# Benchmarking SUCCESS: How do non-cognitive and affective factors vary among college undergraduates?

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## Abstract

The Studying Underlying Characteristics of Computing and Engineering Student Success (SUCCESS) survey has been distributed at three major universities in the United States to measure how non-cognitive and affective factors influence student success. One goal of this National Science Foundation-sponsored study is to measure these traits and find correlations between the measured constructs and a student's academic performance over his or her career as an engineering undergraduate. After compiling and analyzing data, we benchmarked engineering and computer science student survey results from a large public undergraduate-focused west coast university (Cal Poly, San Luis Obispo) for six traits (*Self-Control*, the *Big 5 Personality Traits*, *Grit*, *Test Anxiety*, *Time and Study Environment*, and *Mindset*) with previous studies of undergraduate students, and in some cases with engineering students specifically. We found differences between the studied engineering students and other student populations in *Grit*, *Big 5*, and *Self-Control*. By understanding the similarities and differences between these studies, we hope to find effective ways to help students be successful. Moreover, by using these data, we hope to develop initiatives that will enhance students' experience in engineering education.

## Introduction and Background

Admission to engineering and computer science programs in the United States is often based largely, if not solely on traditional measures of academic achievement such as standardized test scores (e.g. SAT and/or ACT), high school grade point average, high school rank or postsecondary grades from community college or university.[1] Unfortunately, studies have shown that these measures may be poor predictors of academic success in most disciplines;[2] moreover, preliminary analysis of data collected in this project show that SAT may predict only about 10% of the variance in students' self-reported Grade Point Average (GPA), while a group of ten Non-Cognitive and Affective (NCA) factors taken together predict 26% of this variance.[3] We are exploring what NCA profiles exist for engineering and computer science students, how they might predict success for these students and perhaps more importantly how some of these factors which are malleable (e.g. alterable beliefs or behaviors) might be addressed in students to improve their experience and ultimately their success. In order to collect data on these NCA profiles, the SUCCESS[4] survey was constructed using 14 available and validated assessment tools. Details on the survey construction and deployment can be found in the Methods section of this paper. In this paper we are exploring preliminary survey results to begin to answer our first research question by looking at six of the traits (Self-Control, the Big 5 Personality Traits, Grit, Test Anxiety, Time and Study Environment, and Mindset) measured in the survey from engineering students at one large, public college (Cal Poly) and benchmarking those results to national norms for the traits. Understanding

how engineering students' NCA factors may differ in different engineering populations and from non-engineers is one step in determining where to focus efforts to improve student experiences and success in engineering. Short descriptions of the six NCA constructs follow.

*Self Control:* This construct is formed by two sub-constructs: self-discipline and impulse-control.[5] Self-discipline measures one's general ability to show restraint, and impulse-control measures one's impulsivity, or the degree to which a person's behavior is characterized by lack of forethought.[6] In previous studies, self-control has been linked to the ability to control alcohol and drug consumption,[7] and it is also shown to be linked to academic success.[8] Self-control is considered to be something that we can run out of. Basically, as we use our self-control more and more, our likelihood to continue to use it decreases. Self-control has not been found to be significantly malleable, so it is difficult to influence.[6] The Brief Self-Control Scale (BSCS)[9] is a validated instrument consisting of eight different statements (items). For consistency across all items in the SUCCESS survey, the questions asked the students to rate each item on a 1-7 Likert-type scale. For the BSCS the scale ranges from 1, strongly disagree, to 7, strongly agree. Results are given as an average value for the two sub-constructs: self-discipline and impulsivity, with higher values indicating either higher levels of self-discipline or lower levels of impulsivity.

