An Analysis of Motivation Constructs with First-Year Engineering Students: Relationships Among Expectancies, Values, Achievement, and Career Plans

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BACKGROUND
Researchers have identified many factors affecting undergraduate engineering students' achievement and persistence. Yet, much of this research focuses on persistence within academia, with less attention to career plans after graduation. Furthermore, the relative influence of expectancy-versus value-related beliefs on students' achievement and career plans is not fully understood.

PURPOSE (HYPOTHESIS)
To address these gaps, we examined the relationships among the following motivation constructs for female and male first-year engineering students: (a) expectancy-related constructs that included engineering self-efficacy (i.e., a judgment of one's ability to perform a task in engineering) and expectancy for success in engineering (i.e., the belief in the possibility of success in engineering); (b) value-related constructs that included identification with engineering (i.e., the extent to which one defines the self through a role or performance in engineering) and engineering values (i.e., beliefs related to engineering interest, importance, and usefulness); (c) engineering achievement; and (d) engineering career plans.

DESIGN/METHOD
Participants included 363 first-year engineering students at a large state university. The students completed an online survey instrument in the first and second semester of their first year.

RESULTS
Students' expectancy- and value-related beliefs decreased over the first year for both men and women. Men reported higher levels for expectancy-related beliefs than women. Expectancy-related constructs predicted achievement better than the value-related constructs, whereas value-related constructs predicted career plans better for both men and women.

CONCLUSIONS
Expectancy- and value-related constructs predicted different outcomes. Thus, both types of constructs are needed to understand students' achievement and career plans in engineering.

KEYWORDS
expectancy, motivation, value

I. INTRODUCTION

The market demand for engineers is high and engineers remain atop employers' lists of hard-to-fill jobs (Weiss, 2009). Despite numerous attempts to increase enrollments, the number of engineering graduates has decreased over the past 20 years (Ohland et al., 2008) and the lack of diversity in the engineering workforce remains troubling. Increasing the number of engineering graduates is challenging because the factors associated with persistence are complex and not well understood (Eris et al., 2007; Lichtenstein et al., 2007). Further complicating the issue, retention within an engineering curriculum does not necessarily guarantee persistence into an engineering career (Lichtenstein et al., 2009).

To address this need, researchers have examined many factors that affect undergraduate engineering students' achievement and persistence. For example, French, Immekus, and Oakes (2005) reported strong correlations among retention and motivation (as measured by the Academic Intrinsic Motivation Scale), student integration (as measured by the Institutional Integration Scale), and grade point average (GPA). Preliminary results from the Academic Pathways Study (APS) suggested that students who left engineering often enrolled initially as a result of external pressures (e.g., family) and disengaged from the curriculum (as measured by behaviors such as attending class and completing homework) more quickly than non-persisters (Atman et al., 2008; Eris et al., 2007). Other studies have identified self-efficacy (i.e., one's judgment of his or her ability to perform a task in engineering), as an important factor in engineering students' persistence, achievement, and interest (Hackett, 1992; Lent et al., 2003; Schaefers, Epperson, and Nauta, 1997; Seymour and Hewitt, 1997). In fact, interventions have been designed and implemented with the intent of raising engineering students' self-efficacy (e.g., Shull and Weiner, 2002).

Increasing students' persistence within engineering programs, however, is not a goal in itself; it is a means to enhance the overall engineering workforce in both industry and academia. And recent results from the Academic Pathways Study (APS) suggest that even students who graduate with degrees in engineering may not pursue engineering careers (Lichtenstein et al., 2009). As Lichtenstein et al. reported, a recent survey of graduating seniors in engineering at two different U.S. institutions indicated that whereas 42 percent planned to pursue an engineering career, 14 percent definitely did not. Another 12 percent indicated that they were probably not going to pursue an engineering career, with 8 percent unsure and the final 24 percent probably heading into engineering (Lichtenstein et al., 2009). These results indicate that faculty who are interested in enhancing the overall engineering workforce need to consider not only students' choice of major and the factors that enable them to persist in school, but also their choice of career and the factors that enable them to persist beyond school.

The goal of the present study was to contribute to the growing body of literature on persistence in engineering by using motivation theories from the fields of education and psychology as a framework. Specifically, we examined the relationships among the following constructs (defined in Table 1) for female and male first-year engineering students: engineering self-efficacy, expectancy for success in engineering, engineering intrinsic interest value, engineering attainment value, engineering extrinsic utility value, identification with engineering, engineering achievement (i.e., grade point average in engineering-related courses), and engineering career plans (i.e., the likelihood that one's career after graduation will directly pertain to engineering).

This study was necessary for four primary reasons:

1. Although self-efficacy beliefs are important factors in students' persistence and achievement, evidence suggests that achievement (i.e., GPA) is an inadequate determinant of whether a student persists in engineering (Atman et al., 2008; Eris et al., 2007; Korte and Smith, 2007; Lichtenstein et al., 2007; Ohland et al., 2004; Zhang et al., 2006). Theoretical evidence indicates that other factors, including engineering values (i.e., one's beliefs related to engineering interest, importance, and usefulness), may be more important determinants of students' intentions and choice of activities (Eccles, 1984a, 1984b; Eccles et al., 1983; Meece, Wigfield, and Eccles, 1990). Because engineering students' value-related beliefs have been studied much less than self-efficacy beliefs, we included value-related beliefs in the present study.
2. The reasons why students select engineering jobs after graduation are less understood than factors related to undergraduate students' achievement, retention, and attrition within academic curricula. Students who persist in engineering through their undergraduate curriculum might not choose an engineering career after graduation (Lichtenstein et al., 2009; Matusovich, 2008). Thus, we included engineering career plans as a construct in the present study. Although the career plans of first-year students might change significantly over their undergraduate education, understanding the *intentions* of these students represents a key starting point for better understanding the ways in which educational experiences influence career plans over time, as well as the interactions between intended career plans and academic persistence.
3. Given the historic underrepresentation of women in engineering, it is important to continue to build an understanding of how motivation constructs, achievement, and career plans, along with the interactions among them, might vary by gender. In the present study, we analyzed all of the data for differences between females and males.
4. The relationships among all of the motivational constructs included in the present study have not been explored with engineering students. Theoretically, some of the constructs in the present study are similar (e.g., self-efficacy and expectancies for success), but to what extent is unknown. It is possible that in comparing two similar constructs, one is a better predictor than the other of students' achievement and career plans. Knowledge of these differences would be useful to researchers interested in measuring these constructs in future studies.

Constructs	**Abbreviation**	**Definition**
Expectancy-related constructs		
Self-efficacy theory		
Engineering self-efficacy[a]	Self-efficacy	One's judgment of his or her ability to perform a task in engineering
Expectancy-value theory		
Expectancy for success in engineering[a]	Expectancy	One's belief in the possibility of his or her success in engineering
Value-related constructs		
Expectancy-value theory		
Engineering intrinsic interest value	Interest	The enjoyment one experiences from engaging in engineering activities, or the interest one has in engineering activities
Engineering attainment value[b]	Attainment	The importance of doing well in engineering in terms of one's core personal values
Engineering extrinsic utility value	Utility	The usefulness of engineering in terms of reaching one's short- and long-term goals
Identification with academics		
Identification with engineering[b]	Identification	The extent to which one defines the self through a role or performance in engineering

Note: Constructs designated with the same superscript are conceptually similar.

Table 1. Expectancy- and value-related constructs and their definitions.

II. BACKGROUND: RELEVANT MOTIVATION THEORIES

A. Self-efficacy Theory

Self-efficacy theory has recently emerged as an important lens for understanding students' experiences in engineering and it appears to show variation by gender (Hutchison et al., 2006; Hutchison-Green, Follman, and Bodner, 2008). Bandura's (1986) social cognitive theory defines self-efficacy as a person's judgment of his or her ability to perform a task within a specific domain. Self-efficacy is an important part of understanding students' involvement in school because it is associated with the types of activities in which they choose to participate, the level of effort they expend, their degree of persistence, their level of performance (Bandura, 1977, 1982, 1986; Bandura and Cervone, 1983, 1986), and their interest (Lent et al., 2008). Beliefs about self-efficacy are derived through processing information from four sources: mastery experiences (i.e., one's previous performances), vicarious experiences of observing others' performances, verbal persuasion, and physiological states (Bandura, 1986).

