Belonging in Engineering

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Robert is a doctoral student in the learning sciences program a Clemson University. His research focus is on examining the relationship between sense of belonging and the learning/achievement process for undergraduate students and how factors influence this relationship. Prior to starting the Learning Sciences program, Robert, worked as a student affairs professional in higher education focusing on residential curriculum, social justice advocacy and awareness, and Intergroup Dialogue.

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Dr. Jennifer Ogle is a Professor in the Glenn Department of Civil Engineering at Clemson University, and a 2005 graduate of the Department of Civil and Environmental Engineering at Georgia Tech. Her research portfolio focuses on transportation infrastructure design, safety, accessibility, and management. She is currently the facilitator for the NSF Revolutionizing Engineering and Computer Science Departments (RED) grant at Clemson, and is leading three transformation efforts related to culture, curriculum, and community to achieve adaptability, innovation, and shared vision. Alongside her research, Dr. Ogle has been active in the development of engaged learning and has led two interdisciplinary undergraduate translational research and education courses - Clemson Engineers for Developing Countries (CEDC) and Clemson Engage. Both courses include trips to developing countries, international internships and significant fund-raising to support projects with community partners. As a result of her efforts, the CEDC program grew from 25 students to over 100 from 30 different departments and was recognized by the Institute for International Education (IIE) with the Andrew Heiskell Award. As a first generation student, and the first tenured female in her department, Dr. Ogle is an advocate for improving inclusion and diversity in Civil Engineering. In 2012, she was recognized by President Obama as a Champion of Change for Women in STEM. She continues to serve the university in diversity-enhancement programs including serving as the Chair of the President's Commission on Women and as a member of the ADA Commission.

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To Be(long), or Not To Be(long):
Factors Predicting Students' Sense of Belonging in Engineering

Abstract

When examining factors affecting student academic success, it is important to consider how these factors interact with one another. Students' affective attributes are complex in nature; thus, research methods and analyses should holistically examine how these attributes interact, not simply as a set of distinct constructs. Prior research into engineering students' affective attributes, in which we used a validated survey to assess student motivation, identity, goal orientation, sense of belonging, career outcome expectations, grit and personality traits, demonstrated a positive correlation between perceptions of belongingness in engineering and time spent in the program. Other prior research has examined interactions between affective attributes, for example engineering identity as a predictor of grit (consistency of interest). However, more work is needed to examine the complex relationships between sense of belonging, engineering identity, future career outcome expectations and motivation, particularly for students in an engineering program undergoing curricular change. This paper describes a confirmatory factor analysis and structural equation model to examine how engineering identity, career outcome expectations, and time-oriented motivation (specifically, students' future time perspectives, or FTP) impact their sense of belonging in engineering, with grit (consistency of interest) as a moderator of these relationships.

To conduct these analyses, we used survey data collected over two years from sophomores, juniors, and seniors enrolled in an undergraduate civil engineering program (2017-18, $n=358$; 2018-19, $n=556$). Based on descriptive statistics and initial statistical comparisons, we confirmed our prior findings that students' sense of belonging at the course level increased with time in the program (from sophomore to senior year), and that engineering identity increased with time in the program as well. In addition, we observed that seniors had higher perceived instrumentality, a sub-construct of FTP indicating their perceived usefulness of their courses in reaching their future goals, than sophomores and juniors. We found that course belongingness and FTP have the strongest influence on belongingness compared to other affective attributes we assessed. When identity and motivation were factored in, career outcome expectations were not influential to engineering belongingness. Finally, we found that time-oriented motivation (FTP) was also a mediator of this relationship through its influence on grit (consistency of interest).

