2018 ASEE Annual Conference & Exposition, June 24–27, 2018, Salt Palace Convention Center, Salt Lake City, UT

Paper ID #21724

Validity Evidence for the SUCCESS Survey: Measuring Non-Cognitive and Affective Traits of Engineering and Computing Students

Mr. Matthew Scheidt, Purdue University, West Lafayette

Matthew Scheidt is a Ph.D. student in Engineering Education at Purdue University. He graduated from Purdue University with a B.S. in Mechanical Engineering, and The Ohio State University with a M.S. in Mechanical Engineering with a focus in Ultrasonic Additive Manufacturing. Matt is currently part of Dr. Allison Godwin's STRIDE (Shaping Transformative Research on Identity and Diversity in Engineering) research group at Purdue.

Dr. Allison Godwin, Purdue University, West Lafayette (College of Engineering)

Allison Godwin, Ph.D. is an Assistant Professor of Engineering Education at Purdue University. Her research focuses what factors influence diverse students to choose engineering and stay in engineering through their careers and how different experiences within the practice and culture of engineering foster or hinder belongingness and identity development. Dr. Godwin graduated from Clemson University with a B.S. in Chemical Engineering and Ph.D. in Engineering and Science Education. Her research earned her a National Science Foundation CAREER Award focused on characterizing latent diversity, which includes diverse attitudes, mindsets, and approaches to learning, to understand engineering students' identity development. She is the recipient of a 2014 American Society for Engineering Education (ASEE) Educational Research and Methods Division Apprentice Faculty Grant. She has also been recognized for the synergy of research and teaching as an invited participant of the 2016 National Academy of Engineering Frontiers of Engineering Education Symposium and 2016 New Faculty Fellow for the Frontiers in Engineering Education Annual Conference. She also was an NSF Graduate Research Fellow for her work on female empowerment in engineering which won the National Association for Research in Science Teaching 2015 Outstanding Doctoral Research Award.

Mr. Ryan R. Senkpeil, Purdue University, West Lafayette (College of Engineering)

Ryan Senkpeil is a Ph.D. student in Engineering Education at Purdue University who's research is focused on non-cognitive factors that impact engineering student performance and developing interventions to improve students' non-cognitive factors.

Ms. Julianna Sun Ge, Purdue University, West Lafayette (College of Engineering)

Julianna Ge is a Ph.D. student in the School of Engineering Education at Purdue University. At Purdue, she created and currently teaches a novel course for undergraduate engineering students to explore the intersections of wellbeing, leadership, diversity and inclusion. As an NSF Graduate Research Fellow, her research interests intersect the fields of engineering education, positive psychology, and human development to understand diversity, inclusion, and success for undergraduate engineering students. Prior to Purdue, she received dual bachelor's degrees in Industrial Engineering and Human Development and Family Studies from the University of Illinois at Urbana-Champaign. Her prior work experiences include product management, consulting, tutoring, marketing, and information technology.

Dr. John Chen P.E., California Polytechnic State University, San Luis Obispo

John Chen is a professor of mechanical engineering. His interests in engineering education include conceptual learning, conceptual change, student autonomy and motivation, and lifelong learning skills and behaviors.

Dr. Brian P. Self, California Polytechnic State University, San Luis Obispo

Brian Self obtained his B.S. and M.S. degrees in Engineering Mechanics from Virginia Tech, and his Ph.D. in Bioengineering from the University of Utah. He worked in the Air Force Research Laboratories before teaching at the U.S. Air Force Academy for seven years. Brian has taught in the Mechanical Engineering

Department at Cal Poly, San Luis Obispo since 2006. During the 2011-2012 academic year he participated in a professor exchange, teaching at the Munich University of Applied Sciences, and during Fall 2017 he taught at the Karlsruhe University of Applied Sciences. His engineering education interests include collaborating on the Dynamics Concept Inventory, developing model-eliciting activities in mechanical engineering courses, inquiry-based learning in mechanics, and design projects to help promote adapted physical activities. Other professional interests include aviation physiology and biomechanics.

Dr. James M. Widmann, California Polytechnic State University, San Luis Obispo

Jim Widmann is a professor of mechanical engineering at California Polytechnic State University, San Luis Obispo. He received his Ph.D. in 1994 from Stanford University and has served as a Fulbright Scholar at Kathmandu University it Nepal. At Cal Poly, he teaches an Interdisciplinary senior project class and teaches mechanics and design courses. He also conducts research in the areas of creative design, machine design, fluid power control, and engineering education.

Dr. Edward J. Berger, Purdue University, West Lafayette (College of Engineering)

Edward Berger is an Associate Professor of Engineering Education and Mechanical Engineering at Purdue University, joining Purdue in August 2014. He has been teaching mechanics for over 20 years, and has worked extensively on the integration and assessment of specific technology interventions in mechanics classes. He was one of the co-leaders in 2013-2014 of the ASEE Virtual Community of Practice (VCP) for mechanics educators across the country. His current research focuses on student problem-solving processes and use of worked examples, change models and evidence-based teaching practices in engineering curricula, and the role of non-cognitive and affective factors in student academic outcomes and overall success.

Validity Evidence for the SUCCESS Survey: Measuring Non-Cognitive and Affective Traits of Engineering and Computing Students

Abstract

This research paper examines the validity evidence from an exploratory factor analysis for a pilot of the SUCCESS survey (Studying Underlying Characteristics for Computing and Engineering Student Success). This survey was developed to measure underlying factors that may influence student success including personality, community, grit, thriving, identity, mindset, motivation, perceptions of faculty caring, stress, gratitude, self-control, mindfulness, and belongingness. We measure these underlying factors because each engineering and computing student admitted to a university has clear potential for academic and personal success in their undergraduate curriculum from admissions criteria, however, while some thrive academically, others flounder. In this project, we ask, "Why is it that highly credentialed and previously successful students do not see the same success in college?" We posit that some collection of characteristics—apparently not visible on their admission applications and perhaps not related to their talent or intelligence—is an important piece of the student performance puzzle. We developed a survey to measure various non-cognitive and affective factors that we believe are important for student achievement, academically, personally, and professionally. These non-cognitive and affective factors are representative of multifaceted aspects of undergraduate student success in prior literature. Each of the constructs we chose had validity evidence from prior studies, some within an engineering population. We piloted the survey across two different universities, one West Coast and one Midwest (n = 490), in Summer 2017. We used Exploratory Factor Analysis (EFA) to evaluate instrument performance to decide which items to include in the national release of the survey in Fall 2017. Our results provide preliminary validity evidence for items that measure various non-cognitive and affective factors. The wide-ranging constructs within the SUCCESS survey provide multiple pathways to understand students' likelihood for success in engineering and computing. Our future work includes distributing this survey to over a dozen universities across the U.S., yielding a broad dataset of non-cognitive profiles of engineering and computing students broadly. In parallel, we will link these results with students' registrar information at three study sites to develop predictive models for student success.

Motivation for this study

Engineering and computing education remains critical for U.S. workforce development and technological innovation now and into the future [1]–[3]. Many students recognize the importance and opportunity associated with studying STEM majors, and engineering and computing programs today have a talented applicant pool [4]. As a consequence, many institutions see relatively uniform and strong applicant credentials in terms of high school GPA, standardized test scores, and leadership experiences [5].

Each admitted student has the clear potential for academic success in the undergraduate curriculum. However, while some thrive at the university, many languish near the middle of the pack, or worse, they struggle academically. We want to know why highly credentialed and previously successful students sometimes do not see the same success in college. We posit that there are characteristics—apparently not visible on their admission applications—of such students that may make them more likely to navigate successfully the difficult pathways in their engineering and computing programs. We believe that an important piece of the student performance puzzle lies in the collection of non-cognitive and affective (NCA) factors including grit, study habits, personality, feelings of belongingness, and a sense of engineering or computing identity. To decide on these factors, and others, we engaged in an extensive process including a literature review, prioritization based on interests, and constructs with existing measurements to decide on this set of NCA factors. Each of the factors that we included in our pilot survey consisted of items used in other studies and are described in detail below. Differences in these traits, not asked on admissions materials and perhaps formed through the college experience, may explain particular reasons why some students thrive while others struggle. This project begins to answer the call from National Academy of Sciences [6] to see how interpersonal and intrapersonal factors contribute to student success, by focusing on how NCA factors influence student performance.

The purpose of this paper is to introduce the SUCCESS project survey and to describe how we used a pilot study and exploratory factor analysis (EFA) as part of a decision-making process to evaluate items for inclusion on the national survey. In this process, we assume that our sample is reflective of our future national sample and do not anticipate our models to significantly improve [7] or become worse [8]. The results of this work also suggest how items used to measure NCA factors may be useful in future studies.

