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Relationship Between Goal Orientation, Agency, and Motivation in Undergraduate Civil Engineering Students

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Abstract

Understanding the underlying psychological constructs that affect undergraduate engineering students' academic achievement and persistence can inform curricular and programmatic changes in engineering education, with the goal of increasing access and advancement in engineering for a diverse population of students. As part of a larger study examining student experiences in a civil engineering department undergoing curricular and cultural changes, this quantitative study investigated the relationship between goal orientation, agency, and future-oriented motivation, differences in this relationship across academic years, and potential influences from personality types. The larger project seeks to examine the motivation, identity, and sense of belonging for undergraduate civil engineering students. previously tested and established survey that draws from multiple theories of motivation and other affective factors such as agency and identity, and that includes "Big Five" personality constructs, was used to collect data from sophomore, junior and senior civil engineering students at a single institution over a two-year period. Prior studies have focused on the instrument's latent constructs, and this analysis examines how some of the constructs influence each other. Specific latent constructs of goal orientation, agency (students' beliefs that their career in science or engineering can lead to positive effects on the world), future time perspective (FTP), and personality type were selected for secondary data analysis based on existing theory about relationships between motivation, goal setting, agency, and student perceptions of their future. Statistical analyses and modeling included bivariate correlational analysis, MANOVA and MANCOVA. Results indicated significant correlation between goal orientation, agency, and FTP. Furthermore, differences in these constructs between academic years and personality type influenced the relationship. FTP differed between sophomores and seniors, with seniors having higher scores, suggesting future-oriented motivation increases with time in the program. Personality types significantly influenced these relationships, in different ways, but had the strongest effect on agency. The findings that students with certain personality traits are not only motivated to major in civil engineering but believe their major will make a difference in the world have implications for educational practice. Results align with current literature but also shed light on the effects of personality type on future-oriented motivation and agency, expanding theory in engineering education. Further research is needed to determine if the effects of personality type hold true for other engineering and science majors, and to look at individual sub-constructs of agency and future-oriented motivation for more nuanced effects within the model.

Introduction and Study Purpose

Current trends in science, technology, engineering and mathematics (STEM) education work towards a better understand of the underlying psychological constructs impacting undergraduate STEM students [1]-[6]. STEM departments worldwide are examining the designs of their programs and curricula to better serve their student populations. Resulting program and curriculum changes have aimed to implement culturally inclusive practices, create a sense of community for undergraduate students, and introduce real world issues and practices in the field into the undergraduate experience. A central aim of this research project is to examine underlying psychological processes of undergraduate civil engineering students enrolled in a program undergoing such curricular change, examining the dynamic and interconnected relationships between person, behavior, and environment [7]-[9].

This approach provides a unique and potentially powerful lens for examining student experiences as it provides insights for a conceptual model explaining the interactive nature of psychological processes and behaviors impacting engineering students at the undergraduate level. Current research in the field examines portions of these constructs independently, but to date no work has undertaken a comprehensive look at these intersecting constructs. An additional goal of this approach is to use findings from this research to support undergraduate STEM programs through pedagogy, retention and persistence initiatives aimed at increasing access and advancement for all students.

For the work presented here, the focus is on psychological and cognitive constructs of goal orientation, agency and future-oriented motivation of undergraduate students. We are also examining aspects of student personality as these can influence students' affective attributes and their perceptions of their academic experiences [10]. Through a quantitative analysis of survey data collected over three years in an undergraduate civil engineering program, this study seeks to answer the following research questions:

RQ1. What is the relationship between goal orientation, agency, and future-oriented motivation?
RQ2. How does this relationship differ across academic years?
RQ3. Do the "Big Five" personality traits influence this relationship?

