

General Personality Traits of Engineering Students and Their Relationship with Academic Achievement*

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The purpose of this study was to explore whether and to what extent general personality traits based on the Big Five model correlate with and explain unique variance of academic success among undergraduate civil engineering students. In total, 151 college civil and environmental engineering students completed the 240-item NEO Personality Inventory-3 (NEO-PI-3) and released their GPA and SAT scores. We conducted analyses of descriptive statistics, correlation, and hierarchical regression using the IBM statistics software SPSS Version 21. Neuroticism (positively), Extraversion (negatively), and Agreeableness (negatively) were significantly correlated with current term GPA. Neuroticism (positively) and Agreeableness (negatively) were significantly correlated with cumulative GPA. Conscientiousness explained unique variance in the cumulative GPA. The findings from this research indicate that the Big Five personality traits are a significant predictor of academic achievement of engineering students. The results highlight the importance of examining non-academic factors in explaining variance in academic achievement of engineering students.

Keywords: general personality traits; big five model; college engineering students; academic achievement

1. Introduction

The shortage of professionals working in the fields of science, technology, engineering, and mathematics (STEM) is a serious issue that the United States continues to face [1]. A recent report by the National Science Board [2] estimated that approximately half of the students initially seeking bachelor's degrees in STEM fields leave their programs or change majors to non-STEM fields. The issue is more pressing in the field of engineering, in which 41% of engineering students drop out of their programs within their first year of study. The attrition rate is roughly 61% for students pursuing associate's degrees in engineering [3].

To address the issue of high attrition rates among engineering students, the traditional approach has focused on predicting academic achievement based on prior academic performance and cognitive factors. Within the field of engineering, SAT Math scores and high school grade point averages (GPAs) were consistently found to be significant predictors of undergraduate academic performance in engineering programs. However, these factors accounted for only about 25% of the variance in academic achievement [4]. It is generally thought that other factors—such as socioeconomic status,

motivational levels, self-efficacy, personality types, and gender—account for the remaining variance [5]. Some research suggests that personality factors account for roughly 14% of the variance in undergraduate GPA [6, 7]. However, the majority of historical and contemporary empirical studies addressing the issue of academic achievement among engineering students have largely ignored these factors and have focused solely on high school academic achievement and other cognitive-based factors [8].

The present study deviates from the traditionally academic-heavy conceptualizations of predicting academic achievement in STEM fields, particularly within the field of engineering. We sought to examine whether and to what extent general personality traits based on the Big Five model correlate with and explain unique variance of academic achievement among undergraduate engineering students.

2. Literature review

2.1 Overview of trait psychology

Finding an adequate definition of personality that encompasses all aspects of the complex field of personality analysis has been a challenge since the first textbook on personality was published [9].

Larsen and Buss [9] stated that research on personality traits has been based primarily on researchers' ideas of what each trait represents. Two basic formulations of traits, from differing perspectives, have emerged. The first school of thought views traits as internal mechanisms that are causal in nature. These personality traits are consistent across different situations and can be used to explain the behavior of individuals. The second major school of thought understands personality traits as purely descriptive summaries of the attributes of individuals. Traits, in this context, are used to describe, rather than to explain, an individual's behavior [9]. Several theories of personality have been formulated with the goal of explaining the structure of personality as a set of traits that, when combined, comprise the personality of an individual [9]. One of the earliest trait theories was that of Gordon Allport, who is commonly regarded as the founder of trait theory and the first personality psychologist [10]. In the 1930s, Allport utilized an English language dictionary to compile a list of 4,500 terms that would categorize stable personality traits [9, 10].

Cattell [11] used the seminal work of Allport to narrow the list of personality traits from 4,500 to 171 [9]. Cattell continued to refine the list of personality traits, proposing a 16-factor theory in 1946 [12]. Using factor analysis statistics, Fiske [13] further narrowed Cattell's 16-factor theory into a five-factor theory that explained variances in personality [9,10]. Many researchers have subsequently replicated this five-factor theory of personality [14–16]. This five-factor model of personality, conceptualized as the Big Five personality theory, has become the most dominant and well-researched theory within the field of personality psychology [17].

