p < .001$, Table 4.31; DG: rho=.585, $p < .001$, Table 4.32) and enjoying the internship experience overall (rho=.616, $p < .001$, Table 4.31; DG: rho=.587, $p < .001$, Table 4.32). Finding the work challenging had a strong positive correlation with enjoying the work (rho=.554, $p < .001$, Table 4.31). Enjoying the internship experience overall (rho=.520, $p < .001$, Table 4.31; DG: rho=.732, $p < .001$, Table 4.32), enjoying the work (rho=.504, $p < .001$, Figure 4.25 and Table 4.31; DG: rho=.736, $p < .001$, Table 4.32), and having an increased understanding of what it is like to have an engineering career (rho=.620, $p < .001$, Table 4.31) all had strong positive correlations with having an internship experience that resulted in an increased desire to pursue an engineering career. For the December Graduates survey, enjoying the work had a strong positive correlation with enjoying the internship experience overall (DG: rho=.698, $p < .001$, Table 4.32) and enjoying the internship experience overall had a strong positive correlation with having an increased understanding of what it is like to have an engineering career (DG: rho=.610, $p < .001$, Table 4.32).

Enjoying the people (rho=.458, $p < .001$, Table 4.31) and finding the work challenging (rho=.448, $p < .001$, Table 4.31) had moderate positive correlations with having an internship experience that resulted in an increased desire to pursue an engineering career. For the December Graduates survey, enjoying the work had a moderate positive correlation with having an increased understanding of what it is like to have an engineering career (DG: rho=.448, p < .01, Table 4.32) and having an increased understanding of what it is like to have an engineering career had a moderate positive correlation with having an internship experience that resulted in an increased desire to pursue an engineering career (DG: rho=.476, p < .01, Table 4.32).

Enjoying the internship experience overall had a mild positive correlation (rho=.304, p < .01, Table 4.31) with preparedness, while enjoying the people had a weak positive correlation (rho=.288, p < .01, Table 4.31) with preparedness. For the December Graduates, enjoying the people (DG: rho=.311, p < .05, Table 4.32) and enjoying the work (DG: rho=.316, p < .05, Table 4.32) had mild positive correlations with feeling more prepared to pursue an engineering career.

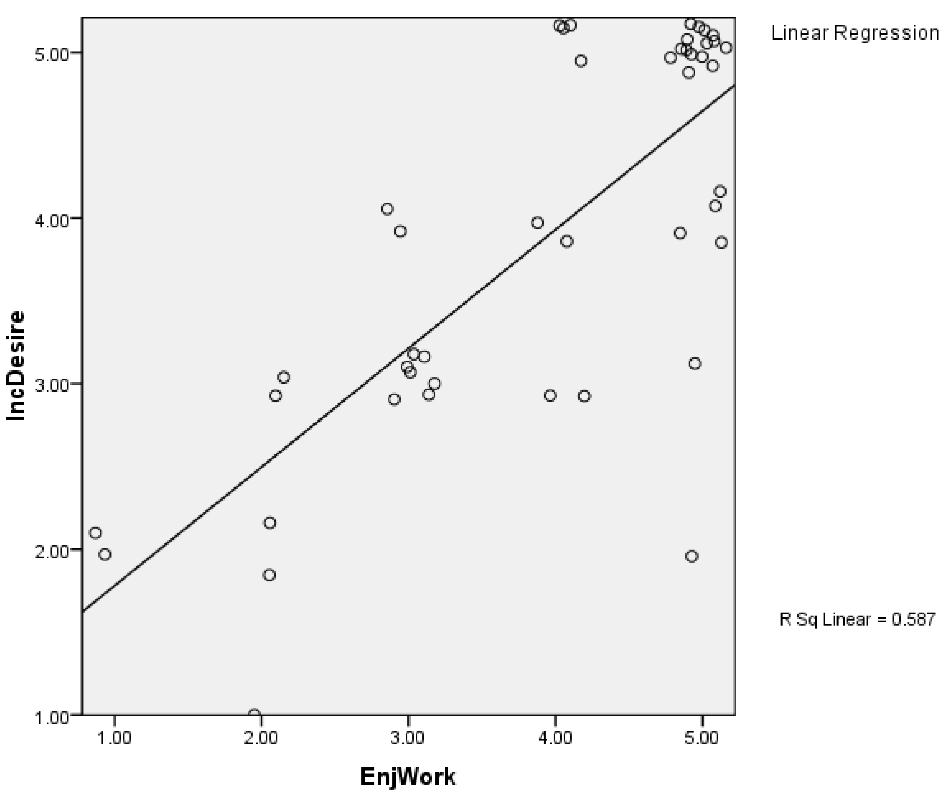


**Figure 4.25: December Graduates Survey: IncDesire vs. EnjWork Correlation: Spearman's rho = .736, p < .001**

The results of the correlation analysis give more evidence to the importance of the following three Group Identification Predictors:

- Preparedness
- Internship experience
- Senior Design Project Course experience

To a lesser degree, the correlations also showed that satisfaction with the quality of instruction, the fourth Group Identification Predictor, may affect preparedness and therefore a student's identification with a particular Post-Graduation Plans Group.

## 4.4 Nonparametric Statistical Analysis of Career Values Rank Question

Survey Item 11, shown in Figure 4.26, asked respondents to rank nine career-related values in order of their importance to them, and to add as many distinct "Other" categories as they wished. For the December Graduates survey, the field "Being challenged by the work" was not present so there were only eight total career-related values. The purpose of the question was to determine if different Post-Graduation Plans Groups had different career-related priorities.

**In choosing a career, what factors are most important to you? Please RANK ALL OF THE FOLLOWING 9 OPTIONS IN ORDER OF THEIR IMPORTANCE TO YOU, with 1 being the most important and 9 being the least important.** (*You may add as many distinct "other" categories as you wish and rank them as well).*

__ Salary
__ Ability to contribute to society
__ Prestige
__ Interest or talent in the career
__ Enjoying the people I would work with
__ Fitting in with the culture of the field
__ Expected number of hours worked per week
__ Geographic location (near family, the mountains, the ocean etc.)
__ Being challenged by the work
__ Other (please specify:)________________________________

**Figure 4.26: Survey Item 11: Career Values Rank Question**

A simple comparison of medians (Table 4.33) gives the following order for the total sample for both surveys:

- Senior Design Survey:

  1. Interest or talent in the career
  2. Other
  3. Enjoying the people I would work with
  3. Salary
  5. Geographic location
  5. Being challenged by the work
  7. Ability to contribute to society
  8. Prestige
  8. Expected number of hours worked per week
  10. Fitting in with the culture of the field

- December Graduates Survey

  1. Interest or talent in the career
  2. Enjoying the people I would work with
  3. Other
  3. Salary
  5. Geographic location
  6. Ability to contribute to society
  7. Fitting in with the culture of the field

8. Prestige
8. Expected number of hours worked per week

The distributions were roughly similar. “Interest or talent in the career” was listed first in both survey samples. Along with “Interest or talent in the career,” “Other,” “Enjoying the people I would work with,” “Salary,” and “Geographic location” were the top five most important career values in both surveys.

**Table 4.33: Median Values for Career Value Rank Question**

| | Senior Design Survey | | December Graduates Survey | |
|---|---|---|---|---|
| **Career Value** | **N** | **Median** | **N** | **Median** |
| Salary | 129 | 4.0 | 34 | 4.0 |
| Contribute | 129 | 6.0 | 34 | 4.5 |
| Prestige | 129 | 7.0 | 34 | 7.0 |
| Interest | 129 | 1.0 | 34 | 1.0 |
| EnjPeopWork | 129 | 4.0 | 34 | 3.0 |
| FitIn | 129 | 8.0 | 34 | 6.5 |
| Hours | 130 | 7.0 | 34 | 7.0 |
| Location | 129 | 5.0 | 34 | 4.0 |
| BeingChall (SD only) | 129 | 5.0 | 34 | - |
| Other | 6 | 1.5 | 7 | 4.0 |

Since the data are ordinal in nature, differences between the Post-Graduation Plans Groups must be measured by with a Kruskal-Wallis test to determine any of the distributions are different. The test statistics are based on the ranks of the data instead of the actual values themselves. Therefore, for the Career Values Rank Question, a lower mean rank implies a more important factor. The Kruskal-Wallis test results are shown in Table 4.34. The post hoc tests (only for items with statistically significant or interesting differences in distributions) to determine which Post-Graduation Plans Groups were different are shown in Table 4.35 through Table 4.37.

**Table 4.34: Kruskal-Wallis Test: Career Values Rank Question: Mean Ranks**

## Kruskal-Wallis Test

| | | Senior Design Survey | | | December Graduates Survey | | |
|---|---|---|---|---|---|---|---|
| | Group | N | Mean Rank | p-value | N | Mean Rank | p-value |
| Salary | Pursuers | 44 | 59.23 | **.001**** | 13 | 16.62 | .377 |
| | Returners | 30 | 85.17 | | 6 | 20.67 | |
| | Pursuers With Reservations | 45 | 53.62 | | 12 | 15.08 | |
| | Leavers | 10 | 81.10 | | 3 | 24.67 | |
| | Total | 129 | | | 34 | | |
| Contribute | Pursuers | 44 | 61.95 | **.062*** | 13 | 15.81 | .553 |
| | Returners | 30 | 65.93 | | 6 | 16.83 | |
| | Pursuers With Reservations | 45 | 73.11 | | 12 | 20.63 | |
| | Leavers | 10 | 39.10 | | 3 | 13.67 | |
| | Total | 129 | | | 34 | | |
| Prestige | Pursuers | 44 | 60.92 | .524 | 13 | 15.58 | .742 |
| | Returners | 30 | 72.15 | | 6 | 17.67 | |
| | Pursuers With Reservations | 45 | 62.62 | | 12 | 18.42 | |
| | Leavers | 10 | 72.20 | | 3 | 21.83 | |
| | Total | 129 | | | 34 | | |
| Interest | Pursuers | 44 | 65.16 | .572 | 13 | 17.08 | .834 |
| | Returners | 30 | 58.33 | | 6 | 20.33 | |
| | Pursuers With Reservations | 45 | 69.50 | | 12 | 17.08 | |
| | Leavers | 10 | 64.05 | | 3 | 15.33 | |
| | Total | 129 | | | 34 | | |
| EnjPeopWork | Pursuers | 44 | 78.27 | **.034**** | 13 | 21.73 | .240 |
| | Returners | 30 | 57.93 | | 6 | 14.67 | |
| | Pursuers With Reservations | 45 | 57.94 | | 12 | 15.46 | |
| | Leavers | 10 | 59.55 | | 3 | 13.00 | |
| | Total | 129 | | | 34 | | |

**** Indicates a statistically significant p-value (p ≤ .05)**
*** Indicates a statistically interesting p-value (.05 < p ≤ .10)**

**Table 4.34 (Continued): Kruskal-Wallis Test: Career Values Rank Question: Mean Ranks**

| | | Senior Design Survey | | | December Graduates Survey | | |
|---|---|---|---|---|---|---|---|
| | Group | N | Mean Rank | p-value | N | Mean Rank | p-value |
| FitIn | Pursuers | 44 | 60.89 | .454 | 13 | 20.58 | .536 |
| | Returners | 30 | 73.70 | | 6 | 14.58 | |
| | Pursuers With Reservations | 45 | 62.31 | | 12 | 15.96 | |
| | Leavers | 10 | 69.10 | | 3 | 16.17 | |
| | Total | 129 | | | 34 | | |
| Hours | Pursuers | 44 | 68.99 | .807 | 13 | 18.19 | .499 |
| | Returners | 30 | 62.77 | | 6 | 17.08 | |
| | Pursuers With Reservations | 45 | 65.69 | | 12 | 18.96 | |
| | Leavers | 11 | 58.23 | | 3 | 9.50 | |
| | Total | 130 | | | 34 | | |
| Location | Pursuers | 44 | 68.08 | .782 | 13 | 18.88 | .774 |
| | Returners | 30 | 60.33 | | 6 | 15.83 | |
| | Pursuers With Reservations | 45 | 63.79 | | 12 | 15.96 | |
| | Leavers | 10 | 70.90 | | 3 | 21.00 | |
| | Total | 129 | | | 34 | | |
| BeingChall | Pursuers | 44 | 67.75 | .457 | - | - | - |
| | Returners | 30 | 56.12 | | - | - | |
| | Pursuers With Reservations | 45 | 69.04 | | - | - | |
| | Leavers | 10 | 61.35 | | - | - | |
| | Total | 129 | | | - | | |
| Other | Pursuers | 3 | 3.67 | .164 | 3 | 3.67 | **.031**** |
| | Returners | 2 | 2.00 | | - | - | |
| | Pursuers With Reservations | 1 | 6.00 | | 4 | 6.00 | |
| | Total | 6 | | | 7 | | |

**** Indicates a statistically significant p-value (p ≤ .05)**
*** Indicates a statistically interesting p-value (.05 < p ≤ .10)**

In the Senior Design survey, two items had statistically different distributions among the Post-Graduation Plans Groups: "Salary" (p=.001, Figure 4.27) and "Enjoying the people I would work with" (p=.034, Figure 4.28). "Salary" was more important to Pursuers (mean rank=59.23, p=.003) and Pursuers with Reservations (mean rank=53.62, $p < .001$) than to Returners (mean rank=85.17). "Enjoying the people I would work with" was more important to Returners (mean rank=57.93, p=.013) and Pursuers with Reservations (mean rank=57.94, p=.016) than to Pursuers (mean rank=78.27). Also, a statistically interesting difference was observed for "Ability to Contribute to Society" (p=.062, Figure 4.29). "Ability to Contribute to Society" was more important to Leavers (mean rank=39.10, p= .010) than to Pursuers with Reservations (mean rank=73.11, p=.010)

The only significant difference observed in the December Graduates survey was the positioning of the "Other" category. Because the answers specified in the "Other" category were all different and the number of respondents who checked the "Other" category was relatively small, no further analysis was conducted.

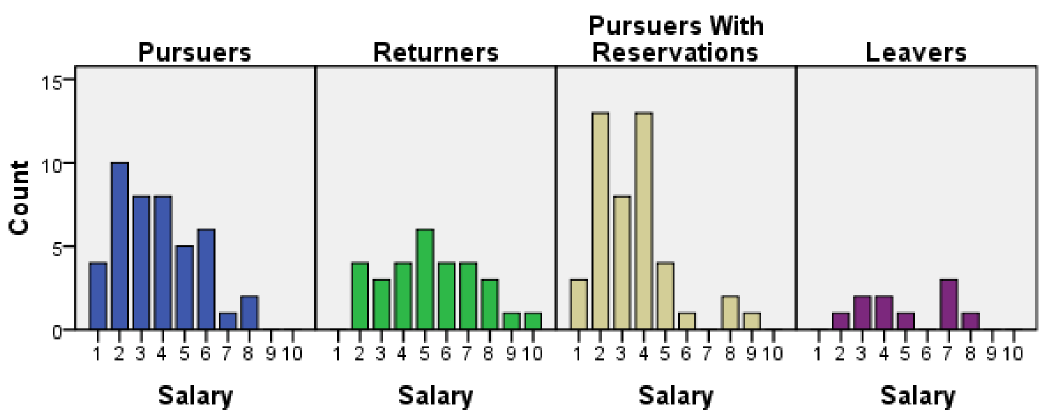


**Figure 4.27: Career Values by Post-Graduation Plans Group: Salary**

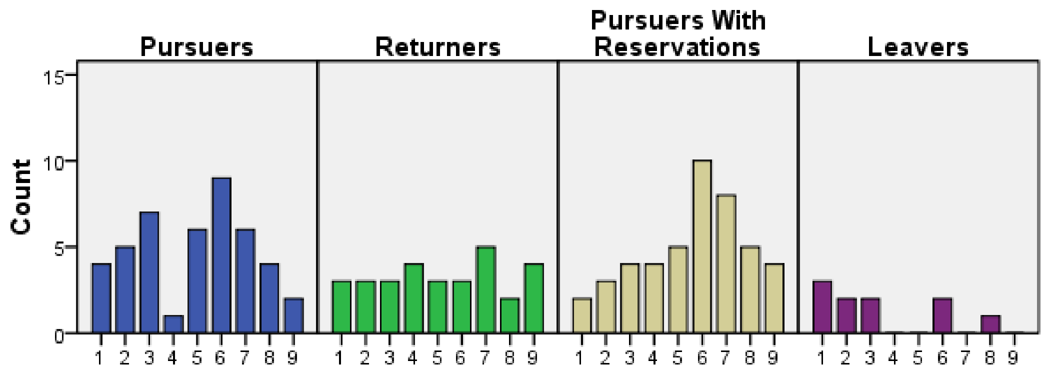


**Figure 4.28: Career Values by Post-Graduation Plans Group: EnjPeopWork**

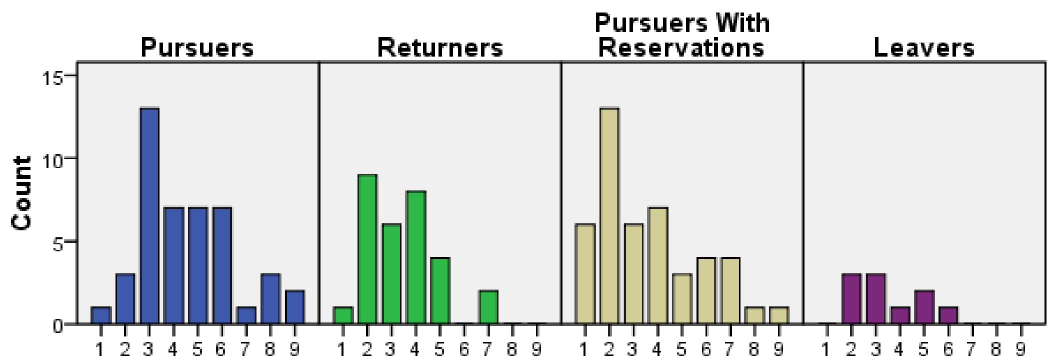


**Figure 4.29: Career Values by Post-Graduation Plans Group: Contribute**

**Table 4.35: Senior Design Survey: Career Values Rank Question Post Hoc Test: Salary**

Salary

| Group | Pursuers | Returners | Pursuers with Reservations | Leavers |
|---|---|---|---|---|
| Pursuers | - | | | |
| Returners | **.003**** | - | | |
| Pursuers with Reservations | .476 | **.000**** | - | |
| Leavers | .083 | .770 | .037 | - |

** Indicates a statistically significant p-value (p_adj ≤ .0083)

**Table 4.36: Senior Design Survey: Career Values Rank Question Post Hoc Test: Contribute**

| Contribute | | | | |
|---|---|---|---|---|
| **Group** | **Pursuers** | **Returners** | **Pursuers with Reservations** | **Leavers** |
| Pursuers | - | | | |
| Returners | .669 | - | | |
| Pursuers with Reservations | .143 | .432 | - | |
| Leavers | .068 | .054 | **.010*** | - |

* Indicates a statistically interesting p-value (.0083 < p_adj ≤ .017)

**Table 4.37: Senior Design Survey: Career Values Rank Question Post Hoc Test: EnjPeopWork**

| EnjPeopWork | | | | |
|---|---|---|---|---|
| **Group** | **Pursuers** | **Returners** | **Pursuers with Reservations** | **Leavers** |
| Pursuers | - | | | |
| Returners | **.013*** | - | | |
| Pursuers with Reservations | **.016*** | .856 | - | |
| Leavers | .107 | .866 | .807 | - |

* Indicates a statistically interesting p-value (.0083 < p_adj ≤ .017)

The following is a summary of the statistically significant and interesting results:

- "Salary"
    - "Salary" is significantly more important to Pursuers than Returners ($p < .05$). This corroborates with a statistically interesting result from the "CareerIncome" Likert-style statement: Pursuers also saw careers as a way to just earn income to a greater extent than Returners, but the difference was only statistically interesting ($p=.10$)
    - "Salary" is significantly more important to Pursuers with Reservations than Returners ($p < .05$). This corroborates with a statistically significant

result from the "CareerIncome" Likert-style statement: Pursuers with Reservations saw careers as a way to just earn income to a greater extent than Returners ($p < .01$)

  - "Salary" is significantly more important to Pursuers with Reservations than Leavers ($p < .05$)

- "Enjoying the people I would work with"
  - "Enjoying the people I would work with" is significantly more important to Returners than Pursuers ($p < .05$)
  - "Enjoying the people I would work with" is significantly more important to Pursuers with Reservations than Pursuers ($p < .05$)
- "Ability to Contribute to Society"
  - "Ability to Contribute to Society" is more important to Leavers than Pursuers, Pursuers with Reservations, and Returners (statistically interesting, $p=.062$).