*Big Five Personality Traits:* The Big 5 personality test measures aspects of personality based on five different traits.[10] These are *Openness*, *Conscientiousness*, *Extraversion*, *Agreeableness*, and *Neuroticism*. Individuals with high values of *Openness* are characterized as more open to new ideas, imaginative, welcoming of change, and insightful. *Conscientiousness* is defined as being hardworking, reliable, and thorough. Individuals with high values of *Extraversion* are described as talkative, assertive and outgoing, and may be described as more excitement seeking. The *Agreeableness* scale measures are related to kindness, generosity and how sympathetic someone is. Finally, *Neuroticism* is a measure of the level of anxiety or personal insecurity in a person.[6] Aspects of the Big 5 personality have been shown to be linked with academic success.[11] In particular, *Conscientiousness* correlates strongly with higher grades at university. As they are measures of personality, the Big 5 are generally considered not to be particularly malleable in the short term; however, they can change due to major life events or over a long period of time.[12] The SUCCESS survey includes 15 items that measure Big 5 constructs, three dedicated to each factor of the Big 5 personality traits. Students rated how well each statement described them on a scale from 1, very inaccurately, to 7, very accurately. A higher score in each personality trait shows the student's personality is strong in that trait.

*Grit:* This construct was proposed by the psychologist Angela Duckworth and is defined as the passion and perseverance for long-term goals.[13] *Grit* is usually unrelated or inversely related to intelligence or talent. The two subcategories of grit are consistency of interest and perseverance of effort. Perseverance of effort is a superior predictor of GPA while consistency of interest is a better predictor of number of lifetime career changes.[14] Undergraduates who scored higher in Grit also

earned higher GPAs than their peers despite having lower SAT scores.[13] The Grit-S (short grit scale), which is comprised of eight items, was used in this study. Reduction of items from Grit-O (original grit scale) to Grit-S was proven to maintain predictive validity. For the SUCCESS survey we scaled each item with anchors of 1, very much like me, and 7, not like me at all. Higher scores indicate a higher level of grit.

*Test Anxiety:* The Test Anxiety Scale is a construct included in the Motivated Strategies for Learning Questionnaire (MSLQ).[15] It was created to measure students' worries, which can hinder performance (cognitive component) and physiological arousal aspects of their anxiety (emotionality component). It has been found that test anxiety is negatively related to academic performance and can lower success expectancies. There are five items to evaluate test anxiety. The questions are scaled with anchors of 1, not true of me, to 7, very true of me. A higher average score corresponds to greater test anxiety.

*Time and Study Environment:* This scale is another section of the MSLQ that seeks to evaluate a student's ability to manage time and regulate study environments. Included in this measure is a student's level of organization, scheduling, and planning. Time management can range from setting aside a night for studying to weekly and monthly scheduling. Study environment refers to the setting where the student studies for class work. The ideal study environment for a student is organized and free from distractions. The time and study environment section of our survey includes eight items, using the same Likert-scale as test anxiety. A higher score corresponds to better time management and use of study environments by the student, which is one of the more strongly correlated MSLQ measurements to better academic performance.[21]

*Mindset:* Mindset is a measurement of an individual's viewpoint of intelligence. This construct is divided into two parts: growth and fixed mindset.[17] A fixed mindset construct is a mentality where an individual believes that there is a fixed ceiling for success and intelligence.[17] On the other hand, an individual with a growth mindset believes that skills and intelligence are malleable and can be improve with effort and practice. In the SUCCESS survey, four items measure a student's growth mindset and four items measure a student's fixed mindset. Like the other traits, each item is evaluated on a seven point scale, 1 meaning that a student strongly disagrees with the statement and 7 meaning that the student strongly agrees with the statement.

**Methods**

The pilot SUCCESS survey was deployed at a large west-coast public university (Cal Poly) in the Spring and Summer of 2017. Data were collected online via Qualtrics.® In parallel, the survey was deployed at a large Midwestern university. Subsequent deployment of the survey has been at all three collaborating schools and to a set of national partner schools that agreed to deploy the survey. To increase participation we placed all respondents into a raffle and awarded a number of gift

cards. The surveys were then sorted and incomplete or inconsistent responses were eliminated, leaving n=356 surveys completed for Cal Poly.  Note that in parallel there was a total of n=1689 surveys collected nationally for comparison.  An exploratory factor analysis of the pilot data verified the validity of the data presented in this paper.[18]

For each item (question) in the survey, we anchored the numeric response on a Likert-type scale from one to seven to provide a consistent scale for the respondents. This scale was often different than the typical implementation of these tools.  For example, responses to the Grit-S survey are typically given in numeric scores of one to five. We combined items that loaded into factors through arithmetic means, which became the factors used for benchmarking. To make comparisons with other reported results in the literature, we simply re-scaled other reported results to be consistent with our scale.