Project Overview

The long-term goal of this research is to promote undergraduate student success in engineering and computing by identifying the key NCA factors that support or limit their success and developing effective NCA-based interventions to help them overcome obstacles they face. Descriptive statistics will allow us to characterize the NCA profiles of the engineering and computing students within our sample, disaggregated by academic major, year in program, institution, etc. Cluster analysis will help reveal the number of archetypes emerging from the NCA data, again with the potential for variations in archetype set by the institution. Taken together, our three partner institutions (from large universities, West Coast, Southwest, and Midwestern) and 10+ national site datasets will substantially advance our understanding of the diversity of NCA profiles prevailing in engineering and computing student populations, as well as the density of each archetype disaggregated by key underlying factors (e.g., academic, demographic). Differences in NCA profiles across the partner institutions driven by demographic differences are expected, particularly for identity and belongingness. We will be able to draw conclusions about both traditional and latent diversity in our sample, and the cognitive and NCA characterizations of each. The central hypothesis for this project is that NCA factors affect student performance acutely, and may be more significant predictors of academic performance than cognitive/academic preparation or aptitude. The rationale for this research is that most prior investigations of STEM undergraduate success and failure have focused on academic preparation or aptitude [6], but few prior studies have done systematic modeling of the impact of NCA factors on academic outcomes.

Brief Descriptions of Non-Cognitive and Affective Constructs Employed in Pilot Study

The following sections provide brief descriptions of each construct measured in the survey. We have provided a definition of each latent variable as well as sources for the original items used or adapted in the SUCCESS instrument. If prior validity and reliability evidence for these constructs existed in the literature, we report it in the sections below. Some of these constructs have been developed using engineering student populations, while others have not. Additionally, some of these constructs have only been tested with particular subpopulations that may not be reflective of a traditional engineering or computer science population. Part of this investigation was to determine if this wide array of non-cognitive and affective factors would function well together in an engineering context.

To adapt the survey for our use, we changed the language in some of the constructs to be inclusive of both engineering and computer science majors. Additionally, we shortened some constructs to minimize the overall length of the survey, either through evidence based on our prior work, or if a set of items sought to measure a similar construct was included elsewhere within the survey. The combination of each of these constructs totaled to 185 different items in our survey. The full survey questions and their respective internal consistencies are included in the Appendix.

Big Five Personality (15 Items). The Big Five survey instrument is a method of measuring five different personality traits. Those include: openness (open to change, new experience, imaginative, insightful); conscientiousness (reliable, hardworking, trustworthy, dependable, orderly, thorough); extraversion (sociable, talkative, impulsive, energetic, assertive); agreeableness (cooperative, helpful, likeable, sympathetic, kind); and neuroticism (anxiety, personal insecurity, tension, hostility, irritability) [9]–[11]. Internal consistencies varied across factors from 0.72 to 0.93 in a study that measured the personality characteristics of both pubescent children through adults up to sixty years old [10]. This measure has also been used as part of a larger study to predict academic success of freshman engineers. When investigating freshman engineers, Kauffmann, Hall, Dixon, and Garner found internal consistencies across all five dimensions ranged from 0.75 to 0.83 with a sample size ranging from 48 to 67 freshman engineers [12]. Based on Exploratory Factor Analysis performed on data collected through our prior work, we narrowed down the 25 item Big Five measure to 15 items, using the top three loading items for each latent factor.

Student Community (6 Items). Student Community is an environmental factor hypothesized to have a relationship with confidence. This set of items measures students' feelings of community within their degree program and consists of six items with an internal consistency of 0.78 [13]. The Student Community factor was part of a larger PACE survey validated on engineering undergraduate students with a sample size of 7,833 [13]. We modified this scale so that two versions were used, one that characterized the degree program as "computer science" and the other as "engineering."

Grit, Short Scale (8 Items). Grit, defined as perseverance and passion for long-term goals, was conceptualized as an essential component to high achievement beyond personality and intelligence [14]. The original Grit scale contained two factors–Consistency of Interest and perseverance of effort–and was subsequently shortened from 12 items to 8 items while retaining its two-factor structure [15]. The Short Grit scale was tested on two samples of West Point graduates (*n* = 1218 and *n* = 1308), a sample of 2005 National Spelling Bee participants (*n* = 175), and a sample of Ivy League undergraduate students (*n* = 139) [15]. Each of these studies showed that grit was a better predictor of academic success than other measures of preparation. Duckworth and Quinn reported internal consistencies for the Consistency of Interest factor ranging from 0.73 to 0.79, and the Perseverance of Effort factor ranging from 0.60 to 0.78 [15]. We acknowledge that there has been some concern about the use of grit as privileged measure of students' ability to focus solely on one goal regardless of their background or circumstances. We intend to further examine grit as a larger part of the NCA factors in our study.

Thriving Inventory (33 Items). The thriving construct was adapted from the Comprehensive Inventory of Thriving, which provided 54 items in 18 subscales of psychological well-being derived from a literature review on previously-reported models [16]. The Tay et al. [11] study examined a total sample of 3,191 U.S. participants including 490 undergraduate college students, 551 adults 60 years and older, 501 adults with annual income of under $20,000, and an additional 1,649 adults from various "age groups, diverse occupations, and a wide range of income and education levels" (p. 7). Only the subscales that did not overlap with other constructs in the survey were included in our pilot study, and these subscales showed internal consistency between 0.71 and 0.96.

Identity (12 Items). We subscribed to Gee's [17] definition of identity as, "being recognized as a certain 'kind of person,' in a given context…" (p. 99). We emphasize that recognition is both from an individual as well as others as individuals tell stories about who they are and act in congruence with these stories [18]. Students whose identities align with their classroom and disciplinary roles experience an improved sense of belongingness, increased persistence, and better retention [19]–[24]. We used Godwin's [25] identity instrument to measure students' engineering identities in three dimensions: performance/competence beliefs (beliefs about one's ability to do well and understand subject material), interest (engagement with the subject), and recognition (feelings that others see you as the kind of person that can succeed). Prior work surveying 2,916 first-year engineering students showed that internal consistency, as evaluated with Cronbach's alpha, was 0.88 for performance/competence, 0.89 for interest, and 0.77 for recognition [25]. More recent work across all four years of undergraduate students (*n* = 586) showed that the items were also valid for all undergraduate students [26]. We modified this scale to also include computer science students and their classroom environments by replacing "engineering" with "computer science" in the phrasing of the items, generating two sets of measures, one for computer science students and the other for engineering students.

Mindset (8 Items). Mindset has been linked to student resilience and their subsequent success [27]. Due to the popularity of her research into the construct, Dweck released a book, *Mindset: The new psychology of success* [28], which generated even more interest in mindset. In it, she described two factors within the construct: growth mindset, which endorsed the idea that intelligence is something that can be developed; and fixed mindset, which is the belief that intelligence is predetermined. A study of 603 Australian high school students found internal consistencies of 0.90 and 0.92 for fixed and growth mindsets, respectively [29].

Future Time Perspective – Motivation (22 Items). We utilized Future Time Perspective theory in measuring students' motivation. This perspective examines motivation based on how students formulate distant motivational goals and develop long-range behaviors to achieve those goals [30]. Future Time Perspective was measured as five latent constructs: expectancy (belief one will do well in their courses, five items); connectedness (tying current tasks to future goals, four items); instrumentality (current tasks are useful for my emerging identity as an engineer, three items); value (value of future goals over present goals, three items); and perceptions of future (domain specific valuing of the future, four items). These items also demonstrated strong validity evidence across face, content, and construct validity [31], [32]. From prior work, internal consistency, was 0.93 for expectancy; 0.83 for connectedness; 0.80 for instrumentality; 0.78 for value; and 0.86 for perceptions of the future [33]. We again modified this scale to be appropriate for computer science students, as described earlier.

Motivated Strategies for Learning Questionnaire (13 Items). Two subscales of the Motivated Strategies for Learning Questionnaire (MSLQ) were included: test anxiety and time and study environment. The MSLQ was created by Pintrich, Smith, Garcia, and McKeachie [34] as a modular way to assess college student motivational orientations and use of learning strategies. In a sample of 380 college students, Pintrich et al. [29] found internal consistencies of 0.80 and 0.76 for the test anxiety and time and study environment subscales, respectively. In addition, various sub-scales of the MSLQ have been used in a multitude of studies to predict academic performance. A meta-analysis of 59 such studies, including data from 19,900 college students, found average reliability estimates of 0.77 and 0.72 for the test anxiety and time and study environment subscales, respectively [35].

Perceptions of Faculty Caring (12 Items). We included parts of the Sense of Belonging Scale [36] which correspond to a student's perception of faculty caring: empathetic understanding (e.g., "I feel that a faculty member really tried to understand my problem when I talked about it"); and perceived faculty support and comfort (e.g., "If I had a reason, I would feel comfortable seeking help from a faculty member outside of class time such as during office hours, etc.") [36]. In the study used to develop the scale, internal consistencies for the factors used were 0.85 and 0.83 respectively. These factors were validated in a study using a population of 205 traditional freshman college psychology students [36].