Increasingly, self-efficacy has emerged as a key framework for analyzing women's experiences in engineering curricula (Baker et al., 2007; Bong 2001; Cross and Vick, 2001; Hackett et al., 1992; Hutchison et al., 2006; Hutchison-Green et al., 2008; Jungert, 2008; Marra and Bogue, 2006, 2007; Marra et al., 2009; Shull and Weiner 2002; Vogt 2008). As an example, Hutchison et al. (2006) reported factors influencing efficacy beliefs among female and male engineering students. They found that although student rankings of the *most* significant factor varied little by gender, more women than men reported factors such as understanding, learning, and help as influences on efficacy beliefs. In a subsequent analysis of interviews, Hutchison-Green et al. (2008) reported that whereas both men and women reported that efficacy beliefs were significantly influenced by performance comparisons, the effects of such comparisons were more often positive for men and negative for women.

In another study, Vogt (2008) documented a strong correlation between level of faculty interaction and self-efficacy, confidence, and performance in a multi-institution study of 713 engineering students across majors and year in school. Most recently, Marra et al. (2009) presented the results of a cross-institutional analysis of women engineering students' self-efficacy, which was conducted over two years and included students at various stages of the curriculum. Their results were mixed, indicating gains in some areas of self-efficacy subscales and losses in others, along with persistent challenges involving inclusion and belonging. Earlier analysis of data from a three-year study across five institutions also demonstrated a strong link between self-efficacy and persistence for both men and women (Marra and Bogue, 2007).

B. Expectancy-Value Theory

Unlike self-efficacy, the expectancy-value theory (Eccles et al., 1983) has been applied less widely in studies of engineering students, although several recent studies (Matusovich, 2008; Matusovich et al., 2008) show promising results. Expectancy-value theory (Eccles et al., 1983; Eccles, Adler, and Meece, 1984; Eccles and Wigfield, 1995; Wigfield, 1994; Wigfield and Eccles, 1992, 2000) expands on the expectancy and value constructs initially developed by Tolman (1932), Lewin (1938), and Atkinson (1957, 1966). The theory developed by Eccles and her colleagues, however, "focuses on the social psychological reasons for people's choices in achievement settings; thus, expectancy and value are defined as cognitive rather than purely motivational constructs" (Wigfield and Eccles, 1992, p. 278). The fact that this theory includes cognition as an important aspect is typical of many current motivation theories applied to educational settings (see Elliot and Dweck, 2005).

This theory predicts that student performance is directly influenced by both their expectancies for success and values. The theory has been tested empirically and students' expectancies for success have been found to relate strongly to their performance on a task, whereas their achievement task values have been found to relate strongly to their intentions and choice of activities (Eccles, 1984a, 1984b; Eccles et al., 1983; Meece, Wigfield, and Eccles, 1990). For example, Meece et al. (1990) found that junior high school students' performance expectancies predicted subsequent grades, whereas their perceptions of the importance of mathematics predicted their future course enrollment intentions.

Although expectancies for success and ability-related beliefs were initially conceptualized as being separate constructs (Eccles et al., 1983), confirmatory factor analyses using data from children in grades one to twelve have demonstrated that students' expectancies and ability-related perceptions are not empirically distinct (Eccles and Wigfield, 1995; Eccles et al., 1993). As a result, Eccles and Wigfield (1995) combine both constructs into one expectancy/ability perceptions factor. In the present study, we have defined expectancies for success as one's belief in the possibility of his or her success in engineering.

With respect to achievement task value, Eccles and Wigfield (1995) found that this construct could be separated into at least three factors: intrinsic interest value, attainment value, and extrinsic utility value (see Table 1 for definitions). Although Eccles and Wigfield (1995) identified these three separate factors within the value construct, they reported positive correlations among them (ranging from 0.56 to 0.79). They also documented at two different time points (i.e., Year 1 and Year 2) that the task value factors were related positively and moderately strongly to students' expectancies/ability perceptions (correlations ranging from 0.37 to 0.53), with the weakest correlation occurring between extrinsic utility value and expectancies/ability perceptions (r = 0.37 and 0.40). They explained that the correlation between expectancy/ability perceptions and extrinsic utility value should be weaker than the correlations between expectancy/ability perceptions and intrinsic interest value (r = 0.53 and 0.51) and attainment value (r = 0.53 and 0.51) because utility is determined by its links to goals and activities that are extrinsic to the task. Thus, utility can be influenced by a wider range of factors than the other constructs.

The expectancy-value theory has received little attention in studies of engineering students, although recent work by Li et al. (2008) and Matusovich et al. (2008) suggests that it holds promise for increasing our understanding of persistence as well as career choice. Li et al. (2008) used the expectancy-value theory to develop an instrument that explores differences between engineering and non-engineering students, and found that whereas both engineering and non-engineering students value the benefits of the field, students in engineering exhibited higher intrinsic value and perceived an increased sense of social utility for the field. In applying expectancy-value theory to case studies from the *Academic Pathways Study*, Matusovich et al. (2008) reported that the expectancies for success construct effectively illuminated the ways in which students developed over time and were influenced by experiences both inside and outside of the classroom. Their work also indicated that students who lack confidence in their engineering abilities can still have a positive expectation for success. Finally, they noted, as we do here, that studies of expectancies must be paired with value to more fully understand students' choices of curriculum and career.

C. Identification With Academics

The construct of "identification with academics" has received little attention in studies of persistence among engineering students, but research from other domains suggests that it may have significant explanatory power (Osborne, 1997; Osborne, Kellow, and Jones, 2007; Voelkl, 1997). Identification with academics is defined as the extent to which an individual defines the self through a role or performance in academics (Osborne, Kellow, and Jones, 2007). The formation of identification with academics has been viewed as the process through which individuals: (1) gain a truer, more accurate, understanding of their competencies; (2) develop a better understanding of their values; and (3) base their self-esteem on these values (Eccles et al., 1989; Wigfield and Wagner, 2005). Thus, in addition to competence beliefs, values play a critical role in the development of one's identification with academics. Identification with academics is important to consider in the present study because it has been linked to positive outcomes such as achievement and classroom participation (Voelkl, 1997), deep cognitive processing of course material and self-regulation (Osborne and Rausch, 2001; Walker, Greene, and Mansell, 2006), grade point average and academic honors (Osborne, 1997), and decreased behavioral referrals and absenteeism (Osborne and Rausch, 2001). Although identification with academics has been used as a construct with students, we found no studies that examined its use specifically with engineering students.

D. Relationships Among Constructs

Table 1 shows the six motivation constructs included in the present study and the theoretical relationships among them. For the remainder of this paper, as presented in Table 1, we use the term "expectancy-related" constructs or beliefs (depending on the context in which we use the term) to refer to "engineering self-efficacy" and "expectancies for success in engineering" and use the term "value-related" constructs or beliefs to refer to "engineering intrinsic interest value," "engineering attainment value," "engineering extrinsic utility value," and "identification with engineering." Expectancies for success in engineering is conceptually similar to the construct of engineering self-efficacy. As noted by Eccles (2005), "Expectations for success (alternatively, a sense of domain-specific personal efficacy) depend on the confidence the individual has in his or her intellectual abilities and on the individual's estimations of the difficulty of the course" (p. 105–106). With respect to the value-related constructs, "engineering attainment value" is conceptually similar to "identification with engineering" in that attainment value is the personal importance of doing well on or participating in a particular task. Eccles (2005) explains, "Our notion of attainment value is closely linked to work in identity: We predict that tasks will be seen as important when individuals view engaging in the task as central to their own sense of themselves (i.e., their core social and personal identities), because such tasks provide the opportunity for the individual to express or confirm important aspects of the self" (p. 109).

