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Predicting Intent to Persist from Career Values and Alignment for Women and Underrepresented Minority Students*

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Researchers theorize that commitment to a college major is supported when there is alignment between career values and perceptions of a career field's value affordances. Research shows substantial gender differences in occupational values and interests, where women are more likely to prefer communal occupations, which may cause misalignment when engineering is seen as only affording the pursuit of status values. The goal of this study was to explore the relationship between first-year engineering students' career values, their perceptions of engineering as a career field that meets different career values, and how this relationship affects major commitment. Using a pre/post-survey design, we explored whether engineering students (N = 996) varied in their perception of engineering as a communal vs. status profession, comparing male/female and underrepresented/other racial groups. We also explored how perceptions and career values predicted commitment to their engineering major. We found variability in perceptions of the affordances of engineering but no group differences, which suggests this is an individual difference that may influence perceptions of career fit. Predictions of major commitment revealed complex relationships between affordance beliefs, career values, and commitment to staying in an engineering major.

Keywords: engineer identity; occupational value; perceptions of engineering; gender differences; underrepresented minorities

1. Introduction

Understanding how and why college students develop commitment to a career field is important to developing programs that support students' academic development and career planning. Fields like engineering seem to struggle more than other fields to retain promising students through graduation [1]. Therefore, research exploring how students develop commitment to engineering is of particular interest. This issue is especially important when considering the widely shared goal of increasing the diversity of engineering and promoting the success of diverse student populations in this field.

To better understand career commitment, this research paper explores the relationship between students' occupational values and their perceptions of engineering as a career field and how this relationship impacts major commitment. Research has documented substantial gender differences in occupational values and interests, where women are more likely to prefer communal or helping occupations while men are more likely to prefer individualistic or status-affording occupations [2, 3]. Researchers theorize that commitment to a college major is supported when there is an alignment between personal values and the value affordances of the career fields (i.e., perceptions of which values the field can meet) [4]. Therefore, gender differences in values may help explain a lack of commitment to engineering if there is a mismatch between values and students' perceptions of the value affordances of engineering [5–7].

Researchers in science, technology, engineering, and mathematics (STEM) education have explored whether these gender differences in career preferences and values can help explain existing gender differences in the choice of STEM college majors [6]. In contrast, the *value affordances* of different career fields—that is, the values the field can help individuals reach—have been viewed as fixed characteristics of fields. Engineering fields, in particular, have been considered only to afford the pursuit of individualistic/status goals and not communal/

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helping goals [5, 8]. Therefore, these fields have been framed as incompatible with women's more typical occupational values profile. However, new research indicates there may be substantial individual differences in the perception of value affordances of different career fields [5]. Furthermore, some intervention research has shown that this perception can be modified through educational activities to increase women's interest in engineering [7, 9]. This perception of value affordances and congruity with career values is the focus of this paper.

1.1 Public relations campaigns

Research on values affordances is critical because the field of engineering, led by the National Academy of Engineering, is making increasing efforts to portray engineering as an important and exciting field of study that has profound impacts on society and can meet pro-social career goals (e.g., "Changing the Conversation", "Grand Challenges", and "Messaging for Engineering") [10–13]. These efforts are intended to address various challenges to the field of engineering. Among those challenges are, first, a lack of interest in engineering among U.S. college students that limits the number of U.S.-citizen students entering undergraduate and graduate engineering programs [1].

Second, the campaigns address a nationally perceived need to increase the diversity of students engaging in engineering majors in terms of gender, race/ethnicity, and socioeconomic status [14–16]. To address both of these issues, the *Changing the Conversation* campaign and other efforts are intended to correct a perceived mismatch between some students' preference for careers that serve a communal or altruistic career goal and the affordances of engineering, which is perceived stereotypically as a field that offers more opportunity to fulfill status values, such as income and social status. These campaigns highlight that engineering actually lends itself to pro-social behaviors and values. The NAE campaigns [10, 11] are therefore designed to challenge common perceptions of engineering's value affordances and increase the number and diversity of students interested in engineering college majors and careers.

The underlying theory of these campaigns is based on three assumptions: (1) perception of career affordances is malleable to intervention, (2) underrepresented groups differ in these perceptions or their personal career values, and (3) retention in engineering among underrepresented groups can be promoted through value-affordances alignment. However, these theoretical links are supported by little empirical research. This study addresses that gap.

1.2 Research on values differences

Schwartz and Rubel [17] conducted a cross-cultural study of value priorities and gender differences in values. Briefly stated, their values dimensions could be summarized as two continuums with competing extremes: self-transcendence (valuing the wellbeing of others) vs. self-enhancement (valuing pursuit of personal goals) and openness to change vs. traditionalism. In their broad analysis of many cultures using different methodologies, they consistently found substantial differences in values where women were more likely to prefer the self-transcendence values (e.g., universalism, benevolence) and men were more likely to prefer self-enhancement values (e.g., power, achievement). Smaller differences on the second continuum showed women more likely to prefer traditionalism and men more likely to prefer openness values.

A parallel line of research has explored occupational interests among men and women. In this area of work, several taxonomies of interests have been explored. Perhaps the most prominent is Holland's [18] Occupational Themes (including realistic, investigative, artistic, social, enterprising, and conventional interests). From this framework, Prediger [19] further simplified these themes into two dimensions: preference for working with people vs. preference for working with things. This (over-) simplification of interests has led to an important finding of large (+ 1 standard deviation) and consistent gender differences where women are much more likely to be more interested in topics related to people (socially demanding jobs or focusing on concerns of people) while men are more interested in things (mechanical, object-focused hands-on work) [2, 3, 20]. Therefore, gender differences in career values are well-established for the general population. Differences among engineering majors are not as well studied and have produced equivocal results [4, 21]. Differences among racial and ethnic groups has also received limited attention [22].

1.3 Research on values and career commitment

Social Cognitive Career Theory focuses on three main constructs related to career identity development: self-efficacy, personal goals, and outcome expectations [23, 24]. Self-efficacy refers to the person's belief they can be successful in activities related to the career field (e.g., expecting to do well in a major course). Personal goals are categorized into choice of particular goals and the choice of actions in line with those goals, which affect engagement and persistence in pursuing a career field. Most importantly to this research, outcomes expectations are defined as a person's beliefs about the probability that *valued* results will be achieved, where these beliefs are based on past (direct or vicarious) experiences. Therefore, experiences and perceptions of the field, including which values it can meet, are critical. Importantly, SCCT theorists emphasize the changing nature and interaction of these constructs to impact career choice and development, especially in late adolescence and early adulthood which is the stage of many first year engineering majors [23, 25].