Self-Control (8 Items). We included both factors, restraint and impulsivity, that are present in the Brief Self Control Scale [37] which has been tested using both EFA and CFA. The sample used for the exploratory factor analysis consisted of 909 Midwestern adults under the age of 30, with the majority being female. The sample used for the confirmatory factor analysis consisted of 364 undergraduate students, primarily female and recruited through a psychology department research. Maloney, Grawitch, and Barber [37] found internal consistencies for impulsivity and restraint at 0.73 and 0.72 respectively. These factors were identified using both exploratory and confirmatory factor analyses.

Student Life Stress Inventory-Revised (32 Items). The Student Life Stress Inventory-Revised is designed to measure stressors and reactions to stressors [38]. The stressors construct contains five factors: frustrations, conflicts, pressures, changes, and self-imposed. The reactions include four types: physiological, emotional, behavioral, and cognitive appraisal. Internal consistencies across the instrument were found to be from 0.63 to 0.85 for each factor. The population sample of 594 consisted primarily of undergraduate students and primarily female students with ages ranging from 17 to 60. We modified this scale significantly. Because of the personal nature of student responses and the ethical debate of how we, as researchers, were to react to their responses, we grouped individual reactions to stressors items into their factor components of physiological, emotional, and behavioral, transforming them into an individual item each. We also added questions centered on personal, family, peer, and institutional (university) support because we posit that these types of support may mitigate negative affects due to stress.

Gratitude (6 Items). The gratitude construct is a six-item single factor subscale adopted from the College Student Subjective Wellbeing Questionnaire (CSSWQ) [39]. We chose to only include the gratitude subscale due to its relatively short length, validity evidence, and lack of overlap with other constructs measured in the SUCCESS survey. For example, other constructs measured in the CSSWQ included academic grit, school connectedness, satisfaction with academics, and self-efficacy. The survey was modified from a 5-point anchored scale response to a 7-point anchored scale response for consistency throughout the survey and showed evidence of strong internal reliability (Cronbach's $\alpha = 0.76$) on a sample of 387 college students [40].

Mindful Attention Awareness Short Scale (6 Items). Mindfulness is defined as intentional, purposeful, focused, and nonjudgmental awareness [41], [42]. Although often associated with Buddhism, mindfulness is conceptualized as a universally applicable practice and an innate human capacity [42]. The Mindful Attention Awareness Short Scale consists of the top four loading items from the Mindful Attention Awareness Scale (MAAS) [43], [44]. The MAAS consists of fifteen items with a single factor structure that showed validity evidence on a sample of 72 undergraduate engineering students at a Western U.S. university [45]. Outside of engineering, other studies have shown strong internal reliability evidence for the MAAS and the top four loading items [42], [44]. Rieken, Schar, and Sheppard [45] found internal consistency of 0.79 across four of the items. We modified this instrument from a 6-point to 7-point anchored scale, to be consistent with other items on the SUCCESS survey.

Belongingness (4 Items). Sense of belonging or a student's belongingness is an important factor in STEM education and is a basic human need, which is dependent on social relationships for fulfillment [47]. Indeed, one of the top reasons that students leave engineering is not academic preparedness but lack of belonging [46], [47]. We used six items to measure belongingness within the engineering community with validity evidence from a previous study of student attitudes in engineering [50]. These items were originally from the longer (15 item) Measures of Belonging in Higher Education instrument [51], which adapted items from the Anderson-Butcher and Conroy [52] measures for belonging and the Lounsbury and DeNeui [53] measures for psychological sense of community for an engineering context. Prior work [50] showed that these items had a single factor structure with an internal consistency of 0.91. We modified this scale to also include computer science majors.

Methods

Survey Participants. We administered our survey across two different populations of engineering students in the Summer of 2017. One portion of our sample population of engineering and computing students from First-Year to Seniors was from a large West Coast university and consisted of 356 participants. The second portion of our sample population was engineering students from a large Midwest university who were transitioning out of the First-Year Engineering curriculum and consisted of 134 participants. Both surveys were administered through Qualtrics™, with each student being sent a unique link to ensure that a single student was only counted once. Participants were defined as those students who answered a validation response correctly (if you are reading this, please mark two). Both samples were combined for analysis. Prior to analysis, the data was cleaned to remove any personally identifiable information and to remove students from the dataset who answered the validation question incorrectly. Of the 566 Students who started the survey, 44 completed only part of the survey and 32 failed to correctly respond to the validation question, for a total sample of 490 participating students.

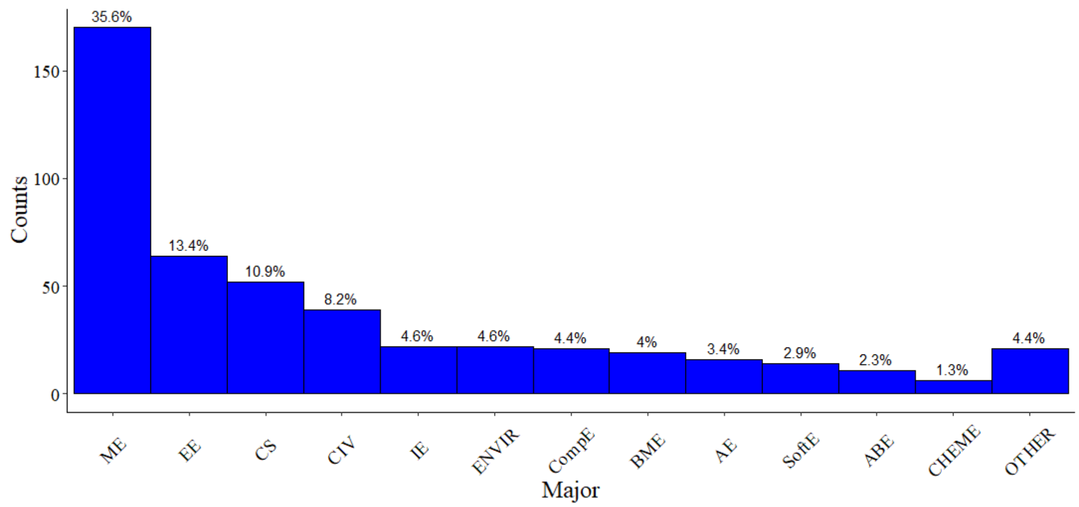

Figure 1. Graph of respondent count by major. Mechanical Engineering (ME), Electrical Engineering (EE), Computer Science (CS), Civil Engineering (CIV), Industrial Engineering (IE), Environmental / Ecological Engineering (ENVIR), Computer Engineering (CompE), Bioengineering / Biomedical Engineering (BME), Aero/Astronautical Engineering (AE), Software Engineering (SoftE), Agricultural and Biological / Biosystems Engineering (ABE), Chemical Engineering (CHEME), and all other majors (OTHER).

Participant Demographics. All reported demographic information from the sample excludes blank responses, which could result in small shifts in reported totals. The total sample consisted of students from the majors shown in Figure 1. The sample population resembles that found in the annual ASEE "Engineering by the Numbers" report [54], with mechanical engineering being most strongly represented. These students represent all years of their degree programs, with 116, 179, 72, and 123 students in year 1, 2, 3, and 4 or higher, respectively. Gender identity and race were also self-reported, with data shown in Table 1 and Table 2. Totals are greater than the total sample number due to students identifying with more than one of the provided gender identity or race options, respectively. Providing the options in a "select-all-that-apply" manner allows for a more inclusive accounting of gender and race identities.

Table 1. Self-reported gender identities of survey participants. Percentages listed add to greater than 100% due to rounding.

Survey Gender Options	Counts	Percent of Total
Female	177	33.3%
Cisgender	38	7.2%
Male	300	56.5%
Transgender	2	0.4%
Agender	9	1.7%
Genderqueer	1	0.2%
I prefer to identify as______________	4	0.8%
Total	531	

Table 2. Self-reported racial identities of survey participants. Percentages listed add to greater than 100% due to rounding.

Survey Race Options	Counts	Percent of Total
American Indian or Alaska Native	6	1.1%
Asian	136	24.3%
Black or African American	3	0.5%
Hispanic, Latino, or Spanish origin	39	7.0%
Middle Eastern or North African	9	1.6%
Native Hawaiian or Other Pacific Islander	6	1.1%
White	346	61.8%
I prefer to identify as______________	15	2.7%
Total	560	

Exploratory Factor Analysis Methods and Procedures. We performed exploratory factor analysis (EFA) in the statistical software R [55] to examine the factor structure for each of the theoretical constructs. The skewness (-2 to 2) and kurtosis (-7 to 7) were checked to ensure that the general univariate normality assumptions associated with EFA were met [56]. Next, all responses that contained a missing response to all questions within a construct were removed. This process was done as these rows cannot be imputed without any reported responses. We examined the correlation matrix for all items composing each construct measuring non-cognitive and affective factors for significance. To determine the initial number of latent factors for each set of items in the EFA, we generated a scree plot. The scree plot displays eigenvectors at each integer number of factors. There are different criteria to evaluate scree plots, one of which is determining visually when the plot becomes asymptotic. This decision is the first point where analyst prerogative and experience shape the factor analysis. Additionally, parallel analysis was used as recommended by Fabrigar and colleagues to help determine the number of factors to extract [56].