III. Research Questions

Students completed a survey instrument during the first and second semester of their first year that included items to measure the six constructs presented in Table 1, as well as their engineering career plans. We also computed students' engineering GPA using their actual grades from their engineering-related courses completed by the end of their first year. This study addressed the following research questions and associated hypotheses (H_{1-6}) with respect to first-year engineering students:

1. Do men or women's engineering expectancy-related beliefs, value-related beliefs, or career plans change during their first year?
2. Do men and women differ with respect to their engineering expectancy-related beliefs, value-related beliefs, achievement, or career plans?
3. What is the degree of relationship between students' engineering expectancy-related beliefs, value-related beliefs, achievement, and career plans?
   H_1: Expectancies for success in engineering and engineering self-efficacy will be significantly correlated.
   H_2: Engineering attainment value and identification with engineering will be significantly correlated.
   H_3: Engineering intrinsic interest value, engineering extrinsic utility value, and engineering attainment value will be significantly correlated.
   H_4: Expectancies for success in engineering will be significantly correlated with engineering intrinsic interest value and engineering attainment value, and to a lesser extent, extrinsic utility value.
4. Which of the expectancy- and value-related constructs best predicts men and women's achievement near the end of their first year?
   H_5: The expectancy-related constructs will predict men and women's achievement.
5. Which of the expectancy- and value-related constructs best predicts men and women's beliefs that their careers will directly pertain to engineering?
   H_6: The value-related constructs will predict men and women's plans to have a career in engineering.

IV. Method

A. Participants and Procedure

We obtained Institutional Review Board approval to conduct this study at a large, public university (in a mid-Atlantic U.S. state) that offers undergraduate engineering degrees. During the second week of a 15-week fall semester, we attended multiple sections of a required first-year engineering course to introduce the study, distribute a study information sheet, and solicit students to participate by completing an online survey instrument (Instrument 1) during the following week and during the Spring semester (Instrument 2). Students were instructed that their participation was voluntary, all personal information would be kept completely confidential, and they would be eligible to win one of ten $30 gift certificates (redeemable at the campus bookstore) if they participated in the study.

Within a day after attending the classes, we sent students an e-mail that included a link to the first online survey instrument,

Activity	Number	Percentage
(1) Total population	1324	100%
(2) Completed Instrument 1 and authorized release of grades	804	60.7%
(3) Completed Instrument 2 and authorized release of grades	427	32.3 % of (1) 53.1% of (2)
(4) Completed Instruments 1 and 2, authorized release of grades, and the study team received grades from the university registrar	363	27.4% of (1)

Table 2. Overall response rate.

Variable	Number	Percentage
Male	285	78.5%
Female	78	21.5%
White/Caucasian	313	87.4%
Asian/Pacific Islander	22	6.1%
Hispanic	8	2.2%
Black/African-American	6	1.7%
Native American	4	1.1%
Unspecified ethnicity	5	1.4%

Table 3. Demographics of respondents.

with reminders sent one and two weeks later. In addition, we distributed and collected release forms in the classes to allow us to access students' course grades at the end of their first year.

During the eighth week of the spring semester, we sent students who had completed the first survey instrument another e-mail asking them to complete a second survey instrument and included a link to the online survey instrument. We re-sent this e-mail one week and two weeks after the initial e-mail as a reminder. Tables 2 and 3 summarize the response rate data and demographics of the respondents.

Data analysis was based on the 363 students (27.4 percent of all students) who completed Instrument 1 and 2, and for whom we received grades from the university registrar's office. The percentage of women in our sample (21.5 percent) was slightly greater than the percentage of women (17 percent) in the entire first-year engineering class at this university. The percentage of minority students in our sample (presented in Table 3) was similar to the percentage of minority students in the entire first-year engineering class at this university (6.5 percent Asian, 3.7 percent Hispanic, 2.5 percent Black, 0.5 percent Native American).

B. Measures

Although survey instruments for use with engineering students are available (e.g., the *Longitudinal Assessment of Engineering Self-Efficacy* [LAESE], see Marra and Bogue, 2006; the *Pittsburgh Freshman Engineering Attitude Survey* [PFEAS], see Besterfield-Sacre et al., 1996, 1998, 2001), these instruments include numerous items that are outside the scope of the research questions addressed in this study and they were not developed to measure the specific motivation constructs being investigated in this study. Consequently, we selected scales that had been used to measure the specific constructs examined in this study. A complete list of the items in each scale is provided in the Appendix. The mean scores reported in the present study represent an average of the items for the scale.

Because some of the scales had not been used with first-year engineering students, we took steps to establish the validity of the scale scores for this population. Two experts in engineering education read all of the scale items to ensure that the content and readability of the questions were appropriate for first-year engineering students (Haynes, Richard, and Kubany, 1995). We made minor revisions to some of the items based on their suggestions. In addition, we asked 23 first-year engineering students who did not participate in the study, but who attended the same university as those who did, to anonymously rate each of the scale items. Students were asked not to answer the items, but rather, to rate the wording of each item with respect to whether the items were clear (i.e., they could understand what the item was asking) and made sense (i.e., the item was logical for a first-year engineering student). Students rated each item on a 5-point Likert-type scale that included 1 (very poor, do not use), 2 (poor, could be used if re-worded), 3 (acceptable, could be used but could be made better), 4 (good, can be used and I don't have any major suggestions for improving it), and 5 (very good, can be used and I can't think of any way to improve it). Students were asked to provide recommendations for how to revise items that they rated a 2, 3, or 4. The mean values for all the items were very high, ranging from 4.78 to 5.00 and the sparse recommendations were not deemed substantial enough to revise any items. These findings provided some evidence for the validity of the scale scores with the study population. After we collected the data, we estimated the internal consistency reliability of the scales by computing Cronbach's alpha and used the following criteria to judge the values (George and Mallery, 2003): greater than 0.9 was excellent, between 0.8 and 0.9 was good, between 0.7 and 0.8 was acceptable, between 0.6 and 0.7 was questionable, between 0.5 and 0.6 was poor, and below 0.5 was unacceptable. The Cronbach's alpha values for each of the scales is presented in the sections that follow.

1) Engineering Self-Efficacy: Engineering self-efficacy was measured using four items from the *Self-efficacy for Academic Milestones* scale developed and used by Lent and his colleagues to measure the engineering self-efficacy of undergraduate engineering students (Lent, Brown, and Larkin, 1986; Lent et al., 2007, 2008). Participants responded to each item on a 10-point Likert-type format that ranged from 1 (no confidence at all) to 10 (complete confidence). To preserve the integrity of the original scale format used by Lent et al., we used a 10-point Likert-type format for this measure instead of the 7-point Likert-type format used for the remainder of the measures. Further, Bandura (2006) recommended that self-efficacy be measured with 10-point scales to improve the sensitivity and reliability of the measure.

To avoid any confusion between the other 7-point scales used in the present study, the engineering self-efficacy scale was presented on a Web page that included only the engineering self-efficacy items and the endpoints were clearly labeled. The directions for the scale were the same as those used by Lent et al. (2007, 2008) and read: "The following is a list of major steps along the way to completing an engineering degree. Please indicate how much confidence you have in your ability to complete each of these steps in relation to the engineering major that you are most likely to pursue." Researchers have documented high internal consistency reliability for this scale, with Cronbach's alphas ranging from 0.89 to 0.91

(Lent et al., 1986; Lent et al., 2005, 2008). The Cronbach's alphas of 0.94 for Instrument 1 and 0.93 for Instrument 2 for the present study were excellent.

2) Engineering Expectancy and Value Scales: The expectancy and value scales have been used with fifth- through twelfth-grade students to assess their expectancies and values (i.e., interest, attainment, extrinsic utility) in academic domains such as mathematics and English (Eccles et al., 1983; Eccles and Wigfield, 1995; Watt, 2004). We administered four scales used by Eccles and Wigfield (1995) as part of the Self-and Task-Perception Questionnaire that included two expectancy-related items, two intrinsic interest value items, three attainment value items, and two extrinsic utility value items. Each item was scaled using a 7-point Likert-type format with a descriptor at each end of the scale.