Theoretical Frameworks

This project is guided by literature pertaining to goal orientation, social cognitive theory (SCT), future-oriented motivation, and the "Big Five" personality traits. A central component of student success in engineering is the ability to see oneself as an engineer in the future [11]. In an era of higher education that demands evidence-based research [12] and cultures of inclusion [13], understanding how students perceive their themselves in the future and how that drives their motivation for present tasks is ever important [14], [15], [11]. Moreover, it is important to consider other affective and personality attributes that might influence or interact with a student's motivation [3], [6].

Goal Orientation

Pintrich's [16], [17] work identified three types of motivation towards goal setting: mastery, performance, and work; and two orientations for these motivations: approach or avoid. Goal orientation can play a role in students' cognitive performance in the classroom [17]. For this study, we focused on three goal orientations found to be most relevant to undergraduate student motivation: mastery approach, performance approach and work avoid [18]. Mastery approach pertains to students' tendency to work towards learning and understanding. Performance approach focuses on students' tendency to work towards outward sign of success (i.e., good grades). Work avoid relates to students' preference to work on academic tasks that take a short amount of time to complete. Together the goal orientation construct provides insight on how students set goals when approaching coursework in engineering.

Agency

Bandura's [19], [20] social cognitive theory explains how individuals gain knowledge. In the context of this study, SCT is considered as an agentic perspective, specifically through collective agency. Collective agency is the notion that people work together to achieve common beliefs. For this study, students' science and engineering agency beliefs were examined, which are beliefs in the power of science and engineering to impact one's life and the world around oneself. Additionally, in a nationally representative study of first-year college students, agency beliefs were found to be one of the factors predicting choice of engineering as a major in college [21]. Together, science and engineering agency provide information about how students believe that their future career in science or engineering can lead them to making a positive impact on the world.

Future-Oriented Motivation

The theoretical framework of future time perspective (FTP) provides a model for how students' perceptions of the future can guide their actions in the present [14], [11]. FTP has been used to provide insight into engineering students' academic decisions students such as persisting in their major and their approaches to tasks in their courses [14]. FTP includes the constructs of perceptions of the future, perceived instrumentality, effects of the future on the present, and connectedness. Perceptions of future describes student perceptions of their future in engineering. Perceived instrumentality focuses on student belief about the usefulness of their courses for obtaining future goals. Effects of the future on the present (referred to hereafter as "future on present") provides a sense of how a student's beliefs about the future impact on their perceptions of their present academic experiences. Connectedness captures any cognitive connections students perceive between the present and future [22]. To capture students' motivations toward long-term goals, Expectancy Value Theory (EVT) provided a framework for understanding students' expectations of how they will perform on a task and how much they value a task or its outcomes [23]-[24]. EVT posits those three main factors contribute to students' achievement motivation: 1) With enough effort, the performance can be achieved; 2) If achieved, performance will lead to desired outcomes; and 3) Those outcomes will lead to satisfaction [25]. In a study of engineering students' expectancies and values, students with higher expectancies were found to have better academic performance, and those with higher value for a task were found to persist longer on that task [26]. For this work, EVT was operationalized to assess expectancy, or how

students expected to do in the engineering course in which they were currently enrolled and informed the conceptualization of motivation and goal orientation.

Big Five Personality Traits

While not technically a theoretical framework, personality attributes can influence affective factors. The "Big Five" personality traits describe a five-factor model of personality: extraversion, agreeableness, conscientiousness, emotional stability, and intellect/imagination. Extraversion is the tendency to be sociable, outgoing, and positive. Agreeableness describes tendencies to be kind, gentle, trusting and trustworthy, and warm. Conscientiousness individuals are dutiful, orderly, deliberate, and self-disciplined, and has been consistently positively associated with academic success at the high school and college levels [27]. Emotional stability, also referred to as neuroticism, describes the tendency to show poor emotional adjustment in the form of stress, anxiety, and depression, and has alternatively been positively and negatively associated with student academic performance [27]-[28]. Intellect/imagination describes an individual's tendency to be creative, flexible, curious, and unconventional. The Big Five have been associated with student motivation [29]-[30]. For example, conscientiousness has been associated with both intrinsic and extrinsic motivation, and agreeableness has been negatively associated with disengagement from learning (i.e., work avoid).