We examined the resulting factor structure, ensuring that all loadings were greater than 0.32 [57] and that no loading across a question was within half of the maximum loading. These cutoff values were used as they indicate an approximately 10% overlapping variance with the other items in that factor [57]. Factor structures are generated using an oblique rotation in the “fa()” R function [55], with the factoring being performed using the minimum residuals method. This method produces solutions very similar to maximum likelihood even for badly behaved matrices, meaning it is robust for small deviations from non-normality [58]. We removed items from the analysis that did not meet the above criteria.

The final step in the analysis was measuring the fit of the model. Both the Tucker-Lewis Index (TLI), also called the non-normed fit index or NNFI, and the root mean square error of approximation (RMSEA) were used as judges of fit, both scaled from 0-1. A TLI value between 0.90 and 0.95 is considered a marginal fit, while above 0.95 is good and below 0.90 is poor [56]. Like the TLI, the RMSEA penalizes a model for complexity, with an emphasis on the sample size (N) and degrees of freedom (df). RMSEA values of 0.01, 0.05, and 0.08 to indicate excellent, good and mediocre fits, respectively [59]. Cronbach's alpha was calculated for each resulting factor. The Appendix includes all of the items used in the survey with factor loadings.

Results

Table 3 presents the overall results of the EFA. The constructs that behaved as expected, based on prior literature, were the Big Five personality traits, grit, engineering identity, mindset, motivation, self-control, and stress (modified Student Life Stress Inventory-Revised). The community, thriving, and test anxiety and time management (MSLQ) factors had marginal fit indices for both TLI and RMSEA. The factors of perception of faculty caring, gratitude, belongingness and mindfulness did not satisfy the RMSEA fit index while meeting the TLI.

Table 3. Summary of EFA results. TLI is ideally above 0.95 with minimum acceptable values at 0.90 and RMSEA should be less than 0.08.

Construct	TLI	RMSEA	Items Expected	Items Found	Expected Factors	Factors Found
BIG5	.990	.024	15	15	5	5
Community	.702	.199	6	6	1	1
Grit	.986	.038	8	6	2	2
Thriving	.842	.098	33	30	11	3
Identity	.954	.071	12	12	3	3
Mindset	.985	.061	8	8	2	2
Motivation	.971	.041	22	22	5	5
MSLQ	.848	.102	13	13	2	2
Perception of Faculty Caring	.946	.085	12	10	2	2
Self-Control	.967	.053	8	7	2	2
Stress	.990	.023	32	16	7	5
Gratitude	.915	.137	6	6	1	1
Belongingness[1]	.909	.137	6	6	1	1
Mindfulness	.951	.148	4	4	1	1
TOTALS	NA	NA	185	161	45	35

[1]Due to an error in survey administration, the sample size for this item was 134.

We were also interested in how the multiple latent constructs were related to one another. There has been significant research in engineering education using many of these constructs, as described above, to understand different aspects of students' success or influence on students' pathways through engineering. However, few studies have examined the interrelationships of these factors. Figure 2 shows a correlation matrix of the items. We chose correlations with significance values < 0.0001 to account for cumulative hypothesis testing.

As a part of our initial pilot, we were interested in understanding how these multiple latent constructs correlate and whether they do, in fact, measure different aspects of students' non-cognitive and affective traits. As expected, we found strong, significant correlations between sub-scales within the same broad construct. For example, we found that engineering identity measures like students' performance competence beliefs, interest, and recognition were related to one another. Additionally, the factors measuring students' Future Time Perspective (i.e., motivation) and mindset were strongly related within each set of theoretical constructs. Identity and motivation items were also significantly related to one another. This relationship is not surprising as a growing amount of research has documented a strong connection between these two affective constructs [60]–[62].

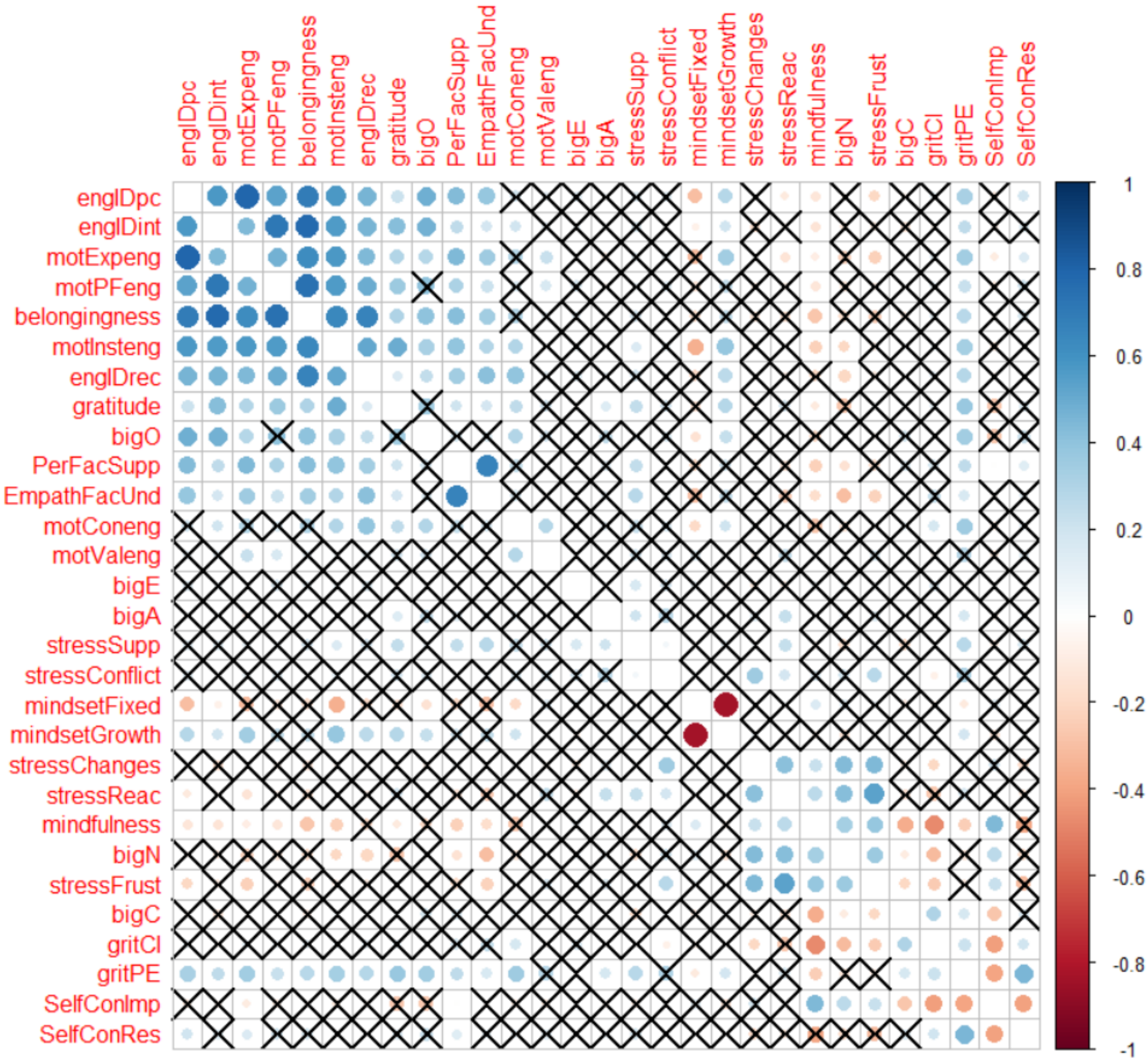

Figure 2. Correlation plot of latent constructs. The color represents positive (blue) or negative (red) correlations, with the larger correlations having larger dots. Statistically insignificant correlations (or $p > 0.0001$) are denoted by an "X." See Table 4 for abbreviation descriptions.

Table 4. Descriptions of abbreviations for Figure 2.