**Results**

To benchmark each construct against other populations, we took the results of the survey from Cal Poly (n=356) and compared that data to the overall responses of engineering and computer science students to the SUCCESS survey (n=1689).  The students within this dataset are engineering and computer science students. Some basic demographics of survey respondents compared to the national SUCCESS survey deployment are given in Table 1.  Next, we researched other studies that utilized survey instruments similar to the SUCCESS survey and assessed the differences. It is important to note that the comparison data were obtained from a variety of sources, including other university students (not engineering and computer science), high school students, and the general population.

| Group | Cal Poly (n=356) | | SUCCESS (n=1689 | |
|---|---|---|---|---|
| | n | % | n | % |
| Woman | 128 | 36.0 | 488 | 28.9 |
| Man | 216 | 60.7 | 1171 | 69.3 |
| Other | 12 | 3.4 | 26 | 1.54 |
| Engineering | 289 | 81.2 | 1492 | 88.3 |
| Computing | 66 | 18.7 | 155 | 9.18 |

Table 1: Self-Reported Demographics. Note that Gender reporting has been simplified to include woman, man and other, which represents respondents who identify as something other than (cis-) woman or (cis-) man.

*Self-Control:* Self-control scores were benchmarked using three comparison studies. The first study surveyed a group of first-year students from multiple majors, the second surveyed students aged 20-26 in the CEIT program, and the third surveyed first year engineering students. As shown in Table 2, the results from the Cal Poly cohort were nearly identical in mean scores from the entire population in the SUCCESS survey. However, when compared to other studies, there were notable differences in measurement of self-control. Mean responses for self-control differed by up to one full point; scores for engineering and computer science students were lower in self-control than any other study we looked at. It is important to note that the comparison studies used a 13-item self-control assessment, but the SUCCESS survey only used an 8-item scale, as is consistent with recommendations from literature.[9]

| | Cal Poly n=356 | | SUCCESS Survey n=1689 | | First-Year Students n=88[19] | | Students Age 20-26 n=60[20] | First-Year Engineering Students n=451[21] |
|---|---|---|---|---|---|---|---|---|
| Student Population | Eng. and Comp. Sci. | | Eng. and Comp. Sci. | | First year students, multiple disciplines | | Comp Sci. | Engineering |
| Construct | ISC | SDSC | ISC | SDSC | ISC | SDSC | ISC | Combined SC |
| Mean | 3.6 | 4.1 | 3.6 | 4.1 | 4.55 | 4.69 | 4.4 | 4.6 |
| SD | 1.23 | 0.81 | 1.28 | 0.83 | 1.176 | 1.204 | 1.06 | 0.907 |

Table 2: A Comparison of Self-Control Scores

Note: ISC = Impulse Self-Control; SDSC = Self-Discipline Self-Control; SD = Standard Deviation; last study only reports one combined score; all scores have been scaled to be out of 7

*Big Five Personality:* Big Five scores were benchmarked using three comparison studies. The first study surveyed students from many majors in an introductory psychology course, the second surveyed students from 30 different universities in the US, and the third surveyed students of multiple disciplines at four British universities. As Shown in Table 3, for the Big Five personality traits, Cal Poly student's results differed significantly from other studies in extraversion, neuroticism, and openness. The scores for agreeableness and conscientiousness were similar. Cal Poly's scores were much lower in *Extraversion* by up to one full point. Their scores in *Agreeableness* were lower as well, up to 0.7 points lower in comparison with one study while being just somewhat lower in comparison to two other studies. *Conscientiousness* was higher in comparison, with a difference of up to 0.5 points. *Neuroticism* was higher with differences of up to 0.4 points. And finally, *Openness* was much lower, with differences of up to 2 points.