Although the evidence is still very limited, there is some indication that different career values, especially those related to salary and co-workers, may influence a student's identification with a particular Post-Graduation Plans Group.

## 4.5 Qualitative Survey Analysis

The Senior Design survey had a total of six open response survey items that allowed respondents to give qualitative explanations of their internship experiences; their post-graduation plans, including if they planned to leave the engineering field in the future and reasons for having reservations, if any; why they did or did not choose engineering as a career; and, if they did not choose engineering as a career, what could have made them choose engineering. The six questions follow:

**Please rate your agreement with the following statements using the scale below:**

*(1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree)*

| | Internship #1 | Internship #2 | Internship #3 | Internship #4 |
|---|---|---|---|---|
| I enjoyed this internship experience overall | | | | |
| I enjoyed the people I worked with | | | | |
| I enjoyed the work | | | | |
| I found the work challenging | | | | |
| This internship increased my understanding of what it is like to have a career in engineering | | | | |
| This internship increased my desire to pursue an engineering career | | | | |

**Please summarize your responses to the above statements. Why do you feel the way you do?**

**Figure 4.30: Survey Item 7: Internship Experience**

**13. Why have you chosen engineering as a career?**

**Figure 4.31: Survey Item 13: Reasons for Choosing an Engineering Career**

**14. Do you have any reservations about your choice?**
__ Yes __ No

*If you answered "Yes", please summarize your response:*

**Figure 4.32: Survey Item 14: Reservations about an Engineering Career**

**15. Do you see engineering as a long-term career for you?**

__ Yes __ No

*If "no," what other career(s) might you pursue?*

**Figure 4.33: Survey Item 15: Other Career Plans**

**17. Do you see yourself pursuing a career in engineering in the future?**
__ Yes __ No

If "no," please summarize your response. Why did you not choose engineering as a career?

What, if anything, could have made you choose engineering?

**Figure 4.34: Survey Item 17: Engineering Career in the Future**

## 4.5.1 Reasons for Choosing Engineering as a Career

Respondents from both surveys had a wide variety of reasons for choosing engineering as a career. Many respondents listed multiple reasons. In sum, 178 reasons from 89 respondents in the Senior Design sample and 62 reasons from 28 respondents in the December Graduates sample were reviewed. (Only Pursuers and Pursuers with Reservations gave answers to this question because of the way the survey was completed—Returners and Leavers were directed to a different survey section). The reasons were classified into five major categories:

1. **Intrinsic Work-Related Factors**: Reasons such as enjoyment/fulfillment from work, enjoying teamwork, find work interesting and challenging, congruence of self-identity and profession, and being kinesthetically inclined.

Sample responses:

*"Because it's challenging and I enjoy building and creating things for people and I feel fulfilled doing so."*

*"Because I enjoy the design process and I know it will continue to challenge me."*

2. **Perceived Competence**: Reasons like talent in career, strength in math and science, a desire to apply degree and skills learned in school, creative inclination and problem-solving aptitude.

Sample responses:

*"I took advanced math and science courses in high school. I wanted to pursue something I was "good at," I have a strong interest in the automotive field and I like design problems."*

*"I like to work on teams. I would like to lead teams. Engineering is challenging, creative, and innovative. My talents lend themselves to it. Money is good."*

3. **Extrinsic Work-Related Factors:** Factor such as money, career stability, having meaningful job responsibilities, opportunity for success and advancement, a good "fall-back if other careers do not work out, or as preparation for another career.

Sample responses:

*"I liked math and science and you are a part of the future of many different fields. I heard there's a lot of money."*

*"I was most interested in ME when I first came to school. It also pays well and usually it is easier to get a job in than other fields."*

4. **People-Oriented**: Reasons like the influence of a mentor or family member, enjoying the people in the field, and ability to contribute to society.

Sample responses:

*"Because it will allow me to contribute to society, both current and future."*

*"Because ever since I was a kid I wanted to be an engineer. I always looked up to my grandpa who had a PhD in physics. He encouraged me to be an ME."*

*"To work with the most intelligent and driven people possible. It is also the best path to my desired employment."*

5. **Practicality**: Reasons such as failing at another career, large investment of time and energy to earn degree, not seeing any other options, and having a degree in the field.

Sample responses:

*"Because I don't know what else I would do."*

*"Because I'm getting a degree in it."*

*"Because I am not qualified for another position."*

The distribution of reasons for choosing an engineering career is shown in Figure 4.35 and Figure 4.36 for the Senior Design and December Graduates surveys, respectively. Intrinsic work-related factors made up the largest portion of reasons for both samples (SD: 47%; DG: 52%). Perceived competence factors made up 22 percent of reasons in the Senior Design sample and 18 percent of reasons in the December Graduates sample, while extrinsic work-related factors composed 14 percent and 29 percent of given in reasons in the two surveys, respectively. Practicality factors were present in both surveys (SD: 11%, DG: 2%), but people-oriented factors were only cited in the Senior Design survey (10%).

The question, "Why have you chosen engineering as a career?" was posed to survey participants so that responses could be contrasted with reasons for having reservations and reasons for not choosing engineering as a career. However, it also revealed two interesting themes:

1. Choosing engineering because of perceived competence in math and science, as opposed to talent or interest in specific engineering skills like design, testing, or manufacturing. Math and science strength made up 51 percent of reasons in the perceived competence category in the Senior Design survey and 45 percent in the December Graduates survey.
2. Choosing engineering for financial rewards. "Money" or "Salary," which was classified as an Extrinsic Work-Related Factor, amounted

to 30 percent in the Senior Design survey and 61 percent in the December Graduates survey of the total Extrinsic Work-Related Factors. Indeed, "money" was the most frequently cited Extrinsic Work-Related Factor in both surveys.

These topics will be discussed in further detail in Chapter 5.

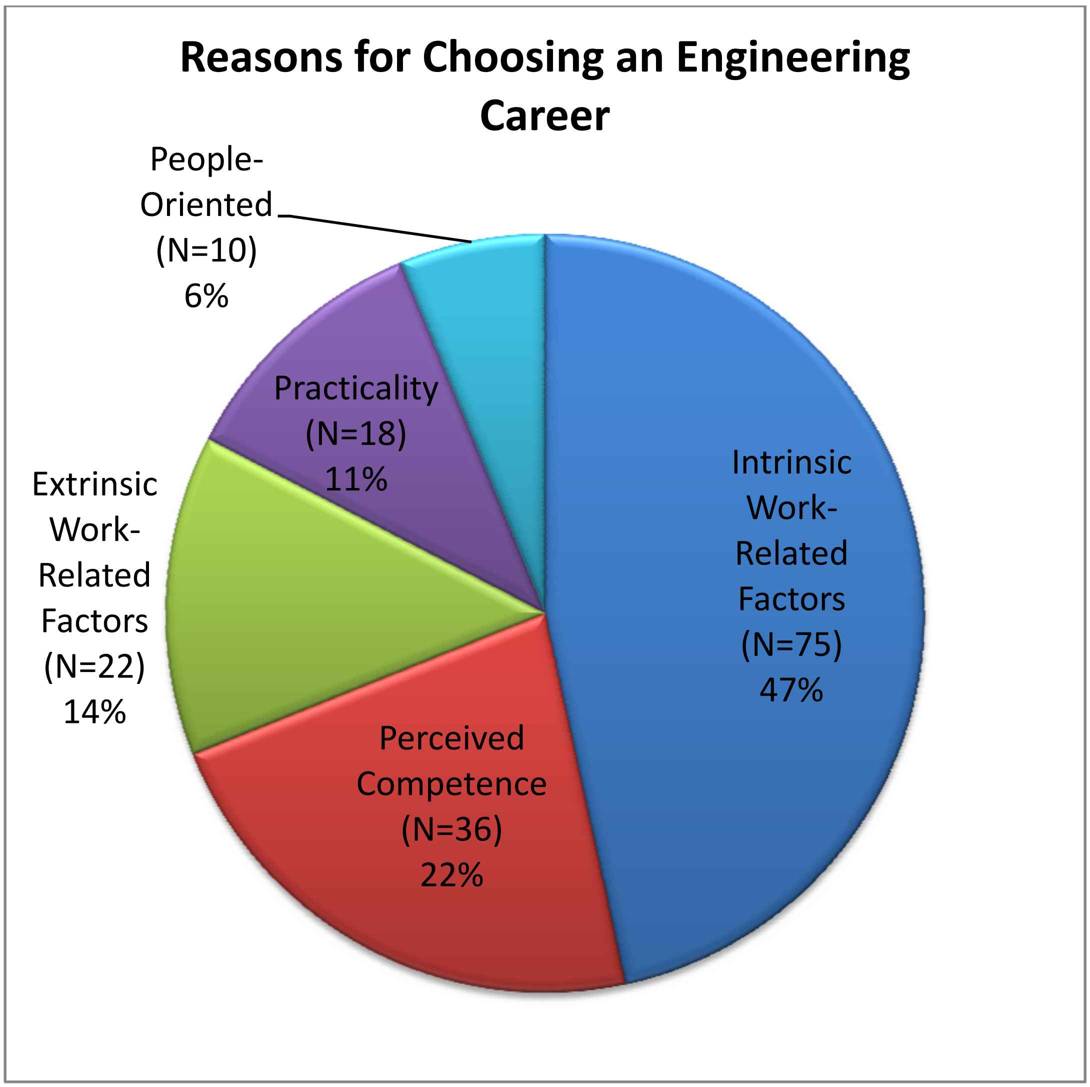


**Figure 4.35: Senior Design Survey: Reasons for Choosing an Engineering Career. N=161 reasons from 89 respondents.**

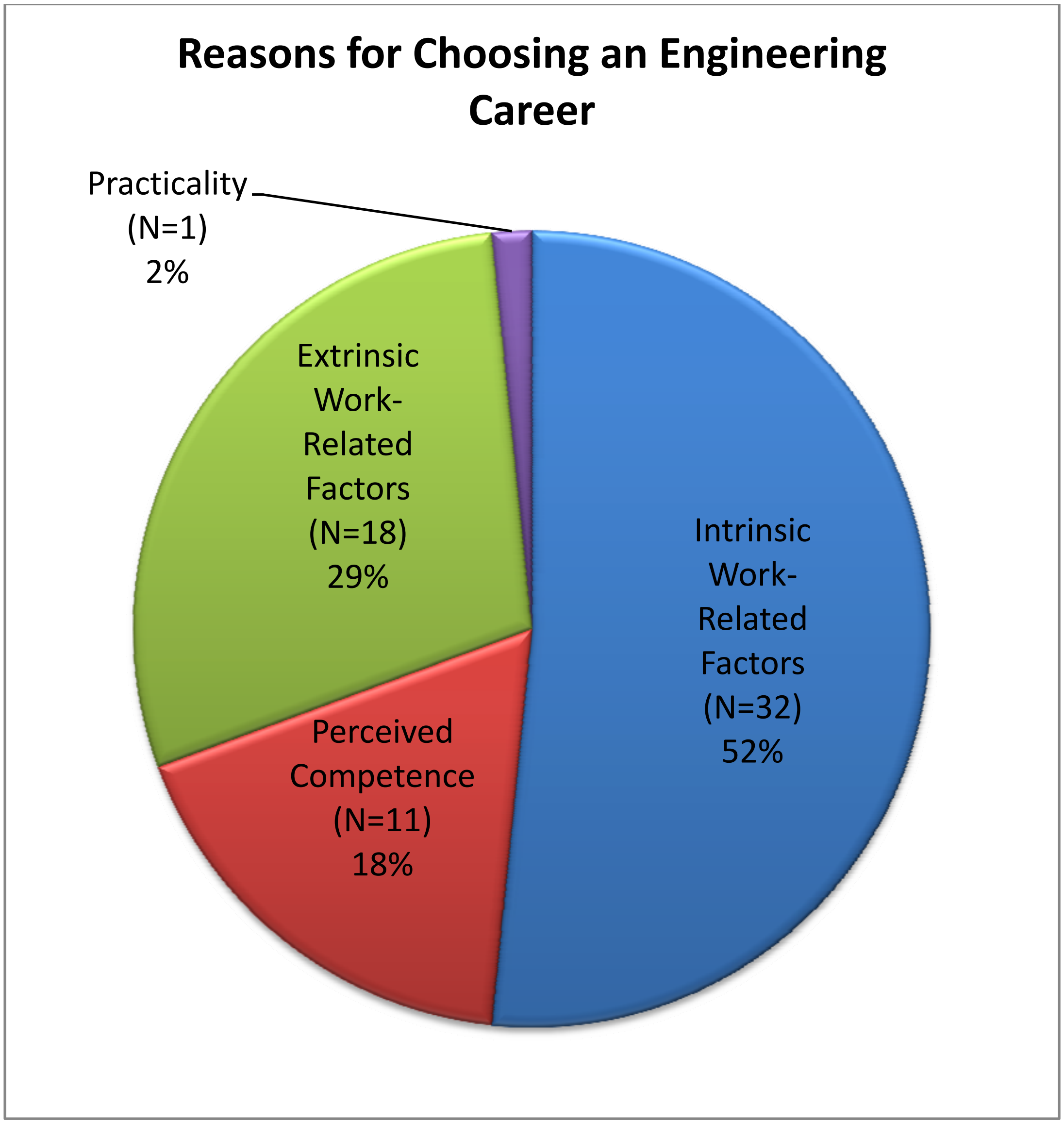


**Figure 4.36: December Graduates Survey: Reasons for Choosing an Engineering Career. N=62 reasons from 45 respondents.**

### 4.5.2 Reasons for Choosing Engineering as a Career: Comparing Pursuers and Pursuers with Reservations

Pursuers and Pursuers with Reservations often had different reasons for choosing engineering careers. The reasons are shown in Figure 4.37 (Pursuers) and

Figure 4.38 (Pursuers with Reservations) for the Senior Design survey and in Figure 4.39 (Pursuers) and Figure 4.40 (Pursuers with Reservations) for the December Graduates survey. For the Senior Design sample, intrinsic work-related factors were still the most frequently cited reasons for choosing an engineering career by both Pursuers (51%) and Pursuers with Reservations (39%). However, Pursuers more often cited people-oriented factors (8% to 4%) while Pursuers with Reservations more often cited extrinsic work-related factors (15% to 9%) and practicality factors (15% to 7%). In the December Graduates sample, the trends were different. The most frequently cited reasons by Pursuers were intrinsic work-related factors (60%), but perceived competence factors (50%) made up the largest share of reasons given by Pursuers with Reservations. Extrinsic work-related factors were more often cited by Pursuers (21%) than Pursuers with Reservations (13%). No people-oriented factors were mentioned by either group and the lone practicality factor (3%) was cited by a Pursuer.

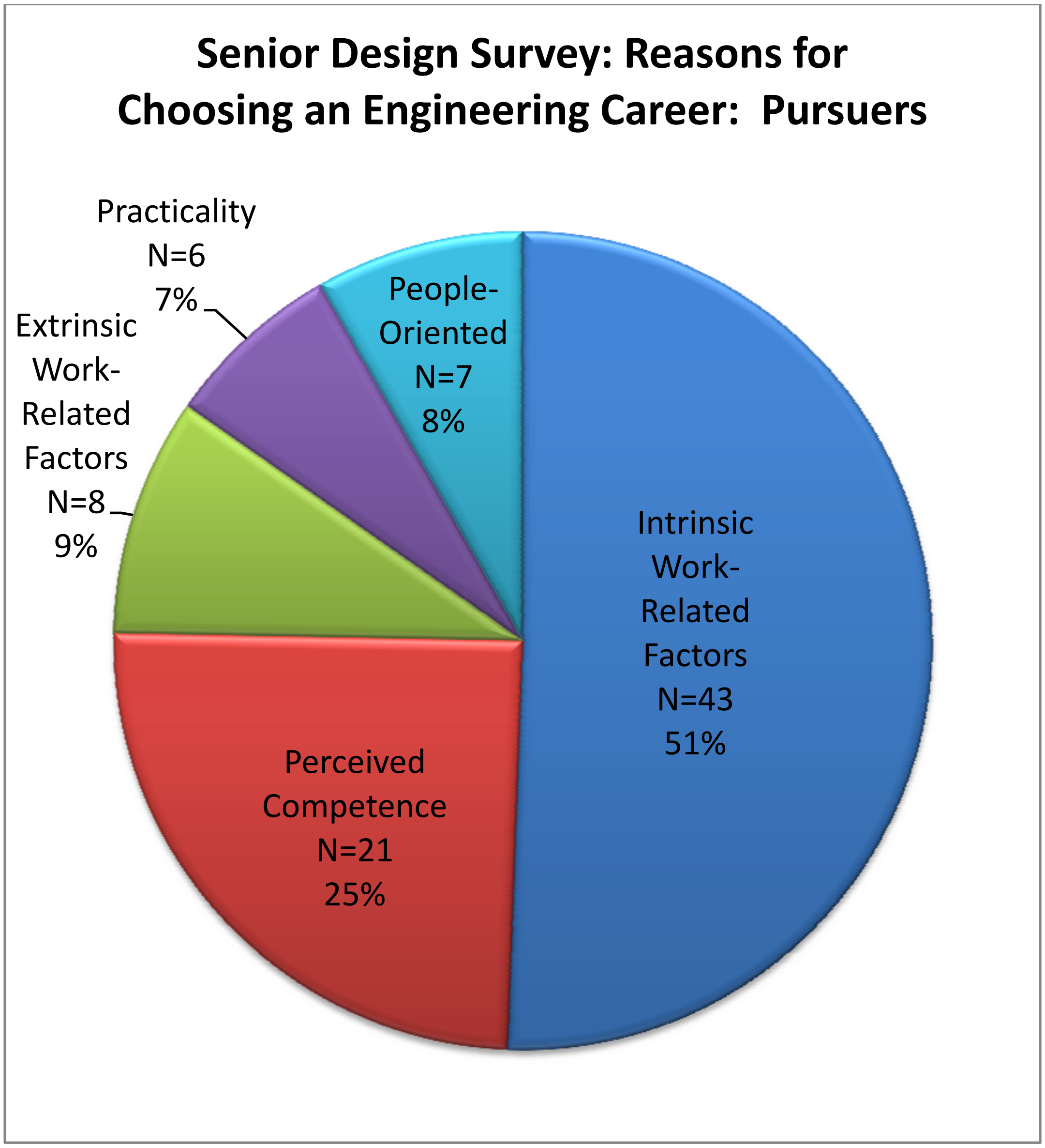


**Figure 4.37: Senior Design Survey: Reasons for Choosing an Engineering Career: Pursuers. N=85 reasons from 44 respondents.**