2.2 Big five personality theory

The contemporary adaptation of Big Five personality theory identifies the five factors of Openness, Conscientiousness, Extroversion, Agreeableness, and Neuroticism [16]. The Openness trait is reported to be associated with individuals who desire to learn new things and who enjoy a variety of new experiences. The attributes of Openness are imaginativeness, insightfulness, and a large range of interests. The trait of Conscientiousness includes promptness and reliability, organization, and methodic and thorough behavior. Those high in the trait of Extraversion are individuals whose energy is derived from interaction with other individuals; in contrast, individuals who score low on this trait derive their energy internally. The attributes of Extraversion are high energy, talkativeness, and assertiveness. Agreeableness refers to an individual's tendency to be helpful, cooperative, and sympathetic towards others. The trait of Neuroti-

cism, also known as emotional stability, relates to the stability of an individual's emotions and the extent of his or her negative emotions. Individuals who score high on this trait are characterized as emotionally unstable. They tend to experience negative emotions, such as being tense and moody, and may have issues with impulse control and anxiety [7, 18].

McCrae and Costa [19] identified six descriptors that correspond to each of the five traits (see Fig. 1). These five traits, and their subsequent descriptors, are not dichotomous in nature, but are presented as existing on a continuum. In other words, there are varying degrees to which each of the five factors is present in individuals. The scales of the NEO Inventories measure the five personality traits [19]. These five factors of the Big Five model are often considered universal regardless of an individual's gender, age, or culture [20]. In fact, research has shown that the Big Five factors have been identified in individuals across 50 varying cultures around the globe [18] and are regarded as stable over the lifespan [12,21]. Research on the development of the five traits has revealed that some traits begin to emerge as early as 3 years of age, whereas others

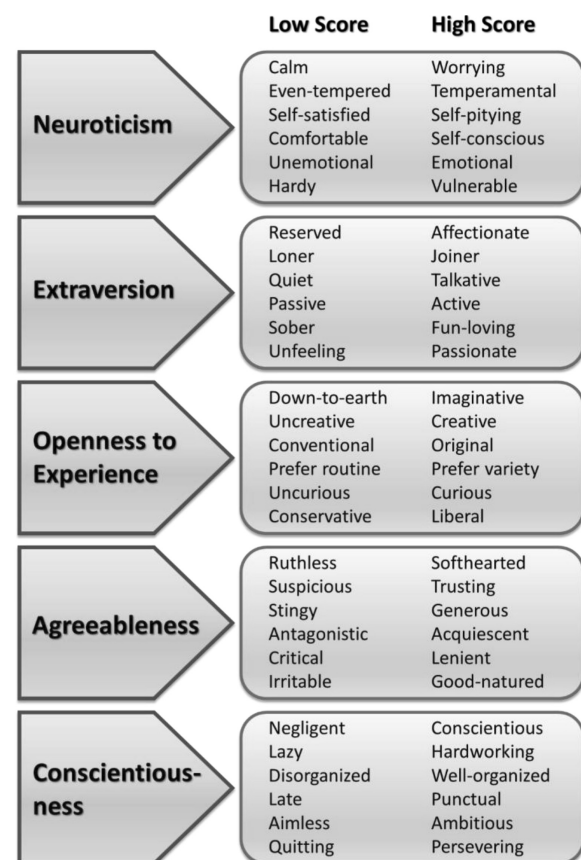


Fig. 1. The Big Five model of personality. Note. Developed based on *Personality in Adulthood: A Five-Factor Theory Perspective* (p. 4), by R. R. McCrae and P. T. Costa, 2003, New York, NY: The Guilford Press.

such as Openness to Experience emerge later during adolescence [18].

2.3 *Academic achievement and retention*

The issue of college retention rates has been and continues to be a major concern in the field of U.S. higher education [22]. Research on this subject indicates that only 58% of college students graduate from the colleges that they initially entered [23], with most attrition taking place during the freshman year [22]. The topic of student retention has been a major focus in recent literature, with most research examining the factors that produce successful college students and, therefore, increased retention rates [23, 24].

In fact, the attrition rates of college students in STEM fields have been such a major concern that policymakers within the United States have developed research grants specifically to examine the factors that contribute to high attrition rates [3]. In one such study, conducted by the National Center for Education Statistics [3], researchers concluded that factors such as precollege academic preparation, demographic characteristics, and performance in STEM coursework were all significant predictors of attrition. Specifically, low cumulative GPA and a high number of failed or withdrawn from STEM courses were significantly correlated with increased attrition rates within STEM programs [3]. In response to shortages within the STEM workforce, increasing the retention rates in these programs is an issue that many higher education professionals are seeking to address.