Construct	Description
Engineering Identity	engIDpc = performance/competence, engIDint = interest, and engIDrec = recognition
Future Time Perspective – Motivation (Eng.)	motExpeng = expectancy, motPFeng = perceptions of the future, motConeng = connectedness, and motValeng = value,
Big Five	bigA = agreeableness, bigE = extraversion, bigO = openness, bigN = neuroticism, and bigC = conscientiousness
Student Life Stress	stressSupp = support, stressConflict = conflicts, stressChanges = changes, stressReact = reactions, and stressFrust = frustrations.
Mindset	mindsetFixed = fixed, and mindsetGrowth = growth
Grit	gritCI = Consistency of Interest, and gritPE = persistence of effort
Perceptions of Faculty Caring	PerFacSupport = perceptions of faculty support, and EmapthFacUnd = empathetic faculty understanding.
Self-Control	SelfConAct = impulsivity, and SelfConRes = restraint.

We also found some interesting relationships between Big Five openness and other affective factors like identity, belongingness, and motivation as well as students' perceptions of faculty support. These results do not indicate causality but may start to highlight that students who see themselves as engineers are motivated in their current and long-term goals, and feel a strong sense of belonging, may be more open to new experiences both socially and in their engineering courses. We also found that neuroticism and conscientiousness are related to students' feeling of stress. These results may be reflective of students who have low emotional stability, seek to follow social norms and conventions, and have abilities to succeed in the "stress culture" of engineering [63]. Grit-persistence of effort was related to the other affective constructs of identity, motivation, and belonging, but Grit-consistency of interest had a weak negative correlation with many of the stress indicators. This result may point to differential factors of how Grit may operate in engineering students when compared to the larger populations in which it has been used previously, like psychology students and adults. In a different study of 417 participants, perseverance of effort predicted greater academic adjustment, college grade point average, college satisfaction, sense of belonging, faculty–student interactions, and intent to persist. Consistency of interest was correlated with intentions to persist but was not significantly associated with other success variables when controlling for background factors [64].

These results provide evidence that many of the items we are measuring are related to student success in different ways. As expected, items measuring positive affect were correlated with one another and items measuring students' negative affect or responses to negative experiences were similarly correlated. However, these sets of items are not strongly correlated with one another. Based on these results, we believe that we have mapped a wide range of the possible non-cognitive and affective factors that may influence student success.

Discussion

Our survey measured 185 items, with most constructs having three or more items, which corresponds with the three to five item recommendation of Fabrigar et al. [56]. One concern about the use of our items in exploratory factor analysis is the small sample size. The ratio of our sample size to items in the survey is low (2.2:1) based on recommendations from the literature of 5:1 or greater [56]. However, another means of determining sample size adequacy is to look at communality (proportion of variance explained by a factor for each question) and the ratios of factors to variables to determine if the sample size is large enough to converge on a proper solution [65]. Our communalities can be classified as wide (primarily distributed across the range of 0.2 to 0.8), as shown in Figure 3. While wide communalities are not excellent, based on the simulations of MacCallum et al. [65], our communalities (considered together with the ratio of items to factors), should result in factor models converging on a proper solution. In general, as the number of samples increases, the likelihood of obtaining convergance increases. Further, while we cannot use our pilot data presented here as validity evidence, it certainly suggests that these data could be used to guide our survey design for the next phase of data collection.

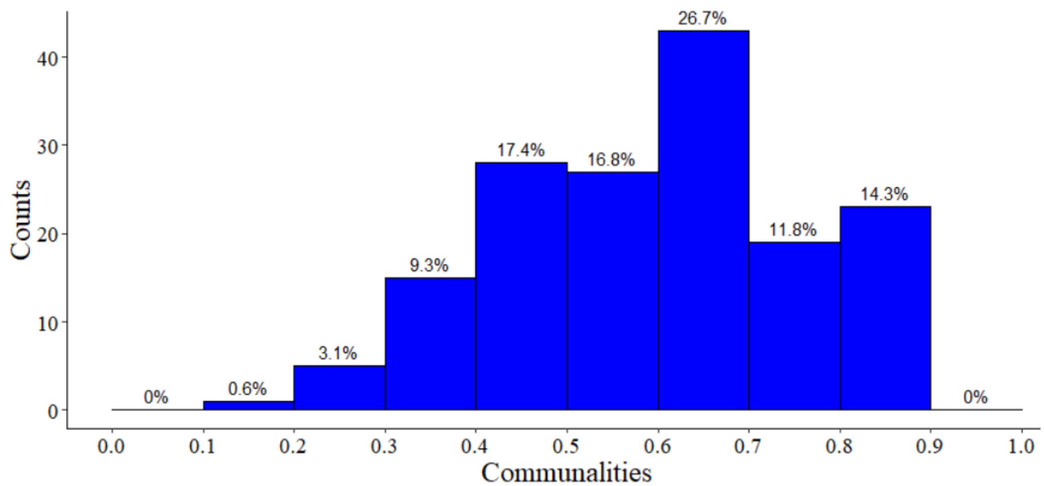

Figure 3. SUCCESS Pilot Communalities for each item that loaded into a factor, showing a wide classification for the distribution of communalities.

Based on showing potential validity evidence (TLI > 0.90 and RMSEA < 0.08), we decided to maintain: Big Five personality, grit, identity, mindset, motivation, self-control, and stress constructs in our survey. We also decided to include other instruments, not necessarily because of their potential for validity evidence, but because of their overall interest within engineering education and other fields of study, as well as their potential for predictive modeling in the future. Those included: the meaning and purpose portion of the Thriving construct; Test Anxiety and Time Management from the MSLQ; Perception of Faculty Caring; gratitude; belongingness; and mindfulness. We removed the Student Community measure and several items in the Thriving construct. Overall, using EFA as a decision tool, we removed 42 items from the original 185-item survey.

We identify a need for items that measure what it means to thrive as an engineer. Thriving, gratitude, and mindfulness are aspects of engineers that are seemingly important to study, but we do not yet have a good way of measuring these, based on the above analysis. These constructs showed strong validity and reliability evidence in the literature with a general population, but we did not observe similar evidence for the population of undergraduate engineering students we surveyed for this large-scale pilot study. Therefore, more work is needed to examine constructs related to thriving within the engineering and computer science context.

As noted in Table 3, the constructs that behaved as expected were the Big Five personality traits, grit, the engineering identity factors, fixed and growth mindset, motivation factors, self-control, and stress (modified Student Life Stress Inventory-Revised). To our knowledge, our survey is the first to sample engineering students and conduct EFA using the mindset, self-control, and stress items. These measures will not only provide a different perspective into engineering students but also contribute to the engineering education community as other potential measures to use for future work. Overall, our initial pilot of the items intended to capture a wide variety of non-cognitive and affective factors for student success showed some expected relationships between latent constructs and some novel results.

Summary and Future Work

In this paper, we introduced the SUCCESS survey, briefly describing non-cognitive and affective factors from the literature that may be used to predict student success. We also showed how we used exploratory factor analysis as a design tool to reduce the number of items in our survey by removing items that we do not expect to present validity evidence beyond this pilot data. Our analysis further found significant correlations between latent constructs. Most significantly, this paper presented preliminary validity evidence for items that measure other dimensions of engineering-student success—the non-cognitive and affective factors that potentially influence their performance. This understanding could begin to answer the call for ways, beyond GPA and SAT/ACT test scores, to predict performance and suggest interventions to promote success.

During the 2017-2018 school year, we are conducting the full SUCCESS survey. We surveyed students from the partnering institutions, two of which were included in this pilot data. At these schools, we plan to link survey response data with registrar data as well as Dean of Students records to have a more complete picture of our student populations for future modeling work. Additionally, we plan to launch an international survey across many universities in the U.S. as well as in Europe. At those sites, we will not collect identifiable information or registrar data. We plan to identify the students that are struggling and eventually to provide interventions that help to increase their prospects for success.

Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant Nos. DUE-1626287 (Purdue), DUE-1626185 (Cal Poly), and DUE-1626148 (UTEP). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. We would like to thank all the students who participated in this study. Without their time spent in thoughtful response, this work would not be possible.

References

[1] U.S. Bureau of Labor Statistics, “Occupational Outlook Handbook,” 2015.

[2] National Academy of Engineering, *Educating the engineer of 2020: Adapting engineering education to the new century*. National Academies Press, 2005.

[3] National Academy of Sciences, National Academy of Engineering, and Institue of Medicine, “Rising above the gathering storm: Energizing and employing America for a brighter economic future.”

[4] B. L. Lowell, H. Salzman, H. Bernstein, and E. Henderson, “Steady as she goes? Three generations of students through the science and engineering pipeline,” 2009.

[5] B. M. Holloway, T. Reed, P. K. Imbrie, and K. Reid, “Research-informed policy change: A retrospective on engineering admissions,” *J. Eng. Educ.*, vol. 103, no. 2, pp. 274–301, 2014.

[6] National Academy of Sciences, “Supporting students’ college success: The role of assessment of intrapersonal and interpersonal competencies,” Washington, D.C., 2017.

[7] Rasch Measurement SIG (AERA), “The Root Mean Square Error of Approximation (RMSEA),” *Rasch Measurement Transactions*, 2017. [Online]. Available: https://www.rasch.org/rmt/rmt254d.htm. [Accessed: 29-Aug-2017].