Methods

The quantitative analysis entails a secondary data analysis of three latent constructs (goal orientation, agency, and motivation) to examine the relationships between the constructs and the direction, strength and potential mediation of these relationships. Additionally, this study examined differences in constructs across academic years and if personality influenced these relationships.

Instrument

The survey used to collect data for this study consisted of 86 items across four constructs, each with several sub-constructs. For purposes of this research, the constructs of goal orientation, agency, and future-oriented motivation will be analyzed to answer the project's research questions. The original survey was created to examine student identities and cultures in engineering [14] and validated using a nationally representative sample of first-year engineering students [15] [31]. Further tests to develop validity and reliability evidence were completed on a similar student engineering population as for this study [32].

Goal Orientation

Questions in this construct focused on what engineering students wanted to get out of their engineering courses. Items were grouped into three sub-constructs adapted from Shell and Husman [18]. These items were originally created by Schraw et al., [33] and were adapted to be measured using a scale originally developed by Dweck and Leggett [34]. Survey items spanning the goal orientation constructs asked students to "Use the scale given (5-point Likert-type) to rate

how important achieving each of the following is to you in this class from "Very Unimportant to Very Important" followed by statements such as those found in Table 1. The goal orientation scale consisted of 13 items and reliability analysis indicated a Cronbach's Alpha ($\alpha = .76$) with acceptable internal consistency [35].

Agency

Items in this construct focused on explaining students' science agency and engineering agency, previously used with undergraduate engineering students [14], [32]. The agency scale consisted of 10 items and reliability analysis indicated a Cronbach's Alpha ($\alpha = .895$), demonstrating very good internal consistency [35].

Future-Oriented Motivation

Questions within this construct, drawing from FTP and EVT frameworks, were arranged in five sub constructs: perceptions of the future, perceived instrumentality, future on present, expectancy and connectedness [14], [32]. The future-oriented motivation scale consisted of 13 items and reliability analysis indicted a Cronbach's Alpha ($\alpha = .813$) demonstrating good internal consistency [35].

Big Five Personality Traits

These five constructs are considered robust indictors of psychological traits present in students [10]. Items are grouped around the personality traits of extraversion, agreeableness, conscientiousness, emotional stability, and intellect/imagination. Each construct consisted of 10 items except emotional stability which had nine. A tenth item was added to emotional stability but was not included in this analysis. Reliability analysis for each personality trait demonstrated Cronbach's Alpha's that ranged from acceptable to very good ($\alpha = .79$-$.899$) indicating reliable internal consistency [35].

Data Collection and Population

The context for this study is a Research One (research-intensive) land grant public institution in the southeastern United States. The survey was administered every semester to students enrolled in one of three civil engineering course-based labs that were required for all students in the major; all students were majoring in civil engineering. Students were asked to identify the course in which they were given the survey, which corresponded to the academic level of the student (sophomore, junior, or senior). Distribution of the survey occurred each semester over three academic years for a total of five times between Fall 2017 and Fall 2019. Students were informed of the study and were recruited to participate through their course instructor, who provided a link to the survey on the course management system (Canvas). Individuals from the research team also visited each section of every course to inform students about the study and encourage them to participate. All recruitment and data collection procedures followed an IRB-approved human subject protocol. The final sample included 762 respondents; demographic information is presented in Table 2 below.