Valued results also align with the concept of attainment value (situated in expectancy-value theory [26]) which is a person's perception of how their current actions reflect their self-concept and align with personal values. Matusovich, Streveler, and Miller [27] found that attainment value was instrumental in students' intentions to pursue an engineering career, where students with low attainment value (i.e., who were less enthusiastic about school and coursework) had to offset this value with a very high belief that the career choice would achieved other valued outcomes in the future (i.e., that the degree would pay off later for other goals).

We argue that these outcome expectations will be shaped by the career values that a student holds (i.e., what outcomes are important to them) and their perception that a particular career path will make it likely those outcomes will occur. Thus, in our framework, outcome expectations are based on the alignment of career values and perceived affordances of a career field. Past research has shown that values and other beliefs related to a STEM major or career field are related to grades [28] as well as other outcomes such as interest in a particular career field [9].

Diekman et al. [5] studied undergraduate students' (including engineering and non-engineering majors) perceptions of the alignment of different career goals with male- vs. female-stereotypical fields as well as STEM fields in general. In particular, they contrasted agentic or status goals (e.g., power, recognition, status, achievement) with communal or altruistic goals (e.g., helping others, serving community, working with others). Male and female stereotypical fields were expected to align with status and communal goals, in line with previous research, while STEM fields were the focus of the study. When their participants were asked about the likelihood that various communal and agentic goals would be met by the three categories of career fields, the researchers found significant differences where male-stereotypical careers were seen to be more aligned with agentic over communal goals and female-stereotypical careers showed the opposite pattern. Most importantly, STEM career fields showed a pattern similar to and more pronounced than male-stereotypical fields where participants rated STEM careers as being much more likely to fulfill agentic over communal goals. They further showed that a stronger communal goal endorsement by students was associated with less interest in STEM fields compared to participants with lower communal goal endorsement, and confirmed that the effect of gender on STEM career interest was partially mediated by the endorsement of greater communal goal orientation. This suggests that major commitment within STEM fields could be affected by value-perception alignment.

In a similar study, Klotz et al. [29] looked at whether students believed their careers would address sustainability issues such as access to clean water, energy availability, equal economic opportunity, and environmental degradation. The researchers compared college students who reported being likely to major in engineering to those likely to major in non-engineering fields in terms of their career outcomes expectations for impacting these sustainability issues. They found that engineering majors were more likely to believe that engineering could address all of these sustainability issues compared to non-engineering majors. Importantly, Klotz et al. also found that some areas of sustainability interest were associated with increased likelihood of majoring in engineering. These included energy, climate change, environmental degradation, and water supply. In contrast, other areas of sustainability interest were less likely to major in engineering, including promoting economic opportunities, food availability, poverty, and disease. Importantly, they found people-focused sustainability issues were more likely to interest non-engineering majors, while more general issues that do impact people, but indirectly, were more interesting to engineering majors.

1.4 Current study

In this study, we explored whether male and female engineering students varied in the degree to which they believed engineering was a communal vs. individualistic profession, assessed their occupational values in terms of status vs. altruistic goals, and explored how both constructs predicted commitment to an engineering major. Table 1 shows our expectations regarding the potential types of value-belief alignment by gender.

Another critical issue not addressed by past research was whether race/ethnicity (including status as an underrepresented minority [URM] student) interacted with gender or had its own impact on values and value-belief alignment. Therefore, we addressed the following questions regarding gender and race/ethnicity:

Table 1. Match and mismatch types among Engineering majors

	Low value for altruism	High value for altruism
Low perception of altruism	Match, low altruism (More likely among men)	Mismatch, low perception high value for altruism (More likely among women)
High perception of altruism	Mismatch, low value for altruism (Unlikely combination)	Match, high altruism (More likely among women)

1. Do first-year engineering students show gender differences in occupational values and beliefs about engineering? Are there differences by race/ethnicity?
2. Are women more likely than men to have value-belief mismatches? Are URM students more likely to have them than non-URM students?
3. Do beliefs about engineering, career values, or commitment to major change over the course of a semester? Does this vary by gender or race?
4. Do engineering beliefs or personal career values predict commitment to an engineering major? Does this vary by gender or race?

2. Methods

This study used a causal-comparative quantitative design to compare differences in the focal constructs (values, perceptions of engineering, and commitment to engineering) between men and women as well as between URM and non-URM students. We administered a survey on engineering attitudes to a large sample of first-year students enrolled in a pre-engineering introductory course at a large four-year, research focused institution. The survey, which was administered as part of a larger project, included scales related to attitudes about engineering. In addition, we asked demographic questions, including race/ethnicity and gender. Six semesters of students have completed the survey over the course of three academic years.

2.1 Participants

The focal university offers a pre-engineering course designed to provide students an opportunity to learn more about the key concepts in their intended major as well as help them develop or review the fundamental skills needed for advanced engineering coursework. To gather a representative sample of the pre-engineering majors at this university, we therefore approached the instructors of this course (required for all pre-engineering majors) to invite their students to participate. This survey occurred within the first two weeks of the semester. A follow-up survey was administered in the last two weeks of the course with the same attitude scales.

Over the course of two years, roughly half of the 10 to 12 course instructors each semester allowed us to survey their students. Participating faculty came from a range of engineering programs including Biosystems, Chemical, Industrial and Systems, Mechanical, Polymer and Fiber, and Computer Science and Software Engineering. Because students are encouraged to take the class section offered by faculty from their intended major, this indicates a wide range of specific engineering majors were likely sampled.

A total of 1,267 students completed either the pre- or post-semester survey. Because of variations in faculty participation, not all students had complete data at post-semester. A total of 1,023 students provided pre-semester data (on which much of the analyses were conducted). For longitudinal comparisons, only students with complete pre- and post-semester data (N = 996) were analyzed.

According to institutional records, around 1,200 first-time freshmen enroll in engineering each year. Therefore, the smaller, complete data sample represents at least one-fifth of eligible students. Most faculty used the online survey for their students, while one exclusively used the paper survey. Several professors gave course credit for completing the online survey. As a result of these procedures, this sample likely excludes students who were not attending their pre-engineering classes regularly or those who did not monitor their course site, which could include less motivated or committed engineering students.