[8] K. A. Bollen, “Sample size and Bentler and Bonett’s nonnormed fit index,” *Psychometrika*, vol. 51, no. 3, pp. 375–377, 1986.

[9] G. Dam and S. Kaufmann, “Computer assessment of interview data using latent semantic analysis.,” *Behav. Res. Methods*, vol. 40, no. 1, pp. 8–20, Feb. 2008.

[10] T. A. Judge, C. A. Higgins, C. J. Thoresen, and M. R. Barrick, “The big five personality traits , general mental ability , and career success across the life span,” *Pesonnel Psychol.*, vol. 52, pp. 621–652, 1999.

[11] B. J. Williams, “Investigation of broad and narrow personality traits in relation to major satisfaction for students in engineering, education and psychology majors,” . University of Tennessee Honors Thesis Projects, 2009.

[12] P. Kauffmann, C. Hall, G. Dixon, and J. Garner, “Predicting academic success for first semester engineering students using personaity trait indicators,” *Am. Soc. Eng. Educ.*, 2008.

[13] E. Litzler, C. C. Samuelson, and J. A. Lorah, “Breaking it down: Engineering student STEM confidence at the intersection of race/ethnicity and gender,” *Res. High. Educ.*, vol. 55, no. 8, pp. 810–832, 2014.

[14] A. L. Duckworth, C. Peterson, M. D. Matthews, and D. R. Kelly, “Grit: Perseverance and passion for long-term goals,” *J. Pers. Soc. Psychol.*, vol. 92, no. 6, pp. 1087–1101, 2007.

[15] A. L. Duckworth and P. D. Quinn, “Development and validation of the short grit scale (Grit-S),” *J. Personal. Assessment2*, vol. 91, no. 2, pp. 166–174, 2009.

[16] R. Su, L. Tay, and E. Diener, “The development and validation of the comprehensive inventory of thriving (CIT) and the brief inventory of thriving (BIT),” *Appl. Psychol. Heal. well-being*, vol. 6, no. 3, pp. 251–279, 2014.

[17] J. P. Gee, “Identity as an analytic lens for research in education,” *Rev. Res. Educ.*, vol. 25, no. 2000–2001, pp. 99–125, 2000.

[18] D. Holland, W. Lachicotte Jr., D. Skinner, and C. Cain, *Identity and agency in cultural worlds*. Cambridge, MA: Harvard University Press, 1998.

[19] A. Godwin, G. Potvin, Z. Hazari, and R. Lock, “Identity, critical agency, and engineering: An affective model for predicting engineering as a career choice,” *J. Eng. Educ.*, vol. 105,

no. 2, pp. 312–340, 2016.
[20] G. Hughes, “Identity and belonging in social learning groups: The importance of distinguishing social, operational and knowledge-related identity congruence,” *Br. Educ. Res. J.*, vol. 36, no. 1, pp. 47–63, 2010.
[21] W. Kraus, “The narrative negotiation of identity and belonging,” *Narrat. Inq.*, vol. 16, no. 1, pp. 103–111, 2006.
[22] T. Perez, J. G. Cromley, and A. Kaplan, “The role of identity development, values, and costs in college STEM retention.,” *J. Educ. Psychol.*, vol. 106, no. 1, pp. 315–329, 2014.
[23] O. Pierrakos, T. K. Beam, J. Constantz, A. Johri, and R. Anderson, “On the development of a professional identity: Engineering persisters vs engineering switchers,” in *39th ASEE/IEEE Frontiers in Education Conference*, 2009, no. 2, pp. 1–6.
[24] A. Wolffram, W. Derboven, and G. Winker, “Women withdrawers in engineering studies: Identity formation and learning culture as gendered barriers for persistance?,” *Equal Oppor. Int.*, vol. 28, no. 1, pp. 36–49, 2009.
[25] A. Godwin, “The development of a measure of engineering identity,” in *123rd American Society for Engineering Education Annual Conference & Exposition*, 2016, pp. 1–15.
[26] A. Godwin and W. C. Lee, “A cross-sectional study of engineering identity during undergraduate education,” in *2017 ASEE Annual Conference & Exposition*, 2017.
[27] D. S. Yeager and C. S. Dweck, “Mindsets that promote resilience: When students believe that personal characteristics can be developed,” *Educ. Psychol.*, vol. 47, no. 4, pp. 302–314, Oct. 2012.
[28] C. S. Dweck, *Mindset: The new psychology of success*. New York, NY: Pinguin Random House, 2016.
[29] K. De Castella and D. Byrne, “My intelligence may be more malleable than yours: The revised implicit theories of intelligence (self-theory) scale is a better predictor of achievement, motivation, and student disengagement,” *Eur. J. Psychol. Educ.*, vol. 30, no. 3, pp. 245–267, 2015.
[30] D. F. Shell and J. Hussman, “The multivariate dimensionality of personal control and future time perspective beliefs in achievement and self-regulation,” *Contemp. Educ. Psychol.*, vol. 26, no. 4, pp. 481–506, 2001.
[31] A. Kirn and L. Benson, “Engineering students’ perceptions of the future: Exploratory instrument development,” in *Proceedings of 2015 American Society for Engineering Education Conference.*, 2015.
[32] D. F. Shell and J. Husman, “Control, motivation, affect, and strategic self-regulation in the college classroom: A multidimensional phenomenon.,” *J. Educ. Psychol.*, vol. 100, no. 2, pp. 443–459, 2008.
[33] C. McGough, A. Kirn, and L. Benson, “Work in progress: Developing a quantitative instrument for measuring undergraduate engineering students’ future time perspectives,” in *123rd American Society for Engineering Education Annual Conference & Exposition*, 2016.
[34] P. Pintrich, D. Smith, T. Garcia, and W. McKeachie, “A manual for the use of the motivated strategies for learning questionnaire (MSLQ),” Ann Arbor, MI, 1991.
[35] M. Credé and L. A. Phillips, “A meta-analytic review of the Motivated Strategies for Learning Questionnaire,” *Learn. Individ. Differ.*, vol. 21, pp. 337–346, 2011.
[36] M. Hoffman, J. Richmond, J. Morrow, and K. Salomone, “Investigating ‘sense of belonging’ in first-year college students,” *J. Coll. Student Retent.*, vol. 4, no. 3, pp. 227–

256, 2003.
[37] P. W. Maloney, M. J. Grawitch, and L. K. Barber, “The multi-factor structure of the Brief Self-Control Scale: Discriminant validity of restraint and impulsivity,” *J. Res. Pers.*, vol. 46, no. 1, pp. 111–115, 2012.
[38] B. M. Gadzella, M. Baloglu, W. G. Masten, and Q. Wang, “Evaluation of the student life stress inventory-revised,” *J. Instr. Psychol.*, vol. 39, no. 2, pp. 82–91, 2012.
[39] T. L. Renshaw and S. J. Bolognino, “The college student subjective wellbeing questionnaire: A brief, multidimensional measure of undergraduate’ s covitality,” *J. Happiness Stud.*, vol. 17, pp. 463–484, 2016.
[40] M. E. McCullough, J.-A. Tsang, and R. A. Emmons, “Gratitude in intermediate affective terrain: Links of grateful moods to individual differences and daily emotional experience.,” *J. Pers. Soc. Psychol.*, vol. 86, no. 2, pp. 295–309, 2004.
[41] J. Kabat-Zinn, “Mindfulness-based interventions in context: Past, present, and future,” *Clin. Psychol. Sci. Pract.*, vol. 10, no. 2, pp. 144–156, 2003.
[42] J. J. Froh and A. C. Parks, *Activities for teaching positive psychology: A guide for instructors.* Washington, DC, US: American Psychological Association, 2013.
[43] K. W. Brown and R. M. Ryan, “The benefits of being present: Mindfulness and its role in psychological well-being.,” *J. Pers. Soc. Psychol.*, vol. 84, no. 4, pp. 822–848, 2003.
[44] J. MacKillop and E. J. Anderson, “Further psychometric validation of the Mindful Attention Awareness Scale (MAAS),” *J. Psychopathol. Behav. Assess.*, vol. 29, no. 4, pp. 289–293, 2007.
[45] B. Rieken, M. Schar, and S. Sheppard, “Trait mindfulness in an engineering classroom: An exploration of the relationship between mindfulness, academic skills, and professional skills,” in *Proceedings - Frontiers in Education Conference, FIE*, 2016.
[46] N. T. Van Dam, M. Earleywine, and A. Borders, “Measuring mindfulness? An item response theory analysis of the Mindful Attention Awareness Scale,” *Pers. Individ. Dif.*, vol. 49, no. 7, pp. 805–810, 2010.
[47] A. H. Maslow, “A theory of human motivation,” *Psychol. Rev.*, vol. 50, no. 4, pp. 370–396, 1943.
[48] B. Geisinger and D. R. Raman, “Why they leave: Understanding student attrition from engineering majors,” *Int. J. Eng. Educ.*, vol. 29, no. 4, pp. 914–925, 2013.
[49] E. Seymour and N. M. Hewitt, *Talking about leaving: Why undergraduates leave the sciences*. Westview Press, 2000.
[50] A. Kirn, A. Godwin, L. Benson, H. Boone, and D. Verdin, “Intersectionality of non-normative identities in the cultures of engineering,” in *Proceedings of 2016 American Society for Engineering Education Conference.*, 2016.
[51] T. F. Smith, D. Wilson, D. Carlson, M. Plett, R. A. Bates, and N. M. Veilleux, “Investigation of belonging for engineering and science undergraduates by year in school,” in *American Society for Engineering Education Annual Conference*, 2012, pp. 1–11.
[52] D. Anderson-Butcher and D. E. Conroy, “Factorial and criterion validity of scores of a measure of belonging in youth development programs,” *Educ. Psychol. Meas.*, vol. 62, no. 5, pp. 857–876, 2002.
[53] J. W. Lounsbury and D. DeNeui, “Collegiate psychological sense of community in relation to size of college/university and extroversion,” *J. Community Psychol.*, vol. 24, no. 4, pp. 381–394, 1996.