2.4 *Personality traits and academic achievement*

Using personality factors as possible predictors of academic performance is not a novel concept within the field of psychology. In fact, this idea dates to the work of Webb [25], who theorized a personality construct, which he called the will factor, that affected and predicted academic performance [26]. In the following century, the practice of using personality to predict academic performance has been visited and re-visited, with each research study contributing a new personality factor to the equation [26]. As the dominant theory in personality research today, the Big Five personality theory has been utilized extensively in research examining correlations between personality factors and academic performance [27]. Much of the research has concluded that personality factors influence the types of learning strategies that students use, which in turn affects their academic performance [28, 29].

A study conducted by Marcela [30] examined the relationship between the Big Five personality traits, four learning strategies (deep processing, elabora-

tive processing, fact retention, and methodical learning), and academic achievement. Marcela [30] found a positive relationship between the four learning strategies and the personality traits of Conscientiousness and Openness. In fact, Conscientiousness and Openness were found to significantly influence the student's preferred learning strategy, which was significantly correlated with academic achievement. Hakimi, Hejazi, and Lavasani [31] found that personality traits overall accounted for 48% of the variance in undergraduate academic achievement whereas Conscientiousness alone accounted for 39%.

Further, personality factors are not only thought to affect academic performance by affecting of learning strategy but also by influencing student motivation, a major factor in student achievement [32]. In one study, Conscientiousness was found to predict both intrinsic and extrinsic motivation, with motivation in academics as the mediator of the relationship between Conscientiousness and Openness to Experience in terms of academic performance [32]. In another study, students who were intrinsically motivated with regard to college attendance were found to be extroverted, conscientious, agreeable, and open to new experiences whereas students who were extrinsically motivated were found to be extroverted, conscientious, agreeable, and neurotic [33].

Using the Big Five personality theory, Laidra, Pullmann, and Allik [34] examined correlations between the five personality factors and the GPAs of 3,618 students attending Grades 2, 3, 4, 6, 8, and 10. Likewise, based on findings obtained in studies of undergraduate students, the researchers concluded that Openness and Conscientiousness were significantly and positively correlated with elementary and secondary students' GPAs whereas Neuroticism was negatively correlated [34]. Similarly, a study focused on secondary school students found that Conscientiousness and Openness were highly correlated with high school GPA [35]. The finding that some traits have consistent correlations with academic achievement across age and/or culture is consistent with the Big Five personality theory, which proposes that the five factors are universal across human demographics [20].

The concept of personality traits as predictors of academic achievement has been utilized in various fields, such as health science, law, and business. In one study, Al-Naggar et al. [36] found that the personality traits of Openness and Conscientiousness were significantly and positively correlated with the academic achievement of health science students. Similarly, Lievens, Coetsier, De Fruyt, and Maeseneer [37] found that the personality traits of Extraversion, Agreeableness, and Con-

scientiousness significantly predicted the academic achievement of medical school students. Lounsbury, Smith, Levy, Leong, and Gibson [38] found that students enrolled as business majors scored high on the scales of Conscientiousness and Extraversion but scored low on Agreeableness and Openness. Other studies have found that arts and humanities majors scored significantly higher on the trait of Openness than law, sciences, and economics students [39]. These findings suggest that each major or field of study is composed of its own unique personality composite that distinguishes it from other majors. Thus, the match between a student's personality traits and the major that the student chooses may assist researchers in understanding the nature of student retention and attrition [40] and academic progress [41].

2.5 Purpose of the present study

Literature examining attrition rates within engineering programs has primarily focused on academic-based factors, such as GPA and performance on standardized examinations, but few researchers have examined personality traits in relation to student success. An extensive review of the literature revealed one study [42] that examined the Big Five personality traits in 256 undergraduate engineering students. The focus of the study was to use Big Five personality traits to predict retention for persisting students [42]. However, Hall et al. [42] utilized the NEO Five-Factor Inventory (NEO-FFI), which is a 60-item measure of personality based on the five-factor model and is considered a shortened version of the 240-item NEO Personality Inventory [43]. NEO-FFI assesses personality characteristics only at the domain level (i.e., the five-factor level) but not at the 30-facet scale level (i.e., subdomains under each factor). The present study is the first of its kind to utilize the 240-item NEO Personality Inventory-3 [44] with a sample of undergraduate civil engineering students. In contrast to previous studies, the focus of the present work was to explore whether and to what extent general personality traits correlate with and explain unique variance of academic success.