Table 1

Sample item from Survey

Construct	Item Language
Goal Orientation	Getting a better grade than other students in this class
	Knowing more than I did previously about these course topics
Future-oriented Motivation	Engineering is the most rewarding future career I can imagine for myself
	I want to be an engineer
Agency	Learning science has made me more critical in general
	Engineering can improve our society
Personality, Big Five	
Extraversion	Am the life of the party
Agreeableness	Sympathize with others' feelings
Conscientiousness	Am always prepared
Emotional Stability	Get stressed out easily*
Intellect/Imagination	Have a vivid imagination

**Reverse coded*

Table 2

Sample demographic information

Race/Ethnicity	n = 762	Gender	n = 762
White	85%	Male	78%
Black or AA[a]	5%	Female	22%
Asian	3%		
>1 Race	6%		

[a] AA: African American

Data Screening/Cleaning

The original sample size of respondents was 843, however data screening revealed 65 cases (7.7%) as missing, resulting in a sample size of 778 cases, representing 92.3% of the original data. With a total enrollment of 1020 students over the five semesters, our original response rate was 82.6%. However, when we accounted for missing data the response rate fell to 76.3%. Of the total enrollment, 404 were sophomores, 344 were juniors, and 272 were seniors. A breakdown of response rates by academic year are 81.2%, 85.5%, and 57.4%, respectively. The threshold for a case being counted as missing was respondents failing to answer an entire single

construct or demographic variable on the instrument (i.e., listwise deletion). Partial answers to constructs were analyzed using a maximum likelihood estimator. Initial descriptive statistical analysis was conducted and used to test normality of data. Dependent variables and hypothesized covariates showed significant *p*-values ($p>.05$) on Shapiro-Wilk test of normality (refer to Table 3). This indicated violations of normality in the data; however, large samples are sensitive to violations of normality (Azen & Walker, 2011; Pituch & Stevens, 2016). As a result, visual inspections of histograms and normality Q-Q plots indicated acceptable normality in the data [36]-[37].

Table 3

Test of normality of data for each survey construct

	Shapiro-Wilk		
	Statistic	df	Sig.
Motivation	.978	762	.000
Goal Orientation	.994	762	.006
Agency	.957	762	.000
Extraversion	.994	762	.002
Agreeableness	.990	762	.000
Conscientiousness	.992	762	.001
Emotional Stability	.994	762	.003
Intellect	.993	762	.001

Statistical Analysis

Statistical analysis for this study was carried out in three steps to answer each of the research questions. For RQ1, a bivariate correlational analysis was conducted (Field, 2009). Results from this analysis let to the answering RQ2 and RQ3 using a series of statistical modeling methods. First, a Multivariate Analysis of Variance (MANOVA) test was conducted to answer RQ2. Those results served as a baseline model for a Multivariate Analysis of Covariance (MANCOVA) test to answer RQ3. These tests were chosen because they powerful tests and are robust to violations of normality [35], [37]. MANOVAs are a useful way of examining group differences among multiple independent and dependent variables. MANCOVAs are used to give an adjusted mean for each group based on the covariate(s) to detect differences (i.e., examining whether there would still be a difference if the covariate was the same for each group). Pituch & Stevens [37] argue that this type of statistical modeling gives a clearer picture of differences between groups than other statistical models. Moreover, effect sizes of the independent variables and covariates can be estimated to give an indication of the magnitude of influence those variables have on the dependent variables [35], [37].

Results

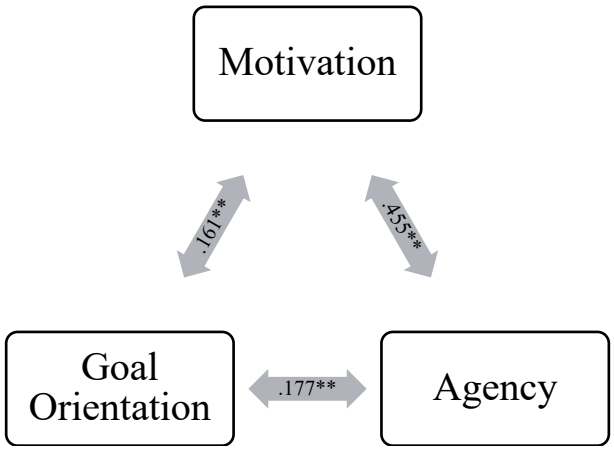
Three research questions guided the design of this study:

RQ1. What is the relationship between goal orientation, agency, and future-oriented motivation?
RQ2. How does this relationship differ across academic years?
RQ3. Do the Big Five personality traits influence this relationship?