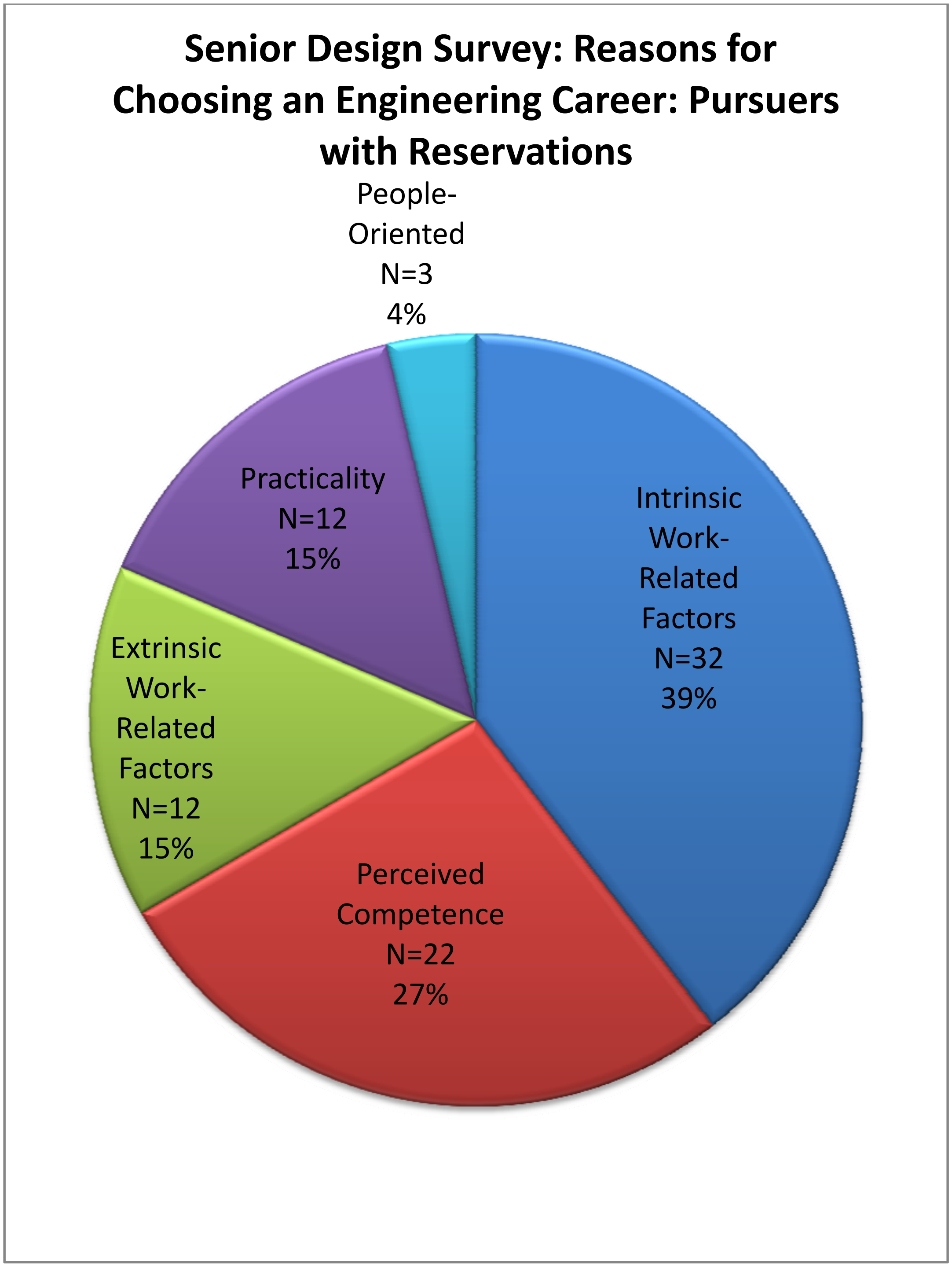


**Figure 4.38: Senior Design Survey: Reasons for Choosing an Engineering Career: Pursuers with Reservations. N=93 reasons from 45 respondents.**

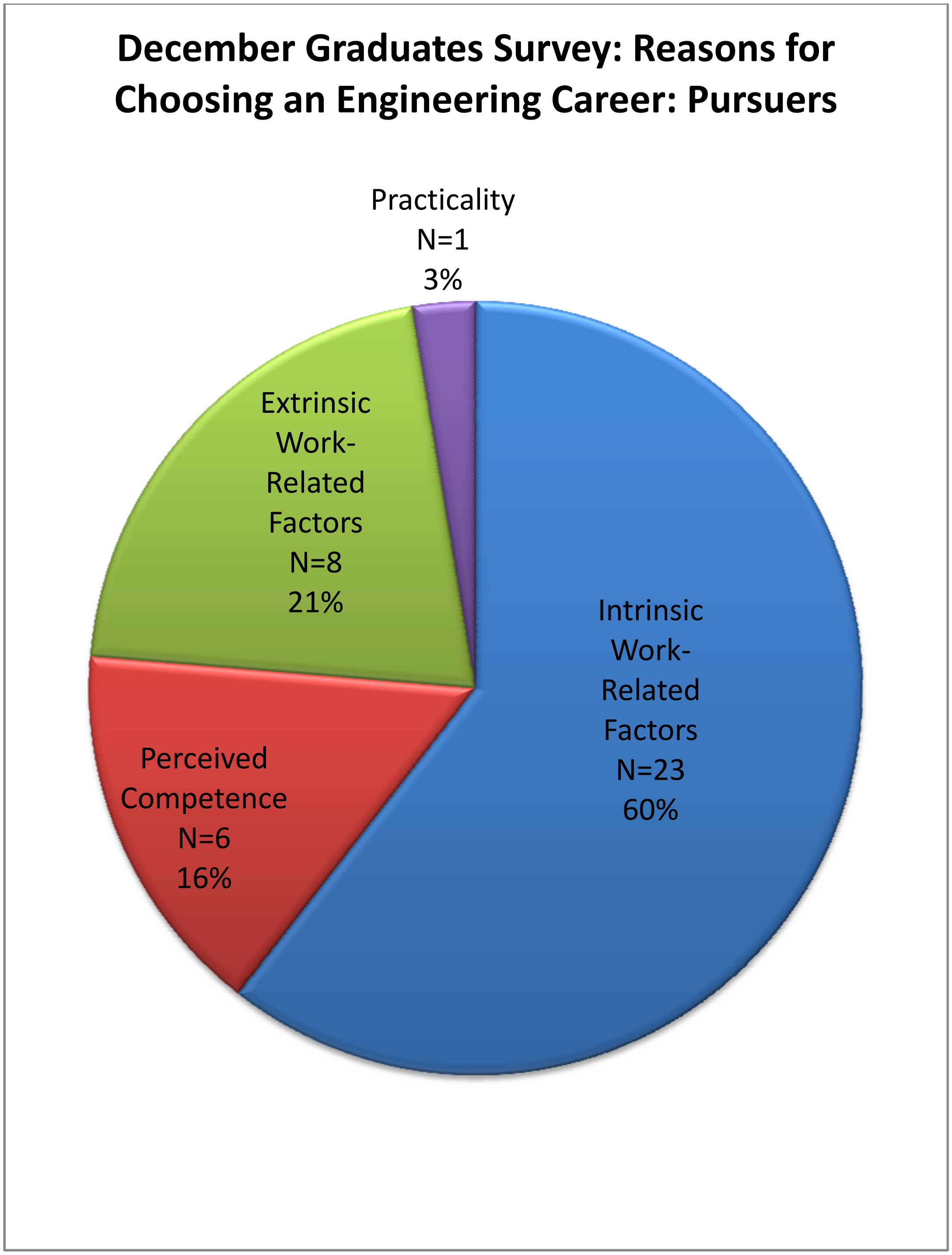


**Figure 4.39: December Graduates Survey: Reasons for Choosing an Engineering Career: Pursuers. N=38 reasons from 15 respondents.**

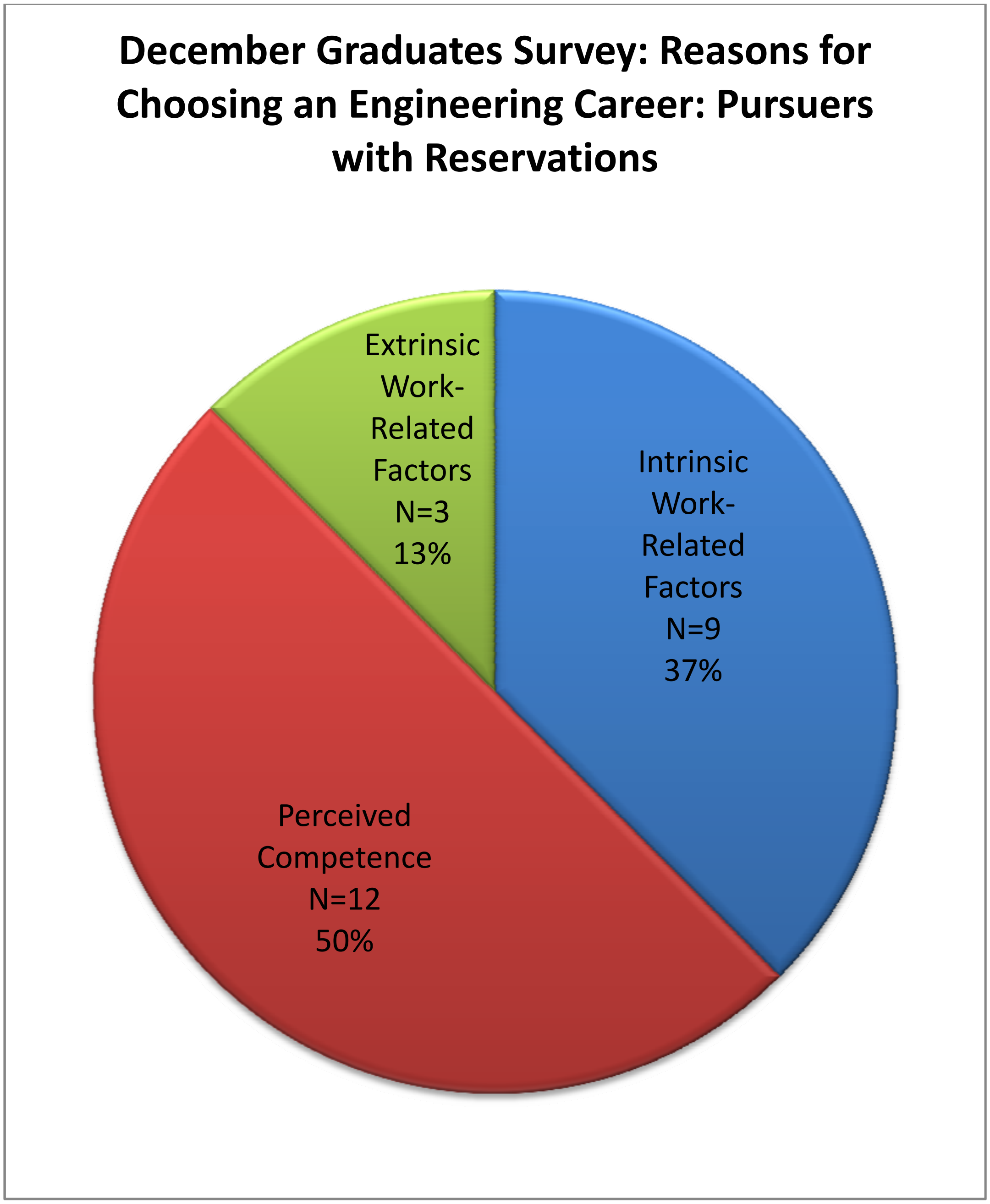


**Figure 4.40: December Graduates Survey: Reasons for Choosing an Engineering Career: Pursuers with Reservations. N=24 reasons from 13 respondents.**

Pursuers and Pursuers with Reservations also cited specific reasons within the five broader categories at different frequencies. Pursuers more often cited the following factors (Note: the first N value given is for Pursuers, while the second is for Pursuers with Reservations):

- **Enjoyment/Fulfillment** (Intrinsic Work-Related Factor)
  - SD: N=10 (23%) to N=5 (16%)
  - DG: N=2 (9%) to N=1 (11%)
- **Kinesthetic Inclination** (Intrinsic Work-Related Factor)
  - SD: N=9 (21%) to N=5 (16%)
  - DG: N=6 (26%) to N=2 (22%)
- **Math and Science Aptitude** (Perceived Competence Factor)
  - SD: N=11 (52%) to N=7 (32%)
  - DG: N=4 (50%) to N=1 (33%)
- **Liking Engineers as People** (People-oriented Factor)
  - SD: N=2 (29%) to N=0 (0%)
  - DG: Not cited
- **Wanting to Contribute to Society** (People-oriented Factor)
  - SD: N=4 (57%) to N=1 (33%)
  - DG: Not cited

Pursuers with Reservations were more likely to cite the following factors (Note: the first N value given is for Pursuers with Reservations, while the second is for Pursuers):

- **Enjoying Teamwork** (Intrinsic Work-Related Factor)
  - SD: N=3 (9%) to N=0 (0%)
  - DG: Not cited
- **Talent in Engineering Skills** (Perceived Competence Factor)
  - SD: N=5 (23%) to N=2 (10%)
  - DG: N=1 (33%) to N=1 (13%)
- **Influence of a Mentor** (People-oriented Factor)
  - SD: N=2 (67%) to N=1 (14%)
  - DG: Not cited

These data suggest that, to a limited extent, reasons for choosing engineering as a career may play a role in Post-Graduation Plans Group Identification.

### 4.5.3 Internship Experiences: Factors Related to Positive and Negative Experiences

The qualitative summaries of internship experiences provided several factors that characterized a student's internship as a positive or negative experience. Factors related to a positive experience are shown in Figure 4.37 and Figure 4.38, while those related to a negative experience are shown in Figure 4.39 and Figure 4.40, for the Senior Design and December Graduates surveys, respectively.

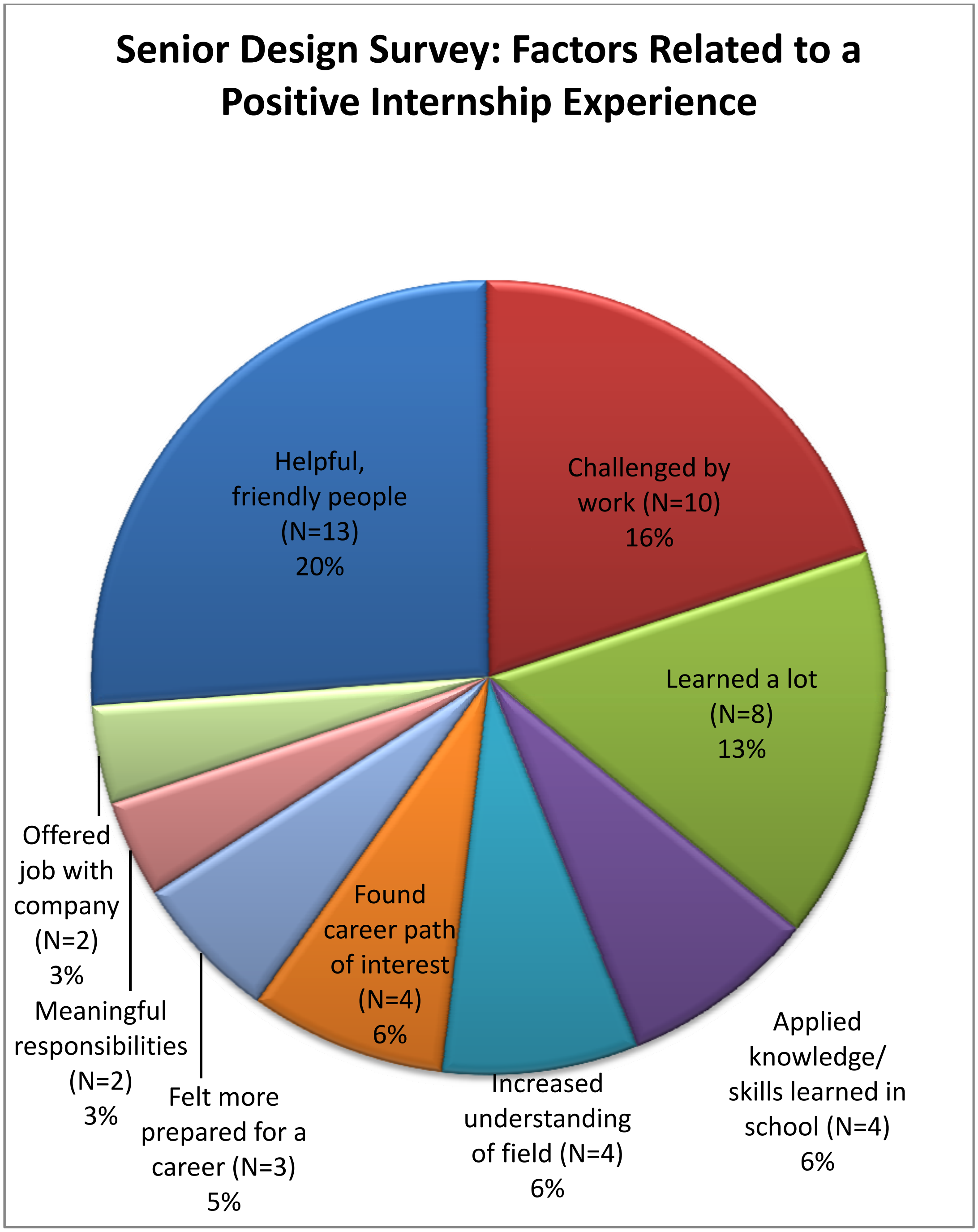


**Figure 4.41: Senior Design Survey: Factors Related to a Positive Internship Experience. N=64 reasons from 65 respondents with 103 internships among them.**