3. Methods

3.1 Participants

The participants were undergraduate students at a private university who had declared or intended to declare civil and environmental engineering as their major. Students were enrolled either part- or full-time in the program and were 18 years or older. The selected sample was representative of the male-to-female engineering student ratio found in the general population, which recent literature indicates is

5:1 [45]. Power analysis for a multiple regression with five predictors (i.e., five factors of Big Five model) was conducted in G*Power to determine a sufficient sample size using an alpha of 0.05, a power of 0.80, and a medium effect size of 0.15 [46] and yielded the desired sample size of 92. We conducted this project over multiple semesters and initially recruited 175 participants. Not all participants completed all measures. Thus, only 151 participants (female = 32; 21.2%, male = 119; 78.8%) who completed all NEO measures and reported SAT and GPA scores were retained for final analysis.

3.2 Measures

SAT Math. The SAT exam is a standardized college admission assessment. SAT scores have been examined in roughly 3,000 research studies, demonstrating the predictive nature of the SAT for college GPA, with validity coefficients ranging from 0.44 to 0.62 [47]. SAT Math scores were found to be consistently correlated with academic success in STEM fields [48]. In Authors [49], we found that SAT Math was more predictive than other SAT domain scores in predicting academic success in college engineering students. Thus, the present study focused only on SAT Math scores as a pre-college indicator of academic achievement.

GPA. GPA has been considered to be synonymous with "academic achievement" [50]. GPA has been used as an overall measure of academic achievement from the time children enter primary school and plays an important role in the decision-making process for college admission [47]. In higher education, GPA has been used as a parameter to determine academic probation. Undergraduate GPA significantly predicted academic performance in graduate school [51]. We used current term and cumulative GPAs as the criterion measures in the present study.

NEO-PI-3. The NEO-PI is one of the most extensively used and rigorously researched instruments for measuring the Big Five personality factors [52]. The NEO-PI-3, the most recent revision of the instrument, is composed of 240 items that assess the five personality factors [53]. As noted, and as shown in Fig. 1, each of the NEO-PI-3's five domains is divided into six facet subscales. In total, the NEO-PI-3 assesses 30 facets of personality and provides a score for each facet. The NEO-PI-3 is a self-reported measure that utilizes a response booklet containing 240 items with answers based on a 5-point Likert-scale. The administration time for this instrument is reported to take between 30 and 40 minutes for an average adult [53].

Norms for the use of this instrument were based on 1,135 participants ranging from 14 to 91 years old. Research examining the reliability of the NEO-

PI-3 indicates that the measure has adequate internal consistency across domains, ranging from 0.87 to 0.95. Internal consistency across the 30 facets was found to be lower, ranging from 0.48 to 0.83. An examination of the criterion validity of the NEO-PI-3 was strongly correlated with the NEO Personality Inventory—Revised (NEO-PI-R), the previous version of the instrument, and ranged from 0.98 to 0.99 at the domain level. Consistent gender and age correlations have also been obtained across the two measures [53]. The NEO-PI-3, along with its predecessor the NEO-PI-R, have well-established validity and reliability and have been used in a multitude of studies with various populations [54]. Cronbach's alpha (a well-used reliability statistic)

for the 30 personality subscales was found to be adequate, ($\alpha = 0.624$) according to guidelines provided in the literature examining internal reliability [55].

3.3 Procedures

The present research was conducted after obtaining Institutional Review Board (IRB) approval from the participating university. Because participant-protected educational data were collected, the Family Educational Rights and Privacy Act (FERPA) consent form was also approved by the participating university. Both the consent form and the FERPA form explained the voluntary nature of the study and the types of data to be collected. All

Table 1. Demographics for Participating Engineering Students (N = 151)

| | Minimum | Maximum | Mean | SD |
|----------------|---------|---------|--------|-------|
| Age | 18.00 | 34.00 | 21.32 | 3.08 |
| SAT Math | 430.00 | 800.00 | 606.51 | 71.06 |
| GPA Current | 1.49 | 4.00 | 3.02 | 0.56 |
| GPA Cumulative | 2.03 | 3.97 | 3.08 | 0.47 |