The study design included three continuous dependent, or outcome, variables: motivation (framed as future-oriented motivation), goal orientation, and agency; and two categorical independent variables, or fixed factors: academic year and semester of survey distribution. Finally, the Big Five personality traits [10] were used as hypothesized covariates.

RQ1: Bivariate Correlational Analysis

Results from the bivariate correlational analysis using Pearson correlation indicated significant (p<.05) positive correlations between the three variables. However, the strongest correlation was between motivation and agency (r=.455, p<.001). Figure 1 represents the relationship between goal orientation, agency, and future-oriented motivation to address RQ1.



Note: **p<.001
Figure 1: *Correlation between constructs based on results of a bivariate correlational analysis.*

Statistical Modeling

RQ2: Differences Between Motivation, Agency, and Goal Orientation Across Academic Years. To address RQ 2, a 2X3 MANOVA was conducted with future-oriented motivation, goal orientation, and agency as the dependent variables. Academic year and semester the survey was taken were used as categorical independent variables. Table 4 displays descriptive statistics by academic year. Scores are nested within academic year; therefore, mean

scores represent the group mean. MANOVA assumption of equality of covariance matrices was failed due to a significant Box's test (*Box's M* = 14.590*, F(6, 2990942.5)* = 2.421*, p*=.024). MANOVAs are robust to this type of violation [37], but with unequal group sizes, the more conservative Pillai's Trace statistic was used [35]-[37]. Initial MANOVA resulted in a multivariate main effect (*p = .003*) for academic year but not for the semester the survey was taken. Therefore, for parsimony, the semester variable was removed from the MANOVA. The more parsimonious MANOVA showed a significant multivariate main effect (*Pillai's Trace* = .024*, F(4)* = 4.777*, p* = .001).

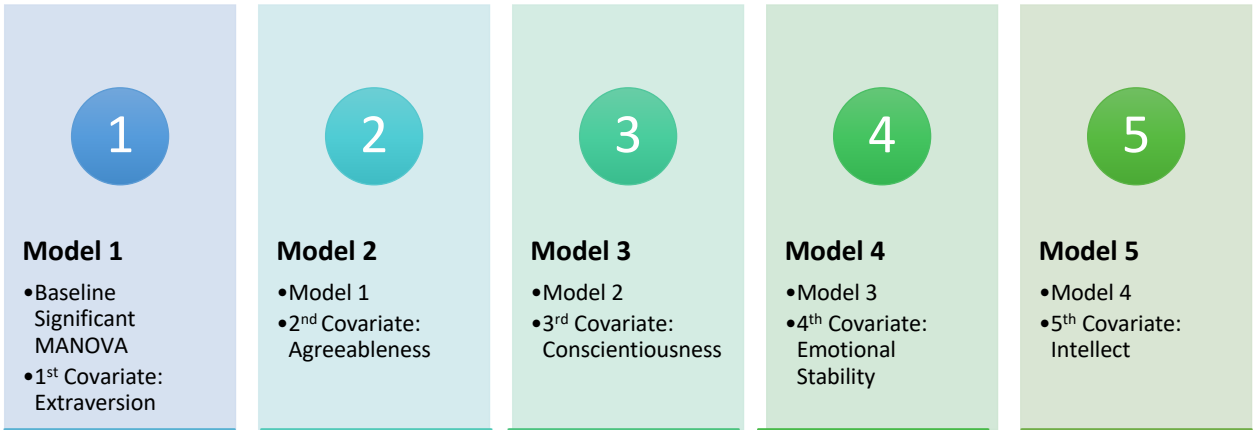
Table 4

Descriptive Statistics for 2X3 MANOVA in RQ2

	Academic Year	Mean	Std. Deviation	n
Motivation	Sophomore	5.0940	.84	328
	Junior	5.1944	.78	294
	Senior	5.3772	.89	156
	Total	5.1887	.83	778
Agency	Sophomore	5.8476	.87	328
	Junior	5.8741	.77	294
	Senior	5.7974	.82	156
	Total	5.8476	.82	778