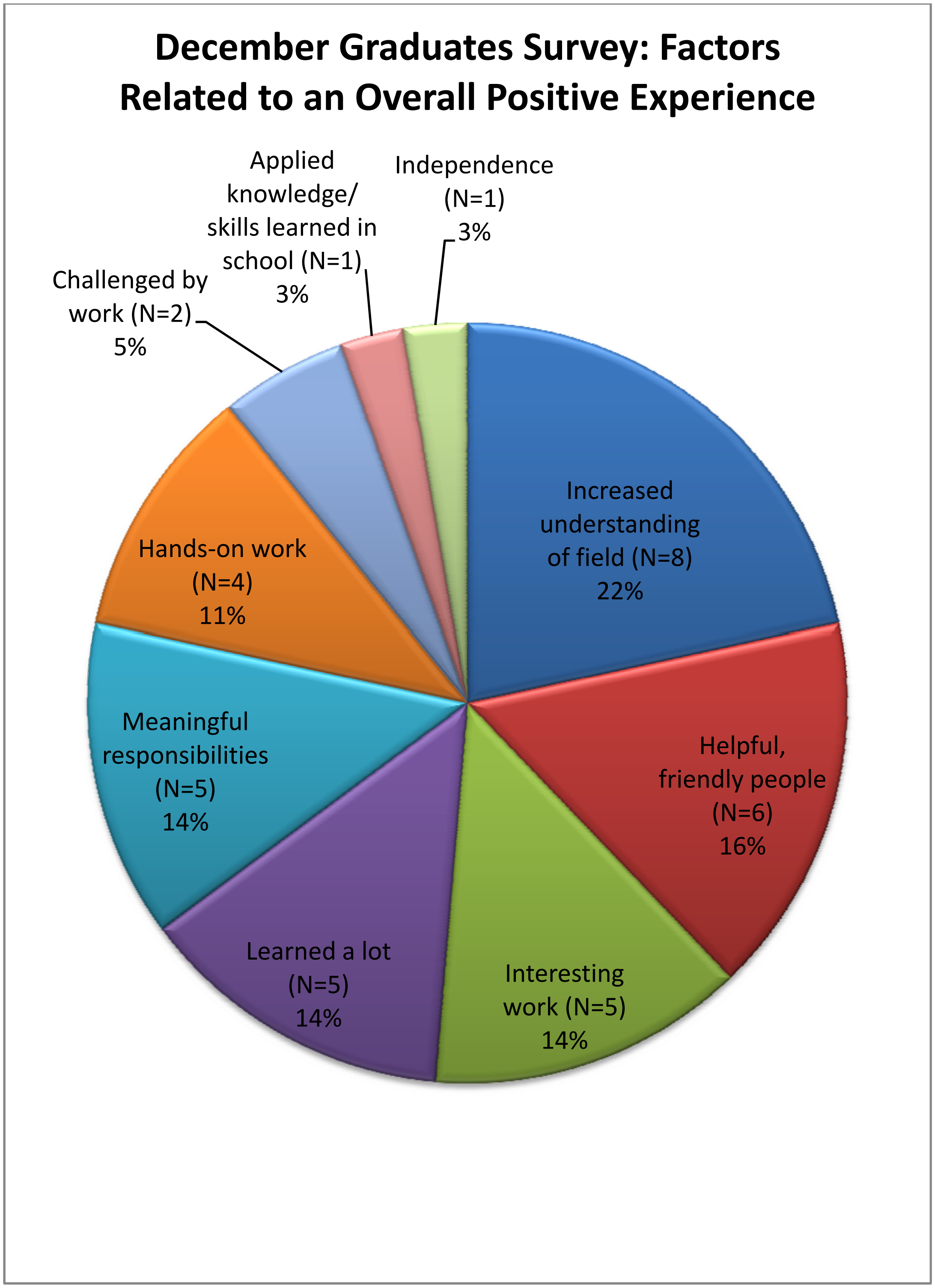


**Figure 4.42: December Graduates Survey: Factors Related to a Positive Internship Experience. N=37 reasons from 28 respondents with 45 internships among them.**

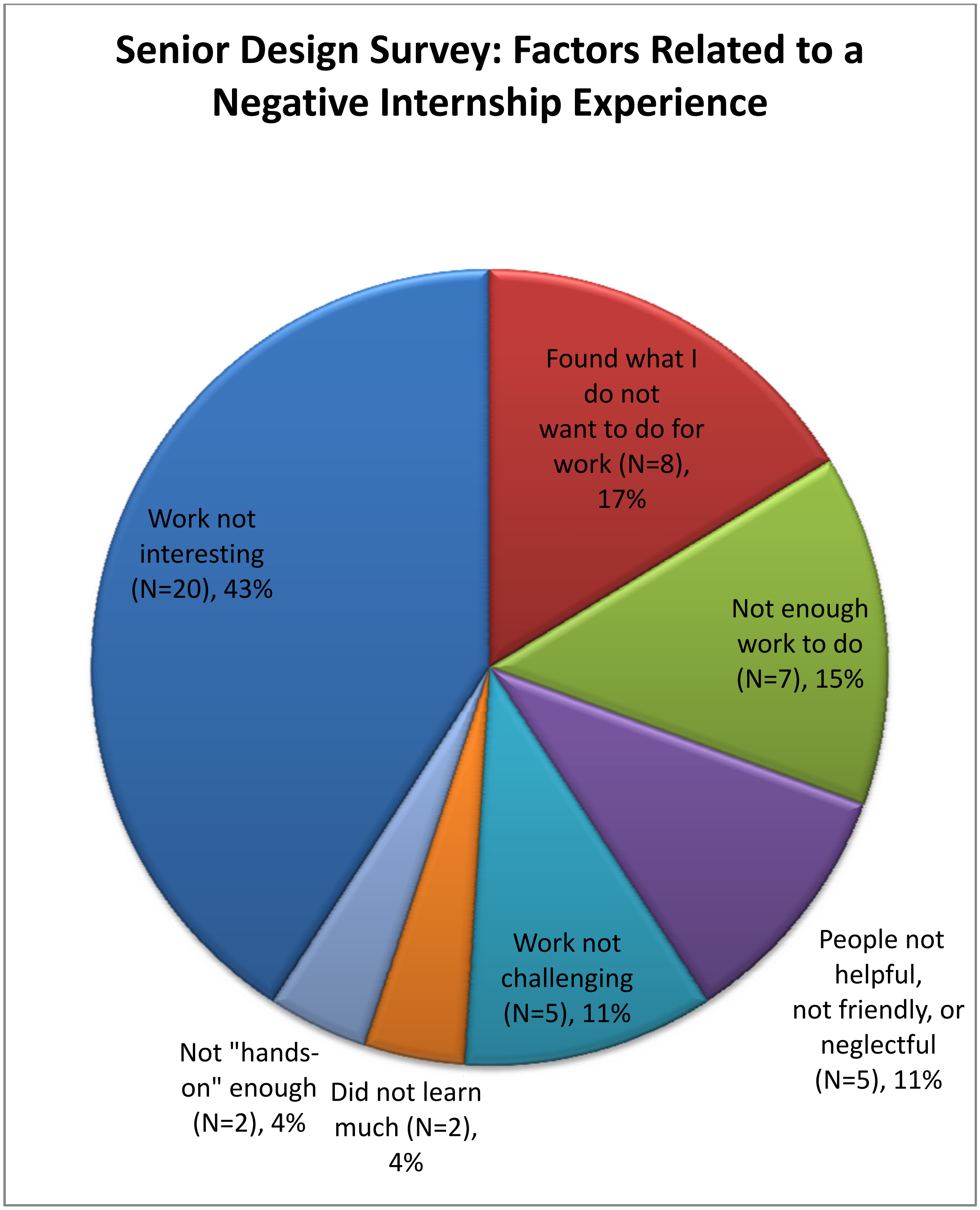


**Figure 4.43: Senior Design Survey: Factors Related to a Negative Internship Experience. N=49 reasons from 65 respondents with 103 internships among them.**

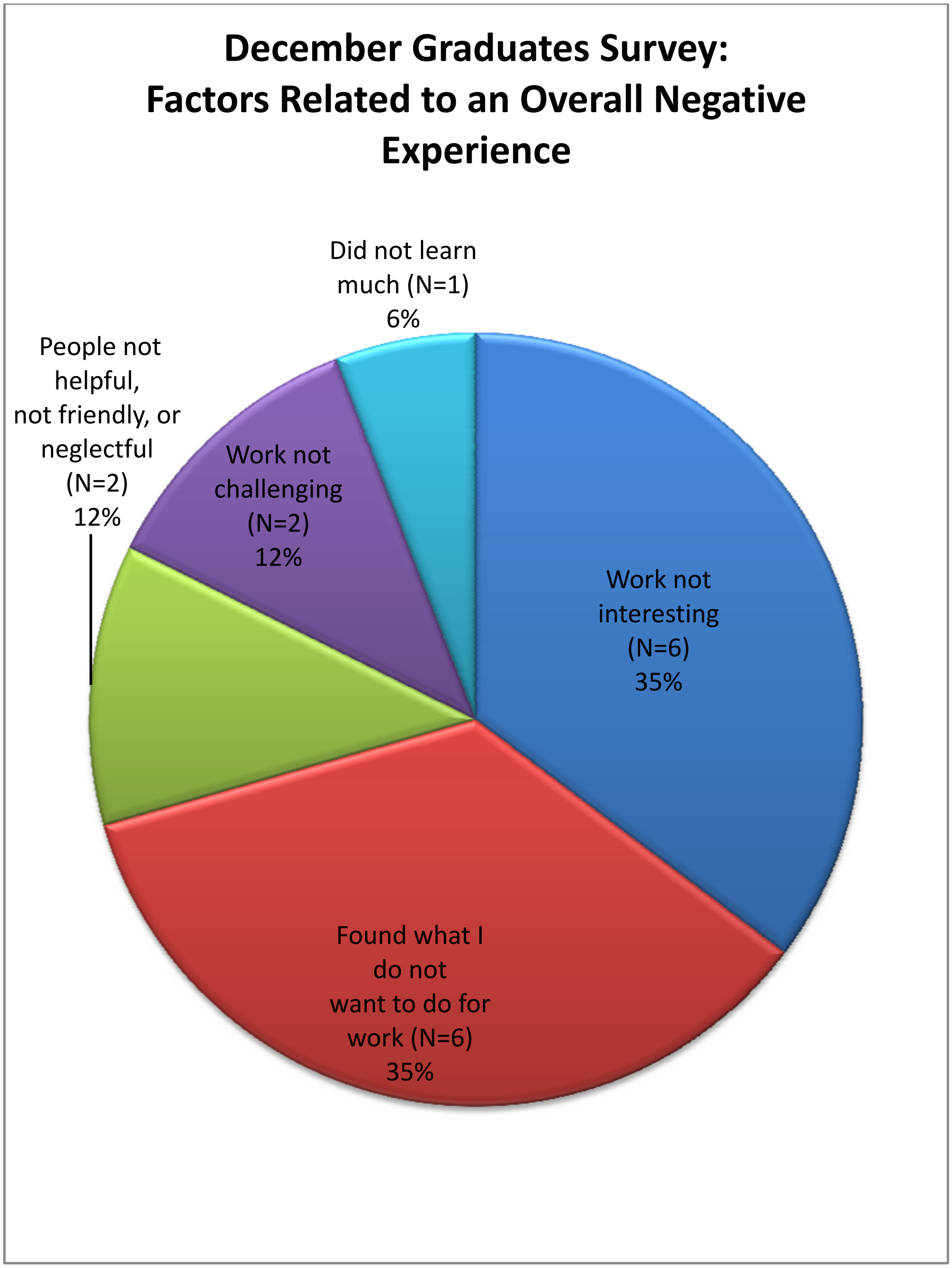


**Figure 4.44: December Graduates Survey: Factors Related to a Negative Internship Experience. N=17 reasons from 28 respondents with 45 internships among them.**

A few factors—such as enjoying the people, finding the work challenging, and having an increased understanding of the field—were similar to the Likert-style statements in the Internship Experience Survey Item. However, the qualitative summaries established the following other factors of interest. Comments from both surveys are presented together, with those from the December Graduates Survey tagged with "DG."

- **<u>Positive Experience</u>**

**1. Meaningful responsibilities**

<u>Sample Reason:</u>

*"Working with [Company X] gave me an opportunity to work in my field and see what the real world is like. I had many large responsibilities. I was made a part of the team and am and designing things of great importance. I was trusted and my input is desired. At [Company Y], I am doing so many interesting projects that depend on me for its success. I work on helicopter simulators; I am the systems engineer for the weapon systems. Cool!" (DG).*

**2. Feeling more prepared for an engineering career**

<u>Sample Reason:</u>

*"I feel that my internship has been the thing that has prepared me the most for a career in engineering. It was a big change from my previous school experience. I realized that I don't want a desk job."*

**3. Finding a career path of interest**

Sample Reason:

*"I love working in the materials lab developing medical devices. Internship #1 really has made my education worthwhile and driven me to pursue a career in biomedical devices research and development."*

**4. Applied knowledge and skills learned in school**

Sample Reason:

*"Without having any other technical experience, the jobs/internships I've had expanded my perception of the engineering field and showed me what I'd be doing after I graduate. Application of subjects learned through coursework improved my confidence as an engineer."*

**5. Learned a lot, and in particular, learned things that were not or cannot be taught in school**

Sample Reason:

*"Working at [Company X] taught me a lot about how engineers work in the real world. It was good to get engineering experience without having to complete problems from a book" (DG).*

**6. "Hands-on work"**

Sample Reason:

*"Hands-on work better suited me internship 2) and I learned more. Internship 1 was office work which I gained nothing from" (DG).*

- **Negative Experience**

**1. Not "hands-on" enough**

Sample Reason:

*"I thought engineering was more hands-on and less writing."*

**2. Not having enough work to do**

Sample Reason:

*"I thought up until last summer that I wanted to do something environmentally-related, but what I did was so boring. No one seemed to care that I had no work to do and well I worked for the government so even if I wanted it probably would have been a hassle to get me more work. It helped me see I could never be happy in a cubicle."*

**3. Not learning as much as expected**

Sample Reason:

*"The internship was boring (lots of testing). The people were not fun. The tasking (sic) was boring. Overall I learned little and [it] did not challenge me."*

**4. Finding a career path one does *not* want to pursue**

Sample Reason:

*"Instead of finding career fields that were exciting for my future career, my internships showed me fields of engineering that I wouldn't want as a career.*

*So the experience is valuable, but I still don't know what career path I will be happy with."*

One theme seemed to be present in the comments. Negative internship experiences often seemed to stem from "boring work." Those experiences were also associated with phrases like "cubicles," "office work," and work that was "not hands-on."

### 4.5.4 Reasons for Reservations about Engineering as a Career

Pursuers with Reservations (not including Future Leavers), who made up 27 of the total respondents in both surveys, gave a variety of reasons for having reservations about the choice of engineering as a career. Not all respondents provided qualitative explanations of their reasons, and others had multiple reasons. The reservations were coded into six broader categories which follow in a numbered list.

1. **Location**: Reservations about location of employment

<u>Sample reasons:</u>

**"***I am moving to Georgia [for my first engineering job], but I love the mountains here."*

*"Only because it may limit where I will be able to find a job, which is very important to me right now."*

2. **Missed Opportunities**: Regrets about missing out on "fun" in college because of the challenge of and time spent on earning an engineering degree

Sample reasons:

*"Engineering was hard and I might have missed some fun in college because of it."*

*"Social reasons."*

3. **Low Self-Efficacy**: Concerns about ability to succeed in engineering

Sample reasons:

*"What if I can't do it…I don't have an internship so why choose me?"*

*"I sometimes think that engineering might be too hard for me but I love the whole process of a new product."*

4. **Negative stereotypes**: Negative stereotypes of engineering as a profession or corporate culture in general

Sample reasons:

*"Not a computer guy. Afraid of cubicle life."*

*"I have no interest in any type of desk job or highly subordinate position. I plan to start my own business eventually, but do not have the capital off the bat."*

5. **Other interests**: Wondering if they should pursue other career interests outside of engineering

Sample reasons:

*"Should have gone into law enforcement. [I] like helping people."*

*"Business has always been an interest to me and I know that I would have a much easier time with it."*

6. **Lack of interest**: An expression of lack of interest in engineering

<u>Sample reasons:</u>

*"My interest has been decreasing, I am worried that sitting in an office and the work will quickly get boring, that I don't have control over the future of my career being wedged somewhere in the corporate ladder."*

*"I know how boring a job will be and I don't want to get one after graduation. I would like to travel and then maybe get a job."*

*"I hope a career job is nothing like school because solving meaningless fluid dynamics problems and calculus were pretty uninteresting."*

The categories are presented by percentage for both surveys in Figure 4.45 and Figure 4.46, respectively. Interest-related factors—lack of interest and other interests—composed the majority of reasons given in both surveys. Negative stereotypes and low-self efficacy reasons were also present in significant numbers. Lack of interest, other interests, negative stereotypes, and low self-efficacy were cited in both surveys. Missed opportunities and location came up in the Senior Design survey only.

One theme reflected in the comments related to reservations about an engineering career was fears of corporate or work culture. This theme was present to a lesser degree in the comments related to negative internship experiences.

Trepidations about "desk jobs," "cubicles," excessive "computer" use, and "being wedged in the corporate ladder" were frequently expressed.