Along with the attitude scales, students were asked to report their gender, race, and whether they were a first-year student, transfer student, or other (occasionally students do not take this course until their second year at the university). Table 2 shows the percent of students in each category.

Typical of most engineering programs and this university, the student makeup was predominantly white (84%) and Asian (7%), while just 8% came from underrepresented racial minority groups. Three percent of students reported Hispanic heritage. About 26% of the students were female, which is also typical of engineering fields, although a bit high for this institution (the freshman engineering class at this university in 2014 was 18% female). As expected, 72% of respondents were first-year students, while 17% were transfer students. All students, regardless of first-year/transfer status, were included in the analyses.

Table 2. Demographic characteristics of sample

Demographic variable		Pre-semester N	Pre-semester Percent	Students with matched pre- and post- data N	Students with matched pre- and post- data Percent
Gender	Female	273	26.6	253	25.6
	Male	752	73.4	735	74.2
	Missing or no response	242		8	
Race	African-American or Black	47	4.6	52	5.3
	Asian or Pacific Islander	74	7.3	72	7.3
	White	857	84.0	814	82.7
	Other or Multi-racial	42	4.1	42	4.2
	Missing or no response	247		16	
Ethnicity	Not Hispanic	977	96.4	946	96.3
	Hispanic	36	3.6	33	3.4
	Missing or no response	254		3	
Enrollment	Freshman	735	71.8	712	71.8
	Transfer	174	17.0	150	15.1
	Other	115	11.2	127	12.8
	Missing or no response	243		7	

Table 3. Details about Attitude Measures

Scale	Primary Source	Sub-Scale	Example item	# items	Cronbach's α (pre, post)
Beliefs about Engineering	Litzler & Lorah [15]	Altruistic/ Helping profession	Engineers help to make the world a better place.	7	0.76, 0.90
		Status	Society values the work engineers do.	7	0.78, 0.86
		Interesting field[a]	I expect that engineering will be a rewarding career.	3	0.33
Occupational Values	Diekman et al. [5]	Communal/Altruistic	Serving humanity	4	0.79, 0.78
		Status/Individualistic	Having power or influence	5	0.67, 0.71
		Creativity/Fun[a]	Using creativity	2	0.53[a]
Engineering Commitment	Perez et al. [28]	–	I am likely to remain in my engineering major to graduation.	4	0.69, 0.78

Notes. [a] These items were included as filler so the two scales were not as obvious.

2.2 Instruments

A battery of attitude scales was assembled for the purposes of the larger study from the literature. See Table 3. The first 17-item scale assessed students' Beliefs about Engineering, with about half of the items reflecting beliefs related to engineering as a helping or communal profession (e.g., "Engineers are helping to solve challenging problems.") and seven related to status (e.g., "Engineers are well paid."). Three items about how interesting students found engineering were included to obscure the two focal scales. This scale was assembled from several common engineering-related attitude scales [15, 30, 31]. These items were presented with a four-point rating scale: strongly disagree, somewhat disagree, somewhat agree, and strongly agree.

Career values were assessed using an 11-item scale adapted from prior research [5]. It used the same four-point scale as the Beliefs measure and reflected values related to individualistic or status values (e.g., "having status or power") as well as altruistic or communal values (e.g., "helping others"). Again, two unrelated items (related to fun and creativity) were included to obscure the focal scales.

In addition to assessing attitudes towards engineering, we also asked four questions about commitment to staying in an engineering major. These items were modified from those used by Perez et al. [28] so that their items referring to STEM majors were revised to refer only to engineering. An example item is "I am likely to remain in my engineering major to graduation." These items also used a four-point scale (Strongly Disagree to Strongly Agree).

In this sample, the subscales had acceptable internal consistency estimates (i.e., 0.7 or above). We used Exploratory Factor Analysis to determine that our intended subscales were the most appropriate organization of items. Removing items or reorganizing them did not increase the internal consistency estimates. Confirmatory Factor Analysis was used to further explore the factor structure and alignment of items with scales and support the present use of the survey scales.

2.3 *Analysis*

Analysis began with descriptive statistics. We then compared the attitude scales by gender and URM status using independent t-tests and ANOVAs. Changes from pre- to post-semester were addressed using repeated measures analyses.

After inspecting the survey data, non-normality was a concern. Therefore, instead of relying solely on standard parametric tests, which could be biased by non-normality, we used non-parametric tests for group differences, including the Mann-Whitney U test. We also used Mplus 7 for the regression analyses because it offers the MLM estimator that is robust in analyses with non-normal variables [32]. Specifically, the manual states that MLM uses "maximum likelihood parameter estimates with standard errors and a mean-adjusted chi-square test statistic that are robust to non-normality" (p. 533, [32]). We report both parametric and non-parametric group comparisons and MLM-estimated regression coefficients in the results.

For research question 2, we needed to compare high and low beliefs and values in status and altruism. Therefore, we split the sample into thirds for each of the four variables. We then contrasted the top and bottom third in crosstab comparisons. Standard errors based on the sample size were used to determine which differences in percentages were significant.

3. Results

Inspection of descriptive statistics as well as histograms indicated that several of the focal variables (which were average composite scores of the corresponding rating scale items) were non-normally distributed, with a negative skew and many scores at or near the scale maximum. Skew was greatest on altruistic beliefs and values as well as commitment.

3.1 *Gender differences in values, beliefs and commitment*

We used t-tests, non-parametric tests, and Cohen's d effect sizes to assess mean differences between men and women in their beliefs about engineering, occupational values, and commitment to engineering. See Table 4. As expected, we found gender differences in career values, with men showing

Table 4. Gender differences in beliefs and values

Variable	**Women (N = 273)**		**Men (N = 752)**		**Gender differences**		
	M	**SD**	**M**	**SD**	**t(1,023)**	**Cohen's d[a]**	**Mann-Whitney U**
Beliefs-Altruism	2.67	0.37	2.62	0.38	1.63	0.12	*
Beliefs-Status	2.38	0.36	2.35	0.39	1.07	0.08	
Value-Altruism	2.31	0.63	2.11	0.62	4.56**	0.32	**
Value-Status	1.77	0.58	1.88	0.56	–2.71**	–0.19	**
Commitment	2.38	0.60	2.41	0.55	–0.58	–0.04	

Notes. * $p < 0.05$, ** $p < 0.01$. We found no significant interaction of race and gender. [a] Cohen's d effect sizes are positive when women had higher means.