Introduction

This research paper reports on part of a larger project examining engineering students' experiences in a civil engineering department at a large, land grant institution in the southeastern U.S. that is developing a culture of inclusion, shared vision, adaptability and innovation. The department-wide project has three overarching goals to achieve the project outcomes: curricular, cultural and community transformations, each underpinned by the goal of increased diversity. Curricular transformations are being realized through new courses, such as a sophomore-level project-based course that provides the foundation for successful teamwork, professional ethics,

design processes, and professional formation as a civil engineer. Project materials for this course are provided by industry partners (e.g., data, plans, construction estimates, stakeholder input and feedback), which are being developed into project case studies that can be integrated horizontally and vertically into coursework to showcase how a component analysis fits within a larger system. (See related paper being presented at this conference [1].) Cultural transformation includes flexible departmental structures, for example replacing the current structure of organizing faculty around sub-disciplines and instead organizing around specific problems facing the department such as critical resource constraints and curricular demands. Community transformation is being realized through annual gatherings, called Discomfort Zones, of faculty, administrators and social scientists to confront persistent challenges, seek change, and evaluate the feasibility of transferring the proposed academic change framework to other engineering departments. To increase diversity and address student needs, a department-wide peer-mentoring program has been established that pairs incoming sophomore and transfer students with junior and senior civil engineering students. Mentors receive leadership and mentoring training through courses and workshops; they meet with groups of mentees informally outside of classes and laboratories. (See related paper being presented at this conference [2].)

As this larger project progresses (we are in Year 3 of a five-year project), students have varying levels of awareness of the curricular, cultural and community transformations taking place in their major. We anticipate that over time, students' motivation and attitudes towards teamwork, projects, their major, communication among and between students and faculty, and sense of community and belongingness will change as their experiences with the various elements of the departmental transformation become more prevalent. This research paper describes a survey instrument, the Motivation and Attitudes in Engineering (MAE) survey we have developed and are using to assess student motivation and attitudes, and to track changes in these affective factors over time. The MAE survey includes questions about gender, race/ethnicity, and other personal characteristics to allow us to track changes in the diversity of students in the program over time. We first describe the theory that supports the design of our study and the MAE survey, then describe the survey itself and how the data were collected and analyzed. The results for this study include a confirmatory factor analysis (CFA) and structural equation model (SEM) that demonstrate the latent variables and relationships between those variables. Finally, we will discuss the implications of the changes we observed in the different attitudinal factors, and relationships between those factors. This work contributes to the literature on the complex relationships between sense of belonging and engineering identity, and fills gaps in our understanding of how time-oriented motivation (future time perspective and future career outcome expectations) are related to sense of belonging and engineering identity, particularly for students in an engineering program undergoing curricular change.

Background Literature and Theoretical Framework

As the numbers of students pursuing degrees in engineering increases, it is important that educational research explore the experiences of these students. To do this, researchers must identify what drives students to pursue and obtain degrees in engineering. The MAE survey was created to examine undergraduate student identities and cultures in engineering and validated

using a nationally representative sample of engineering students [3]. Theories that relate to the constructs in the survey are discussed below. Each subheading represents a synopsis of the relevant literature used to create survey items for that individual construct. Collectively, this literature serves as the theoretical framework for analyzing and interpreting results from this study.

Community

Students' sense of belonging at different levels – university, engineering major and their courses – is defined as "community" in our survey. Feeling connected, accepted, and validated at an institution and within courses at that institution are crucial to success and persistence of undergraduate students [4]-[7]. Students' sense of belonging in engineering has been shown to affect grit (persistence of effort) and to mediate the relationship between engineering identity and grit (persistence of effort) [8].

Goal Orientation

Research shows the importance of how students approach goal setting in their coursework, particularly in engineering [9]-[11]. Goal orientation focuses on what engineering students want to get out of their engineering courses, and prior research has demonstrated that three of the goal orientation sub-constructs are particularly relevant for engineering students: performance approach, mastery approach and work avoid [12], [13]. Performance approach is conceptualized as a student's tendency to work towards an outward sign of success (i.e. getting a good grade). How students work towards learning and mastering concepts was captured by the mastery approach construct. Work avoid encompasses questions related to a student's preference to do the least amount of work in the shortest time possible.