[54] B. L. Yoder, “Engineering by the numbers.” American Society of Engineering Education, pp. 1–37, 2015.

[55] R. C. Team, “R: A language and environment for statistical computing.,” *R Foundation for Statistical Computing, Vienna, Austria.*, 2017. [Online]. Available: https://www.r-project.org/.

[56] L. R. Fabrigar, R. C. MacCallum, D. T. Wegener, and E. J. Strahan, “Evaluating the use of exploratory factor analysis in psychological research,” *Psychol. Methods*, vol. 4, no. 3, pp. 272–299, 1999.

[57] B. G. Tabachnick, *Using multivariate statistics*, 4th ed. . Boston, MA : Boston, MA : Allyn and Bacon, 2001.

[58] W. Revelle, “Psych: Procedures for personality and psychological research,” Evanston, Illinois, 2017.

[59] R. C. MacCallum, M. W. Browne, and H. M. Sugawara, “Power analysis and determination of sample size for covariance structure modeling,” *Psychol. Methods*, vol. 1, no. 2, pp. 130–149, 1996.

[60] D. Oyserman, “Identity-based motivation: Implications for action-readiness, procedural-readiness, and consumer behavior,” *J. Consum. Psychol.*, vol. 19, no. 3, pp. 250–260, 2009.

[61] D. Oyserman and M. Destin, “Identity-based motivation: Implications for intervention,” *The Counseling Psychologist*, vol. 38, no. 7. pp. 1001–1043, 2010.

[62] Motivation and Identity Special Issue, “No Title,” *Educ. Psychol.*, vol. 44, no. 2, 2009.

[63] E. Godfrey and L. Parker, “Mapping the cultural landscape in engineering education,” *J. Eng. Educ.*, vol. 99, no. 1, pp. 5–22, 2010.

[64] N. A. Bowman, P. L. Hill, N. Denson, and R. Bronkema, “Keep on truckin’ or stay the course? Exploring grit dimensions as differential predictors of educational achievement, satisfaction, and intentions,” *Soc. Psychol. Personal. Sci.*, vol. 6, no. 6, pp. 639–645, 2015.

[65] R. C. MacCallum, K. F. Widaman, S. Zhang, and S. Hong, “Sample size in factor analysis,” *Psychol. Methods*, vol. 4, no. 1, pp. 84–99, 1999.

Appendix: Factors and loadings found through EFA for each question

*Items are reverse coded

BIG 5 Personality Items	Extroversion	Neuroticism	Agreeableness	Openness	Conscientiousness	Uniqueness	Chronbach's Alpha
How accurately do the following describe you now?							.58
Have a vivid imagination				.64		.59	.77
Have excellent ideas.				.68		.52	
Am full of ideas.				.92		.15	
*Leave my belongings around.					.70	.49	.76
*Make a mess of things.					.76	.41	
*Often forget to put things back in their proper places.					.71	.51	
*Don't talk a lot.	.82					.32	.87
*Keep in the background.	.85					.26	
*Am quiet around strangers.	.84					.29	
Sympathize with others' feelings.			.91			.18	.78
Have a kind heart.			.5			.69	
Feel others' emotions.			.83			.31	
Get upset easily.		.58				.66	.83
Change my mood a lot.		.91				.17	
Have frequent mood swings.		.9				.19	

Student Community	Student Community	Uniqueness	Chronbach's Alpha
Please answer the following with the answer that best describes you.			.81
I feel group projects are valuable.	.52	.73	.81
I feel like I am part of an engineering community.	.71	.50	
I like studying with other students in a group.	.64	.60	
I am involved with student study groups.	.57	.67	

I feel engineering students help each other succeed in class.	.75	.44
I feel other students take my comments/suggestions in class seriously.	.68	.53

Grit	Consistency of Interest	Perseverance of Effort	Uniqueness	Chronbach's Alpha
Q18: Please respond to each of the following statements to the best of your ability.				.72
New ideas and projects sometimes distract me from previous ones*	.56		.70	.76
I have been obsessed with a certain idea or project for a short time but later lost interest*	.74		.47	
I often set a goal but later choose to pursue a different one*	.77		.42	
I have difficulty maintaining my focus on projects that take more than a few months to complete*	.59		.55	
I am a hard worker		.78	.42	.75
I am diligent		.78	.38	
Items that didn’t load:				
I finish whatever I begin				
Setbacks don't discourage me				

Thriving	Mastery, Engagement, Meaning and Purpose	Subjective Wellbeing	Relationship Support and Respect	Uniqueness	Chronbach's Alpha
					.96
We would like to know about how you perceive yourself in terms of your relationships with others. Please indicate your agreement or disagreement with each of the following statements using the scale below:					.90
There are people who appreciate me as a person			.86	.31	
There are people who give me support and encouragement			.85	.37	
People are polite to me			.84	.30	
There are people I can depend on to help me			.73	.51	
People respect me			.72	.37	
I am treated with the same amount of respect as others			.63	.51	

We would like to know about how you perceive your subjective well-being. Please indicate your agreement or disagreement with each of the following statements using the scale below:				.96
I feel negative most of the time		.90	.28	
I experience unhappy feelings most of the time		.92	.24	
I feel bad most of the time		.92	.23	
I feel good most of the time		.92	.16	
I feel positive most of the time		.92	.15	
I feel happy most of the time		.92	.13	
In most ways my life is close to my ideal		.53	.55	
I am satisfied with my life		.64	.34	
My life is going well	.23	.58	.35	
We would like to know about how you perceive yourself in terms of your perceived experiences. Please indicate your agreement or disagreement with each of the following statements using the scale below:				.95
What I do in life is valuable and worthwhile	.69		.39	
The things I do contribute to society	.74		.51	
The work I do is important for other people	.79		.44	
I get to do what I am good at every day	.81		.40	
I use my skills a lot in my everyday life	.87		.39	
I frequently use my talents	.77		.38	
I am fulfilling my ambitions	.85		.33	
I am achieving most of my goals	.80		.30	
I am on track to reach my dreams	.71		.36	
My life has a clear sense of purpose	.83		.39	
I have found a satisfactory meaning in life	.66		.37	
I know what gives meaning to my life	.56		.52	
I get excited when I work on something	.75		.56	
I get fully absorbed in activities I do	.67		.61	
In most activities I do, I feel energized	.61		.53	

Items that didn't load:

I expect more good things in my life than bad
I have a positive outlook on life
I am optimistic about my future

Engineering Identity	Performance Competence Beliefs	Interest	Recognition Beliefs	Uniqueness	Chronbach's Alpha
To what extent do you agree or disagree with the following statements:					.91
My parents see me as an engineer			.47	.71	.81
My instructors see me as an engineer			.87	.31	
My peers see me as an engineer			.95	.20	
I have had experiences in which I was recognized as an engineer			.61	.57	
I am confident that I can understand engineering in class	.59	.24		.39	.90
I am confident that I can understand engineering outside of class	.66			.41	
I can do well on exams in engineering	.88			.40	
I understand concepts I have studied in engineering	.99			.16	
Others ask me for help in engineering	.68			.48	
I can overcome setbacks in engineering	.61			.47	
I enjoy learning engineering		.96		.15	.91
I find fulfillment in doing engineering		.93		.18	

I am interested in learning more about engineering. (Kurtosis >7, removed)