Table 5. Percent of women or men in each value-belief contrast

			Altruistic Beliefs	
			Bottom third	**Top third**
Altruistic Values	Bottom third	Women	36%	11%
		Men	52%	15%
	Top third	Women	14%	39%
		Men	8%	25%
			Status Beliefs	
			Bottom third	**Top third**
Status Values	Bottom third	Women	28%	33%
		Men	27%	23%
	Top third	Women	5%	34%
		Men	11%	39%

Note. Percentages calculated within gender groups. Based on standard errors for each percentage, differences of 5.5% or greater between genders are statistically significant.

statistically higher status values (d = –0.19) and women having significantly higher altruism values (d = 0.32). We also found small differences in the beliefs of men and women about the altruistic nature of engineering where women had slightly more positive beliefs. There were no differences in status beliefs or commitment to the major at the start of the semester.

We identified the top and bottom third of scores for each value and belief variable in order to classify students as matching or mismatching in terms of high (top 33%) and low (bottom 33%) levels of each belief and value. See Table 5. Women were more likely to have a match of high altruistic values and beliefs (39% of women vs. 25% of men), and, as we expected, somewhat more likely to have a mismatch of high altruistic values with low altruistic beliefs about engineering. Men were more likely to have matching low altruistic values and beliefs (52% of men vs. 36% of women).

Mismatches were also found for status beliefs and values. Men were more likely to have low status beliefs with strong status values (11% vs. 5%). Women were more likely to have high status beliefs along with low status values (33% of women, 23% of men).

3.2 Race/ethnicity effects on values and beliefs

As part of the gender comparisons, we also considered race (divided into underrepresented minorities and other students) to look for main effects or interactions with gender, but we found no significant effects. However, main effects of race alone would be of interest, so we analyzed the race and ethnicity in five groups: African American, Asian or Pacific Islander, Hispanic (any race), White, or other/multi-racial. A one-way ANOVA of each of the five dependent variables resulted in significant effects between groups for beliefs about altruism and beliefs about status (Table 6).

An inspection of posthoc tests showed that for beliefs about altruism, students from Asian and "other" race categories gave lower ratings to engineering as an altruistic profession compared to White and African American students. Asian students also had significantly lower commitment to engineering than African American and White students. For beliefs about engineering as a status field as well as altruism values, only the "other" category was significantly lower than the ratings of African American and White students. Because of the mix of students choosing the "other" category (which included a wide range of non-responses as well as multiracial students), it is difficult to interpret these differences meaningfully.

Unlike for gender, no distinctive mismatch patterns were found, although there were differences in the matching rates of URM and non-URM students. See Table 7. URM students were less likely to have matching low altruistic beliefs and values than non-URM students (39% for URM vs. 50% for non-URM). They were more likely to have matching high altruistic beliefs and values (39% vs. 26% of non-URM students). They were also more likely to have matching high status beliefs and values (46% vs. 36% of non-URM).

Table 6. Race/ethnicity differences in beliefs and values

	Mean (SD)					**Mean comparisons**			
	African-American or Black	**Asian or Pacific Islander**	**White, not Hispanic**	**Hispanic, any race**	**Other**	**F test (4, 1020)**	**Kruskal-Wallis test**	**d effect sizes for significant contrasts**	**Significant differences**
Beliefs-Altruism	2.70 (0.49)	2.45 (0.50)	2.65 (0.35)	2.61 (0.51)	2.50 (0.47)	6.09**	**	0.36, 0.51	Asian and Other sig. lower than African Amer.
Beliefs-Status	2.42 (0.51)	2.28 (0.46)	2.37 (0.37)	2.33 (0.42)	2.20 (0.37)	2.64*	*	0.49 0.50	Other sig. lower than African Amer.
Value-Altruism	2.38 (0.67)	2.17 (0.56)	2.16 (0.62)	2.16 (0.67)	2.04 (0.70)	1.71	*		African Amer. students sig. higher than Other
Value-Status	1.91 (0.61)	1.88 (0.63)	1.85 (0.56)	1.83 (0.55)	1.78 (0.65)	0.38			No sig. differences
Commitment	2.40 (0.62)	2.23 (0.57)	2.42 (0.56)	2.31 (0.55)	2.38 (0.54)	2.08	*	0.29, 0.34	White/African Amer. sig. higher than Asian

Notes. * $p < 0.05$, ** $p < 0.01$.

Table 7. Percent of URM or non-URM in each value-belief contrast

			Altruistic Beliefs	
			Bottom third	**Top third**
Altruistic Values	Bottom third	non-URM	50%	14%
		URM	39%	10%
	Top third	non-URM	9%	26%
		URM	11%	39%
			Status Beliefs	
			Bottom third	**Top third**
Status Values	Bottom third	non-URM	28%	26%
		URM	24%	21%
	Top third	non-URM	10%	36%
		URM	9%	46%

Note. Percentages calculated within URM groups. Based on standard errors for each percentage, differences of 6.8% or greater between URM groups are statistically significant.

Table 8. Gender differences in means from pre- to post-semester

		Pre-semester		**Post-semester**		**Time effects**		
	Group	**M**	**SD**	**M**	**SD**	**Cohen's d[a]**	**Within-subject comparisons**	**Mann-Whitney U**
Beliefs-Altruism	Women	2.66	0.32	2.69	0.56			
	Men	2.64	0.36	2.66	0.46			
	Total	2.65	0.35	2.67	0.49	0.05	NS	**
Beliefs-Status	Women	2.38	0.33	2.45	0.55			
	Men	2.37	0.36	2.46	0.46			
	Total	2.38	0.35	2.46	0.48	0.19	<0.001	**
Value-Altruism	Women	2.30	0.66	2.42	0.63			
	Men	2.10	0.63	2.21	0.63			
	Total	2.15	0.64	2.27	0.63	0.18	<0.001	**
Value-Status	Women	1.83	0.60	1.88	0.64			
	Men	1.89	0.54	1.88	0.62			
	Total	1.87	0.56	1.88	0.63	0.02	NS	
Commitment	Women	2.43	0.61	2.29	0.81			
	Men	2.44	0.53	2.34	0.72			
	Total	2.44	0.55	2.32	0.74	–0.18	<0.001	*

Notes. * $p < 0.05$, ** $p < 0.01$. Female N = 142. Male N = 381. No significant interactions of gender by time were found. [a] Cohen's d effect sizes are positive when post-semester had higher means.