Motivation: Future Time Perspective

Future Time Perspective (FTP) theory examines time-oriented motivation in terms of how students view themselves and their goals in the future, and how those views interact with their motivation for tasks in the present [14]. Because education is future oriented [14], [15], we focus on students' future time orientation. Future goals affect student motivation to varying degrees and in different ways, which comprise a student's FTP [14], [16], and have been shown to relate to students' academic success. There are many constructs within the FTP framework, and those that are relevant to our work include perceptions of the future, perceived instrumentality, expectancy, value and connectedness. Perceptions of the future for this work is interpreted as students' perceptions of the future in relation to their engineering degree and their desire to be an engineer [17]. Perceived instrumentality is the connection of a present task to one's future goals and is a task-specific, cognitive construct [12], [14]. Expectancy is defined as students' beliefs about competence in a domain and is not necessarily task-specific. Students with higher expectations for success in their courses have significantly higher grade point averages [18]. Value, or valence, within the FTP framework refers to the extent to which a student values thinking about the future [14]. Connectedness refers to the cognitive connections students make between the future and their current activities [12]. Both value of the future [19] and connectedness [12] have been associated with increased student academic performance.

Grit

Taken from the research of Duckworth, Peterson, Matthews, and Kelly [20], grit is defined as "perseverance and passion for long-term goals" (p. 1087). Duckworth et al. described grit as having two constructs: consistency of interest over time and persistence of effort.

Identity

Scores of articles, chapters, and monoliths have sought to explain identity. Researchers since Erikson and Marcia have examined, defined, and redefined identity. However, in recent years issues have risen regarding the conceptualization of identity in educational research: causing some to refer to it as a "buzzword" [21], p. 19. Research in STEM and importantly in engineering have pointed to a lack of conceptualizing what STEM or engineering identity means [22]. Within the survey, identity is looked at through three lenses—physics, math, and engineering identity. Taken together these identity constructs give researchers a sense of how students identify with STEM and engineering identities, and moreover, how strongly they associate with each of those identities.

Agency

Agency describes a student's beliefs in two different constructs: science and engineering. When looked at holistically, these constructs give an indication of how student's belief that their careers in science or engineering can lead them to make a positive impact in the world [23].

Personality

Personality is defined using the "Big 5" personality traits. These personality traits have been shown to be valid and reliable indictors of psychological traits present in students [20]. Questions centered on extraversion, agreeableness, conscientiousness, emotional stability, and intellect. Holistically, these traits are indicators of how a student approach their environments.

Methods

In this research project, we are using the MAE survey, which was previously shown to have validity and reliability with first year engineering students; we extend this work by testing validity with a mid-year and upper-level engineering student population. The following sections discuss the eight constructs of the instrument and their subconstructs. All items are measured using a seven-point Likert-type scale; anchors for each set of constructs vary (i.e. strongly agree to agree, or most to least important). A list of all survey constructs and their descriptions are listed in the Appendix, with the final number of items within each construct resulting from our analysis.

Community

Our measure of community consists of three latent constructs: sense of belonging at the university level (six items), sense of belonging in engineering (12 items), and sense of belonging at the course level (six items). University level items access a student's sense of how they fit in and belong at the institution, for example "I enjoy going to school here." Engineering level items

access the perception of how students feel they fit in and belong in an engineering discipline, for example "I feel I belong in engineering." Course level items access sense of belonging in the course they are currently in while taking the survey—one of three required lab courses (see data collection below) – for example, "I feel accepted in my engineering class."

Goal Orientation

Goal orientation consists of three subconstructs: performance approach (six items), mastery approach (four items), and work avoid (three items). The constructs together aim to understand how students approach work, either setting goals to master the material, to perform well, or to do the least amount of work to get by in a class.