*Grit:* As shown in Table 4, the mean grit score for students at Cal Poly is almost identical to the entire SUCCESS survey population. These scores were compared with other studies including first-year engineering students at an east coast school, Ivy League undergraduates, and West Point cadets. The mean grit score for the SUCCESS survey, 4.60, is significantly lower than the other studies evaluated, the next closest score being 4.84. The highest grit score, 5.25, comes from a study of West Point cadets. Also, the SUCCESS survey's standard deviation for grit is significantly larger than the other studies; the SUCCESS survey's standard deviation for grit is 1.13, while the other studies are all smaller than 0.85, demonstrating a wider spread of data for the SUCCESS survey's population.

| Student Population | | Cal Poly n=356 | SUCCESS Survey n=1689 | Intro to Psychology n=192[22] | 30 US Colleges n=856[23] | UK Students n=101[24] |
|---|---|---|---|---|---|---|
| | | Eng. and Comp. Sci | Eng. and Comp. Sci | Multiple Disciplines | Multiple Disciplines | Multiple Disciplines |
| Extraversion | Mean | 3.7 | 3.8 | 4.76 | 4.634 | 4.62 |
| | SD | 1.47 | 1.44 | 1.12 | 1.274 | 1.213 |
| Agreeableness | Mean | 4.8 | 4.6 | 5.18 | 5.502 | 5.23 |
| | SD | 1.35 | 1.36 | 0.84 | 0.98 | 0.98 |
| Conscientiousness | Mean | 5.0 | 5.1 | 4.76 | 4.998 | 4.48 |
| | SD | 1.03 | 1.03 | 0.84 | 1.134 | 1.31 |
| Neuroticism | Mean | 5.3 | 5.3 | 4.2 | 3.92 | 3.92 |
| | SD | 1.15 | 1.13 | 1.12 | 1.12 | 1.26 |
| Openness | Mean | 3.1 | 3.2 | 4.9 | 5.25 | 5.09 |
| | SD | 1.36 | 1.40 | 0.7 | 1.064 | 1.07 |

Table 3: A Comparison of Big 5 Scores

Note: SD = Standard Deviation; all scores have been scaled to be out of 7

*Test Anxiety:* The mean test anxiety score for Cal Poly (B=4.1) and the general SUCCESS survey (B=4.2) are nearly identical as shown in Table 5. These scores are similar to the other studies examined and reside in the middle of the range of scores. The other studies used for comparison consist of first-year engineering students at a U.S. school, STEM undergraduate students (majority computer science major), and U.S. students of all different majors (attending either community college, private university, or public university). The mean test anxiety scores from these studies are 3.81-4.29. The students in the SUCCESS survey do not have significantly higher or lower levels of test anxiety than students from other universities.

| | | Cal Poly n=356 | SUCCESS Survey n=1689 | First-Year Engineering Students at East Coast School n=374[25] | Ivy League Undergraduates n=138[25] | West Point Cadets n=1308[25] |
|---|---|---|---|---|---|---|
| Student Population | | Eng. and Comp. Sci | Eng. and Comp. Sci | Engineering | Multiple Majors | Multiple Majors |
| Grit | Mean | 4.55 | 4.60 | 4.97 | 4.84 | 5.25 |
| | SD | 1.13 | 1.13 | 0.69 | 0.85 | 0.76 |

Table 4: A Comparison of Grit Scores

Note: SD = Standard Deviation; all scores have been scaled to be out of 7

| | | Cal Poly n=356 | SUCCESS Survey n=1689 | First-Year Engineering Students at U.S. School n=360[26] | STEM Undergraduates n=111[27] | US Students (CC, Private, Public Schools) n=365[28] |
|---|---|---|---|---|---|---|
| Student Population | | Eng. and Comp. Sci | Eng. and Comp. Sci | Engineering | 40% Comp. Sci students, 60% other STEM Majors | All Majors |
| Test Anxiety | Mean | 4.1 | 4.2 | 4.29 | 3.90 | 3.81 |
| | SD | 1.69 | 1.59 | 1.26 | 1.35 | 1.49 |

Table 5: A Comparison of Test Anxiety Scores

Note: SD = Standard Deviation; all scores are out of 7

*Time and Study Environment:* The mean time and study environment management scores are identical for Cal Poly and the overall SUCCESS survey at a value of 4.9 (see Table 6). Other studies looked at involved first-year civil engineering students at a Chilean University, STEM undergraduates (majority computer science major), and U.S. students of all different majors (attending either community college, private university, or public university). All of the studies examined have very similar mean scores for time and study environment management. The maximum difference between scores is 0.15, which is minimal. The standard deviations are all very similar as well.