3.3 Changes in beliefs, values, and commitment over time by gender

In addition to gender differences at the start of the semester (where our sample was larger and perhaps more representative), we looked at whether these differences changed from the beginning to the end of the semester. We were also interested in whether the perceptions of engineering (beliefs about its value affordances) appeared to vary over time, suggesting that those beliefs are malleable.

We found that status beliefs, but not altruistic beliefs, did tend to vary (significantly increasing) over the course of a semester for both men and women (d = 0.19). See Table 8. We did not find any interactions where the change in attitudes varied by gender. Interestingly, the career values for altruism also increased for all students as did their commitment to engineering as a major. It runs counter to our expectations that apparent mismatch of values and beliefs may increase during this first-semester course while an increase in major commitment is also observed. Greater exploration of this result is found in the regression analyses section.

3.4 Changes in beliefs over time by race/ethnicity

As with gender, we wanted to see if race/ethnicity was associated with differences in changes over the semester. To increase statistical power, we combined all underrepresented minority groups (URM; African American, Hispanic, Other) and

Table 9. Race/ethnicity differences in means from pre- to post-semester

		Pre-semester		Post-semester		Time effects	
	Group	M	SD	M	SD	Cohen's d[a]	Mann-Whitney U
Beliefs-Altruism	Non-URM	2.64	0.36	2.67	0.50		
	URM	2.61	0.50	2.70	0.38		
	Total	2.65	0.35	2.67	0.49	0.05	**
Beliefs-Status	Non-URM	2.36	0.38	2.45	0.50		
	URM	2.33	0.46	2.48	0.40		
	Total	2.38	0.35	2.46	0.48	0.19	**
Value-Altruism	Non-URM	2.16	0.62	2.27	0.64		
	URM	2.22	0.70	2.35	0.62		
	Total	2.15	0.64	2.27	0.63	0.18	**
Value-Status	Non-URM	1.87	0.56	1.87	0.63		
	URM	1.97	0.62	1.97	0.56		
	Total	1.87	0.56	1.88	0.63	0.02	
Commitment	Non-URM	2.40	0.57	2.32	0.76		
	URM	2.37	0.58	2.33	0.57		
	Total	2.44	0.55	2.32	0.74	-0.18	*

Notes. * p < 0.05, ** p < 0.01. URM = underrepresented minority (African American, Hispanic, Other). Non-URM N = 452. URM N = 53. No significant interactions of URM status by time were found. Because of the lack of interaction, the time effects for the total sample are identical to the gender results in Table 9. [a] Cohen's d effect sizes are positive when post-semester surveys had higher means.

Table 10. Correlations by Gender (pre-semester attitudes with both measures of commitment)

	Beliefs-Status	Beliefs-Altruism	Value-Status	Value-Altruism	Commitment	Commitment (end of term)
Beliefs-Status	1	0.62**	0.08	0.08	0.04	0.04
Beliefs-Altruism	0.68*	1	0.06	0.20**	0.02	0.10
Value-Status	0.31**	0.30**	1	0.46**	0.13*	–0.01
Value-Altruism	0.23**	0.39**	0.30**	1	0.07	–0.06
Commitment	0.07	0.20*	0.11	0.17*	1	0.38**
Commitment (end of term)	0.15	0.10	0.02	0.12	0.42**	1

Notes. * p < 0.05, ** p < 0.01. Female correlations below the diagonal; male above the diagonal.

Table 11. Correlations by URM status (pre-semester attitudes with both measures of commitment)

	Beliefs-Status	Beliefs-Altruism	Value-Status	Value-Altruism	Commitment	Commitment (end of term)
Beliefs-Status	1	0.72**	0.30**	0.18	–0.08	–0.15
Beliefs-Altruism	0.63**	1	0.22*	0.14	–0.05	–0.14
Value-Status	0.30**	0.18**	1	0.41**	0.01	0.10
Value-Altruism	0.14**	0.20**	0.40**	1	0.02	0.04
Commitment	0.18**	0.13**	0.11**	0.08*	1	0.36**
Commitment (end of term)	0.12**	0.09*	–0.02	0.00	0.40**	1

Notes. * p < 0.05, ** p < 0.01. URM = underrepresented minority (African American, Hispanic, Other). Non-URM correlations below the diagonal; URM above the diagonal.

all non-URM (White, Asian). We found no significant interactions, indicating similar changes in all attitudes for both groups. Because of the lack of interactions, the main effects of time in Table 9 are identical to the results in Table 8.

3.5 Predicting commitment to engineering from values and beliefs

Table 10 shows that the patterns of correlations appeared to differ somewhat for men and women and Table 11 shows that patterns differ minimally for underrepresented minority versus other groups. Beliefs about status and altruism were highly correlated for all groups, indicating that responses may reflect a generally positive or negative view of engineering that affects both scales. Correlations between values were more modest indicating greater differentiation between domains of career values than field perceptions. There was no significant relationship of beliefs or values to commitment in this analysis, but we were cautious because of the non-normality of the distributions. Of most interest was the relatively low correlation between identical measures of major commitment at the start and end of the semester (around 0.40).

An inspection of trends at the item level suggested that most students started the semester with no plans to change major (73% strongly disagreed that "At the present time, I am likely to switch to a major that is NOT in engineering" [reverse scored]), but 13% of those students giving the strongest disagreement with this statement at the start of the semester reported the strongest *agreement* with this statement at the end of the semester (26% total decreased in their ratings for this item by at least one point), indicating serious consideration of other majors by students who initially had no plans to change majors. A similar question, "I am considering other majors outside of engineering" (also reverse scored), initially had 52% strongly disagreeing with this statement, but 27% of students who at pre-test gave the strongest disagreement rating with this item had reduced their disagreement at the end of the semester (6% completely reversed their response). Again, indicating a small group who drastically revised their attitudes toward engineering during the semester. The other items ("I am likely to remain in my engineering major to graduation" and "I am confident that my current major is right for me") were also more likely to show decreases than increases for individuals at post-test, but increased overall across students (meaning that a small minority greatly increased their attitude). Thus, the inconsistency may be due to students being more certain of their chosen major, but being more aware of other major options available to them. This may include students who were interested in science and biomedical fields, who may become aware of and consider majors outside of the Engineering college that align with those interests.