Motivation: Future Time-Perspective

Prior research with mid-year engineering students [24] has shown that five constructs can define engineering students' FTP: perceptions of the future, perceived instrumentality, expectancy, value and connectedness. Perceptions of the future comprises students' attitudes towards their future goals in engineering, for example "I am confident about my choice of major." Perceived instrumentality captures how student's belief about the usefulness of their courses for obtaining future goals, for example "I will use the information I learn in this engineering course in the future." Expectancy, value and connectedness explain what students are expecting from their coursework, the value they place on thinking about the future, and connections they are making between the present and future. Examples items for these constructs include (respectively) "I am certain I can master the skills being taught in this engineering course," "Long range goals are more important than short range goals," and "What one does today will have little impact on what happens ten years from now" (reverse coded). The future on present construct captures beliefs about the impact of the future on the present, for example "My future career influences what I learn in this course."

Career Outcomes

Career outcome expectations were assessed with singular items pertaining to 15 indicators of career expectations. Each item consisted of a stem asking how important the following factors were to the students' future career satisfaction are, ranging from making money to applying math and science. Holistically, these items give a sense of how students' conceptualizations of career expectations are influencing them currently.

Grit

The grit scale consists of two constructs, each with six items: consistency of interest and perseverance of effort [20]. Items provide an indication of how a student in engineering is interested in the area despite other inhibiting or enhancing behaviors experienced by the student.

Identity

The identity construct consists of three scales each measuring an aspect of a student's identity: physics identity (14 items), math identity (14 items), and engineering identity (16 items).

Agency

Agency consists of two subscales, science and engineering, each with five items. Items in the science subscale probe how students feel about the use of science in the future; likewise, engineering agency items probe how students feel about the purpose of engineering.

Personality

The final construct of the survey consists of five scales using the Big 5 personality types [25]. Each scale consists of 10 items and are used as indicators they type of personality a student has. The big-5 personality types are extraversion, agreeableness, conscientiousness, emotional stability (neuroticism), and intellect (openness to experience).

Data Collection & Statistical Analysis

The survey was administered every fall and spring semester starting in fall 2017 through spring 2019. The survey population consists of sophomores, juniors or seniors in one civil engineering department (see Table 1 for demographic information). The survey was administered in the labs of three core courses, one from each program year. Members of the research team visited each lab section of the three courses to introduce the survey and invite students to participate. The survey was administered electronically using Qualtrics software; data were de-identified and totally incomplete responses were removed.

Confirmatory factor analysis (CFA) was used to test the validity of latent constructs and examine the relationship between observed items and latent variable constructs [26]-[28]. Structural equation modeling (SEM) is comprised of two parts: a measurement model and a structural model. Results from the CFA comprise the measurement model of the SEM and the structure model is comprised of a series of multivariate regression models explaining the relationship between observed dependent variables and latent variables called factors [26], [27]. Mplus 8.3 [26] was used to conduct the statistical analysis in this research paper.

Table 1: Participant demographic information

Race/Ethnicity	n = 762	Gender	n = 762
Asian	3%	Female	22%
Black or African American	5%	Male	78%
White	85%		
>1 Race	6%		

Results

Statistical analysis for this study was carried out in two steps: a CFA, and an SEM using CFA results with engineering belongingness as the dependent variable. Because of the varying anchors associated with each seven-point Likert scale, standardized estimates are provided to allow for easier interpretation of data. Descriptive statistics were generated using SPSS statistical packaging for social sciences, version 26 [29]. Those results indicated the assumption of linearity was met and no multivariate outliers were found. However, the assumption of multivariate

normality was not met. Additionally, 9.4% of the data was found to be missing. All missing data was coded as -999 within Mplus to account for missing identification. Due to the presence of missing data and unequal group sizes across academic years, a maximum likelihood robust (MLR) estimator was used in all data analysis. In Mplus, an MLR estimator produces parameter estimates, standard errors, and chi-squared statistics using a sandwich estimator, which are robust to non-normality and non-independence [26]. Using different numbers of data points in the CFA for each construct based on MLR in Mplus allows for maximizing the data available [26].