A univariate effect for academic year was held for motivation (*F(2) = 6.189 p* = .002). The assumption of equality of error variances was met. Levene's test indicated a non-significant statistic for dependent variables ($p > .05$). Post-hoc test with a Bonferroni adjustment indicated a significant difference in future-oriented motivation scores between seniors and sophomores (Δ = .2832*, p* = .003). MANOVA results indicated motivation was higher for seniors than for sophomores. No significant differences were found between juniors and seniors or sophomores and juniors. This suggests that the further students go in the program, the stronger their future-oriented motivation. This final model served as the baseline model for exploring RQ3.

MANCOVA Nested-Modeling. Because there are five hypothesized covariates being used in the analysis, a form of nested modeling was conducted. This allowed for the covariates to enter the analysis one by one and a full versus reduced model test was completed to determine model fit [36]. When an additional variable is added to a model, the previous model becomes nested within the larger model. The full versus reduced model test allows us to calculate a *F*-statistic with an associated *p*-value to determine if the reduction in error, for each dependent variable, was significant. The process is similar to the R^2 change test used in regression analysis.



RQ3: Influence of personality type on relationships between motivation, agency, and goal orientation. To answer RQ3, a series of nested MANCOVAs were conducted, with each personality type added one at a time as covariates to the final model found in RQ2. Covariates were added in the order in which they appeared in the survey. Goal orientation and agency were not significant in the baseline model, however when the first covariate was added, agency became significant in the model. However, goal orientation remained nonsignificant. This coupled with the finding that goal orientation had a significant but weak correlation to both future-oriented motivation and agency informed our decision to remove goal orientation from the baseline MANOVA model.

The first MANCOVA included the baseline MANOVA and the covariate extraversion. Model one became nested within the more complex model two, which added agreeableness, the second covariate and so on until all five of the personality constructs were estimated. After each covariate was added, a test of full versus reduced model fit was done. The full versus reduced model fit test examines the change in error between the full model and nested model and produces a F-statistic with an associated p-value. These tests resulted in a total of five models (one for each covariate) being compared. The fifth model—all five personality types as covariates—provided the best fit (refer to Figure 2). Model fit F-test values were significant for future-oriented motivation ($F(1, 754) = 4.948$, $p = .03$) and agency ($F(1, 754) = 43.194$,

Figure 2: *Diagram of nested models for MANCOVA.*

$p<.001$).

Following the pattern from analysis in RQ2, Pillai's Trace was the multivariate statistic used because Box's M test was failed. However, the additional assumption of a MANCOVA, homogeneity of regressions slopes, was met. No significant interaction was found between academic year and each covariate. The full MANCOVA had a multivariate main effect for all five covariates ($p < .001$) and academic year ($p = .006$). Univariate tests results showed all covariates significantly influenced motivation. Moreover, parameter estimates showed extraversion had a small, negative effect on scores, while the other four personality types saw a small to medium positive effect on motivation. For agency beliefs, extraversion and emotional stability did not significantly influence scores. However, the other three personality types saw

medium to large, positive effects on agency scores. Table 5 displays the *p*-value and eta-squared (η^2) for each covariate on each dependent variable. Eta-squared in the analysis of variance framework gives an indication of the magnitude of difference found between independent and dependent variables (Azen & Walker, 2011; Pituch & Stevens, 2016).