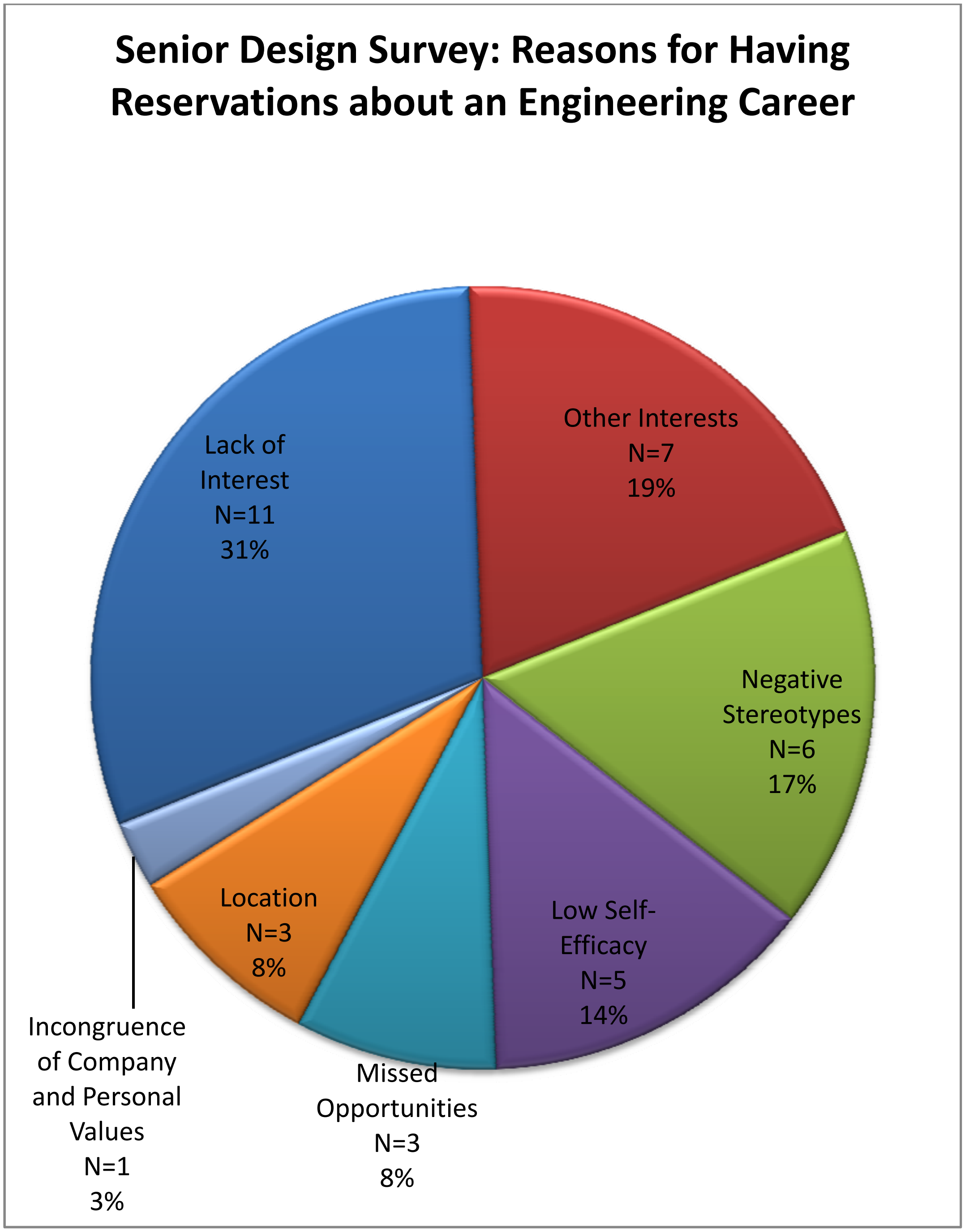


**Figure 4.45: Senior Design Survey: Reasons for Reservations about Engineering as a Career. The total number of given reasons was N=35.**

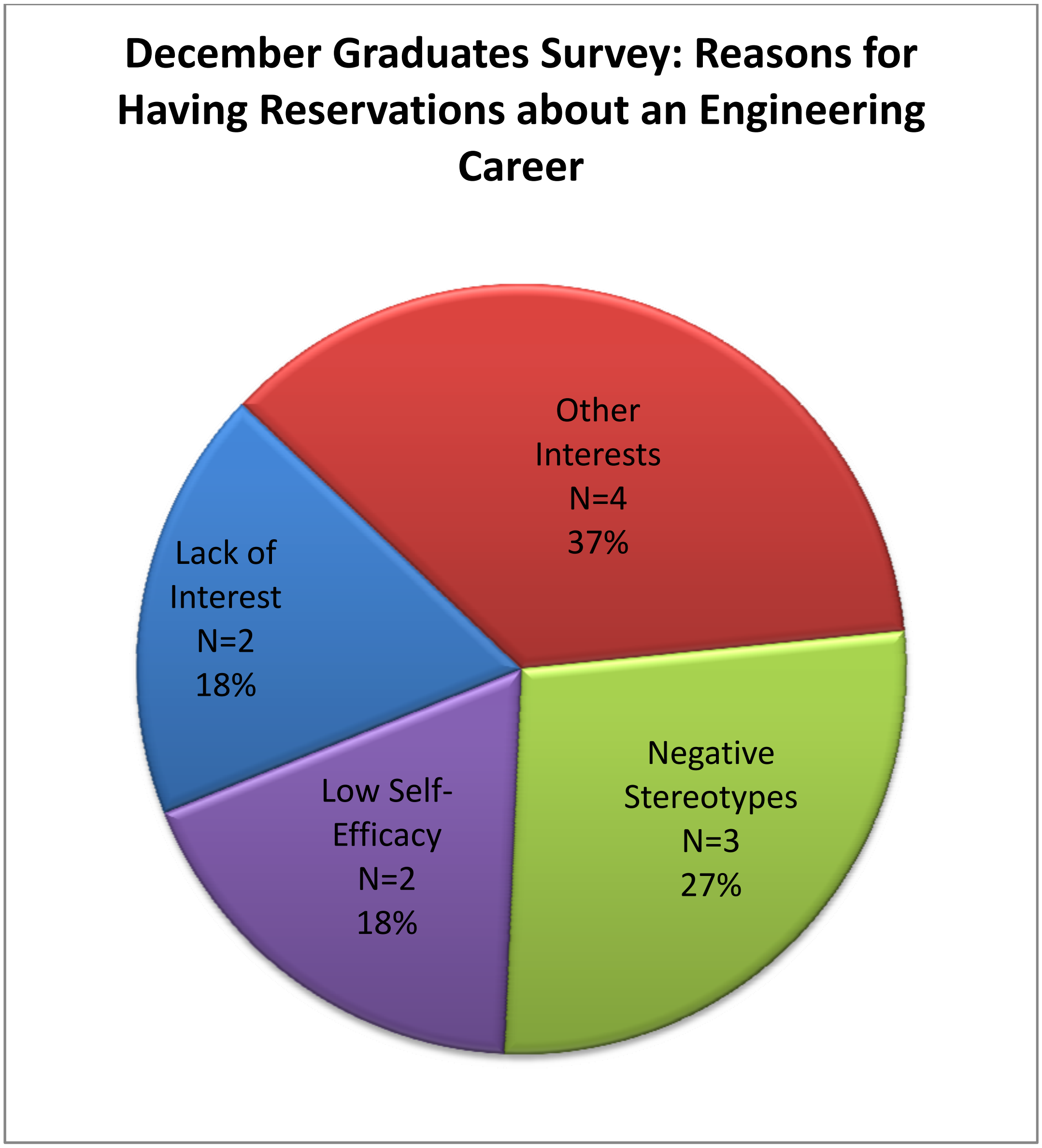


**Figure 4.46: December Graduates Survey: Reasons for Reservations about Engineering as a Career. The total number of given reasons was N=11.**

### 4.5.5 Future Leavers: What Careers Do They Want to Pursue?

A total of 28 Senior Design survey respondents—32 percent of those pursuing an engineering career immediately after graduation, or 21 percent of the total survey sample—answered that they did not see engineering as a long-term career. Similarly, nine December Graduates survey respondents—32 percent of those pursuing an engineering career immediately after graduation, or 24 percent of the total survey sample—answered that they did not see engineering as a long-term career. Many students listed multiple careers of interest, which accounts for the difference in respondents and careers. Figure 4.47 and Figure 4.48 show the distribution of all careers listed by the Future Leavers for both surveys, respectively. Business was by far the most common career listed (SD: 33%, Figure 4.47; DG: 25%, Figure 4.48) followed by management (SD: 23%, Figure 4.47; DG: 8%, Figure 4.48). A multitude of other careers, from real estate to health to aviation, were reported by only one respondent each.

The numbers of Future Leavers planning management careers highlights a theme in the qualitative comments. Some students seem to have a narrow definition of "engineering" that does not connect the technical background required to manage a group of engineers within a company. This will be discussed further in Future Work Recommendations.

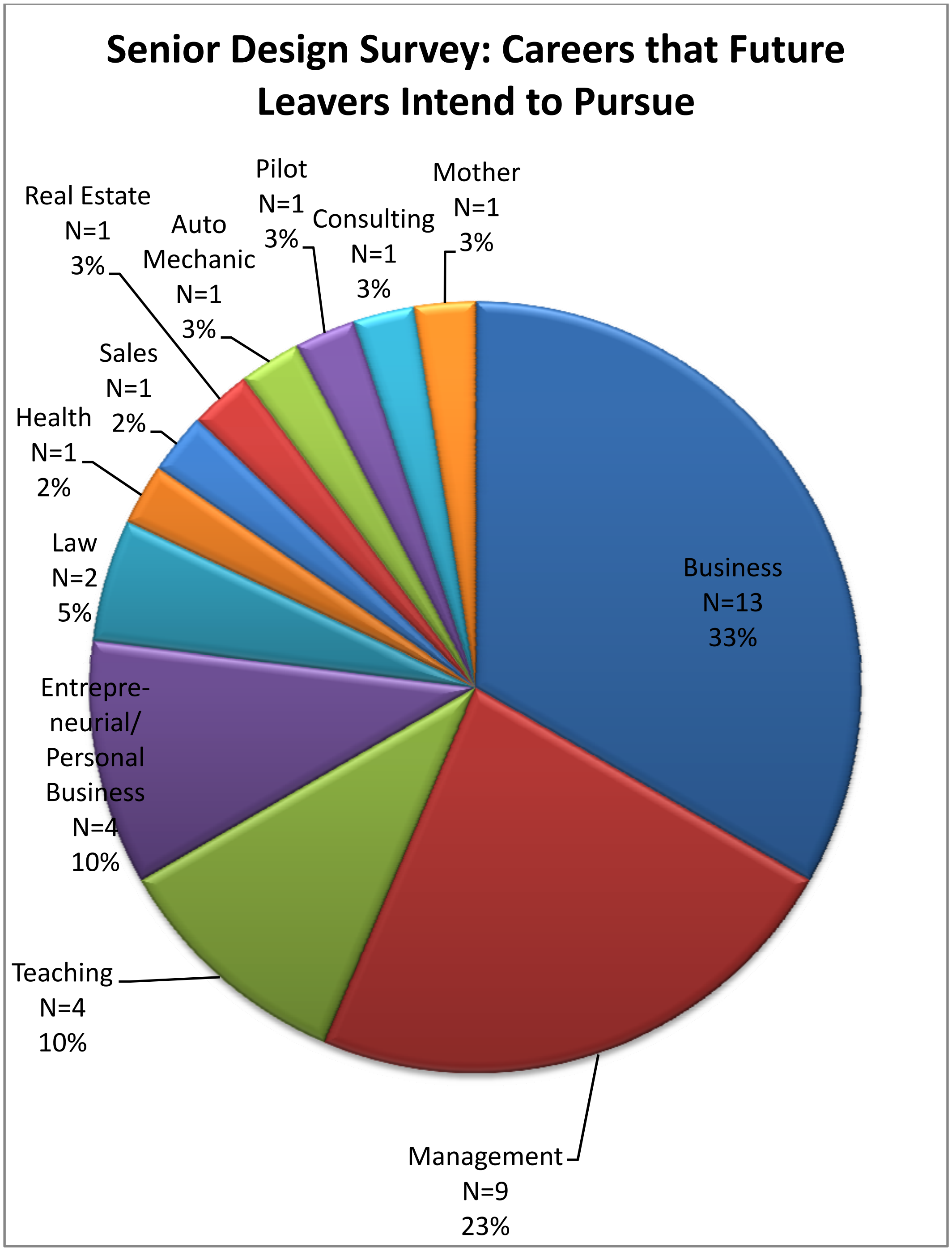


**Figure 4.47: Senior Design Survey: Careers that Future Leavers Intend to Pursue. N=39 total careers were suggested.**

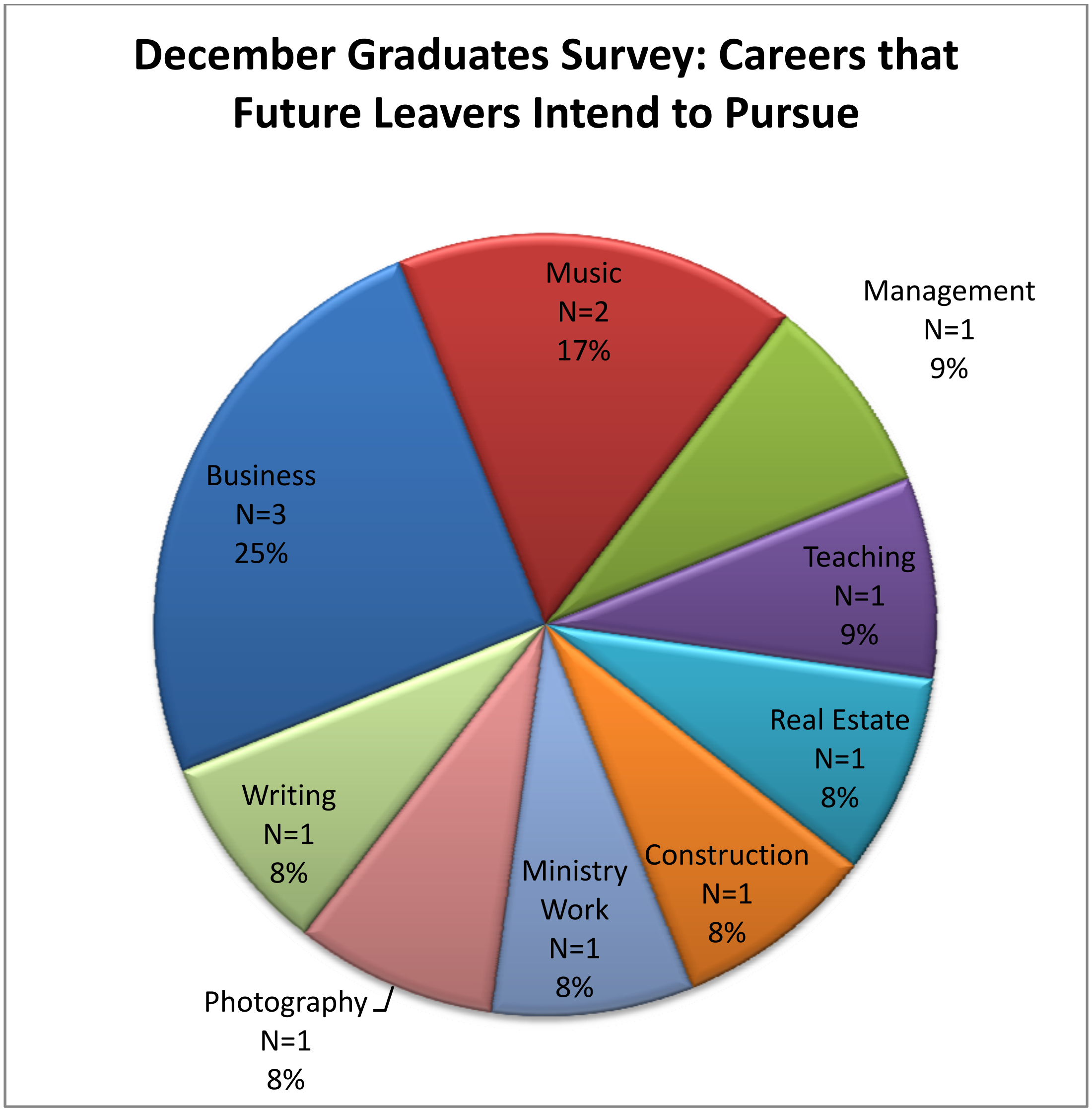


**Figure 4.48: December Graduates Survey: Careers that Future Leavers Intend to Pursue. N=12 total careers were suggested.**

### 4.5.6 Immediate Post-Graduation Plans of Returners and Leavers

The immediate post-graduations plans for both the Returners and Leavers are documented in Figure 4.49 through Figure 4.52 for the Senior Design and December Graduates surveys, respectively. In the Senior Design sample, most Returners were planning to attend graduate school in engineering (35%), pursuing non-engineering employment (19%) or had plans to travel (19%). Most Leavers were pursuing military careers (34%), had unknown plans (25%), or were pursuing non-engineering employment (17%). In the December Graduates sample, most Returners were pursuing non-engineering employment (33%) or planning to travel (33%). The three Leavers each had different plans: attend medical school, an MBA program, and non-engineering-related graduate school.