Confirmatory Factor Analysis

Seven separate CFAs were conducted, one for each construct within the survey. Goodness of fit statistics, factors, and parameter estimates for each construct are listed for each construct. Additionally, items removed from constructs based on model indices produced by Mplus to improve model fit are listed where applicable. All seven constructs produced models that fit the data in their current structure, meaning the theoretical factors used within constructs fit adequately to the data. However, improvement to model fit from model modification indices and review of literature resulted in the removal of 58 items out of the 210 items on the overall survey, resulting in a more succinct instrument. A table listing all constructs, sub-constructs with the numbers of items within each, and construct Cronbach's alpha is shown in the Appendix.

The agency construct was theoretically defined using two subconstructs, science agency and engineering agency. However, based on model indices, the engineering agency item "Engineering allows me to think deeply about problems" was dropped due to lack of variance explained by that item. The goodness of fit tests (n=786) indicated adequate fit of the model to the data, RMSEA = .067 (.055, .079). The final model included two factors, science agency consisting of five items and engineering agency consisting of four items. Lambda coefficients for all variables indicated significant ($p<.05$) factor loadings.

FTP consists of seven factors: six individual factors and a seventh factor (overall FTP, with 30 items, α = .867, comprised of the other six factors). Results from the CFA (n=820) resulted in nine items dropped from the overall FTP construct. Goodness of fit tests indicated adequate fit for the model, RMSEA = .068 (.066, .071). The final model had significant lambda coefficients for all items including the a priori seventh factor consisting of significant loadings from the other six latent factors.

CFA on the goal orientation construct (n=818) resulted in a model with three factors consisting of ten items overall: performance approach, mastery approach, and work avoid. Three items were dropped from the construct and the final model produced adequate fit, RMSEA = .054 (.043, .066).

The grit construct originally consisted of 12 items in two factors, which were confirmed with our CFA (n=789). However, results indicated one item needed to be removed, resulting in 11 items. Goodness of fit tests indicated adequate model fit, RMSEA = .074 (.065, .083). The first factor, consistency of interest, consisted of six items, while the second factor, persistence of effort, consisted of five items.

CFA on personality constructs (n=777) indicated a model with five factors loading onto 41 items. Goodness of fit tests indicated adequate fit of the model, RMSEA = .074 (.027 .077). Model modification indices indicated nine items removed from the original 50 items.

CFA results on the community construct (n=821, resulted in final model of three factors measured by 20 items. Four items were removed due to lack of significance and prevalent theory on belongingness. Goodness of fit tests revealed acceptable fit for the model, RMSEA = .080 (.076, .085).

Results from a CFA on identity constructs resulted in a model that did not provide adequate fit for the data. As a result, the authors re-evaluated the constructs and considered additional literature (see discussion below). This resulted in physics and math identity items being deleted from the survey, leaving 16 items for engineering identity. The overall data were split into two equal datasets, randomly, using SPSS version 26 [29]. One half was used to conduct an exploratory factor analysis (EFA) in Mplus. Using a Geomin oblique rotation, results indicated good model fit for four factors—self-awareness, recognition, interest, and performance / competence—using all 16 items. The four indicated factors were tested with a CFA using the second half of the data and results indicated good model fit aligned with prior research and literature [22].

Structural Equation Model

A major goal of this study was to determine what significant factors influence sense of belonging in undergraduate engineering students. Hypothesized predictors used in the structural equation model (SEM) were time-oriented motivation, engineering identity, university belongingness, belongingness with a major course, and career outcome expectations. The hypothesized SEM model is shown in Figure 1. We performed a SEM analysis using data collected from 839 responses. Items were used from the survey measuring community (belongingness), FTP (*a priori* combined factor), and identity. Circles represent latent variables and rectangles represent observed (measured) variables. Due to the large number of items used in the survey, a correlation table with means and standard deviations is not included in this paper but can be provided upon request. The hypothesized model appears to be a good fit to the data. The RMSEA was .072 (.071, .074) indicating adequate fit [30]. No post-hoc modifications were made because the RMSEA showed adequate fit of the data.