To look at the combined effects of beliefs and values on commitment, we conducted multiple regression in Mplus with robust estimators so that non-normality did not bias the statistical significance tests. See Table 12. We found that at both pre- and post-semester, altruistic beliefs about engineering were positively associated with commitment in model 1, which did not control for race or gender effects. At the end of the semester, status-related values were also significant positive predictors. When gender and underrepresented minority status were added in regression model 2, both altruistic beliefs and status values were significant predictors as was URM status at the start of the semester and gender at the end of the semester, suggesting some variation in commitment within these groups. Altruistic values were a slight negative predictor of commitment at the end of the semester. However, it is important to note that value differ-

Table 12. Standardized regression coefficients for pre- and post-semester measures of values, beliefs, and commitment

		Pre-semester Commitment			**Post-semester Commitment**		
		Model 1 *β*	**Model 2** *β*	**Model 3** *β*	**Model 1** *β*	**Model 2** *β*	**Model 3** *β*
Predictors of commitment	Belief-status	–0.04	–0.02	0.17	0.11	0.08	0.00
	Belief-altruistic	**0.17****	**0.15****	0.07	**0.41****	**0.42****	–0.04
	Value-status	0.06	**0.08***	0.23	**0.23****	**0.25****	–0.09
	Value-altruistic	–0.01	–0.02	–0.01	–0.08	**–0.10****	0.00
	Gender		0.01	–0.02		**–0.08***	0.07
	URM		**–0.12***	0.66		0.00	0.47
Value-status interactions	Belief-alt*Value-alt			–0.37			–0.22
	Belief-alt*Value-status			0.54			**0.54****
	Belief-status *Value-alt			0.39			–0.02
	Belief-status*Value-status			**–0.81***			**–0.84****
Ethnicity interactions[a]	URM*Belief-status			–0.11			0.52
	URM*Belief-alt			–0.79			**–1.42****
	URM*Value-status			0.22			**–0.37***
	URM*Value-alt			**–1.05***			**–0.56***
	URM*Belief-alt*Value-alt			**1.49****			0.14
	URM*Belief-alt*Value-status			–0.76			**0.97****
	URM*Belief-status*Value-alt			–0.59			0.35
	URM*Belief-status*Value-status			0.74			**–0.65****
R^2		**0.03**	**0.04**	**0.05**	**0.48**	**0.48**	**0.53**

Notes. * $p < 0.05$, ** $p < 0.01$. URM = underrepresented minority group (Hispanic, African American, or Native American).
[a] No significant interactions for gender were found.

ences by gender may mediate gender main effects (e.g., if women have lower commitment and higher altruistic values, the confounding may lead to a negative effect of altruistic values).

In the final model (3) we added interaction terms for gender and URM status with each of the beliefs and values. Table 12 includes only interactions with URM, because gender interactions were not significant even when gender, and not URM, interactions were included. Relationships were similar but stronger with post-test measures compared to pre-test measures. One of the most pronounced interaction effects was that believing that engineering afforded altruistic goals while personally holding status values was related to greater commitment (β = 0.54). This effect was greater for URM students (β = 0.97 for the three-way interaction in addition to the two-way interaction effect). Also intriguing was the finding that beliefs about engineering as a status field and personally holding status values was associated with less commitment to the major at post-test (β = –0.84). Again, this effect was more pronounced for URM students (β = –0.65). Possible interpretations of both results are explored in the Discussion.

Two-way interactions with URM and attitudes also had interesting patterns, where URM students with either high status or altruistic values or holding high altruistic beliefs about engineering were less likely to be committed to their major. The non-significant main effects for beliefs and values in model 3 suggests that those influences might be more pronounced for URM students, because adding the interaction terms removed the main effect of beliefs and values. Most notable is the larger negative effect of altruistic and status values on commitment for URM students (β = –0.56 and –0.37, respectively). Altruistic beliefs for URMs actually reversed its effect from Model 2 so that URM students with higher altruistic beliefs were substantially less likely to feel committed to their major post-semester (β = –1.42).

3.6 Limitations

Self-report of attitudes and beliefs are always subject to potential biases like social desirability and a tendency to acquiesce or agree with survey questions (Anastasi, 1992). In longitudinal studies, there is also a concern about response-shift bias (Howard, 1980), which refers to the problem of how participants' changing perceptions during the course of a study may affect the accuracy of earlier ratings (i.e., not knowing what you don't know). Therefore, we cannot rule out that changes in ratings from pre- to post-semester are influenced by a response shift based on their increased familiarity with the field. However, we feel this increased familiarity, accuracy of career beliefs, or any shift in attitudes is likely a real and important effect to consider.

We also acknowledge that categorizing student demographics (race, ethnicity, gender, and educational experience), leads to oversimplification of complex variables. Our classification of racial and ethnicity variables naturally combines many individuals with varied backgrounds, but is consistent with best practices in quantitative research and provided balance between statistical power and group variability.

4. Discussion

Researchers have only recently explored how individual perceptions of occupational fields like engineering can interact with individuals' personal values and goals to affect commitment to completing degrees. This study adds an important perspective on this new area of research in understanding why men and women as well as race/ethnicity groups differ in their engagement in and completion of engineering degrees. Because much of the past research has treated the characteristics or affordances of fields like engineering as fixed characteristics, research has focused on how to change the attitudes and values of women and minority students to better align with engineering. This new line of research is important because the *perception* of career affordances may be more malleable to interventions than individual career values. Although we did not attempt to manipulate students' perception of engineering in this study, it lays the foundation for future intervention research.

We assessed students' personal career values for altruism and status as well as their perceptions of engineering as a field that has altruistic or status outcomes. We found that, consistent with much prior work on the general population, men and women in first-year engineering programs differ significantly in their career values, with women showing greater value for altruism and men showing greater value for status. The magnitude of these effects was smaller for this sample than in the general population (differences of .3SD for altruism in this sample, compared to an effect of 1.0SD in other research [2]). Men and women had similar perceptions of the affordances of engineering, apart from a small difference in women reporting more altruistic affordances. Importantly, we found significant variation in those perceptions, meaning that there are individual differences in how students perceive the value affordances of the field. There was no difference in major commitment between men and women.

In contrasting the values and beliefs of students, we confirmed our expectation that women were more likely than men to have congruent values and beliefs regarding the altruistic affordances of engineering; likewise, men were more likely to have congruency in low values and affordances for altruism. We also observed a small difference where women were more likely to have incongruity (mismatch) in their values and beliefs where they perceived engineering as *not* affording altruistic goals while personally holding greater altruistic values for themselves. We expected this to decrease commitment to engineering, although this was not supported in the present study. This is discussed below.