Because the scales used by Eccles and Wigfield (1995) measured students' perceptions in the domain of mathematics, we replaced the word "mathematics" in each item with "engineering." Also, the questionnaire instructions explicitly stated (1) "For all of the questions that ask you about 'engineering,' please think of the field of engineering, not any one particular engineering class," and (2) "When you are asked about 'engineering-related courses,' please refer to your math, science, and engineering courses." We included these instructions because we did not want students to limit their responses to the one introductory two-semester engineering sequence required of all first-year students. In some of the items, we also explicitly referred to "math, science, and engineering courses."

Researchers (e.g., Eccles and Wigfield, 1995; Eccles et al., 1984; Watt, 2004) have empirically evaluated the psychometric properties of the scales and have reported strong factorial validity (through the use of factor analytic techniques, see Eccles and Wigfield, 1995) and reliability of scores, such as Cronbach's alphas ranging from 0.79 to 0.93 for the ability/expectancy scale, 0.76 to 0.94 for the intrinsic interest value scale, 0.70 to 0.74 for the attainment value scale, and 0.62 to 0.93 for the extrinsic utility value scale. For the present study, the Cronbach's alphas were good for the expectations for success in engineering scales ($\alpha = 0.82$ for Instrument 1; $\alpha = 0.81$ for Instrument 2), acceptable for the engineering intrinsic interest value scales ($\alpha = 0.73$ for Instrument 1; $\alpha = 0.76$ for Instrument 2), borderline acceptable for the engineering attainment value scales ($\alpha = 0.64$ for Instrument 1; $\alpha = 0.71$ for Instrument 2), and unacceptable for the extrinsic utility value scales ($\alpha = 0.36$ for Instrument 1; $\alpha = 0.43$ for Instrument 2). Eccles and Wigfield (1995) had used the same two extrinsic utility value items that we used in the present study and they obtained a Cronbach's alpha of 0.62. However, they had asked students about high school mathematics and we asked students about undergraduate mathematics, science, and engineering. We speculate that this may have made a difference in students' responses. High school students may be more likely to understand how high school mathematics is of use in their daily life outside of school (Item 2 of this scale; see Appendix), whereas first-year undergraduate students may not understand how courses that might be more theoretical, such as calculus, physics, or chemistry, are of use in their daily life outside of school. As a result, the scores obtained from this item might lack validity for a population of undergraduate engineering students. Due to this problem, we used only the first item of this scale, which asked students how useful learning engineering is for what they want to do after they graduate and go to work.

3) Identification With Engineering: This scale is based on the work of Schmader, Major, and Gramzow (2001), who created a four-item "Devaluing" scale that measured the extent to which undergraduate students devalued academics. We modified their devaluing scale by reverse coding all of the items and replacing more general terms, such as "academics" and "school," with "engineering" and "engineering school." Lesko and Corpus (2006) created a similar identification scale for undergraduate students in the domain of mathematics. Items were scaled using a 7-point Likert-type format with a descriptor at the mid-point (4 = neutral) and at each end of the scale (1 = strongly disagree; 7 = strongly agree). Schmader, Major, and Gramzow (2001) and Lesko and Corpus (2006) reported Cronbach's alphas of 0.78 and 0.85, respectively. Cronbach's alphas for the scale in the present study were found to be good ($\alpha = 0.84$ for Instrument 1; $\alpha = 0.89$ for Instrument 2).

4) Engineering Career: The "Engineering Career" item measured the likelihood that students' careers after graduation would directly pertain to engineering. This item did not measure students' actual career choice; rather, it measured students' beliefs about their future career as they perceived it during their first year. This item was modified based on a similar item used by Schmader, Johns, and Barquissau (2004) to measure undergraduate students' interest in having a career in mathematics or science (these students were majoring in one of several math-related majors that included engineering). Students provided responses to the item on a 7-point Likert-format scale with a descriptor at each end of the scale. We replaced the subjects "mathematics or science" in the original item with the term "engineering."

5) Engineering Grade Point Average (GPA): We calculated students' engineering GPA based on the grades that they had received in their engineering-related courses during their first year at the university. We received students' course grades from the university registrar. We did not calculate students' overall GPA because it might have included grades from non-engineering-related courses, such as English or electives, and we wanted an accurate measure of their engineering achievement. We included only the nine courses related to mathematics, science, and engineering that are typically required of first-year engineering students at the university, which included Elementary Linear Algebra (2 credits), Calculus I (3 credits), Calculus II (3 credits), Vector Geometry (2 credits), Foundations of Physics (4 credits), General Chemistry (3 credits), General Chemistry Lab (1 credit), Engineering Exploration I (2 credits), and Engineering Exploration II (2 credits). To compute students' engineering GPA, we multiplied the grade point for the course by the number of credits for the course and averaged the sum of these values for all of the students' courses. Grade points were assigned as follows: A = 4.0; A− = 3.7; B+ = 3.3; B = 3.0; B− = 2.7; C+ = 2.3; C = 2.0; C− = 1.7; D+ = 1.3; D = 1.0; D− = 0.7; and F = 0.0. Because some students had Advanced Placement (AP) or transfer credit for one or more of these courses, the engineering GPA for these students was based on fewer than the nine courses previously listed.

C. Analysis and Interpretation of Values

The critical level for statistical significance (α) was set at 0.05 for reporting purposes. When we conducted multiple t-tests for the same research question, however, we used stricter criteria to address the problem of multiple comparisons and set the critical level of statistical significance at $\alpha = 0.01$. For t-tests, we reported Cohen's d as the measure of effect size, which is a standardized measure of the strength of the relationship between two variables. We interpreted the Cohen's d values using an often-cited rule of thumb: that a d of 0.2 is small, 0.5 is medium, and 0.8 is large (Cohen, 1988).

For all of our regression analyses, we set the entry probability of F at 0.05 and the removal probability of F at 0.10. We did not present or discuss the predictor variables that, when added to the model, explained a change in variance of 2 percent or less ($\Delta R^2 \leq 0.02$) because these variables explained so little of the variance. We examined the tolerance values as measures of collinearity for the regression analyses. A small tolerance value can be problematic because it indicates that the variable is highly collinear with the other predictor variables, which can cause problems in estimating the regression coefficients. We considered tolerance values of less than 0.25 as indicating a problem with collinearity (Miles and Shevlin, 2004), but found that none of the tolerance values were less than this value for any of our analyses.

V. Results

A. Research Question 1: Examining Changes During the First Year

Our first research question was: Do men or women's engineering expectancy-related beliefs, value-related beliefs, or career plans change during their first year? All of the mean values from Instrument 1 and Instrument 2 were in the upper third of the scale values (see Table 4), indicating that students generally had high expectations for success in their engineering-related courses (expectancy), were interested in and enjoyed engineering (interest), believed that engineering was important (attainment), found engineering to be useful for their career (utility), believed that engineering was a part of their identity (identification), were confident in their engineering ability (self-efficacy), and believed that their eventual career would pertain to engineering (career).

To assess whether the mean values for these seven variables on Instrument 1 were statistically higher or lower than on Instrument 2, we conducted paired-sample t-tests. Students reported statistically lower means on all seven variables on Instrument 2 than on Instrument 1 (see Table 4), indicating that the mean values were lower near the end of their first year than near the beginning of their first year.

A follow-up question related to our first research question was: Given that both men's and women's scores decreased significantly on all the variables during the first year, were the decreases similar in magnitude for men and women? We conducted t-tests between women and men on the mean score differences between Instrument 1 and Instrument 2 and found no statistical differences at the $\alpha = 0.01$ level for expectancy, $t(355) = 0.43, p = 0.67$; for interest, $t(358) = 0.85, p = 0.40$; for attainment, $t(352) = 0.39, p = 0.70$; for utility, $t(359) = 0.42, p = 0.68$; for identification, $t(344) = 1.40, p = 0.16$; for self-efficacy, $t(339) = 1.26, p = 0.21$; and for career, $t(349) = 0.40, p = 0.69$. This indicates that both men and women decreased a similar amount over the course of the year on these seven variables.