Model results indicated FTP, engineering identity, university and major belongingness significantly predicted (p < .05) engineering belongingness. We hypothesized that when all variables were included in the model, career outcome expectations would have no influence on engineering belongingness. That hypothesis was accepted in our SEM analysis: Career outcome expectations were not significant in the model (p > .05). To test our hypothesis that consistency of interest mediated engineering belongingness through the influence on FTP, we included FTP to be regressed on by consistency of interest. Consistency of interest was found to predict FTP($\beta = .413, p < .001, R^2 = .171$). Additionally, a small significant indirect influence of consistency of interest on engineering belongingness through FTP was found (.047, *p*=.009)

Figure 1 provides a visual of the significant predictor factor loadings on engineering belongingness. An interesting finding, contrary to our hypothesis, was belongingness in course proved to be the most significant predictor of engineering belonging (i.e. largest parameter estimates). Moreover, engineering identity had the least amount of influence on engineering belongingness. It is worth noting that all the predictors had positive influences on engineering belongingness suggesting that unit increases in a predictor increases engineering belongingness. The final model produced an R^2 of .871, suggesting the model produced explains 87.1% of the variability in engineering belongingness.

The question that remained was how the variables that predict engineering belongingness look in relation to one another. Part of the explanation comes from the measurement model of the SEM, or the results of the CFA. By testing factor loadings and creating parsimonious scales, we were able to measure latent constructs effectively using Likert-scale items. The SEM showed the relationship among the variables with the measurement error removed from factor loadings. From model results we were able to determine which latent constructs significantly covaried (or correlated) with one another. Figure 1 lists the standardized correlations between the latent constructs in our structural model. This finding suggests that engineering belongingness consists of an interconnecting web of latent behaviors. The next section of this paper discusses how the findings relate to the literature.
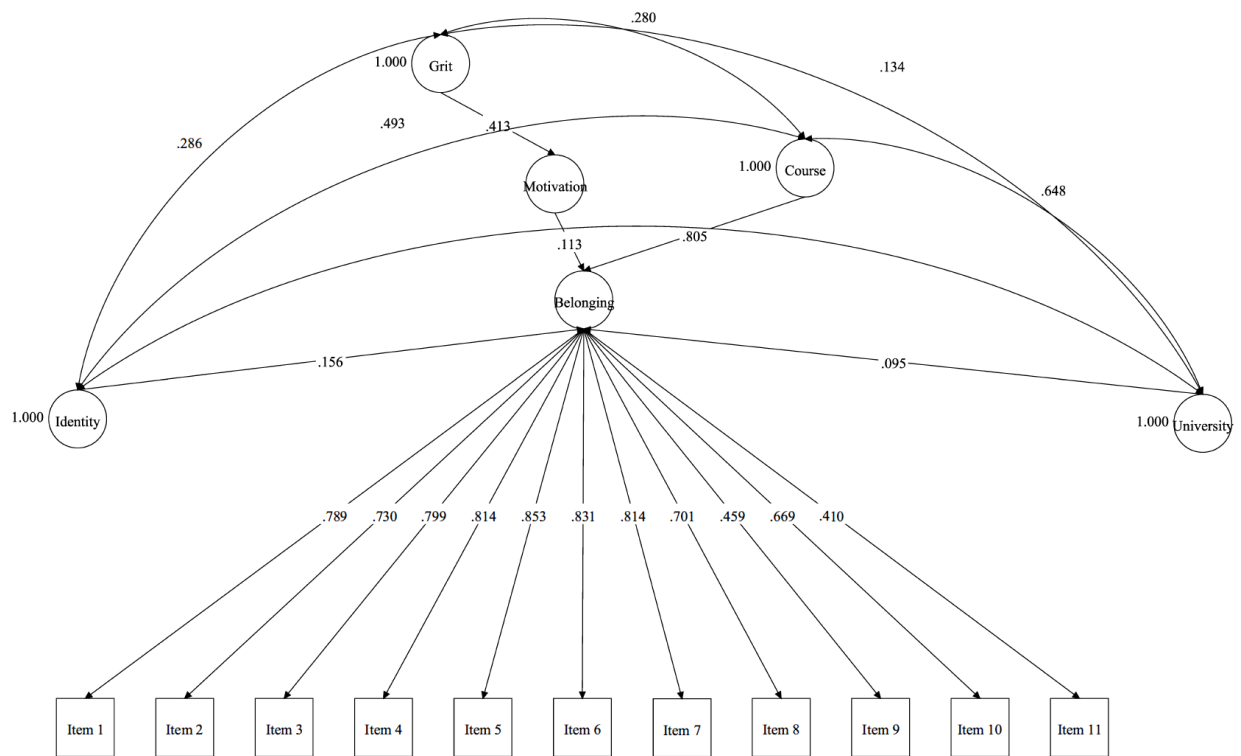