The general result for changes in values and beliefs was that students tended to increase their perception of engineering as affording altruism slightly over this semester (d = 0.05) and increased their belief that engineering afforded status goals more substantially (d = 0.19). There were no significant interactions, which would indicate these patterns differ by gender. Although we did not predict changes in values, altruistic values also increased during the semester (d = 0.18). Changing values could be explained by the young age of most first-year engineering students, where they are more likely to be in career exploration and identity development stages [25, 33]. The observation of very low correlations in commitment from pre- to post-semester may be due to the same effects of career identity exploration.

4.1 Role of race/ethnicity

Our sample sizes for students in various race/ethnicity categories were not sufficient to consider the interaction of race/ethnicity and gender, but we were able to consider the effect of race/ethnicity alone. Among the effects found, the most notable was the greater commitment to engineering at the start of the semester of African American and white students compared to Asian students (d = 0.51, 0.36, respectively), who had the lowest commitment to the major. Asian students also gave much lower ratings of altruistic beliefs about engineering compared to African American students (d = 0.51). In a past study of this same institution, we found that Asian students were much less likely to change from a STEM major to a non-STEM major, so their lower commitment may not predict actual major change [35].

In terms of value-beliefs mismatches, we did not find any patterns based on students who were classified as underrepresented minority (URM), including Hispanic and African American students. We did find that, similar to women, URM students were more likely to have matching high altruistic beliefs and values. Intriguingly, they also were more likely to have matching high status beliefs and values. Explorations of how students differentiate the value affordances of their careers (i.e., how they form beliefs about what the career is like) is needed.

4.2 Predicting commitment to major

Contrary to our expectations, alignment of status beliefs and values actually had a substantial negative effect on commitment (β = –0.8 at pre- and post-). At post-test, holding strong altruistic beliefs and high personal value for status was actually associated with greater major commitment (β = 0.54). This is consistent with prior work that shows that personal values *and* expected outcomes influence major commitment [27], so that perhaps those with the strongest major commitment are bolstered both by the potential for status and by having positive social impacts through their career. This would counter our theory that alignment of values is important for retention, and instead suggests that broadly positive outcomes of the field are desired and status and altruistic values are not in competition with each other.

The reduced commitment by those with status congruity is difficult to explain, but could reflect the reduced motivation experienced by students primarily focused on extrinsic rewards for learning [34].

Negative effects of gender and URM on major commitment at pre- and post-semester disappeared when interactions of values, beliefs, and URM status were added to the model. Specifically, URM students who held higher levels of either status or altruistic values or that believed engineering afforded altruistic values were *less likely* to feel committed to their major, at least at the end of the semester. Future research should explore which career fields appeal most to URM students with different career values [22].

4.3 Implications for interventions

This study lends support to interventions that focus on changing perceptions of career fields rather than trying to change the personal values or the types of students drawn to engineering. Efforts to change perceptions, such as the *Messaging for Engineering* project [11], may result in larger increases in diversity for engineering because it seeks to reframe engineering as a helping profession in line with the goals of many students. Our study suggests that it is not so much important to counter the beliefs that engineering serves status goals, but to help potential student see that it serves altruistic values as well.

As the *Grand Challenges* are increasingly incorporated into engineering curricula [13, 15], more research is needed on the degree to which Grand Challenges appeal to students, enhance interest, promote diversity, and promote persistence in engineering via changing perceptions of the values and career goals that engineering careers can meet. In the effort to increase the number and diversity of students in engineering, such considerations of value-affordances alignment may be a critical framework for interventions.

Future is research is needed, however, to understand the paradoxical effects where status values and belief alignment as well as URM students holding stronger altruistic or status beliefs were all associated with lower major commitment. Understanding how individuals incorporate values and beliefs judgments into career decisions in the first year of college is greatly needed. The Social Cognitive Career Theory [25] may be a useful framework for understanding this paradox.

5. Conclusions

This study confirmed the value in studying beliefs about a career field as well as personal career values in understanding career commitment in university students. Perceptions of the field are critical to understanding students' perceptions of alignment with their career values.

We confirmed previous research on gender differences in the general population and found similar differences among engineering students. Specifically, we found that women in engineering were more likely to have higher altruism values than men in engineering. Men, on the other hand, had higher status values. Both were medium in effect size, suggesting they may be important differences to consider further. In terms of race, we found that African American students reported higher beliefs about engineering as a status and an altruistic career field. African American students also showed higher altruistic values than some other race/ethnicity groups. There were no differences in status values.

As expected, we found mismatches in values and beliefs were differed by gender, though not by URM status. Women were somewhat more likely to have a mismatch of high altruistic values with low altruistic beliefs. Women were also more likely to have low status values and high status beliefs about engineering. Importantly, both women and URM students were more likely than other students to have a match of high altruistic values and beliefs. This suggests that students may indeed seek congruity between their career's value affordances and their career values. Thus, mismatches for other students may pose problems for retention in the major.

Our next question related to changes in these attitudes and commitment to major over the course of a semester. We found that status beliefs, but not altruistic beliefs, did tend to increase over the course of a semester for both men and women. We did not find any interactions where the change in attitudes varied by gender or by URM status. Interestingly, the career values for altruism also increased for all students as did their commitment to engineering as a major. It runs counter to our expectations that a growing mismatch of values and beliefs would affect major commitment.

Finally, we explored the relationship of beliefs and values to major commitment. Beliefs about engineering as a status and altruistic career field were highly correlated, suggesting that students did not strongly differentiate what types of affordances engineering offered. An overall positive or negative view of engineering may influence both variables. We found that students' commitment to their major showed low correlations, indicating that the first semester is a time of shifting views of the major and the available alternatives for these students. More exploration of when and why career values and beliefs correlate with commitment is needed. Qualitative exploration and/or more detailed survey scales may be needed to explore this relationship.