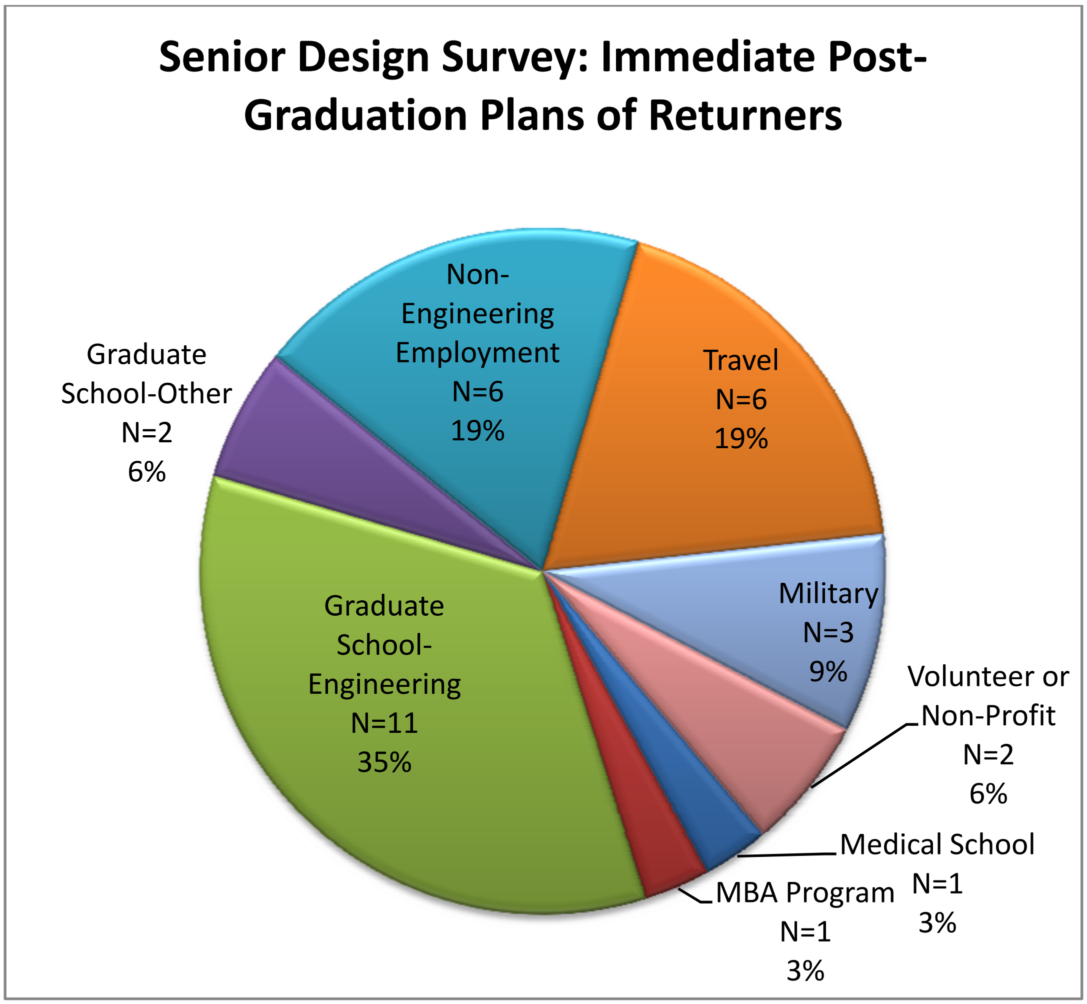


**Figure 4.49: Senior Design Survey: Immediate Post-Graduation Plans: Returners**

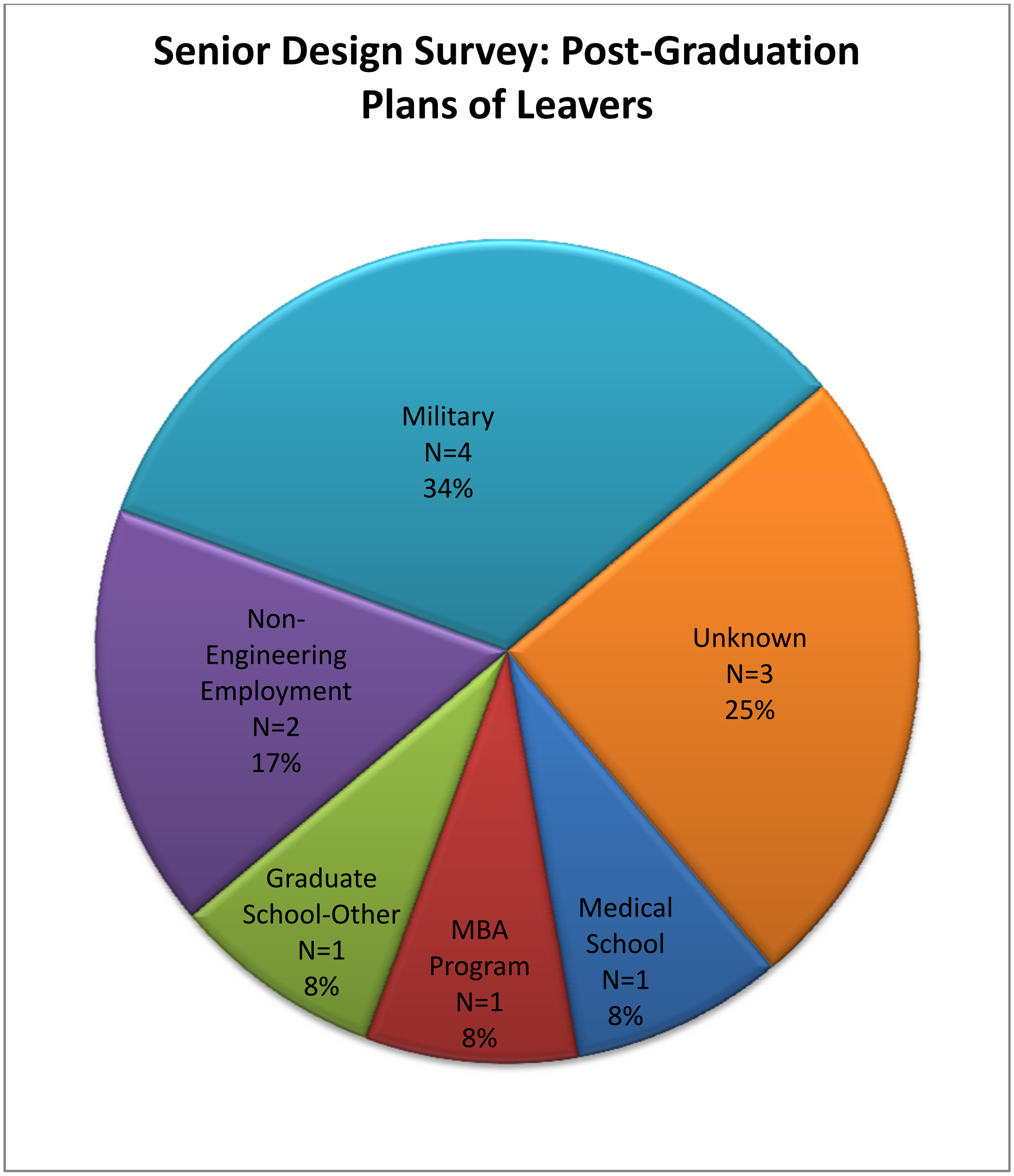


**Figure 4.50: Senior Design Survey: Immediate Post-Graduation Plans: Leavers**

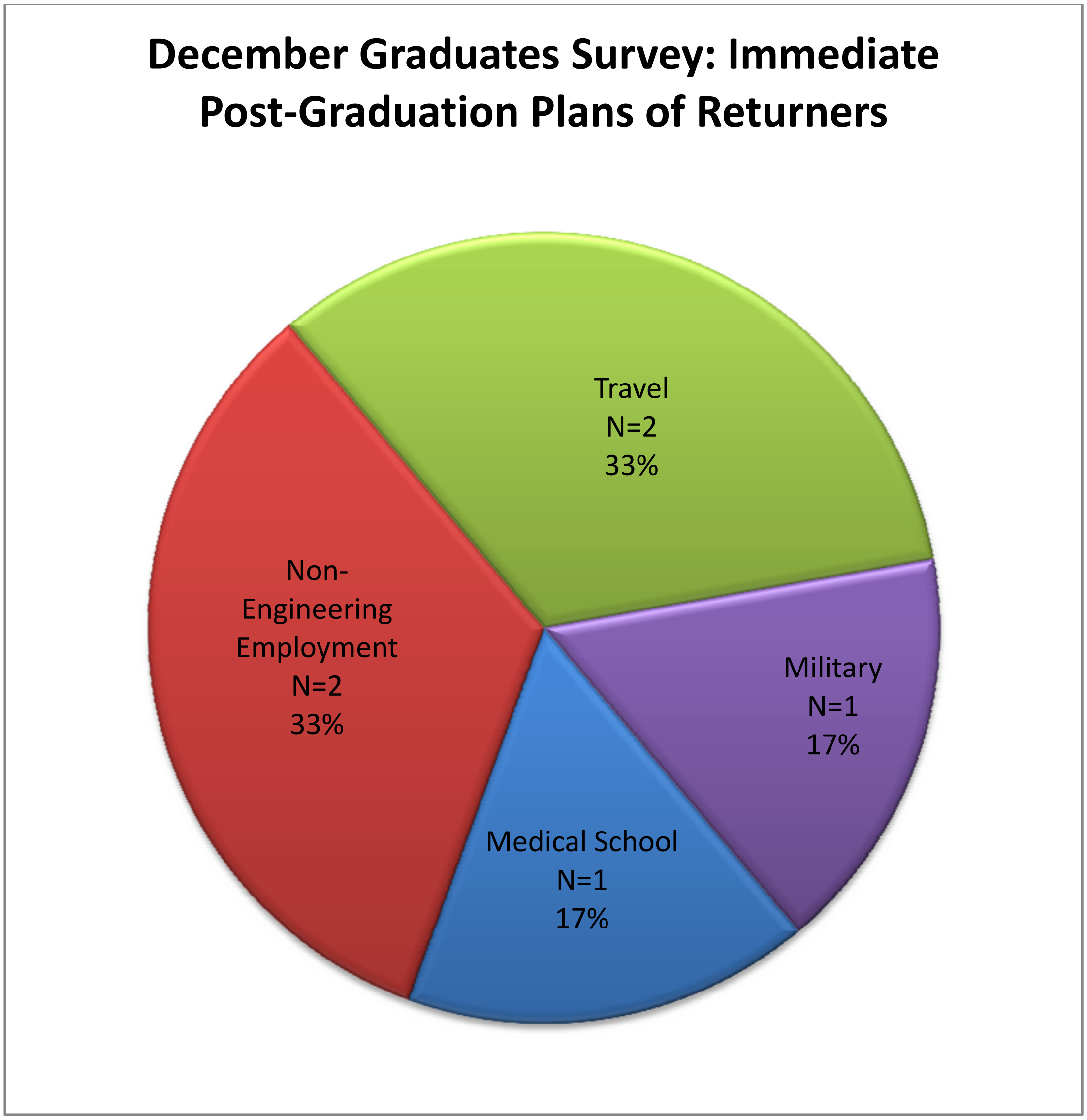


**Figure 4.51: December Graduates Survey: Immediate Post-Graduation Plans: Returners**

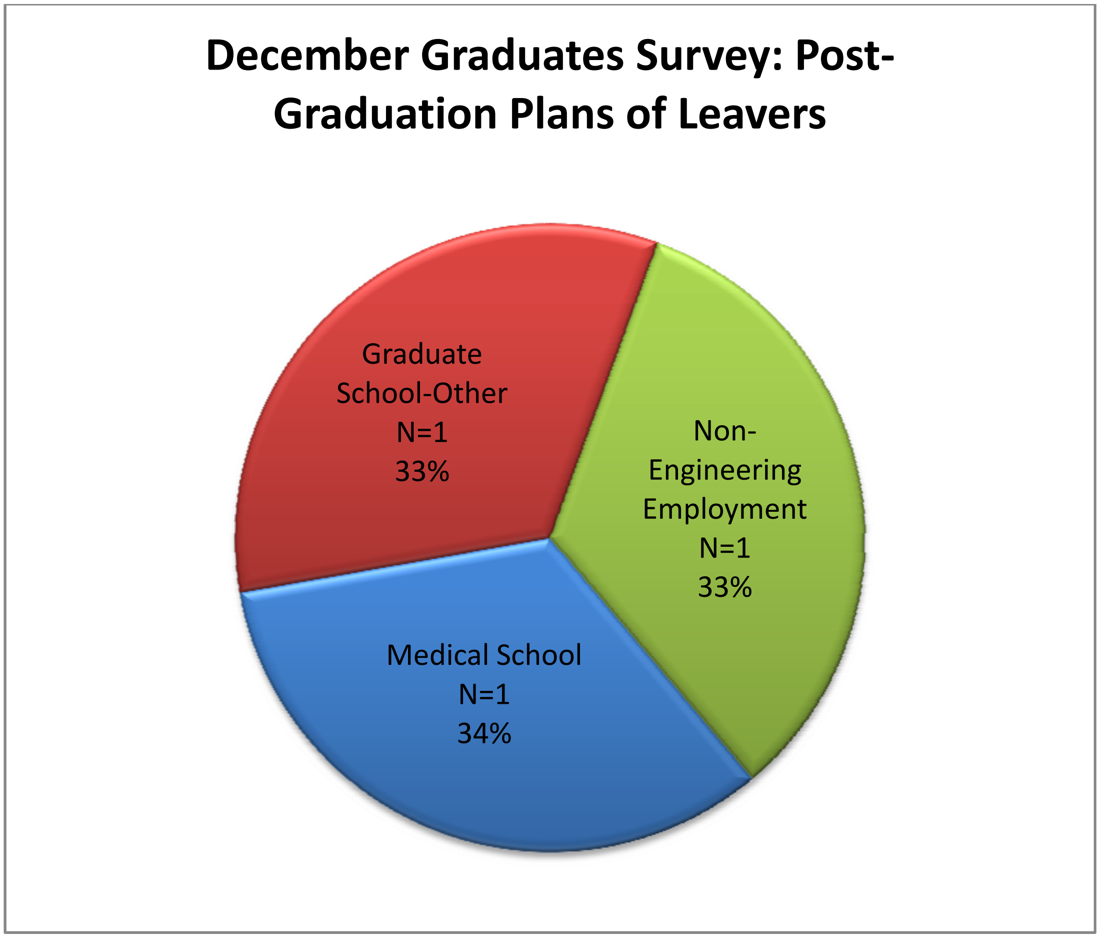


**Figure 4.52: December Graduates Survey: Immediate Post-Graduation Plans: Leavers**

### 4.5.7 Leavers: Why don't they want to pursue careers in engineering?

Respondents in the Leavers group—12 students in the Senior Design survey and three from the December Graduates survey—had a multitude of reasons for why they did not choose engineering as a career. (Due to their small size, comments from Leavers in both groups will be presented together in the analysis below. Comments from December Graduates survey Leavers will be followed with a "DG" label).

Most reasons (46 percent of total reasons) were interest-related—lack of interest in the engineering discipline, not enjoying the work, not feeling passionate about engineering, feeling burnt out, or other overriding interests.

> *"[I would] rather do industrial design or business. I didn't choose engineering as a career because most jobs afterwards I wouldn't be interested in."*

> *"I don't enjoy the work. I've found that I truly enjoy medical work. If anything, I may try to incorporate engineering into medical research and development in the future, but I'll probably never make engineering a career."*

> *"I think one bad thing about engineering is that there is so much work that after a while you begin to get burnt out. That's how I feel now. While I know a career in engineering is the most practical decision, I've had enough of it (DG)."*

> *"I have enjoyed the challenge of engineering but have never gotten that passionate about it."*

> *"[While] I understand technical concepts well and enjoy learning about technical and scientific fields, I enjoy other ways of applying that knowledge and interest--such as teaching, policymaking, etc. (DG)"*

Some respondents' reasons for not choosing engineering were related to negative stereotypes of careers in engineering (15 percent) or an ambiguous or narrow definition of "engineering" or "engineering work" (15 percent).

*"[It] seems that engineering is a tedious and stressful career during and after school. This does not sound very appealing."*

*"I don't like the idea of doing "engineering" for the rest of my life."*

*"I will be overseeing a manufacturing operation which entails a lot of engineering, but I will not do any engineering-specific design work."*

The last response is a good example of just how narrow a student's definition of "engineering" may be, and how different that definition may be from that of a professor or employed engineer. The respondent implies that "design work" is required for a job to be considered "engineering." And though the respondent clearly states that the manufacturing operation "entails a lot of engineering," he does not see the job of overseeing the manufacturing operation as an engineering job.

Another Leaver had a similarly narrow perception of an engineering job:

*"I would like to do engineering sales, project management, or on my own (sic)."*

The previous two quotes contrast with another Leaver's broader definition of an engineering-related job. This respondent is going to be a pilot in the United States Air Force.

*"I am in AFROTC and I am going hopefully into the pilot field. I see this being partly engineering-related but not completely."*

A respondent who is planning to pursue a career in Meteorology cited incongruence between his identity and his perception of the engineering profession in general:

*"I do not see myself as an engineer. Challenging degree and a good foundation, but not what I want to do in life."*

In one respondents' case, a perception of higher standards required for success and a perceived inability to meet those standards led to a decision not to pursue an engineering career.

*"To be successful in an engineering career, I would feel the need to go to engineering [graduate] school. I couldn't handle another 2 years of this. I do feel that I could get an MBA and be qualified to manage engineers."*

The theme an overwhelming workload seemed to pervade the Leavers' reasons for not choosing engineering as a degree. Respondents cited reasons related to "tedious and stressful" work, feeling "burnt out," and not being able to "handle [more] of this."

### 4.5.8 Leavers: What could have made them choose an engineering career?

Leavers also had an array of reasons that could have made them choose engineering as a career. A summary follows:

When asked what could have made them choose engineering as a career, most respondents simply said:

*"Nothing."*

One gave a humorous response that was a *de facto* "nothing:"

*“$300,000+ salary with 6 months/year vacation time.”*

Factors relating to a negative stereotype of engineering and a negative experience in the workplace were also cited.

*“Less cubicle-computer interaction. This will only get worse in the future as software advances.”*

Some responses were related to the quality and focus of the respondents’ educational experience or suggested ideas to improve the curriculum:

*“Make classes more hands-on and bring in more real world scenarios. Boring lectures five days a week kill creativity.”*

*“If we learned more everyday/practical knowledge. For example, I don't know how to machine a piece of metal, but I can look up a formula in a book and fill in the blanks even though I don't know what I'm even solving for. What good is that?”*

*“Co-ops--let people know what they really do in the field.”*

*“I viewed the need to get and perform an internship as the 'make or break' to be an engineer. The fact the school doesn't have a required internship class (like PSCI does) let alone went out of its way not to give credit for it was very frustrating and seemed counter-productive.”*

*“It's very self-centered. I spend most of my time in a book or at a computer alone. Sometimes that's okay, but after a long time, that gets to you. I would*

*say that more group work or all group work [is needed], but I don't think you can develop the skills you need in engineering with just group work (DG)."*

One Leaver, rather than give a reason as to why he did not want to pursue an engineering career, defended his choice of majoring in engineering based on the his perception of the degree's broad utility:

*"I chose [to study] engineering because I can still have the freedom to choose whatever career path I want."*

Several respondents cited extrinsic job-related reasons, ranging from job quality, money, and flexible hours:

*"My choice was based on the quality of job offers. A better engineering-related offer would have made me choose engineering."*

*"If it paid better than any of my other options or if my family had an engineering company that they expected me to take over some day."*

*"More flexible hours, less work. I can't work a 9-5 with no flexibility."*

*"There is not enough money and I don't like the thought of consuming all of my brain power on engineering when I could focus on business and make more money. Also, I ultimately would like to work with my dad, who is very knowledgeable and business-savvy."*

As with the comments about internship experience and reasons for having reservations about an engineering career, the theme of fears of corporate or work culture came up once in the Leavers' responses to what could have made them choose an engineering career. For example, “cubicle-computer interaction” and being alone “in a book or at a computer” were cited. A second theme also came up—a frustration at the lack of “real-world scenarios” in classes and not being taught “more everyday/practical knowledge.”

## 4.6 Summary of Results

The analysis of the survey results elucidated several factors that may influence a student’s Post-Graduation Plans Group identification, or possible reasons why an engineering student may or may not choose to purse an engineering career. Comparing the groups on their Likert-style statement response means of the response means revealed the following Group Identification Predictors:

- Preparedness, measured in the form of how well prepared one feels to pursue an engineering career
- Internship experiences
- Senior Design Project experiences
- Satisfaction with the quality of instruction
- Career values related to salary

An analysis of the career values rank question and the qualitative survey identified another factor that may influence Post-Graduation Plans Group identification:

- Career values related to *salary and co-workers*

The significance of these results will be discussed in Chapter 5: Discussion of Results, Conclusions, and Future Work Recommendations.

# Chapter 5: Discussion of Results, Conclusions, and Future Work Recommendations

## 5.1 Discussion of Results

The quantitative and qualitative analysis of the survey results revealed the following factors that may influence a student's identification with a particular Post-Graduation Plans Group:

- Preparedness, measured in the form of how well prepared one feels to pursue an engineering career
- Internship experience
- Senior Design Project experience
- Satisfaction with the quality of instruction
- Career Values, especially values related to financial rewards and co-workers

The evidence behind each of these factors and their importance to post-graduation attrition will be critiqued in detail. Where possible, comparisons to corroborating, contradicting, or parallel evidence from the research literature will be made. The research questions established in 1.1 Motivation and Research Questions will then be addressed based on the discussion of results.

### 5.1.1 Characterizing the Four Post-Graduations Plans Groups

Table 5.1 characterizes, in relative terms, the four Post-Graduation Plans Groups with qualitative statements relating to the Group Identification Predictors.

**Table 5.1: Characterization of the Post-Graduation Plans Groups**

| **Pursuers** tended to… |
|---|
| –Feel ***more*** prepared |
| –Rate internship experiences ***higher*** |
| –Rate Senior Design experiences ***higher*** |
| –Be ***more*** satisfied with instruction |
| –View salary as ***more*** important |
| –View co-workers as ***less*** important |

| **Returners** tended to… |
|---|
| –Feel ***less*** prepared |
| –Rate internship experiences ***higher*** |
| –Rate Senior Design experiences ***higher*** |
| –Be ***less*** satisfied with instruction |
| –View salary as ***less*** important |
| –View co-workers as ***more*** important |

| **Pursuers with Reservations** tended to… |
|---|
| –Feel ***less*** prepared |
| –Rate internship experiences ***lower*** |
| –Rate Senior Design experiences ***lower*** |
| –Be ***less*** satisfied with instruction |
| –View salary as ***more*** important |
| –View co-workers as ***more*** important |

| **Leavers** tended to… |
|---|
| –Feel ***less*** prepared |
| –Rate internship experiences ***lower*** |
| –Rate Senior Design experiences ***lower*** |
| –Be ***less*** satisfied with instruction |
| –View salary as ***less*** important |
| –View co-workers as ***more*** important |

### 5.1.2 Discussion of the Influence of Preparedness on Post-Graduation Plans Group Identification

In both the Senior Design and December Graduates surveys, Pursuers reported feeling more prepared for an engineering career than all other groups. In the Senior Design sample, the observed order of preparedness (based on mean ranks), from more prepared to less prepared, was Pursuers, Returners, Pursuers with Reservations, and Leavers. In the December Graduates survey, the observed order was Pursuers, Returners, Leavers, and Pursuers with Reservations. However, a statistical analysis with a conservative multiple comparison procedure revealed only one statistically interesting result—Pursuers in the Senior Design sample felt more prepared than Leavers.