B. Research Question 2: Exploring Differences Between Men and Women

Our second research question was: Do men and women differ with respect to their engineering expectancy-related beliefs, value-related beliefs, achievement, or career plans? The overall mean engineering GPA for students at the end of their first year was 3.09 ($SD = 0.69$), and there was not a statistically significant difference between the mean engineering GPA for men ($M = 3.12$, $SD = 0.65$, $n = 285$) and women ($M = 2.97$, $SD = 0.82$, $n = 78$), $t(104.8) = 1.48$, $p = 0.141$.

We also conducted t-tests for each of the seven variables on both Instrument 1 and Instrument 2 and found differences for two of the variables: expectancies for success and self-efficacy (see Table 5). Men reported higher expectancies for success for Instrument 1 ($p = 0.001$) and Instrument 2 ($p = 0.008$). Men also reported higher self-efficacy for Instrument 2 ($p = 0.003$), but there was not a statistical difference at the significance level of 0.01 for Instrument 1 ($p = 0.028$). Men and women reported statistically similar values for the remainder of the variables.

To examine whether women or men were more accurate in their expectancy-related beliefs, we calculated the strength of association between their expectancy-related beliefs and their GPA. The correlations between expectancies for success and GPA, and between self-efficacy and GPA, were not statistically different for men and women on Instrument 1 or Instrument 2 (for expectancies for success on Instrument 1, $z = 0.92, p = 0.36$; for expectancies for success on Instrument 2, $z = 0.82, p = 0.41$; for self-efficacy on Instrument 1, $z = 0.39, p = 0.69$; for self-efficacy on Instrument 2, $z = 0.63, p = 0.53$), indicating that both men and women are equally accurate at matching their expectations with their course grades.

Variable related to engineering	Instrument 1 M (SD)	Instrument 2 M (SD)	Mean difference	t	df	p	d
Expectancy	5.31 (0.92)	5.08 (1.09)	0.22	4.42	356	< 0.001	0.22
Interest	5.34 (1.03)	4.89 (1.19)	0.45	7.26	359	< 0.001	0.41
Attainment	6.17 (0.72)	5.71 (1.00)	0.46	9.21	353	< 0.001	0.53
Utility	6.31 (1.09)	5.84 (1.42)	0.46	5.86	360	< 0.001	0.37
Identification	5.89 (0.80)	5.51 (1.04)	0.38	7.32	345	< 0.001	0.41
Self-efficacy	8.04 (1.39)	7.40 (1.93)	0.64	7.01	340	< 0.001	0.38
Career	6.01 (1.19)	5.79 (1.58)	0.21	2.62	350	0.009	0.15

Note: All items were rated on a 7-point Likert-type scale except for self-efficacy, which was rated on a 10-point Likert-type scale.

Table 4. A comparison of mean values of variables in Instrument 1 and Instrument 2.

Variable related to engineering	Men M (SD)	Women M (SD)	Mean difference	t	df	p (2-tailed)
Instrument 1						
Expectancy	5.40 (0.89)	5.00 (0.99)	0.40	3.41	360	0.001
Interest	5.36 (1.00)	5.26 (1.15)	0.09	0.72	360	0.474
Attainment	6.17 (0.70)	6.18 (0.75)	− 0.02	0.17	357	0.869
Utility	6.32 (1.08)	6.26 (1.11)	0.07	0.49	360	0.627
Identification	5.90 (0.82)	5.77 (0.84)	0.14	1.25	355	0.212
Self-efficacy	8.12 (1.36)	7.72 (1.50)	0.40	2.21	354	0.028
Career	6.06 (1.12)	5.76 (1.49)	0.30	1.62	98.7	0.108
Instrument 2						
Expectancy	5.16 (1.07)	4.79 (1.12)	0.37	2.67	356	0.008
Interest	4.88 (1.17)	4.91 (1.25)	−0.03	0.18	359	0.860
Attainment	5.72 (0.96)	5.67 (1.14)	0.05	0.42	356	0.673
Utility	5.87 (1.40)	5.73 (1.49)	0.14	0.79	360	0.432
Identification	5.51 (1.04)	5.46 (1.14)	0.04	0.32	350	0.747
Self-efficacy	7.56 (1.87)	6.80 (2.06)	0.76	3.04	346	0.003
Career	5.85 (1.52)	5.59 (1.77)	0.26	1.17	107.5	0.245

Note: All items were rated on a 7-point Likert-type scale except for self-efficacy, which was rated on a 10-point Likert-type scale.

Table 5. Mean values for variables by gender.

C. Research Question 3: Examining Intercorrelations Among Variables

Our third research question asked: What is the degree of relationship between students' engineering expectancy-related beliefs, value-related beliefs, achievement, and career plans? We computed Pearson correlation coefficients for all of the variables in Instrument 1 (presented below the diagonal in Table 6) and separately for Instrument 2 (presented above the diagonal in Table 6). The highest correlations (above 0.70) were between expectancies for success and self-efficacy ($r = 0.74$ for Instrument 1; $r = 0.77$ for Instrument 2), between attainment value and identification ($r = 0.73$ for Instrument 2), and between extrinsic utility value and engineering career ($r = 0.72$ for Instrument 2). We found a similar pattern of correlations for men and women on Instrument 1 and 2.

We examined the relationships between the constructs in the expectancy-value theory of motivation and found that the three value constructs (intrinsic interest, extrinsic utility, and attainment) were significantly correlated. We also examined whether there were differences in the magnitude of correlations between expectations for success and the three value constructs. For Instrument 1, the correlation between expectancies for success and extrinsic utility value ($r = 0.22$) was statistically lower than that between expectancies for success and intrinsic interest value ($r = 0.47$; $z = 3.97, p < 0.001$, one-tailed) and less than that between expectancies for success and attainment value ($r = 0.46$; $z = 3.74, p < 0.001$, one-tailed). For Instrument 2, however, the correlation between expectancies for success and extrinsic utility value ($r = 0.31$) was not statistically lower than that between expectancies for success and intrinsic interest value ($r = 0.44$; $z = 0.27, p = 0.39$, one-tailed) or between expectancies for success and attainment value ($r = 0.55$; $z = 1.51$, $p = 0.07$, one-tailed).

D. Research Question 4: Predicting First-Year Engineering GPAs

Our fourth research question was: Which of the expectancy- and value-related constructs best predicts men and women's achievement near the end of their first year? To address this research question, we used stepwise multiple regression for two reasons. First, as is indicated by the high correlations between some of the variables in Table 6, some of the predictor variables are highly related (e.g., expectancies for success and self-efficacy; attainment value and identification). As a result, standard multiple regression, which only measures the unique contribution of each predictor variable, would reduce the importance of any one variable that was highly correlated with another variable. Stepwise regression eliminates this problem by adding variables one at a time, starting with the variable that correlates most strongly with the criterion variable. Another reason that we used stepwise regression was that, ultimately, we are interested in determining which predictor variable(s) should be targeted for interventions based on the greatest amount of variance explained in the criterion variable (i.e., GPA). Using stepwise regression allowed us to identify the variable(s) that best predicted the criterion variable given the presence of the other predictor variables.

To examine how the predictor variables might change over time, we conducted one stepwise regression analysis using predictor variables from Instrument 1 and another analysis using predictor variables from Instrument 2 (see Table 7). Near the beginning of the first year (Instrument 1), expectancies for success was the only variable that was a significant predictor of students' engineering GPA at the end of their first year (explaining 12 percent of the variance). Near the end of the first year (Instrument 2), self-efficacy predicted the greatest amount of variance (35 percent) in students' engineering GPA, followed by expectancies for success (3 percent).