6. References

1. National Science Foundation, *Foreign graduate enrollment in science and engineering continues to rise while overall graduate enrollment remains flat. (Publication No. NSF 14-313).* Arlington, VA: National Science Foundation, 2014.
2. R. Lippa, Gender-related individual differences and the structure of vocational interests: The importance of the people—things dimension, *Journal of Personality and Social Psychology*, **74**(4), 1998, pp. 996–1009.
3. R. Su, J. Rounds and P. I. Armstrong, Men and things, women and people: a meta-analysis of sex differences in interests, *Psychological Bulletin*,**135**(6), 2009, pp. 859–884.
4. K. G. Schaefers, D. L. Epperson and M. M. Nauta, Women's career development: Can theoretically derived variables predict persistence in engineering majors?, *Journal of Counseling Psychology*, **44**(2), 1997, pp. 173–183.
5. A. B. Diekman, E. R. Brown, A. M. Johnston and E. K. Clark, Seeking congruity between goals and roles: A new look at why women opt out of science, technology, engineering, and mathematics careers, *Psychological Science,* **21**(8), 2010, pp. 1051–1057.
6. S. J. Ceci and W. M. Williams (eds.), *Why aren't more women in science? Top researchers debate the evidence*. Washington, DC: American Psychological Association, 2007.
7. E. S. Weisgram and R. S. Bigler, Effects of learning about gender discrimination on adolescent girls' attitudes toward and interest in science, *Psychology of Women Quarterly,* **31**, 2007, pp. 262–269.
8. R. Stevens, D. Amos, A. Jocuns and L. Garrison, Engineering as lifestyle and a meritocracy of difficulty: Two pervasive beliefs among engineering students and their possible effects, in *Proceedings of the 2007 American Society for Engineering Education Annual Conference*, Honolulu, HI, 2007.
9. B. M. Capobianco and J. H. Yu, Using the construct of care to frame engineering as a caring profession toward promoting young girls' participation, *Journal of Women and Minorities in Science and Engineering,* **20**(1), 2014, pp. 21–33.
10. National Academy of Engineering [NAE], *NAE Grand Challenges for Engineering*, ed: National Academies Press, 2008.
11. National Academy of Engineering [NAE], *Messaging for Engineering: From Research to Action*, ed: National Academies Press, 2013.
12. National Academy of Engineering [NAE], *U.S. Engineering*

Schools to Educate 20,000 Students to Meet Grand Challenges, ed, 2015.
13. C. M. Vest, Context and challenge for twenty-first century engineering education, *Journal of Engineering Education,* **97**(3), 2008, pp. 235–236.
14. N. R. Augustine, C. Barrett, G. Cassell, N. Grasmick, C. Holliday and S. A. Jackson, *Rising above the gathering storm, revisited: Rapidly approaching category 5*. Washington, DC: National Academy of Sciences, National Academy of Engineering, Institute of Medicine, 2010.
15. E. Litzler and J. A. Lorah, A Natural Experiment: NAE's Changing the Conversation Report and Students' Changing Perceptions of Engineering, in *ASEE Annual Conference*, 2013, Atlanta, GA.
16. S. Olson and D. G. Riordan, *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics. Report to the President*, ed, 2012.
17. S. H. Schwartz and T. Rubel, Sex differences in value priorities: cross-cultural and multimethod studies, *Journal of personality and social psychology*, **89**(6), 2005, pp. 1010–1028.
18. J. L. Holland, *Making Vocational Choices; A Theory of Careers*. Englewood Cliffs, NJ: Prentice Hall, 1973.
19. D. J. Prediger, Dimensions underlying Holland's hexagon: Missing link between interests and occupations? *Journal of Vocational Behavior*, **21**(3), 1982, pp. 259–287.
20. D. Lubinski, Scientific and social significance of assessing individual differences: "Sinking shafts at a few critical points, *Annual Review of Psychology,* **51**(1), 2000, pp. 405–444.
21. B. D. Jones, M. C. Paretti, S. F. Hein and T. W. Knott, An analysis of motivation constructs with first-year engineering students: Relationships among expectancies, values, achievement, and career plans, *Journal of Engineering Education,* **99**(4), 2010, pp. 319–336.
22. R. H. Wade, *Feeling different: An examination of underrepresented minority community college students' major persistence intentions through the lens of STEM identity*, Unpublished doctoral dissertation, 2012.
23. R. W. Lent, S. D. Brown and G. Hackett, Toward a unifying social cognitive theory of career and academic interest, choice, and performance, *Journal of Vocational Behavior*, Monograph **45**(79–122), 1994.
24. R. W. Lent, S. D. Brown and G. Hackett, Contextual supports and barriers to career choice: A social cognitive analysis, *Journal of Counseling Psychology*, **47**, 2000, pp. 36–49.
25. R. W. Lent and S. D. Brown, Social cognitive model of career self-management: Toward a unifying view of adaptive career behavior across the life span, *Journal of Counseling Psychology*, **60**(4), 2013, pp. 557–568.
26. A. Wigfield and J. S. Eccles, Expectancy—value theory of achievement motivation, *Contemporary Educational Psychology,* **25**(1), 2000, pp. 68–81.
27. H. M. Matusovich, R. A. Streveler and R. L. Miller, Why do students choose engineering? A qualitative, longitudinal investigation of students' motivational values, *Journal of Engineering Education,* **99**(4), 2010, pp. 289–303.
28. T. Perez, J. G. Cromley and A. Kaplan, The role of identity development, values, and costs in college STEM retention, *Journal of Educational Psychology*, **106**(1), 2014, pp. 315–329.
29. L. Klotz, G. Potvin, A. Godwin, J. Cribbs, Z. Hazari and N. Barclay, Sustainability as a route to broadening participation in engineering, *Journal of Engineering Education*, **103**(1), 2014, pp. 137–153.
30. S. Bouvier, *Increasing Student Interest in Science, Technology, Engineering, and Math (STEM): Massachusetts STEM Pipeline Fund Programs Using Promising Practices*, ed, 2011.
31. O. Eris, D. Chachra, H. L. Chen, S. Sheppard, L. Ludlow, C. Rosca, and G. Toye, Outcomes of a longitudinal administration of the persistence in engineering survey, *Journal of Engineering Education*, **99**(4), 2010, pp. 371–395.
32. L. K. Muthén and B. O. Muthén, *Mplus User's Guide*, 5th ed. Los Angeles, CA: Muthén & Muthén, 1998.
33. F. Meijers, The development of a career identity, *International Journal for the Advancement of Counselling,* **20**(3), 1998, pp. 191–207.
34. R. M. Ryan and E. L. Deci, Intrinsic and extrinsic motivations: Classic definitions and new directions, *Contemporary educational psychology*, **25**(1), 2000, pp. 54–67.
35. J. M. Lakin and D. C. Elliott, STEMing the shock: Examining GPA "Transfer Shock" and its impact on STEM major and enrollment persistence, *Journal of the First-Year Experience & Students in Transition*, **28**(2), 2016, pp. 9–32.

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