Table 5

Covariate significance and effect size of Model 5 MANCOVA for RQ3

	Dependent Variable	Significance	η^2
Extraversion	Motivation	*p<.001*	.02
	Agency	*p=.211*	-
Agreeableness	Motivation	*p<.001*	.02
	Agency	*p<.001*	.05
Conscientiousness	Motivation	*p<.001*	.03
	Agency	*p<.001*	.03
Emotional Stability	Motivation	*p<.001*	.01
	Agency	*p=.357*	-
Intellect	Motivation	*p=.026*	.01
	Agency	*p<.001*	.04

Discussion

The primary aim of this study was to better understand the psychological and cognitive processes of engineering undergraduate students. The relationships between future-oriented motivation, goal orientation, and agency were examined, looking also for changes across academic years, and determining if personality type influenced these relationships. Results indicated a significantly strong positive correlation between future-oriented motivation and agency. Additionally, a significantly weak correlation was found between future-oriented motivation and goal orientation as well as agency and goal orientation. Moreover, goal orientation was not significant in any statistical models. One explanation for this surprising finding is the lack of academic achievement constructs included in this study, as literature suggests goal orientation and academic achievement work in concert [23]-[25]. However, the use of future-oriented motivation through a future-time perspective framework [11] may have also contributed to this lack of significance, as it may have masked the effects of goal orientation in the model. Future research on the crossover between future-time perspective and goal orientation is needed.

Future-oriented motivation significantly differed for sophomores and seniors, with seniors seeing higher future-oriented motivation scores. While no significant differences were found between juniors and seniors after the multiple comparison adjustment, one was found without the adjustment. There is argument in the literature [37] that the powerfully conservative

nature of the MANOVA already protects against type I and II errors, therefore an adjustment should not have to be made if the multivariate model is significant. Taking that into consideration, there may be a significant difference between juniors and seniors. These findings suggest that as students advance in programs, their future-oriented motivation increases. These findings align and extend other studies that found increases in motivation between the first two years using data from gateway courses (see [3], [38]). This finding is important for engineering education for a few reasons. First, research has indicated that a leading cause of students leaving engineering majors is related to a loss of motivation [3], [38]. Second, results in this study were found when a specific department was undergoing cultural and curriculum change. These findings suggest that as students experience cultural change, they are more motivated to progress in engineering. Further analysis is needed to confirm this suggestion.

Perhaps the most significant findings came from the results in answering RQ3. Results found that the Big Five personality traits significantly influenced motivation and agency, albeit in slightly different ways. In context, future-oriented motivation is the perspective one has on their future and to what extent that perspective affects their perceptions of tasks in the present. This study used the sub-constructs of perceptions of future, perceived instrumentality, and future on present in this analysis. Although these results suggest that as students are more externally engaged with the world, their future-oriented motivation decreases, the effect size is small and in combination with other personality types, the effect of this decrease is likely minimal. The largest effect on future-oriented motivation comes from conscientiousness ($\eta 2 = .03$). People with high conscientiousness scores are more likely to be deliberate and self-disciplined; therefore, it is no surprise that the more deliberate and self-disciplined a person is the larger the effect will be on their future-oriented motivation.

Effect of personality on agency scores paints a different, interesting picture. Agency in this study looked at science and engineering agency through a collective agency lens [19]-[20]. Extraversion and emotional stability did not significantly influence agency scores, suggesting that regardless of how outgoing someone is or how susceptible someone is to negative behaviors does not influence their agency in science or engineering. On the other hand, agreeableness, conscientiousness, and intellect/imagination saw medium to large positive effects on science and engineering agency (refer to Table 4 for multivariate effect sizes). Interestingly, agreeableness had the largest effect size ($\eta^2 = .05$), suggesting that those students who tend to be more harmonious in personality would have a larger increase in science and engineering agency scores than students who have a less harmonious personality.