Variables	1	2	3	4	5	6	7	8
1. Expectancy	—	**0.44**	**0.55**	**0.31**	**0.43**	**0.77**	**0.32**	**0.57**
2. Interest	**0.47**	—	**0.65**	**0.62**	**0.67**	**0.40**	**0.53**	0.16*
3. Attainment	**0.46**	**0.55**	—	**0.57**	**0.73**	**0.57**	**0.46**	**0.29**
4. Utility	**0.22**	**0.45**	**0.41**	—	**0.62**	**0.32**	**0.72**	**0.24**
5. Identification	**0.34**	**0.55**	**0.57**	**0.49**	—	**0.47**	**0.58**	**0.22**
6. Self-efficacy	**0.74**	**0.43**	**0.39**	**0.16**	**0.37**	—	**0.35**	**0.59**
7. Career	**0.28**	**0.45**	**0.34**	**0.64**	**0.45**	**0.26**	—	**0.23**
8. GPA	**0.35**	0.09	**0.20**	−0.03	0.04	**0.27**	0.04	—

Note: Pearson correlation coefficients below the diagonal are for Instrument 1 only and coefficients above the diagonal are for Instrument 2 only.
* $p < 0.01$; $p < 0.001$ for values in bold

Table 6. Intercorrelations among variables.

Step and predictor variable	ΔR^2	R^2	*df*	ΔF	B	SE B	β^a	*t*	*p*
				Using predictors from Instrument 1					
Step 1	0.12	0.12	343	44.51***					
Expectancy					0.25	0.04	0.34	6.67	< 0.001
				Using predictors from Instrument 2					
Step 1	0.35	0.35	336	182.67***					
Self-efficacy					0.21	0.02	0.59	13.52	< 0.001
Step 2	0.03	0.38	335	17.44***					
Self-efficacy					0.13	0.02	0.38	5.57	< 0.001
Expectancy					0.18	0.04	0.28	4.18	< 0.001

** $p \leq 0.01$; *** $p \leq 0.001$
[a] Standardized coefficient β

Table 7. Stepwise regression analysis of predictors of engineering GPA.

Because expectancies for success and self-efficacy are conceptually similar and were highly correlated for Instrument 1 ($r = 0.74$) and Instrument 2 ($r = 0.77$), we hypothesized that expectancies for success would explain a similar amount of variance in GPA as self-efficacy when self-efficacy was not included as a predictor variable for the Instrument 2 analysis. To test our hypothesis, we conducted the regression analysis presented in Table 7 again, without including self-efficacy as a predictor variable. Consistent with our hypothesis, we found that expectancies for success explained 33 percent of the variance in GPA, compared to 35 percent explained by self-efficacy, as shown in Table 7 for the Instrument 2 data. This finding suggests that the expectancies for success and self-efficacy scales are measuring a similar construct and that having both in the model explains only a little more of the variance than having only one of the variables in the model (expectancies for success explains an additional 3 percent of the variance for the Instrument 2 analysis in Step 2).

To determine whether the predictor variables for engineering GPA were similar for men and women, we conducted four additional stepwise regression analyses: two using predictors from Instrument 1 and two using predictors from Instrument 2 (see Table 8). The same variables predicted engineering GPA for both men and women. Near the beginning of their first year (Instrument 1), expectancies for success explained 9 percent of the variance in engineering GPA for men and 16 percent of the variance in engineering GPA for women. None of the other five variables were significant predictors of end-of-year engineering GPA. Near the end of the first year, self-efficacy and expectancies for success were the two significant predictors of engineering GPA for both men and women. Self-efficacy was the best predictor for men (33 percent of the variance explained) and women (41 percent of the variance explained), but intrinsic interest value was also a predictor for women (4 percent of variance).

Similar to our previous analysis, we examined the relationship between expectancies for success and GPA, excluding self-efficacy as a predictor variable. The analyses revealed that for Instrument 2, expectancies for success explained 30 percent of the variance in GPA for men (compared to 33 percent of the variance explained by self-efficacy, in Table 8) and 39 percent of the variance in GPA for women (compared to 41 percent of the variance explained by self-efficacy, in Table 8). Thus, because expectancies for success is conceptually similar to and highly correlated with self-efficacy, it explains a similar amount of variance in GPA as self-efficacy for both men and women.

Step	Predictor variable	ΔR^2	R^2	df	ΔF
		Using predictors from Instrument 1			
Men only					
Step 1	Expectancy	0.09	0.09	273	28.32***
Women only					
Step 1	Expectancy	0.16	0.16	68	13.34***
		Using predictors from Instrument 2			
Men only					
Step 1	Self-efficacy	0.33	0.33	265	129.74***
Step 2	Expectancy	0.03	0.36	264	11.81***
Women only					
Step 1	Self-efficacy	0.41	0.41	69	47.20***
Step 2	Expectancy	0.05	0.45	68	6.00*
Step 3	Interest	0.04	0.49	67	4.62*

* $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$

Table 8. Stepwise regression analysis of predictors of engineering GPA by gender.

E. Research Question 5: Predicting Engineering Career

Our fifth research question was: Which of the expectancy- and value-related constructs best predicts men and women's beliefs that their careers will directly pertain to engineering? We used stepwise multiple regression to address this research question for the same reasons discussed in the previous section. For all of the analyses in this section, the criterion variable was the likelihood that students' eventual career after graduation will directly pertain to engineering (abbreviated as "engineering career"). To examine how the predictor variables might change over time, we conducted three stepwise regression analyses using: (1) predictor variables from Instrument 1 and the engineering career from Instrument 1, (2) predictor variables from Instrument 1 and the engineering career variable from Instrument 2, and (3) predictor variables from Instrument 2 and the engineering career variable from Instrument 2. All of the results are presented in Table 9.

Of the six variables entered as predictors, only two were significant predictors of the criterion variable (engineering career). At the beginning of the first year, extrinsic utility value predicted the most variance (39 percent) in students' beliefs that they were likely to pursue a career in engineering. Intrinsic interest value predicted an additional 3 percent of the variance in Step 2. Overall, for the beginning of the first year, these two variables accounted for 42 percent of the variance in the criterion variable.

Near the end of the first year (Instrument 2), the predictor variables from Instrument 1 were much less predictive of student beliefs about the likelihood of pursuing an engineering career. Intrinsic interest value predicted 10 percent of the variance explained and extrinsic utility value added another 4 percent for a total of only 14 percent of the variance explained by these predictor variables. Finally, near the end of the first year, two significant predictor variables emerged from Instrument 2 and explained 54 percent of the variance in students' beliefs about selecting an engineering career. Extrinsic utility value predicted 51 percent of the variance and identification predicted an additional 3 percent of variance explained in the engineering career variable.

Because we were interested in whether the predictor variables were different for men and women, we conducted six additional stepwise regression analyses (two for each of the conditions in Table 9). The results of all six analyses are presented in Table 10. For both men and women at the beginning of the year (Instrument 1), extrinsic utility value was the best predictor (35 percent and 59 percent of the variance, respectively) of their beliefs about whether they were likely to pursue an engineering career. For women, self-efficacy was another predictor and explained 8 percent of the variance.

Similar to the overall analysis presented in Table 9, students' perceptions at the beginning of the year had little ability to predict their engineering career plans near the end of their first year. Intrinsic interest value was the best predictor for men (9 percent of variance explained), followed by extrinsic utility value (3 percent of variance explained). For women, extrinsic utility was the only predictor (22 percent of variance explained). Near the end of the year (Instrument 2), extrinsic utility value explained the most variance for both men (47 percent) and women (64 percent), followed by identification, which explained 4 percent of the variance for men. We conducted a statistical test of the difference between the correlation coefficients between extrinsic utility value and engineering career plans for men ($r = 0.70$) and women ($r = 0.79$), but found no statistical difference ($z = 1.65$, $p = 0.10$, two-tailed).