Figure 1: Structural model of factors predicting students' sense of belonging in engineering. "Motivation" = Overall Future Time Perspective (FTP), "Course" = Sense of belonging at the engineering course level; "University" = sense of belonging at the university level; "Belonging" = Sense of belonging in engineering.

Discussion

The goal of this research paper was to describe a survey instrument that assesses student motivation and attitudes in engineering, as well as track changes in those constructs over time for mid-year and upper level civil engineering students. Student attitudes and beliefs are complex in nature and change as students learn and develop, and ultimately affect undergraduate student academic success in a variety of ways. Results from our CFA allowed us to fine tune an existing instrument to better capture latent constructs related to student motivation and attitudes towards engineering. Those results influenced our model of relationships among these constructs, which we developed to help explain how students in a program undergoing cultural and curricular changes are viewing engineering and their place in it.

Our results from the CFAs confirmed the latent constructs within our theoretical framework and provide further construct validity for these constructs with a specific population. For example, Godwin's [22] latent factors for engineering identity were developed and tested with first-year engineering students. Our sample resulted in similar factor results with a population of mid-year and upper-level civil engineering students. These CFA results support the latent constructs in engineering identity for this population. Moreover, we were able to reach a better parsimonious instrument by removing items that were highly correlated with other items or that could not explain any additional variance within our constructs. In general, more finely tuned instruments result in higher completion rates, which in turn allow researchers to gain a stronger, clearer picture of what they are trying to measure.

In recent engineering education research, socially constructed attributes such as motivation, identity and belongingness that affect student learning and behaviors allow us to understand important issues such as learning – both inside and outside the classroom – and persistence and retention of students in engineering programs [31]. Our SEM accounts for more than 85% of the variance in engineering belongingness. Research has indicated belongingness as a significant predictor of persistence, retention, and achievement in STEM related fields [5]-[6]. However, even more important than accounting for the majority of variance in engineering belongingness, we were able to determine that for engineering students, their sense of belonging at the course and departmental levels involve a complex network of interrelated latent constructs.

Perhaps the most important finding in our research was the impact that belongingness at the course level, a latent construct comprising items asking how connected students feel in their engineering class, had on overall engineering belongingness. With a standardized factor loading of .805, course belongingness was the overwhelmingly largest contributor to overall engineering belongingness. This indicates that faculty play a crucial role in facilitating engineering belongingness in undergraduate students. Faculty set the environment in a course; one that is open and accepting of all types of students is one that can create a space where students feel welcomed, accepted, and that they belong [32]. Additionally, environment plays a vital role in student development and learning, further underscoring the need for faculty to give more attention to course environments particularly when diverse students are present [33].

Future Work

Our results confirmed certain latent constructs for mid-year and upper-class civil engineering students. Ongoing work is examining individual FTP constructs (perceptions of the future, perceived instrumentality, expectancy, value and connectedness) in addition to the overall FTP construct. Accepted research practice acknowledges the influence of a specific population on CFA results [34]. As such, future work should focus on expanding beyond civil engineering to other types of engineering students and possibly other STEM students as well. Would our SEM still hold for all types of engineering students—or STEM undergraduates in general? Additionally, further research should examine specific environmental factors within a course that enhance or inhibit course belongingness for engineering students.