Overall, results suggest that personality has a stronger influence on agency beliefs than on future-oriented motivation for civil engineering students. This suggests that students with more of an agreeableness, conscientiousness, and intellect type personality are not only motivated to go into this field, but also believe their major will make a difference in the world. Results align some with current literature but shed light on the impact personality has on future-oriented motivation and agency—adding to research, theory, and practice in engineering and more broadly in STEM. Further research is needed to determine if the effects of personality hold true, not only for other civil engineering students, but also other STEM majors. A major

assumption in this research was the understanding that students make meaning through interconnected reciprocal interactions between behavioral, cognitive, and environmental influences that occur within nested ecological systems over time, see [7]-[9], [39]. Therefore, how students respond to survey items is reciprocally influenced by who they are, where they come from, and how they are currently making sense of things. This paper focused on differences in psychological and cognitive constructs and personality influences across academic year. As a result, our analysis did not include individual student demographic information, per se. We understand that these data shape how students respond to items and analysis from that point of view could add substantive voice to the story we told here. While the results would not necessarily change, how we make sense of them and their context certainly would.

Limitations

There are some limitations to this study. First, the quantitative study relied on self-reported student data. Additionally, responses from students came from a civil engineering program that is currently undergoing curriculum change. Repeated measures were not taken into consideration so causality claims cannot be made regarding how changes in the curriculum impacted the variables in the analysis. Future studies will need to analyze data through cohorts to determine causality and directional claims regarding departmental changes. There are also limitations in terms of the transferability and generalizability of these results given that the study was conducted at a single institution. The context of the study is a research-intensive, land grant institution in the southeastern United States, and as such, results cannot be generalized to other types of institutions. The institution is a primarily White institutions (PWI), and there was limited diversity in our study population in terms of race and ethnicity. This limited our ability to take race and ethnicity into account in our analyses. Future work will include expanding the study sample to include more diverse populations of students, and other disciplinary contexts.

Future Directions

The bioecological systems theory [9], [40] explains human development through various, nested, ecological levels. Within this theory exists a conceptual model that allows researchers to simultaneously examine the impact of developmental systems on individuals. The process-person-context-time (PPCT) model describes the interactive nature of human development. Proximal processes are controlled by the interactions of person, context, and time allowing researchers to see the "form, power, content, and direction of proximal processes" [9, p. 6]. Future research would benefit from analyzing results through a bioecological lens to better understand the environmental implications and their relationship to these results. This would allow for a richer understanding of how individuals navigate engineering environments. Moreover, research and practice would benefit from having two additional constructs examined within this model. Sense of belonging has been shown to be a strong indicator and predictor of motivation and agency in post-secondary students [2], [5], [6], [10]. Furthermore, academic achievement has been shown to be impacted by motivation and agency [2], [4], [6], [16], [38], [41]. Future research should examine how these relationships change in relation to one another as a more complex model is analyzed. Finally, future studies should extend beyond civil engineering into other areas of STEM at the post-secondary level.

Conclusion

This study aimed to determine the relationships between goal orientation, agency, and future-oriented motivation. Furthermore, it looked to see if these relationships differed across academic years and if personality type influenced these relationships. All three constructs (goal orientation, agency, and future-oriented motivation) were found to be significantly correlated with one another, with the correlation between future-oriented motivation and agency being the strongest. Results also indicated that future-oriented motivation differed between sophomores and seniors with seniors have higher scores, suggesting future-oriented motivation increases as time in program increases. This could also be due to the students who have strong perceptions of their future in the discipline are the ones who remain in the program through to senior year. Personality significantly influenced these relationships in different ways but had the strongest effect on agency. The Big Five personality traits that had the strongest influence on agency were agreeableness, intellect/imagination, and conscientiousness, with agreeableness having the strongest effect.

These findings have implications for how engineering departments interact with students as they are making cultural and curricular changes to their programs. For example, with the understanding that future-oriented motivation increases with time in the program, instructors can help students build positive perceptions of their future careers in the discipline in their first years, providing a variety of career pathways and options. More importantly, however, is that results provide a deeper understanding into the minds and personas of undergraduate engineering students. Knowing that students' varying personality types are correlated with their motivation and sense of agency can help instructors, advisors and administrators leverage students' strengths, such as their sense that they can effect change in the world through their academic pursuits in science and engineering, to help them succeed academically.

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