Table 2. Descriptive Statistics of Big Five Domains and Facets

| Domains & Facets | Min | Max | Mean | SD | Norm Mean/SD |
|--------------------------|-----------|------------|---------------|--------------|---------------------|
| Neuroticism | 25 | 148 | 91.54 | 21.39 | 86.60/22.60 |
| Anxiety | 4 | 28 | 17.54 | 5.30 | |
| Angry hostility | 2 | 32 | 14.26 | 4.95 | |
| Depression | 2 | 29 | 16.15 | 5.24 | |
| Self-consciousness | 4 | 30 | 15.36 | 5.31 | |
| Impulsiveness | 5 | 28 | 16.61 | 4.76 | |
| Vulnerability | 0 | 25 | 11.69 | 4.28 | |
| Extraversion | 9 | 166 | 117.18 | 23.49 | 117.30/18.50 |
| Warmth | 7 | 32 | 21.72 | 4.81 | |
| Gregariousness | 0 | 32 | 17.73 | 5.46 | |
| Assertiveness | 4 | 29 | 17.44 | 4.99 | |
| Activity | 5 | 33 | 18.55 | 4.75 | |
| Excitement | 6 | 32 | 21.89 | 4.29 | |
| Positive emotions | 1 | 32 | 20.23 | 5.85 | |
| Openness | 11 | 166 | 116.77 | 18.81 | 111.90/19.60 |
| Fantasy | 8 | 29 | 19.40 | 4.55 | |
| Aesthetics | 6 | 30 | 17.25 | 5.59 | |
| Feelings | 2 | 32 | 20.34 | 4.83 | |
| Actions | 9 | 28 | 16.57 | 3.98 | |
| Ideas | 10 | 32 | 22.46 | 4.66 | |
| Values | 10 | 32 | 21.54 | 4.20 | |
| Agreeableness | 60 | 155 | 111.74 | 17.28 | 111.30/18.30 |
| Trust | 4 | 29 | 16.77 | 4.80 | |
| Straight-forwardness | 4 | 30 | 17.52 | 5.39 | |
| Altruism | 8 | 31 | 23.68 | 4.12 | |
| Compliance | 2 | 28 | 15.06 | 4.30 | |
| Modesty | 3 | 29 | 17.59 | 5.32 | |
| Tender-mindedness | 8 | 31 | 20.79 | 4.38 | |
| Conscientiousness | 68 | 178 | 125.67 | 19.62 | 118.60/21.60 |
| Competence | 12 | 31 | 21.56 | 3.81 | |
| Order | 6 | 31 | 20.13 | 5.10 | |
| Dutifulness | 13 | 32 | 22.51 | 3.78 | |
| Achievement striving | 6 | 31 | 22.72 | 4.83 | |
| Self-discipline | 4 | 32 | 20.59 | 5.14 | |
| Deliberation | 9 | 27 | 18.19 | 4.12 | |

Note. Norm Mean/SD column provides means and standard deviations of the standardization norm of young adults ages 21-30 years from the professional manual [44].

participants voluntarily participated in the study and completed related measures. After researchers received the signed consent forms, participant data including SAT scores, current term GPA, and cumulative GPA were obtained. We assigned each participant an ID number to ensure confidentiality.

4. Results

4.1 Descriptive statistics

The participants had a mean age of 21.32 ($SD = 3.08$) years with a range from 18 to 34 years. Among the participants, 21.2% were female and 78.8% were male. The mean SAT Math score was 606.51 ($SD = 71.06$). The mean current GPA was 2.85 ($SD = 0.68$) and the mean cumulative GPA was 2.94 ($SD = 0.53$). Full descriptive statistics are presented in Table 1. The descriptive statistics of the participants' scores on the NEO-PI-3 are presented in Table 2. In comparison to the mean and standard deviations of the scores on five domains based on the standardization norm [44], which represented typical young adults age 21 to 30 years, the engineering participants showed slightly elevated mean scores on Neuroticism, Openness, and Conscientiousness. However, such differences were not statistically significant.

4.2 Correlations between personality traits and academic performance

A correlation analysis was conducted to examine the Big Five personality traits of the NEO-PI-3 and academic performance as measured by current term and cumulative GPA. At the domain level, Neuroticism was found to be significantly and positively correlated with both current term and cumulative GPA ($r = 0.172^*$ and $r = 0.257^*$). Extraversion was significantly and negatively correlated with current term GPA ($r = -0.202^*$) only. Agreeableness was found to be significantly and negatively correlated with SAT Math ($r = -0.238^*$), current term GPA ($r = -0.195^*$), and cumulative GPA ($r = -0.183^*$). At the facet level, anxiety, angry hostility, and self-consciousness were significantly and positively correlated with GPA measures. Warmth, gregariousness, and excitement were significantly and negatively correlated with GPA measures. Altruism and tender-mindedness were significantly and negatively correlated with GPA measures. Full correlation results are presented in Table 3.