| | | Cal Poly n=356 | SUCCESS Survey n=1689 | 1st-Year Students at Chilean Univ. n=339[30] | STEM Undergrads n=111[27] | Midwestern University n=380[31] |
|---|---|---|---|---|---|---|
| Student Population | | Eng. and Comp. Sci | Eng. and Comp. Sci | Civil Eng. | 40% Comp. Sci students, 60% other STEM Majors | All Majors |
| Time and Study Environment | Mean | 4.9 | 4.9 | 4.75 | 4.86 | 4.87 |
| | SD | 1.03 | 0.94 | 1.04 | 0.66 | 1.05 |

Table 6: A Comparison of Time/Study Environment Scores
Note: SD = Standard Deviation; all scores are out of 7

*Mindset:* Unlike other traits, there are not many studies focused on determining a student's mindset index. However, one study conducted by Allyson Devers from Saint Mary's College of Maryland used Carol Dweck's 16-item Likert-type questionnaire[29] and provides data on growth and fixed mindset. The limitation to this study is that the sample size is significantly smaller than our current dataset. Devers' results were scored on a six-point scale. Because our results are scored on a seven point scale, the results of the other study were re-scaled for comparison. These results are highlighted in Table 7.

From evaluating the scores, we see a substantial difference between the two pairs of data sets. From the statements evaluating growth mindset, the students surveyed through the SUCCESS survey demonstrated lower beliefs in growth mindset. In Devers' research, the opposite is shown with scores higher than 3.5. For the items measuring fixed mindset, the students in the SUCCESS study scored 2.8, which reflects the mentality of a somewhat fixed mindset. The comparison groups of high school students in AP Physics and undergraduate students scored 3.86 and 4.03, which signifies the viewpoint of a student with a stronger growth mindset.

| Institution | Cal Poly n=356 | SUCCESS Survey n=1689 | High School n=22 | University (Physics Students)[29] n=10 |
|---|---|---|---|---|
| Student Population | Engineering and Computer Science | Engineering and Computer Science | AP Physics[7] | Physics Students[7] |

| | | Cal Poly n=356 | SUCCESS Survey n=1689 | High School n=22 | University (Physics Students)[29] n=10 |
|---|---|---|---|---|---|
| Growth | Mean | 2.7 | 2.7 | 3.94 | 3.77 |
| | SD | 1.3 | 1.27 | 0.73 | 0.69 |
| Fixed | Mean | 2.8 | 2.8 | 4.03 | 3.86 |
| | SD | 1.4 | 1.38 | 0.72 | 0.71 |

Table 5: A Comparison of Mindset Scores

Note: SD = Standard Deviation; all scores are out of 7

**Discussion and Summary**

In this study we have attempted to benchmark survey data measuring several non-cognitive and affective traits of engineering and computing students against a contemporaneous and larger data set, as well as against data from the literature for different populations. Our results show that the data from Cal Poly are largely identical to (and thus a fair sample of) the larger SUCCESS survey data, but in many instances, substantially different from reported results from the literature. The traits that differed substantially include *Self-Control*, *Extraversion*, *Neuroticism* and *Openness* from the Big 5 survey, and growth and fixed mindset beliefs from the mindset survey. Several reasons could explain these differences. First, there may be some variation due to different survey instruments being deployed. For example, for the self-control measure, other research has used the original, 13-item Self-Control Scale, while we chose to use the updated, 8-item Brief Self-Control Scale. This explanation, however, would only explain the self control and mindset constructs (which also has different survey instruments in the literature, all based on the same original author and primary research) and have no effect on the others. A second possibility is that some differences may be attributed to a recent change in attitudes and beliefs, especially for these 18-22 year-olds living in our rapidly changing culture, and the pressures they experience or evolving values that they possess. Finally, it is simply possible that students who choose to study engineering and computer science are actually different in some NCA traits, even from the general undergraduate population, and the SUCCESS survey is exposing these differences. As we described earlier, one overarching goal of this study is to discover which traits have a substantial impact on student success, understand their malleability for change, and develop initiatives that can help students to reach their potential for success.

## Acknowledgements

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