Mindset	Incremental Self Beliefs	Entity Self Beliefs	Uniqueness	Chronbach's Alpha
Please answer the following with the answer that best describes you.				.95
I don’t think I personally can do much to increase my intelligence.		.69	.37	.92
I can learn new things, but I don't have the ability to change my basic intelligence.		.72	.35	
My intelligence is something about me that I personally can’t change very much.		.87	.14	
To be honest, I don’t think I can really change how intelligent I am.		.78	.18	
Regardless of my current intelligence level, I think I have the capacity to change it quite a bit.	.67		.41	.92
With enough time and effort I think I could significantly improve my intelligence level.	.88		.18	
I believe I can always substantially improve on my intelligence.	.80		.18	
I believe I have the ability to change my basic intelligence level considerable over time	.77		.26	

Motivation	Expectancy	Perceptions of the Future	Connectedness	Value	Instrumentality	Uniqueness	Chronbach's Albha
The following questions relate to your attitudes and beliefs about your experiences in engineering classes and in your engineering major. Please rate your agreement for each item.							.88
I expect to do well in my engineering classes.	.83					.27	.94
I am certain I can master the skills being taught in my engineering classes	.75					.30	
I believe I will receive an excellent grade in my engineering classes.	.99					.15	
I am confident I can do an excellent job on the assignments in my engineering classes.	.90					.19	
Considering the difficulty of my engineering classes, the teacher, and my skills, I think I will do well in my engineering classes.	.90					.18	
I don’t think much about the future.*			.69			.55	.84
I don’t like to plan for the future.*			.75			.46	
It’s not really important to have future goals for where one wants to be in five to ten years.*			.65			.56	
One shouldn’t think too much about the future.*			.79			.38	
Planning for the future is a waste of time.*			.74			.43	
I will use the information I learn in my engineering classes in other classes I will take in the future.					.59	.57	.85
I will use the information I learn in engineering classes in the future.					.91	.13	
What I learn in my engineering classes will be important for my future occupational success.					.80	.31	
It is better to be considered a success at the end of one’s life than to be considered a success today.				.50		.69	.80
The most important thing in life is how one feels in the long run.				.53		.72	
It is more important to save for the future than to buy what one wants today.				.60		.57	
Long range goals are more important than short range goals.				.79		.39	
What happens in the long run is more important than how one feels right now.				.85		.34	
I am confident about my choice of major.		.70				.35	.90
Engineering is the most rewarding future career I can imagine for myself.		.92				.26	
My interest in an engineering major outweighs any disadvantages I can think of.		.90				.23	
I want to be an engineer.		.79				.38	

MSLQ: Time Management and Test Anxiety	Test Anxiety	Time Management	Uniqueness	Chronbach's Alpha
Please respond to the following items to the best of your ability.				N/A
When I take a test I think about how poorly I am doing compared to other students.	.75		.42	.89
When I take a test I think about items on other parts of the test I can't answer.	.69		.52	
When I take tests I think of the consequences of failing.	.80		.35	
I feel my heart beating fast when I take an exam.	.80		.36	
I have an uneasy, upset feeling when I take an exam.	.89		.22	
I rarely find time to review my notes or readings before exams. *		.52	.70	.81
I usually study in a place where I can concentrate on my course work.		.62	.61	
I make good use of my study time for my courses.		.75	.44	
I make sure I keep up with the weekly readings and assignments for my courses.		.57	.68	
I find it hard to stick to a study schedule. *		.67	.53	
I often find that I don't spend very much time on my courses because of other activities. *		.67	.55	
I attend class regularly.		.42	.82	
I have a regular place set aside for studying.		.53	.69	

Perceptions of Faculty Caring	Empathetic Faculty Understanding	Comfort with Faculty	Uniqueness	Chronbach's Alpha
To what extent do you agree or disagree with the following statements:				.91
Faculty connect relevant topics to my major.	.55		.56	.85
I feel that a faculty member would be sensitive to my difficulties if I shared them.	.77		.47	
I see faculty members as role models.	.81		.49	
I feel that a faculty member would take the time to talk to me if I needed help.	.61		.45	
I know faculty who are like me.	.60		.57	
I feel that a faculty member would be sympathetic if I was upset.	.84		.41	
e		.96	.17	.91
I feel comfortable seeking help from a faculty member before or after class.		.99	.14	
I feel comfortable talking about a problem with faculty.		.70	.32	
If I had a reason, I would feel comfortable seeking help from a faculty member outside of class time (i.e., during office hours, etc.)		.66	.39	

Items that didn’t load:
Q6a = I feel comfortable asking a faculty member for help with a personal problem.
Q6e = I feel comfortable socializing with a faculty member outside of class.
Q6m = I feel that a faculty member really tried to understand my problem when I talked about it.

Brief Self Control Scale	Impulsivity	Restraint	Uniqueness	Chronbach's Alpha
To what extent do you agree or disagree with the following statements:				0.8
I do certain things that are bad for me, if they are fun.	.79		.58	.74
Pleasure and fun sometimes keep me from getting work done.	.59		.54	
Sometimes I can’t stop myself from doing something, even if I know it is wrong.	.71		.44	
I often act without thinking through all the alternatives.	.53		.66	
I have a hard time breaking bad habits. *		.54	.61	.71
I wish I had more self-discipline. *		.92	.31	
People would say that I have very strong self-discipline.		.48	.64	

Items that didn’t load:
I am good at resisting temptation.*

Student Life Stress Inventory - Revised	Stressors - Changes	Reactions to Stressors	Stressors - Frustrations	Stressors - Conflicts	Stress Support	Uniqueness	Chronbach's Alpha
							.85
As a student:							.76
I have experienced frustrations due to delays in reaching my goals.			.90			.37	
I have experienced daily hassles which affected me in reaching my goals.			.66			.42	
I have experienced failures in accomplishing the goals that I set.			.61			.54	
I have experienced conflicts which were:							.75
Produced by two or more positive options.				.57		.69	
Produced by two or more negative options.				.70		.43	
Produced when a goal had both positive and negative options.				.88		.22	
I have experienced:							.89
Rapid unpleasant changes.	.88					.23	

Too many changes occurring at the same time.	.94			.21	
Change which disrupted my life and/or goals.	.79			.33	
As a person:					
I worry and get anxious about taking tests.		.57		.63	.77
With reference to stressful situations, I have:					
Experienced physical reactions (sweating, biting fingernails, headaches, etc.)		.57		.56	
Experienced fear, anxiety, worry, frustration, etc.		.92		.27	
Cried, was irritable towards others, separated myself from others, indulged excessively, etc.		.54		.59	
Engaged in personal support (exercised, meditated, etc.)			.49	.76	.64
Sought family support (talked to parents, siblings, etc.)			.78	.39	
Sought peer support (talked to friends, classmates, etc.)			.57	.65	

Items that didn't load:

I have experienced lack of sources (money for auto, books, etc.).
I have not been accepted socially (became a social outcast).
I have experienced dating frustrations.
I feel I was denied opportunities in spite of my qualifications.
I like to compete and win.
I like to be noticed and be loved by all.
I worry a lot about everything and everybody.
I have a tendency to procrastinate (put off things that have to be done).
I feel I must find a perfect solution to the problems I undertake.
Thought about and analyzed how stressful the situations were.
Thought and analyzed whether the strategies I used were most effective.
Sought institutional support (attended support groups, visited counseling services, talked with an advisor, visited Dean of Students, etc.)

College Gratitude Scale	Gratitude	Uniqueness	Chronbach's Alpha
Please answer the following with the answer that best describes you.			.88
I feel thankful for the opportunity to learn so many new things	.78	.39	.88
I appreciate the things I have learned in my college classes	.72	.48	
I am grateful to the professors and other students who have helped me in class	.78	.39	
I am so thankful that I'm getting a college education	.79	.38	
I am grateful for the people who have helped me succeed in college	.83	.31	

If I had to list everything I felt grateful for about my academic experience at my university, it would be a very long list	.71	.49

Belongingness	Engineering Belongingness	Uniqueness	Chronbach's Alpha
We would like to know about how you feel that you fit in engineering and belong in your engineering community.			.93
I feel comfortable in engineering.	.90	.19	.93
I feel I belong in engineering.	.85	.27	
I enjoy being in engineering.	.85	.27	
I feel comfortable in my engineering classes.	.82	.33	
I feel supported in my engineering classes.	.74	.46	
I feel that I am part of my engineering classes.	.79	.37	

Items that didn't load:

Q35g = I feel that my engineering classes are large.

Mindfulness	Mindfulness	Uniqueness	Chronbach's Alpha
Below is a collection of statements about your everyday experience. Using the 1-7 scale below, please indicate how frequently or infrequently you currently have each experience. Please answer according to what really reflects your experience rather than what you think your experience should be. Please treat each item separately from every other item.			.91
It seems that I am "running on automatic," without much awareness of what I'm doing.	.79	.38	.91
I rush through activities without being really attentive to them.	.82	.32	
I do jobs or tasks automatically, without being aware of what I'm doing.	.90	.19	
I find myself doing things without paying attention.	.85	.27	