4.3 Regression analyses

We conducted two hierarchical regression analyses to determine to what extent NEO-PI-3 factors explained variance in cumulative GPA and current term GPA (see Table 4). When GPAs were the dependent variables, SAT Math as a control vari-

Table 3. Correlations between Big Five Domains and Facets and Academic Performance

| Domains & Facets | SAT Math | GPA Current | GPA Cumulative |
|--------------------------|----------|-------------|----------------|
| Neuroticism | 0.107 | 0.172* | 0.257** |
| Anxiety | -0.068 | 0.101 | 0.180* |
| Angry hostility | 0.170 | 0.163* | 0.235** |
| Depression | 0.008 | 0.029 | 0.109 |
| Self-consciousness | 0.165 | 0.211* | 0.231** |
| Impulsiveness | 0.124 | 0.106 | 0.162 |
| Vulnerability | 0.052 | 0.129 | 0.138 |
| Extraversion | -0.150 | -0.202* | -0.136 |
| Warmth | -0.200* | -0.221* | -0.165* |
| Gregariousness | -0.126 | -0.262* | -0.221** |
| Assertiveness | -0.187 | -0.120 | -0.097 |
| Activity | -0.072 | -0.042 | 0.007 |
| Excitement | -0.033 | -0.225* | -0.107 |
| Positive emotions | -0.082 | -0.125 | -0.058 |
| Openness | 0.048 | -0.069 | 0.073 |
| Fantasy | 0.168 | -0.086 | -0.029 |
| Aesthetics | -0.138 | -0.046 | 0.072 |
| Feelings | 0.098 | 0.014 | 0.112 |
| Actions | 0.040 | 0.044 | 0.103 |
| Ideas | -0.013 | -0.028 | 0.051 |
| Values | 0.201* | 0.042 | 0.158 |
| Agreeableness | -0.238* | -0.195* | -0.183* |
| Trust | 0.010 | -0.049 | -0.026 |
| Straight-forwardness | -0.132 | -0.135 | -0.145 |
| Altruism | -0.232* | -0.233** | -0.217** |
| Compliance | -0.177 | 0.012 | -0.076 |
| Modesty | -0.062 | -0.003 | -0.014 |
| Tender-mindedness | -0.273** | -0.195* | -0.132 |
| Conscientiousness | -0.108 | 0.045 | 0.068 |
| Competence | 0.058 | -0.009 | 0.006 |
| Order | -0.172 | 0.013 | -0.008 |
| Dutifulness | -0.012 | -0.003 | 0.083 |
| Achievement striving | -0.144 | 0.088 | 0.108 |
| Self-discipline | -0.185 | -0.013 | 0.011 |
| Deliberation | 0.022 | 0.103 | 0.118 |

* $p < 0.05$; ** $p < 0.01$.

able was entered in the equation as Step 1 because it is well-known that SAT Math is a reliable predictor of academic achievement of engineering students. Scores on the NEO-PI-3 (five domains) were entered as Steps 2, 3, 4, 5, and 6, respectively. The same procedure was conducted for both current term GPA and cumulative GPA. We examined the assumption of normality. Based on Tabachnick and Fidell [56], the absolute values of skewness indices for these measures were not extreme, indicating no severe violation of normality assumptions.

In the first regression model, the current term GPA was the dependent variable. SAT Math explained 21.4% unique variance in the cumulative GPA. After controlling for SAT Math, NEO-PI-3 explained 13.5% unique variance in the current term GPA. When we examined each NEO-PI-3 domain, Neuroticism (3.4%) and Agreeableness (3.3%) explained unique variance in the current term GPA. In the second regression model, the cumulative GPA was the dependent variable. SAT Math

Table 4. Hierarchical Regression Analyses for NEO-PI-3 and GPA

| Steps | Variables | Current GPA | | | Cumulative GPA | | |
|-------|--------------------------|-------------|----------------|-----------------------|----------------|----------------|-----------------------|
| | | β eta | R ² | R ² Change | β eta | R ² | R ² Change |
| 1 | SAT Math NEO Measures | 0.389*** | 0.214 | 0.214 | 0.467*** | 0.278 | 0.278 |
| 2 | Neuroticism | 0.244* | 0.248 | 0.034 | 0.312** | 0.339 | 0.061 |
| 3 | Extraversion | -0.148 | 0.265 | 0.017 | -0.078 | 0.340 | 0.001 |
| 4 | Openness | -0.171 | 0.294 | 0.029 | -0.087 | 0.347 | 0.007 |
| 5 | Agreeableness | -0.198* | 0.327 | 0.033 | -0.168* | 0.370 | 0.023 |
| 6 | Conscientiousness | 0.162 | 0.349 | 0.022 | 0.206* | 0.406 | 0.036 |