Conclusions

This study focused on performing a CFA and SEM on survey data collected over six semesters from engineering students (sophomores, juniors and seniors) in a civil engineering program using the Motivation and Attitudes in Engineering survey. Our goal was to examine the relationships between affective factors known to influence students' academic success and students' sense of belongingness in engineering for students in a department undergoing cultural and curricular change. Specifically, we wanted to better understand how engineering identity, motivation, career outcome expectations, and grit influenced engineering belongingness in undergraduate civil engineering students. Results indicated engineering identity, university belongingness, time-oriented motivation, and belongingness in major courses significantly predicted engineering belongingness. Additionally, we found that consistency of interest mediated this relationship through the influence it has on time-oriented motivation. Our work contributes to the literature in engineering education by providing an in-depth look at the interconnectedness of latent constructs influencing undergraduate students. Moreover, it provides avenues to explore more fully how environments, particularly classroom environments, strongly influence how connected undergraduate students feel towards their major.

Furthermore, our findings underscore the importance of inclusive and equitable pedagogical methods for our undergraduate courses – particularly those in the entry-level sophomore year. The research team members have been working closely with student accessibility, access, equity, and multicultural offices to bring inclusive educational programming to the faculty through the departmental culture transformation. With the value of "inclusive community" driving the cultural adaptation, these findings strengthen the need for these activities and will hopefully provide metrics of positive movement as the transformation is institutionalized.

Acknowledgements

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Appendix

Motivation and Attitudes in Engineering (MAE) survey constructs used in the SEM analysis, including sub-constructs, descriptions, and final number of items within each sub-construct.

Construct	Sub-Construct	Description	# of items	Cronbach's Alpha
Sense of community (Belongingness)	Sense of Community - University	Sense of fit, community and belonging at the university	5	.843
	Sense of Community - Engineering	Sense of fit, community and belonging in engineering	10	.930
	Sense of Community - Course	Sense of fit, community and belonging in their course	5	.891
Goal Orientation	Performance Approach	Tendency to work toward outward indicators of success, such as grades	4	.917
	Mastery Approach	Tendency to work towards learning and understanding	3	.906
	Work Avoid	Preference for working on academic tasks that can be completed in a short amount of time	3	.923
Time-oriented motivation	Perceptions of Future	Perceptions of their future in engineering	5	.844
	Perceived Instrumentality	Perceptions of how useful their courses are for reaching their future goals in engineering	4	.785
	Expectancy	Expectations of success in their courses	6	.916
	Value (Valence)	Value placed on thinking about the future	6	.793
	Connectedness	Tendency to make cognitive connections between the present and the future	7	.802
Career Outcome Expectations	Making money	Importance of _____ for future career satisfaction	1 item per sub-construct	No alpha needed. Single item construct
	Becoming well known			
	Helping others			
	Supervising others			
	Having job security and opportunity			
	Working with people			
	Inventing/designing things			
	Developing new knowledge and skills			
Grit	Persistence of effort	Tendency to persevere through challenges on tasks	5	.710
	Consistency of interest	Tendency for interests to remain unchanged over time	6	.827

Identity	Engineering Identity	Students' perceptions of themselves as an "engineer"	16	.936
Agency	Science Agency	Student's perception of their ability to change their world through science	5	.899
	Engineering Agency	Student's beliefs about how a career in engineering could make a positive impact in the world	3	.882
"Big 5" Personality Traits	Extraversion	Tendency to be sociable, outgoing, and positive	10	.900
	Agreeableness	Tendency to be kind, gentle, trusting, trustworthy, and warm	10	.837
	Conscientiousness	Ways in which individuals are dutiful, orderly, deliberate, and self-disciplined	9	.815
	Emotional Stability (Neuroticism)	Tendency to show poor emotional adjustment in the form of stress, anxiety, and depression	8	.874
	Intellect/Imagination (Openness to Experience)	Tendency to be creative, flexible, curious, and unconventional	7	.729