VI. Discussion and Implications

A. Research Questions 1 and 2: Changes During the First Year and Differences Between Men and Women

Incoming first-year engineering students generally expected to do well in their engineering-related courses, valued engineering (i.e., they enjoyed it and believed that it was important and useful), and believed that their eventual career would pertain to engineering. Near the end of their first year, students' perceptions decreased in all

Step and predictor variable	ΔR^2	R^2	*df*	ΔF	B	SE B	β^a	*t*	*p*
Using predictors from Instrument 1 to predict the dependent variable in Instrument 1									
Step 1	0.39	0.39	343	219.40***					
Utility					0.68	0.05	0.63	14.81	< 0.001
Step 2	0.03	0.42	342	19.33***					
Utility					0.59	0.05	0.54	11.93	< 0.001
Interest					0.23	0.05	0.20	4.40	< 0.001
Using predictors from Instrument 1 to predict the dependent variable in Instrument 2									
Step 1	0.10	0.10	333	37.70***					
Interest					0.49	0.08	0.32	6.14	< 0.001
Step 2	0.04	0.14	332	14.85***					
Interest					0.35	0.09	0.23	4.06	< 0.001
Utility					0.32	0.08	0.22	3.85	< 0.001
Using predictors from Instrument 2 to predict the dependent variable in Instrument 2									
Step 1	0.51	0.51	335	351.25***					
Utility					0.81	0.04	0.72	18.74	< 0.001
Step 2	0.03	0.54	334	21.60***					
Utility					0.66	0.05	0.58	12.12	< 0.001
Identification					0.33	0.07	0.22	4.65	< 0.001

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$
[a] Standardized coefficient β

Table 9. Stepwise regression analysis of predictors of engineering career.

Step	Predictor variable	ΔR^2	R^2	*df*	ΔF
Using predictors from Instrument 1 to predict the dependent variable in Instrument 1					
Men only					
Step 1	Utility	0.35	0.35	273	146.31***
Women only					
Step 1	Utility	0.59	0.58	68	97.30***
Step 2	Self-efficacy	0.08	0.66	67	15.33***
Using predictors from Instrument 1 to predict the dependent variable in Instrument 2					
Men only					
Step 1	Interest	0.09	0.09	265	26.84***
Step 2	Utility	0.03	0.23	264	8.10**
Women only					
Step 1	Utility	0.22	0.22	66	18.23***
Using predictors from Instrument 2 to predict the dependent variable in Instrument 2					
Men only					
Step 1	Utility	0.47	0.47	264	231.39***
Step 2	Identification	0.04	0.51	263	23.01***
Women only					
Step 1	Utility	0.64	0.64	69	123.26***

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 10. Stepwise regression analysis of predictors of engineering career by gender.

of these areas. Nonetheless, these perceptions were still relatively high in that they remained in the upper third of the scale values. We were encouraged that women's perceptions did not decrease more than those of men, indicating that whatever the reasons for the decline in these variables, they affect men and women similarly. Other researchers have documented similar decreases in ability-related perceptions in women during the first year of college, but have also found that these ability-related perceptions increased again (though did not fully recover) during their senior year (Brainard and Carlin, 1998; see Malicky, 2003 for a discussion). In contrast, Marra et al. (2009) reported that longitudinal data collected over the first two years of women's engineering coursework presented a more complex picture, showing gains in some areas and decreases in others. Further research could examine how the perceptions of undergraduate engineering students' ability-related beliefs change over the course of their entire undergraduate engineering program.

It is reasonable that students' expectancy-related beliefs would decrease over their first year in college because beliefs about self-efficacy are based in part on information students receive through mastery experiences (i.e., their previous performances) and vicarious experiences of observing others' performances (Bandura, 1986), both of which are likely to be affected after their transition from high school to college. In college, the assignments and exams students complete are likely harder than those in their high school courses. This increased difficulty could result in a greater academic challenge that could lower their performance or cause them to put forth more effort. These outcomes could have a negative effect on their mastery experiences, and thus, lower their self-efficacy. Also in college, students begin making comparisons to peers who are likely more capable, than peers from their high school classes (because university students have been selectively admitted, in part, based on school achievement). Seeing other "smart" students struggle in courses and/or put forth a lot of effort could lower their self-efficacy through their vicarious experiences.

What is more difficult to explain, however, is the finding that at the end of the year, students reported enjoying engineering less and viewed it as less important and useful than they did at the beginning of the year. One explanation may be that freshmen are idealistic at the beginning of their college careers and that a decrease in beliefs about engineering enjoyment, importance, and usefulness is to be expected. Another explanation is that some aspect of the first-year curriculum is negatively affecting these value-related beliefs. If this is the case, one implication would be that, given the wide variation in first-year programs across the United States, it could be useful to examine how the curriculum and specific courses influence students' value-related beliefs. Research into how specific aspects of the curriculum affect students would be useful for identifying ways to maintain or improve students' beliefs about engineering enjoyment, importance, and usefulness.

In examining gender differences, we found that the means for women were lower than those for men for expectancies for success (on Instrument 1 and 2) and self-efficacy (on Instrument 2 only). This finding is consistent with other research that has documented that females report lower competence beliefs than males on tasks perceived as masculine (Meece, 1991), including mathematics and science (Wilkins, 2004) and scientific occupations (Matsui and Tsukamoto, 1991). Women in undergraduate engineering programs have also reported lower levels of competence than men in physics and mathematics (Zastavker, Ong, and Page, 2006), lower levels of confidence in technology-related skills (Pieronek, McWilliams, and Silliman, 2003), and lower levels of confidence in engineering skills (Besterfield-Sacre et al., 2001). Our finding, however, is inconsistent with a recent study by Concannon and Barrow (2009) in which they documented that men and women reported similar self-efficacy scores. We have no explanation for why some findings have found gender differences and others have not. Clearly, more research related to these differences is needed to fully understand this phenomenon.

Because women reported lower values for expectancies for success and self-efficacy than men, we expected their GPAs to be lower (because expectancy-related beliefs have been found to be correlated with GPA). We found that women's GPAs at the end of their first year were not statistically different from those of men. Because we found that both men and women are equally accurate at matching their expectations with their achievement (as measured by course grades), we do not know whether men overestimated their abilities, women underestimated their abilities, or both. Given that other researchers have documented that men tend to overestimate their abilities and that women underestimate theirs (Carmichael and Taylor, 2005), we can speculate, but not substantiate that this is the case for students in the present study as well.

B. Research Question 3: Intercorrelations Among Variables

Because expectancies for success has been described as conceptually similar to domain-specific efficacy (Eccles, 2005), our first hypothesis was that expectancies for success in engineering would be highly correlated with engineering self-efficacy, which it was ($r = 0.74$ for Instrument 1 and $r = 0.77$ for Instrument 2). This relationship is discussed further in the "Research Question 4: Predictors of GPA" section. Our second hypothesis was that attainment value and identification would be highly correlated because they are theoretically very similar constructs. The correlation between attainment value and identification was 0.57 for Instrument 1 and 0.73 for Instrument 2. This finding provides some evidence that these constructs are similar; however, more research is needed to determine the ways in which these variables may be assessing different aspects of an identity construct.

As predicted by our third hypothesis, all three of the value-related constructs were correlated for Instrument 1 ($r = 0.55$, 0.45, and 0.41) and Instrument 2 ($r = 0.65$, 0.62, and 0.57). This demonstrates that students who are interested in engineering and enjoy it tend also to view engineering as important and believe that it is useful for what they want to do when they begin their careers. This finding is consistent with the expectancy-value theory of motivation because these three aspects of value have been shown to comprise three components of one value factor (Eccles and Wigfield, 1995).

In support of our fourth hypothesis, we documented that expectancies for success was positively correlated with intrinsic interest value ($r = 0.47$ and 0.44), attainment value ($r = 0.46$ and 0.55), and extrinsic utility value ($r = 0.22$ and 0.31). This suggests that individuals who expect to do well (i.e., have a high level of expectancies for success) generally enjoy those activities (i.e., have a high intrinsic interest value), rate engineering as important to them (i.e., have a high attainment value), and believe that learning engineering is useful to them (i.e., have a high extrinsic utility value). Our prediction that the relationship between expectancies for success and extrinsic utility value would be weaker than the other two relationships was true for the Instrument 1 data, but not the Instrument 2 data.

In sum, the pattern of correlations among the expectancy- and value-related constructs for engineering students in the present study is similar to that obtained by Eccles and Wigfield (1995) with ninth-grade students in the domain of mathematics. The implication is that the relationships between these constructs are generalizable to at least one domain (i.e., engineering) at the college level.