Note. NEO = NEO Personality Inventory-3 (NEO-PI-3); GPA = grade point average. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

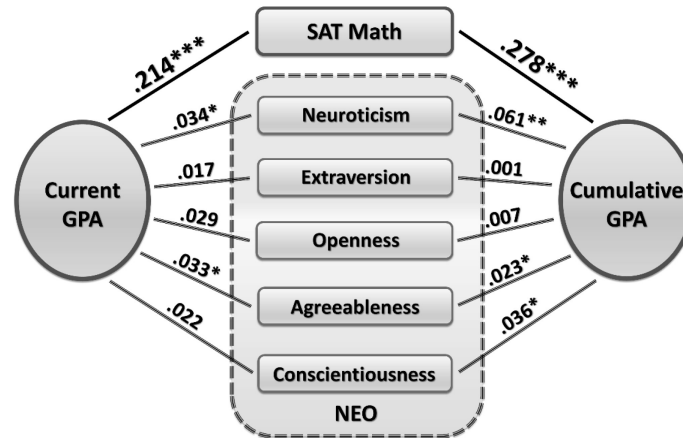


Fig. 2. NEO personality traits predicting GPAs. Note. The numbers indicated R² change that each factor contributed to the variance of each dependent variable.

continued to explain large unique variance (27.8%) in the cumulative GPA. After controlling for SAT Math, NEO-PI-3 explained 12.8% unique variance in the current term GPA. When we broke down to each NEO-PI-3 domain, Neuroticism (6.1%), Agreeableness (2.3%), and Conscientiousness (3.6%) explained unique variance in the cumulative GPA. In short, the main findings based on regression analysis are summarized in Fig. 2.

5. Discussion

The first research question examined the correlations between the Big Five personality traits and the academic achievement of engineering students. A correlational analysis using the NEO-PI-3 as a measure of the Big Five personality traits revealed that the personality trait of Neuroticism was significantly and positively correlated with GPA measures. Although this finding was not expected, a review of the literature examining Neuroticism and academic achievement revealed that higher levels of Neuroticism do not always lead to lower grades, as some previous research has suggested [57]. It is theorized that students with higher levels of Neuroticism may experience greater anxiety about their

academic achievement, which may then lead to more intense preparation and studying [58]. Furthermore, research suggests that individuals who score high on the Neuroticism trait often possess learning styles that are associated with structured environments, such as those found in the engineering field [58, 59]. When examining the relationship between Neuroticism and the academic achievement of college students, Vedel et al. [39] described an inverted U-shaped relationship. That being the case, a certain degree of Neuroticism should be expected among students with higher academic achievement; however, extremely high or low levels can correlate negatively with academic performance.

The personality trait of Extraversion and some facets (i.e., warmth, gregariousness, and excitement) under this domain were found to be significantly and negatively correlated with GPA measures. Such findings were not surprising; there have been mixed results regarding the relation between Extraversion and academic performance [60–62]. These findings suggest that individuals who scored high on Extraversion might spend more time socializing whereas those who scored low might spend more time on independent studying [63]. A

meta-analysis study conducted by O'Connor and Paunonen [64] indicated an overall negative relation between Extraversion and academic performance, although there are studies suggesting a positive association between Extraversion and academic success [65].

The personality trait of Agreeableness and some facets (i.e., altruism and tender-mindedness) were found to be significantly and negatively correlated with GPA measures. This finding was expected, and it indicates that engineering students who had a greater tendency to be helpful and sympathetic towards others were more likely to obtain lower GPA scores. Research examining the relationship between Agreeableness and academic performance suggests that students who score high on the Agreeableness trait often prefer to learn through group projects and assignments, but they may not possess sustained individual study behaviors outside of these settings [59]. The negative correlation found in this study between Agreeableness and academic achievement is consistent with the personality profile of engineering students who scored lower on traits assessing Extraversion, which indicates that these students prefer independent work and are self-directed in their studies. These findings are in direct contrast to research examining the personality profiles of "helping professions," such as school psychologists and counselors, which involve high levels of human interaction. Research examining these professions found that participants scored higher on the Agreeableness and Openness traits, which indicates that these traits are positively correlated with fields that involve human interactions, which the engineering field traditionally has not emphasized [66]. Certain aspects of engineering, such as structure and design, often require engineers to work with technical details rather than with people. According to Holland's vocational personality theory [67], some engineering firms may prefer individuals who are analytical, independent, practical, fact centered, and performance focused, rather than individuals who are people centered and communication focused. Thus, personality characteristics that reflect the ability to work with people and a concern for positive communication with others might be less critical in such engineering fields. However, the findings did not indicate that the abilities to work with people are not important for engineers because some engineering fields (i.e., construction and civil engineers) require a great deal of social interaction and communication with people. It is plausible that the examinations and projects endorsed by this particular civil engineering program did not explicitly measure such traits.