Though statistical evidence from this study is lacking, the importance of "feeling prepared" has some parallels in research on self-efficacy development. Some research on occupational self-efficacy, education students in student teaching positions, and first-year college students indicates that preparedness influences self-efficacy (47; 48; 49). Although none of these studies are directly related to engineering careers or engineering education, the connection is at least reasonable enough to allow for some limited comparisons between preparedness and self-efficacy. Recall from the literature that self-efficacy, among other factors, influences academic performance, enjoyment of course material and teamwork issues (3; 16; 33). In turn, academic performance can be affected by pedagogy and student social capital (5; 10; 22; 23; 24). Self-efficacy can also be influenced by success in work or internship experiences (6; 29). In the following sections, these important factors in self-efficacy development—academic performance, internship experiences, enjoyment of work and co-workers, pedagogy, and faculty interactions—will be related to findings in this study.

#### 5.1.2.1 Academic Performance and Preparedness

GPA seems to have some effect on preparedness. In the Senior Design survey, a very weak positive correlation between feeling more prepared for an engineering career and having a higher GPA was observed, but it was only statistically interesting. However, the December Graduates survey showed a statistically significant moderate positive correlation between feeling more prepared and having a higher GPA. Though these results are far from conclusive, the literature supports the idea that self-efficacy plays a role in academic performance(16; 33), so one might expect that GPA would positively correlate with feeling prepared. However, this relationship is contradicted by two other observations in this study—there were no meaningful difference in the mean GPA among Post-Graduation Plans Groups, but there were some limited differences in their preparedness for an engineering career. The available evidence suggests that the relationship between GPA and preparedness should be considered inconclusive.

#### 5.1.2.2 Senior Design Experience, Satisfaction with Instruction, Internship Experience: Influence on Preparedness

Enjoying the people on the Senior Design team, enjoying the work done on the Senior Project, and having a Senior Design project experience that resulted in an increased desire to pursue an engineering career all had weak or mild positive correlations with feeling prepared. The first two results have parallels with previous research—enjoyment of course material is important to self-efficacy (3; 16) and enjoying team members is important to both self-efficacy and student social capital(3; 10; 16).

Satisfaction with the quality of instruction and with the accessibility of instructors had weak positive correlations with feeling prepared. Research shows that good instruction and adequate accessibility influence academic performance (22; 23; 24); academic performance, in turn, influences self-efficacy (16; 33). Though the comparison is indirect, these results are, at the very least, not contradicted by established research.

Having had an internship—regardless of whether the experience was regarded as positive or negative—had a statistically interesting effect on increasing students' feeling of preparedness for an engineering career. In both the Senior Design and December Graduates sample groups, enjoying the people that students worked with in the internship had a weak positive correlation with feeling prepared. In the Senior Design sample, enjoying the internship experience overall had a moderate positive correlation with feeling prepared. Given the links between internship experiences and self-efficacy (6; 29) and the importance of enjoying co-workers with social capital (3; 10; 16), these results reinforce the importance of feeling prepared to pursue a career in engineering.

#### 5.1.2.3 Conclusions on the Importance of Preparedness

Research has established the importance of self-efficacy in career choice(33). Additionally, the positive effects of academic performance, student social capital, and self-efficacy on undergraduate engineering retention are also well-documented(3; 10; 16; 22; 24). Thus, it seems reasonable, or at least not contradictory to existing evidence, that preparedness would play a role in determining post-graduation attrition of engineering students. The results of this study indicate that preparedness does affect identification with a particular Post-Graduation Plans Group, a finding that can be reasonably triangulated with existing research, albeit indirectly. However, there may be some limitations on the consistency of the measured preparedness in this survey and that from the CEAS graduation survey. This consequence will be discussed in 5.3 Future Work Recommendations.

### 5.1.3 Discussion of the Influence of Internship Experiences on Post-Graduation Plans Group Identification

In both the December Graduates and Senior Design survey, Pursuers tended to rate their overall internship experience higher than Pursuers with Reservations or Leavers. Pursuers also reported more agreement with the statements "My internship experience increased my understanding of an engineering career" and "My internship increased my desire to pursue an engineering career" than did Pursuers with Reservations or Leavers. An ANOVA on the Senior Design sample revealed only statistically interesting differences, but the results may not be reliable since sample size assumptions were not met. A t-test between Pursuers and Pursuers with Reservations showed a significant difference—Pursuers tended to agree more with

"My internship increased my desire to pursue an engineering career" than did Pursuers with Reservations or Leavers.

The December Graduates survey had some statistically significant differences. Pursuers enjoyed the overall internship experience, enjoyed the people they worked with in their internship, and enjoyed the work they performed in their internship to a greater extent more than Leavers. Pursuers, Returners, and Pursuers with Reservations found that their internship experiences increased their desire to pursue an engineering career to a greater extent than Leavers. However, drawing conclusions from such a small sample may give misleading results.

Despite similar trends among Post-Graduation Plans Groups, the surveys offer limited triangulation in terms of Post-Graduations Plans group identification. The correlations between internship factors offer some corroborating evidence, however. Both surveys showed strong positive correlations between enjoying the internship experience overall and enjoying the work. Enjoying the people in an internship had a moderate positive correlation in the Senior Design survey and a mild positive correlation in the December Graduates survey with an increased desire to pursue an engineering career. Qualitative results related to internship factors offer more support for the importance of enjoying the work and people in an internship. Those factors were among the top three most frequently cited factors related to positive internship experiences and among the top four most frequently given factors relating to negative internship experiences in both surveys. Uninteresting work, which is a measure of enjoying the work, was the top factor related a to a negative internship experience in both surveys.

#### 5.1.3.1 Conclusions on Internship Experiences

Existing research supports the importance of internship experiences in student retention (6). Seymour and Hewitt reported that internship experiences were often "confirmatory experiences"—students found that internships confirmed their interest and desire to persist, led to them to switch majors, or to persist in an SME major but make plans not to pursue an SME career (5). Interestingly, the topic of internships has not received nearly as much attention in the research literature as other retention-related factors. Though differences in internship experiences between groups, the effect of an internship on making students feel more prepared for an engineering career, and existing research all support the hypothesized importance of internship experiences on Post-Graduation Plans Group identification, the survey results, on the whole, are somewhat inconclusive.

### 5.1.4 Discussion and Conclusions on Senior Design Experience

Corroborating evidence from both surveys indicates that a student's experience in Senior Design may be one of the more important factors influencing Post-Graduation Plans Group identification. In both survey samples, there was a significant difference between Pursuers and Leavers—the Senior Design project increased Pursuers' desire to pursue an engineering career to a greater extent than the Leavers. For both surveys, the mean response of Leavers to the statement "My Senior Design project increased my desire to pursue an engineering career" was below (and statistically different from) the neutral response—one of the few Likert-style statements that actually had a mean response below the neutral response from any group. This finding suggests that the Senior Design project experience may have actually *decreased* Leavers' desire to pursue an engineering career. Comparing Pursuers and Pursuers with Reservations in both surveys revealed a similar trend—the Senior Design project increased Pursuers' desire to pursue an engineering career to a greater extent than Pursuers with Reservation, but the difference was only significant in the Senior Design survey.

As was observed in the internship experiences, enjoying the people and the work in Senior Design were important to a Senior Design experience that increased one's desire to pursue an engineering career. In both samples, enjoying the people and the work in Senior Design had strong positive correlations with a Senior Design experience that increased one's desire to pursue an engineering career. This finding has some indirect support from existing research. Recall from the literature that self-efficacy, known to be important in career choice, is influenced by enjoyment of course material and teamwork issues (3; 16).

### 5.1.5 Discussion and Conclusions on Satisfaction with Instruction

The satisfaction with the quality of instruction was measured only in the Senior Design survey, so there is less evidence upon which to triangulate findings about the influence of instruction on Post-Graduation Plans Group identification. However, some important observations can still be made. Overall, Pursuers tended to be more satisfied with the quality of instruction than all other groups. The difference was only statistically significant between Pursuers and Returners, but was statistically interesting between Pursuers and Pursuers with Reservations and Pursuers and Leavers. Additionally, Returners, Pursuers with Reservations, and Leavers had mean responses to the satisfaction with instruction quality statement that were below (and statistically different from) the neutral response, while Pursuers did not.

A comment from the qualitative responses about having reservations about an engineering career, though solitary, was particularly striking:

> *"I think that going to school here made me dislike engineering. Some of the professors are great, but most hate their job. How can I love something and try to learn it from someone who hates it?"*

Satisfaction with the quality of instruction also seemed to have a small effect on feeling prepared, established in 5.1.1 Discussion of the Influence of Preparedness on Post-Graduation Plans Group Identification.

However limited the evidence linking satisfaction with instruction and Post-Graduation Plans Group identification may be, the influence of pedagogy and interactions with faculty on undergraduate retention (5; 50; 24) established by the research literature suggests the significance of instruction should not be ignored.

### 5.1.6 Career Values and Post-Graduation Plans Group Identification

The final factor that seemed to influence Post-Graduation Plans Group identification were career values, especially those related to salary and co-workers. Evidence related to financial rewards comes from two survey items: the career values rank questions and the Likert-style statement related to the perception of a career as a way to earn income. The career value "Salary" was significantly more important to

Pursuers than Returners. Pursuers also saw careers as a way to just earn income to a greater extent than Returners, but the difference was only statistically interesting. "Salary" was also significantly more important to Pursuers with Reservations than Returners. This corroborates with a statistically significant result from the "CareerIncome" Likert-style statement: Pursuers with Reservations saw careers as a way to just earn income to a greater extent than Returners. "Salary" was significantly more important to Pursuers with Reservations than Returners. Furthermore, from qualitative survey results, financial reward was the most frequently cited Extrinsic Work-Related Factor for choosing an engineering career, amounting to 30 (Senior Design survey) and 61 (December Graduates survey) percent of all Extrinsic Work-Related Factors.

Recall that both Seymour and Hewitt and Stevens, Amos, et al found evidence that engineering students believed that good material rewards were due to them solely because of the hard work required to earn an engineering degree (5; 36). The Future Leavers, included in the Pursuers with Reservations group, frequently cited business and management careers in their future career plans. US Department of Labor Statistics show that engineering managers earn significantly greater salaries on average than technical engineers (51). The combination of an engineering and business career is often reported to earn an individual just as much, if not much more, than purely technical engineers. Thus, there is some evidence that financial rewards may draw students to engineering careers and determine their plans for leaving an engineering career in the future.

The importance of financial rewards has an interesting contrast with another result observed in the Senior Design survey. There was a statistically interesting (p_adj=.010) difference that the career value "Ability to Contribute to Society" was more important to Leavers than Pursuers with Reservations. The mean ranks indicated that Pursuers and Returners also saw the "Ability to Contribute to Society" as less important compared to Leavers, but there were no statistical differences. Though the evidence behind this contrast suffers without statistical significance and corroboration from the December Graduates survey (though the trend was the same), Seymour and Hewitt and Stevens, Amos, et al also found that some students do not possess a true understanding of an engineering career and its role as "a meaningful craft" that can be used to help others. It appears that career values and reasons for choosing an engineering career—specifically those related to financial rewards—may play a relevant role in Post-Graduation Plans Group identification.

Given the importance of "enjoying the people" in internship and Senior Design experiences, its importance as a career value also deserves some attention. "Enjoying the people I would work with" was found to be more important to Returners and Pursuers with Reservations than to Pursuers, but the differences were only statistically interesting. Yurtseven suggests that negative stereotypes of engineers negatively impact retention rates (1). Additionally, Thomas, et al, suggests that introverted and task-oriented students are more likely to persist in engineering (8), so it is not surprising that Pursuers see co-workers as relatively less important. Thus, as a career value, the perception of co-workers may help determine Post-Graduation Plans Group Identification.

### 5.1.7 Parallels with *Talking About Leaving*: The Concerns of SME Undergraduate Students and Pursuers with Reservations and Leavers

Seymour and Hewitt identified the concerns about SME majors of both switchers and non-switchers in their study. Their research provides a basis for comparison with the reasons for having reservations about an engineering career given by Pursuers with Reservations and the reasons cited by Leavers for not pursuing an engineering career. "Lack of/loss of interest in SME: turned off science" was the most frequently cited factor in switching decisions (at 43 percent) and was mentioned as a concern by 49 percent of all students, switchers or non-switchers(5). In the Senior Design survey, "lack of interest" was the most frequently cited reason (31 percent of all given reasons) for having reservations. In the December Graduates survey, "lack of interest" was the third most common reason (18 percent of all given reasons) for having reservations.

The appeal of other SME majors ("offering better education/more interest") was the second most common factor in switching decisions at 40 percent of reasons and was mentioned as a concern by 46 percent of all students(5). For the Senior Design and December Graduates surveys, respectively, "Other interests" were cited at 20 and 36 percent of reasons for having reservations about an engineering career. For Leavers in both surveys, interest-related reasons—either "lack of interest" or "other interests"—were the most the common reasons given, at 46 percent of all reasons, for not pursuing an engineering career.

Other frequently given factors related to having reservations or not choosing an engineering career—negative stereotypes of engineering and low self-efficacy—have some less direct parallels. Seymour and Hewitt found that "rejection of SME careers and associated lifestyles" was a factor in 29 percent of all switching decisions and a concern cited by 33 percent of all students. This rejection was due, in part, to negative stereotypes associated with SME careers (5). Thus, it is interesting to note that negative stereotypes played an important role in having reservations and choosing a non-engineering career. The Senior Design sample reported negative stereotypes of engineering as a career as 17 percent of reasons related to having reservations, while the December Graduates survey reported it as 27 percent of reasons. Leavers cited negative stereotypes as 15 percent of reasons related to not choosing an engineering career, second to interest-related factors. Additionally, a common theme in the qualitative comments relating to internship experiences and reasons for having reservations about engineering as a career were fears of corporate or work culture—common negative stereotypes of an engineering career.

Low or lost confidence was found to be a factor in 23 percent of switching decisions and 24 percent of all students' concerns in Seymour and Hewitt's study (5). Though low confidence was not cited by any Leaver, low self-efficacy, related to feeling prepared, was given as 14 percent and 18 percent of reasons related to having reservations about an engineering career by the Senior Design and December Graduates samples, respectively.

A final parallel relating to the choice of an SME major in Seymour and Hewitt's findings can be made with the survey results. In what Seymour and Hewitt call “the uninformed choice,” 13 percent of switchers and 9 percent of non-switchers “realized that they had chosen a science-based major because it seemed (or was presented to them as) a logical extensions of doing well in mathematics and/or science classes in high school”(5). Math and science strength made up 51 percent of factors in “Perceived Competence” in the Senior Design survey and 45 percent in the December Graduates survey. “Perceived Competence” was the second most common reason for choosing an engineering career (22 percent of all given reasons) in the Senior Design survey and the third most common reason (18 percent of all given reasons) in the December Graduates survey. In the Senior Design survey, 39 percent of those who cited math and science strength were Pursuers with Reservations—the rest were Pursuers by virtue of the survey completion directions. In the December Graduates survey, 20 percent (only one respondent of the five who cited math and science strength) were Pursuers with Reservations. Though there is no direct evidence linking an “uninformed choice” to having reservations about an engineering career, the parallel is at least interesting given its relative importance in Seymour and Hewitt’s findings.

### 5.1.8 Other Interesting Findings

Several other findings in this research deserve discussion in terms of their significance and their support from the research literature. The discussions follow under the italicized headings.

*Similarities among the Post-Graduations Plans Groups*

The lack of meaningful differences in GPA among Pursuers, Returners, Pursuers with Reservations, and Leavers suggests the groups are not academically different. This corroborates with a major finding from Seymour and Hewitt—switchers and non-switchers were not academically different, but often had reasons for switching related to structural or cultural sources in institutions (5). This research also revealed the similarity of Pursuers with Reservations and Leavers in terms of their preparedness, internship and Senior Design experiences, satisfaction with instruction, and the view of the importance of co-workers. Seymour and Hewitt found that switchers and non-switchers often had the same concerns about SME majors, but that various structural and institutional factors influenced switching decisions (5). Thus, it may be that the Pursuers with Reservations and Leavers are, in fact, not that different. Given the high proportion of Pursuers with Reservations who were also Future Leavers, it is possible that post-graduation attrition may occur over a longer period of time. This contrasts with undergraduate attrition, which occurs in shorter periods of time—mostly in the freshman and sophomore years (4).

*The High Proportion of Pursuers with Reservations: Post-Graduation Attrition and Employment Statistics*

Statistics from the U.S. Department of Labor indicate that 65 percent of employed people with engineering degrees work as engineers, engineering managers, or as engineering teachers (51). Thus, 35 percent of employed people with engineering degrees work outside of engineering-related fields. Future Leavers (included in

Pursuers with Reservations) and Leavers together made up 30 percent of the total sample in the Senior Design survey and 32 percent of the total sample in the December Graduates survey. Thus, the proportion of Future Leavers and Leavers seems to match up well with current trends in the American workforce. Given this support, the fact that many career choice theories suggest that career choice development occurs over a long period of time, and research indicating that career aspirations are equally predictable among students and employed engineers, dismissing the high combined proportion of Future Leavers and Leavers as a symptom of indecisive and stressed students as they near graduation may be fallacious.

*Having Reservations about an Engineering Career*

Cross tabulations revealed two interesting, albeit statistically insignificant, trends: females were more likely to have reservations than males, and students who had internships were more likely to have reservations. The first trend seems to be typical of many issues in engineering education, such as retention and self-efficacy. Females tend to have lower persistence rates and lower self-efficacy beliefs (4), so it is not surprising that more females might have reservations. However, when Pursuers with Reservations and Leavers are combined for genders, males are slightly more likely to be in the Pursuers with Reservations or Leavers groups than females.

The second trend indicates an interesting dichotomy in the research findings. Pursuers and Returners rated their internship experiences higher than Pursuers with Reservations and Leavers. Also, students who had internships tended to feel more prepared and Pursuers tended to feel more prepared than the other groups. However, the cross tabulations seemed to indicate that students who had internships were more likely to have reservations. Further research in this area is urged to clarify this apparent contradiction.

## 5.2 Addressing the Research Questions

Since this study was only two surveys over the course of one year, it would be inappropriate to draw definitive conclusions from the data. However, the research questions posed in the introduction to this paper can still addressed in terms of the evidence presented in the discussion of results. The relevance of the results and the study in general will also be addressed.