C. Research Question 4: Predictors of GPA

Our fifth hypothesis, that the expectancy-related constructs would predict men and women's achievement, was supported. Of the variables measured in this study, the largest predictor of student engineering GPA at the end of the first year was expectancies for success in engineering and engineering self-efficacy. The findings were similar across gender, and self-efficacy accounted for 33 percent of the variance in GPA for men and 41 percent of the variance in GPA for women in Instrument 2 (see Table 8).

The evidence indicates that expectancies for success and self-efficacy are similar constructs because (a) they both explained a similar amount of variance in GPA (33 percent for expectancies for success and 35 percent for self-efficacy) when independently included as a predictor variable in the model, and (b) expectancies for success only explained an additional 3 percent of the 38 percent of variance when included in the model simultaneously with self-efficacy. An implication of this finding is that researchers who are interested in predicting achievement likely need to include only one of these variables as a measure of students' achievement, depending on the research questions to be investigated.

D. Research Question 5: Predictors of a Career in Engineering

As predicted in our sixth hypothesis, the value-related constructs explained the most variance in whether students believed that their eventual career would directly pertain to engineering. This finding is consistent with prior research in other domains (Eccles, 1984a, 1984b; Eccles et al., 1983; Meece et al., 1990). The results in Table 9 indicate that the best predictor of student intention to pursue a career in engineering was the level of extrinsic utility value near the end of the first year (it explained 51 percent of the variance in their intention). These results are also consistent with the qualitative findings of the Extraordinary Women Engineers project, which documented that for female high school students, "relevance" was a critical career motivator (Extraordinary Women Engineers Project, 2005). Identification with engineering added another 3 percent of variance in the present study, which indicated that 54 percent of the variance in students' career intentions can be accounted for with extrinsic utility value and identification with engineering. In a comparison of the values by gender, it is clear that extrinsic utility value is an important factor for both men and women in whether they believe that they will choose engineering as an occupation.

An implication of this finding is that it is important to consider students' values (i.e., extrinsic utility value and identification with engineering) when trying to understand students' career plans. Increasing students' expectancy-related beliefs, such as their engineering self-efficacy, is often considered an important aim of retention interventions. Yet, the results of this study remind us that values such as utility and identification are highly related to students' career goals. We believe that without some moderate level of engineering self-efficacy, students grades might be negatively affected, which could cause them to question their abilities in engineering, possibly to the point of dropping out of an engineering major. But we found that simply because students have a high level of self-efficacy does not mean that they will plan to select a career in engineering. Rather, their belief in the usefulness and importance of engineering is what correlated with their plans to choose a career in engineering. We speculate that by showing and teaching students why engineering is useful and important, they would be more likely to choose a career in engineering. It would be interesting to investigate how the curriculum and mentors could be used to affect students' values towards engineering. For example, does providing real-world, useful problems for students to solve in courses increase their beliefs about the usefulness of engineering?

VII. Limitations and Future Research

The findings of our study must be interpreted within the context of the limitations. Our sample consisted of only one cohort of students at one large public university, which limits the generalizability of the results. Further, we examined the perceptions of only first-year students, not all undergraduate engineering students. It is possible that students in their second, third, or fourth year of engineering school have different beliefs from those of first-year students. It would be useful to examine students' perceptions longitudinally to determine how their beliefs change over the span of their education. Many first-year students do not know much about the field of engineering, which can affect how they answer questions related to the constructs measured in this study. Finally, the demographic profile of the sample limited our ability to examine the research questions for underrepresented groups other than women; therefore, we would recommend future research consider such examinations.

With respect to the measures used in this study, two of the constructs, engineering extrinsic utility value and engineering career plans, were measured using only one item each. Adding more items to these measures could improve the internal reliability of the scores obtained from those items. Also, the engineering career plans item only assessed first-year students' *intentions* to choose a career in engineering. We do not know whether the students will *actually choose* a career in engineering. As noted, however, understanding the intentions of first-year students is an important starting point for more robust examinations of factors that influence engineering students' career plans over time. Future research could follow the students longitudinally and collect data on whether or not students choose a career in engineering when they complete their undergraduate education.

VIII. Key Findings and Conclusion

In summary, the key findings of the study are as follows:

- Students' expectancy-related beliefs (expectations for success in engineering and engineering self-efficacy) and value-related beliefs (identification with engineering and engineering intrinsic interest value, attainment value, and extrinsic utility value) decreased over the first year for both men and women.
- No major differences were found in the value-related beliefs of men and women, but men reported higher levels of expectations

for success in engineering and engineering self-efficacy than women.

- Expectations for success in engineering and engineering self-efficacy appear to be similar constructs.
- Engineering attainment value and identification with engineering are closely-related constructs.
- The relationships between the constructs in the expectancy-value model of motivation (i.e., expectations for success, intrinsic interest value, attainment value, and extrinsic utility value) were similar for men and women and similar to the relationships found in other populations of students in other domains.
- Expectancy-related constructs predicted achievement better than the value-related constructs for both men and women.
- The value-related constructs (i.e., extrinsic utility value, intrinsic interest, and identification) predicted career plans better than the expectancy-related constructs for both men and women.

One of the most important contributions of this study is the finding that expectancy- and value-related constructs predicted different outcomes: expectancy-related constructs predicted achievement and value-related constructs predicted career plans. These predictors were generally similar for both men and women, indicating that the relationships among these variables are consistent across gender. As a result, both expectancy- and value-related constructs are useful in studying the motivations of undergraduate engineering students. These findings point to the need to integrate multiple motivation constructs to better understand students' educational experiences and career plans. As engineering education seeks to increase the number of graduates in general, as well as the diversity of the engineering workforce, researchers need to continue to examine both the ways in which individual factors such as expectancy- and value-related constructs operate within engineering and the ways in which these factors interact as students move through the curriculum.

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APPENDIX

All items, except those for Engineering Self-Efficacy, were rated on a 7-point Likert-type scale with end points as noted. The self-efficacy items were rated on a 10-point Likert-type scale ranging from 1 (*no confidence at all*) to 10 (*complete confidence*).

Engineering Self-Efficacy

- How much confidence do you have in your ability to:
  1. complete all of the "basic science" (i.e., math, physics, chemistry) requirements for your engineering major with grades of B or better?
  2. excel in your engineering major over the next semester?
  3. excel in your engineering major over the next two semesters?
  4. complete the upper level required courses in your engineering major with an overall grade point average of B or better?

Expectancy for Success in Engineering

1. Compared to other students, how well do you expect to do in your math, science, and engineering courses this year (Note: we replaced "year" with "semester" for Instrument 2)? (*much worse than other students, much better than other students*)
2. How well do you think you will do in your engineering-related courses this year (Note: we replaced "year" with "semester" for Instrument 2)? (*very poorly, very well*)

Engineering Intrinsic Interest Value

1. In general, I find working on engineering-related assignments (*very boring, very interesting*)
2. How much do you like engineering? (*not very much, very much*)

Engineering Attainment Value

1. Is the amount of effort it will take to do well in math, science, and engineering courses worthwhile to you? (*not very worthwhile, very worthwhile*)
2. I feel that, to me, being good at solving engineering-related problems is (*not at all important, very important*)
3. How important is it to you to get good grades in engineering-related courses? (*not at all important, very important*)

Engineering Extrinsic Utility Value

1. How useful is learning engineering for what you want to do after you graduate and go to work? (*not very useful, very useful*)
2. How useful is what you learn in math, science, and engineering courses for your daily life outside school? (*not at all useful, very useful*)

Identification With Engineering

For all items: 1 = *strongly disagree*; 4 = *neutral*; and 7 = *strongly agree*
1. Being good at engineering is an important part of who I am.
2. Doing well on engineering tasks is very important to me.
3. Success in engineering school is very valuable to me.
4. It matters to me how I do in engineering school.

Engineering Career

1. How likely is it that your eventual career after graduation will directly pertain to engineering? (*not at all likely, very likely*)