*Is there a post-graduation attrition problem among Mechanical Engineering graduates at the University of Colorado at Boulder?*

The definition of post-graduation attrition as a problem truly depends upon why the graduates may leave. This issue was debated in the background—controllable attrition issues such as low self-efficacy, negative stereotypes of engineering careers fed by lack of information about engineering careers, or bad educational experiences should be a concern; a desire among students to creatively apply engineering skills to other fields should not be a concern. The best way to address this question is consider whether evidence in the results suggests students are being "pushed away" by bad experiences (a problem) or "pulled away" by a desire to apply their degree in another way (not a problem). Institutional factors such as feeling prepared, Senior Design experience, and satisfaction with instruction tended to rate lower among Pursuers with Reservations and Leavers. While Pursuers with Reservations made up surprisingly large parts of both survey samples and Future Leavers were present in significant numbers in both groups, Leavers remained few in number, perhaps discounting the scale of the post-graduation problem compared to the undergraduate retention problem. Though this study was exploratory, more data still needs to be collected, and it was not designed to specifically measure being "pushed away" versus "pulled away," some available evidence at least hints that a post-graduation attrition *problem* could exist. Given the significance of undergraduate retention problems, it does not make sense to ignore the possibility of post-graduation attrition as irrelevant or uncontrollable to universities.

*What factors, if any, influence post-graduation attrition? In other words, what factors affect an engineering student's choice to pursue an engineering or non-engineering career?*

This study identified the following factors as important to post-graduation attrition:

- Preparedness, measured in the form of how well prepared one feels to pursue an engineering career. Feeling more prepared was correlated with plans to persist in engineering careers.
- Internship experience. Higher ratings of internship experiences were associated with plans to persist in engineering careers.
- Senior Design Project experience. Higher ratings of Senior Design experiences were associated with plans to persist in engineering careers.

- Satisfaction with the quality of instruction. Being more satisfied with the quality of instruction in the engineering program was associated with plans to persist in engineering careers.
- Career Values, especially values related to financial rewards and co-workers. Respondents who viewed financial rewards as more important were more likely to persist in engineering careers initially after graduation. However, students who saw financial rewards as relatively more important were equally likely to have plans to persist in an engineering career or to have reservations about engineering as a career and/or plans to leave engineering in the future. Respondents who viewed co-workers as more important were less likely to express plans to persist in engineering careers.

*What, if any, changes in the educational experience could decrease post-graduation attrition rates?*

Given the numbers of Pursuers with Reservations and Leavers in both surveys, surprisingly few suggestions for improvement were made by the respondents. However, the survey may not have been designed well enough to properly elicit such responses. From what was suggested, it seems like co-op program or an internship and career placement program would give students a better picture of engineering careers and would make them feel more prepared for an engineering career. Improving students' Senior Design experiences through increased monitoring of the course and the continued implementation of improved pedagogy that connects theory and practice in engineering could also help to decrease post-graduation attrition.

## 5.3 Future Work Recommendations

This study was almost entirely exploratory and all results should be treated as so. Therefore, future research in the broad area of post-graduation attrition is urged. However, the results of this study suggest some specific topics that may yield useful information. These topics will be presented below in bulleted form, framed with available evidence from the results and/or the research literature. Some points will be followed with specific research questions.

- Case study interviews and focus groups are valuable second-step research methods for investigating ideas identified in exploratory studies. With these methods, clarification and refinement could be brought to the factors related to post-graduation attrition identified in this study.
- The research literature suggests that congruence between self-image and occupational image plays a major role in career choice. Do engineering students have an opportunity to test this congruence if they are not properly exposed to occupational images, specifically in the form of internships or co-ops? Do engineering courses focus enough on providing information about engineering careers? Are there alternatives to classes and internships being the sources of career information? Would mentoring or job-shadowing programs be effective?

- The number of students who cited "math and science strength" as a reason for pursuing an engineering career was surprising. While that might be a good reason for choosing engineering as a major, why don't students, especially in their senior year, cite more refined interests directly related to engineering? Was the survey question poorly phrased or did student misread it? Or do graduating students not have refined reasons for choosing an engineering career? Do unrefined reasons for choosing engineering careers stem from a poor understanding of engineering as a career?
- Peer groups have been demonstrated to be of great importance in preventing engineering undergraduate student attrition. What role do peer groups play in the attrition of engineering graduates?
- At the University of Colorado, less than half of graduating mechanical engineers have jobs secured upon graduation. This statistic comes from data from the CEAS collected in March, April, and May of 2007 for the May 2007 graduates. Does the time it takes students to find jobs affect post-graduation attrition? Other universities, such as Ohio State University and Michigan Tech, have placement rates as high as 98 percent. These universities have engineering job placement programs—do these programs significantly reduce post-graduation attrition?
- Meeting ABET certification requirements has been an impetus for the CEAS Dean's Office and the ITLL to measure students' self-efficacy in many engineering-related subjects. With a little additional work, specific results for

each student could be combined with their post-graduation plans. What specific self-efficacy factors relate to post-graduation attrition?

- What specifically about the Senior Design course results in an increased desire to pursue an engineering career? What is the role of the faculty advisor and the industry mentor in providing a positive or negative experience?
- This study indicated that if students don't enjoy their Senior Design teammates, it may affect their desire to pursue an engineering career. What specific factors are related to "enjoying the people?" Do students look at a disliked teammate and ask, "What if I had to work with someone like him or her in my career? Should I reconsider engineering as a career?"
- This research did not measure the attitudes of students toward engineering careers beforehand. What is the effect of students' incoming attitudes on both survey results and their career choices? Do students enter the Senior Design course knowing that they do not want to be in engineering, and could that lead to a poor experience in the Senior Design course?
- The offshoring of U.S. engineering jobs has become a hot topic of debate in the technology community. The U.S. Congress and prominent national science and engineering organizations have claimed that job prospects for engineers in the U.S. are getting dimmer as engineering jobs are offshored to countries like India and China. Although a recent Duke University study challenges such claims on the basis of misreported statistics, students in an engineering management class at Duke University have been asking "What jobs are 'offshoring-proof?' (2)" Is there a pervasive fear that the engineering

job market in the United States isn't as good as it once was? Do such beliefs towards offshoring or other globalization issues affect the attrition of engineering graduates or movement into management and business careers?

- Financial rewards seem to be an important factor in many students' choice of engineering as a career. What factors are behind this association? Are the increasing costs of attending university or student loan debts important?
- The results of this study suggested that some students see "Management" as a career outside of engineering. While the US Department of Labor puts "Engineering Managers" in a separate category from "Engineers," the two occupations are acknowledged to be related—"Many engineers become engineering managers..."—and the statistics are collected together(51). What is the distinction that students see between "engineers" and "engineering managers?" What attracts students to either "technical engineering" or "engineering management?"
- Some minor observations in the qualitative survey results suggest that students have differing, and sometimes narrow, definitions of "engineering." Some students associate "engineering" with only design work. Two of the 15 Leavers (total from both surveys) reported employment in which their engineering degree would be useful but not required for their jobs. These Leavers also reported that they do not see themselves as "engineers." How do students define the words "engineer" and "engineering?" What role does their definition play in their career choice?

- What attracts Future Leavers to business and management careers? Why does salary seem to be relatively important to Pursuers with Reservations, which includes Future Leavers? Is there a connection between the importance of salary to Pursuers with Reservations and the common belief that engineers in business and management earn more money?
- What plans do engineering students hold about their careers when they enter college compared to when they graduate? If they change, how and in what ways do these plans change over time? Could post-graduation attrition be predictable before the graduation year, say in the freshman or sophomore years?
- This survey did not provide a way of measuring whether Returners had reservations about an engineering career or whether they planned to leave in the future. Returners were similar to Pursuers with Reservations and Leavers in several areas, including their preparedness, satisfaction with instruction, and view of the importance of co-workers as a career value. How many Returners have reservations or plans to leave engineering in the future?
- The survey question on career values in this study was designed based on a broad sampling of topics from the research literature and some intuitive supposition. Consequently, the results are not directly comparable to the existing research. Would an established career typology, such as Schein's Career Anchors, yield more useful results?
- How would a co-op program or internship and career placement program affect post-graduation attrition?

- The results of this study suggest that gender and ethnicity do not seem to influence post-graduation attrition, which is different many other issues in engineering education. Of particular interest were the observations that all Leavers were white and that 14 of the 15 Leavers (from both surveys) were male. Is it possible that the underrepresented minorities who had thoughts of leaving engineering are already gone at this point (i.e. that they switched majors) and that the underrepresented minorities who graduate with engineering degrees have the intrinsic interest and motivation required to pursue an engineering career? Or, would more data reveal disproportionate effects of post-graduation attrition on underrepresented minorities?
- Evidence from the CEAS graduation survey indicates that the distribution of preparedness for mechanical engineering graduates is different from what was observed in this study. Overall, students responding to the CEAS graduation survey reported being more prepared to pursue a career in engineering. What are the possible sources of this discrepancy? Are the differences due to the lengths of the surveys or the time given? Are the samples truly different? What is the effect on students of knowing that they are responding to an official college survey—are their responses altered? What is the effect of a Senior Design course in which not all students are graduating the semester in which the survey is given?
- Career choice development theories offer valuable insights into how students choose their careers. However, these theories are rarely emphasized in engineering education. Could using these theories to guide curriculum and

pedagogy changes produce better educational experiences for engineering students?

- Are post-graduation attrition rates different in other engineering disciplines? How do the rates vary at different institutions?

Further research on post-graduation attrition may identify many relevant factors related to the issue. This research could be valuable in improving the educational experience of undergraduate engineering students by determining strengths and weaknesses in student abilities. The most definitive way to study post-graduation attrition would be in a longitudinal, cross-institutional, and cross-disciplinary study. That is truly a long-term research goal; in the immediate future, brief one-page surveys, such as the ones administered in this study, will be the most effective way to measure the initial scale and scope of this possibly emergent problem.

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# Appendix A: Senior Design Survey

*This survey is being conducted as part of research for a master's thesis. Your insights will be used to improve the educational experience for future students.* ***Please answer the questions truthfully and thoughtfully.*** *Thank you! Results from this survey will be used for research purposes only. Your anonymity will be maintained during data analysis and in the publication or presentation of results. Please contact James Margolis (james.margolis@colorado.edu or 303.957.7488) if you object to participating in this survey.*

1. **What is your name?**

   ______________________________________________

   **Would you be willing to be contacted for an interview? __ Yes __ No**
   **Email: ____________________**
2. **What is your gender?** __ Female __ Male
3. **What is your ethnicity?** __White (Not Hispanic Origin) __African American __Asian or Pacific Islander __Hispanic, Chicano, Mexican American __Native American __I do not wish to answer __Other:__________
4. **What is your degree?** __ BS __ BS/MS __ MS
5. **What is your cumulative GPA?** ____________ Please list to 2 digits after the decimal, i.e. 3.45
6. **How well prepared do you feel to pursue a career in engineering?** (check one)

   __ not at all prepared

   __ slightly prepared

   __ prepared

   __ well prepared

   __ highly prepared
7. **Have you ever had an engineering-related internship?** __ Yes __ No

| |
|---|
| *If you answered "yes" to Question 7, please answer the questions below. If you answered "no," please skip to Question 8.* |

***PLEASE PUT A CHECK UNDER THE CATEGORY THAT BEST DESCRIBES YOUR INTERNSHIP, or describe it in the "Other" category. If you had multiple internships, number them and answer the questions for each one.***

| Internship # | Technical (design, testing, manufacturing, etc.) | Project Management | Sales Engineering | Other (Please Specify): |
|---|---|---|---|---|
| | | | | |

**Please rate your agreement with the following statements using the scale below:**

*(1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree)*

| | Internship #1 | Internship #2 | Internship #3 | Internship #4 |
|---|---|---|---|---|
| I enjoyed this internship experience overall | | | | |
| I enjoyed the people I worked with | | | | |
| I enjoyed the work | | | | |
| I found the work challenging | | | | |
| This internship increased my understanding of what it is like to have a career in engineering | | | | |
| This internship increased my desire to pursue an engineering career | | | | |

**Please summarize your responses to the above statements. Why do you feel the way you do?**

8. **Did you ever change or consider changing your major?** __ Yes __ No

*If "Yes," to what major(s) and for what reasons?*

9. **Senior Design Project Experience. Please rate your agreement with the following statements:**

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| I enjoy working with the people on my senior design team | 1 | 2 | 3 | 4 | 5 |
| I enjoy the work I am doing on my senior design project | 1 | 2 | 3 | 4 | 5 |
| I find the work challenging | 1 | 2 | 3 | 4 | 5 |
| My senior design project has increased my desire to pursue an engineering career | 1 | 2 | 3 | 4 | 5 |

10. **Please RATE YOUR AGREEMENT with the following statements:**

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| Pursuing an engineering degree has challenged me | 1 | 2 | 3 | 4 | 5 |
| I need to be challenged in my career to feel satisfied | 1 | 2 | 3 | 4 | 5 |
| I see a career as a way to earn income so that I can pursue my passions in my own time | 1 | 2 | 3 | 4 | 5 |
| I see a career as something I should be truly passionate about | 1 | 2 | 3 | 4 | 5 |
| I am satisfied with the quality of instruction in CU's engineering program | 1 | 2 | 3 | 4 | 5 |
| I am satisfied with the accessibility of my instructors | 1 | 2 | 3 | 4 | 5 |

11. **In choosing a career, what factors are most important to you? Please RANK ALL OF THE FOLLOWING 9 OPTIONS IN ORDER OF THEIR IMPORTANCE TO YOU, with 1 being the most important and 9 being the least important.** (*You may add as many distinct "other" categories as you wish and rank them as well).*

__ Salary

__ Ability to contribute to society

__ Prestige

__ Interest or talent in the career

__ Enjoying the people I would work with

__ Fitting in with the culture of the field

__ Expected number of hours worked per week

__ Geographic location (near family, the mountains, the ocean etc.)

__ Being challenged by the work

__ Other (please specify:)_______________________________

12. **Do you plan to pursue a career in engineering immediately after graduation?**
__ No

__ Yes, and I have job offers available or I have applied/will apply, and I think I will get at least one job offer   __ Yes, I would like to, but I don't think I will get a job offer

| |
|---|
| *If you chose any two of the "Yes" options to Question 12, please answer only Questions 13-15 and leave Questions 16-17 blank.*<br><br>*If you answered "no" to Question 12, please skip Questions 13-15 and answer Questions 16-17.* |

13. **Why have you chosen engineering as a career?**

14. **Do you have any reservations about your choice?**
__ Yes   __ No

15. **Do you see engineering as a long-term career for you?**
__ Yes   __ No

*If you answered "Yes", please summarize your response:*

*If "no," what other career(s) might you pursue?*

16. **If you answered no to Question 12, what are your plans after graduation?**

__ Medical school

__ Law school

__ MBA program

__ Graduate school in engineering

__ Graduate school in a different field (please specify): _________________

__ Employment outside of engineering (please specify): ________________

__ Travel

__ Other (please specify): _________________________

17. **Do you see yourself pursuing a career in engineering in the future?**

__ Yes __ No

If "no," please summarize your response. Why did you not choose engineering as a career?

What, if anything, could have made you choose engineering?

# Appendix B: December Graduates Survey

*This survey is being conducted as part of research for a master's thesis. Your insights will be used to improve the educational experience for future students.* ***Please answer the questions truthfully and thoughtfully.*** *Thank you! Results from this survey will be used for research purposes. Your anonymity will be maintained during data analysis and in the publication or presentation of results. Please contact James Margolis (james.margolis@colorado.edu or 303.957.7488) if you object to participating in this survey.*

1. **What is your name?**

   ______________________________________________

   **Would you be willing to be contacted for an interview? __ Yes __ No**

   **Email: ____________________**

2. **What is your gender?** __ Female __ Male
3. **What is your degree?** __ BS __ BS/MS __ MS
4. **What is your cumulative GPA?** ____________ Please list to 2 digits after the decimal, i.e. 3.45
5. **How well prepared do you feel to pursue a career in engineering?** (check one)

   __ not at all prepared __ slightly prepared __ prepared __ well prepared __ highly prepared

6. **Have you ever had an engineering-related internship?** (circle one)

   Yes No

*If you answered "yes" to Question 6, please answer the questions below. If you answered "no," please skip to Question 7.*

*If you had multiple internships, please number them and answer the questions for each one.*

| Internship # | Company Name | Position | Briefly Describe What You Did |
|---|---|---|---|
| | | | |

**Please rate your agreement with the following statements using the scale below:**

*(1=strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree)*

| | Internship #1 | Internship #2 | Internship #3 | Internship #4 |
|---|---|---|---|---|
| I enjoyed this internship experience overall | | | | |
| I enjoyed the people I worked with | | | | |
| I enjoyed the work | | | | |
| This internship increased my understanding of what it is like to have a career in engineering | | | | |
| This internship increased my desire to pursue an engineering career | | | | |

**Please summarize your responses to the above statements. Why do you feel the way you do?**

7. **If you did not have an engineering-related internship, what did you do during your college summers?**

__ Summer School

__ Travel/Study Abroad

__ Employment or volunteer position in a non-engineering-related job (*Please fill in the table below)*

` __ Other: Please specify:

_______________________________________________________________

| Job # | Company Name | Position | Briefly Describe What You Did |
|---|---|---|---|
| | | | |

*Regardless of your answer for Question 7, please answer the following question:*

Why did you choose this over an engineering-related internship?

__ Higher pay

__ Applied to engineering-related internship(s) but was rejected

__ Did not know how to find an engineering-related internship

__ Did not find an engineering-related internship of interest

__ Did not want an engineering-related internship

__ Other (Please specify):

_______________________________________________________________

8. **Senior Design Project Experience. Please rate your agreement with the following statements:**

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| I enjoyed working with the people on my senior design team | 1 | 2 | 3 | 4 | 5 |
| I enjoyed the work I did on my senior design project | 1 | 2 | 3 | 4 | 5 |
| My senior design project increased my desire to pursue an engineering career | 1 | 2 | 3 | 4 | 5 |

9. **In choosing a career, what factors are most important to you? Please rank all of the following 9 options in order of their importance to you, with 1 being the most important and 9 being the least important.** (*You may add as many distinct "other" categories as you wish and rank them as well).*

__ Salary

__ Ability to contribute to society

__ Prestige

__ Interest or talent in the career

__ Enjoying the people I would work with

__ Fitting in with the culture of the field

__ Expected number of hours worked per week

__ Geographic location (near family, the mountains, the ocean etc.)

__ Other (please specify:)____________________________________

10. **Do you plan to pursue a career in engineering immediately after graduation?**

__ No

__ Yes, and I have job offers available

__ Yes, I have applied or am planning to apply, and I think I will get at least one job offer

__ Yes, I would like to, but I don't think I will get a job offer

*If you chose any three of the "Yes" options to Question 10, please answer only Questions 11-13 and leave Questions 14-15 blank.*

*If you answered "no" to Question 10, please skip Questions 11-13 and answer Questions 14-15.*

11. **Why have you chosen engineering as a career?**

12. **Do you have any reservations about your choice?**

__ Yes __ No

If you answered "Yes", please summarize your response:

13. **Do you see engineering as a long-term career for you?**

__ Yes __ No

If "no," what other career(s) might you pursue?

---

14. **If you answered no to Question 10, what are you plans after graduation?**

__ Medical school

__ Law school

__ MBA program

__ Graduate school in engineering

__ Graduate school in a different field (please specify): _________________

__ Employment in a field outside of engineering (please specify): _________

__ Travel

__ Other (please specify): _________________________

15. **Do you see yourself pursuing a career in engineering in the future?**

__ Yes __ No

If "no," please summarize your response. Why did you not choose engineering as a career?

Could anything have made you choose engineering?