The second research question examined whether and to what extent the Big Five personality traits

contribute to the additional variance in engineering student's GPA measures after controlling for SAT Math. An examination of personality traits revealed that overall the Big Five personality factors contributed significantly to the additional variance in both current term and cumulative GPAs. The findings held true even after we accounted for SAT Math. An examination of the individual traits revealed that both Neuroticism and Agreeableness significantly contributed to the additional variance in current term and cumulative GPAs, concurring with our findings based on correlation analysis. These findings are consistent with the literature finding that Neuroticism and Agreeableness have a significant impact on academic performance [7, 59]. Conscientiousness explained unique variance in the cumulative GPA, concurring with numerous empirical studies conducted with students in other majors [60, 68–70]. Conscientiousness has been the most consistent predictor of academic success at the postsecondary level. For example, Conscientiousness has shown positive correlation with GPA [60, 66, 68] and is predictive of academic performance in narrower domains such as a final grade in a specific undergraduate course [68, 71]. Conscientiousness is often considered a personality characteristic related to motivation and orderly behaviors, such as being motivated to do well and to be hardworking, task oriented, and organized [63]. Our findings confirm the role of Conscientiousness in engineering students' undergraduate learning success.

In short, main findings are summarized in Table 5, with comparison to the empirical findings in the literature.

6. Educational implications

The findings of the present study can contribute to a large body of literature examining factors influencing college students' choice of academic major, which has primarily focused on early academic performance, career goals, math aptitude, potential earnings, and peer influences [72–75]. Researchers in engineering education and educators who are involved in recruiting students into engineering programs should begin to incorporate personality factors into current models examining engineering major choice, as the present study demonstrates that personality plays a major role in academic achievement after an individual is enrolled in college. By doing so, researchers and educators will obtain a more complete understanding of the differing and complex factors that affect college major choice and, in turn, they may be able to assist prospective students in determining an appropriate college major, one that is tailored to their specific needs and learning styles. Although personality assess-

Table 5. Main Findings in Comparison to The Existing Literature

| Findings in the present study | Findings in the existing literature |
|---|--|
| <p><i>Neuroticism</i> $\uparrow \Rightarrow$ GPA \downarrow</p> <p>A certain degree of <i>Neuroticism</i> should be expected among students with higher academic achievement; however, extremely high or low levels can correlate negatively with academic performance.</p> | <p>Higher levels of <i>Neuroticism</i> do not always lead to lower grades [57].</p> <p>Vedel et al. [39] described an inverted U-shaped relationship, indicating the right amount of anxiety/stress can tune up the brain and improve performance but too much could be harmful.</p> |
| <p><i>Extraversion</i> $\uparrow \Rightarrow$ GPA \downarrow</p> | <p>Individuals who scored high on <i>Extraversion</i> might spend more time socializing whereas those who scored low might spend more time on independent studying [63, 64].</p> |
| <p><i>Agreeableness</i> and some facets $\uparrow \Rightarrow$ GPA \downarrow</p> | <p>Some engineering fields may prefer individuals who are analytical, independent, practical, fact centered, and performance focused, rather than individuals who are people centered and communication focused [67].</p> |
| <p><i>Conscientiousness</i> explained unique variance in the cumulative GPA.</p> | <p><i>Conscientiousness</i> has shown positive correlation with GPA [60, 66, 68] and is predictive of academic performance [68, 71].</p> |

ment alone should not be used as a sole predictor of students' academic achievement in a specific major, it can contribute to an understanding of the motivational and behavioral differences among college engineering students that might impact their academic achievement.

The findings revealed that engineering students with high scores in Neuroticism tended to have high GPAs. It is plausible that some students learned to harness their anxiety, so they could direct it positively to effective test preparation. It is also possible that some anxious students might be engaging in surface-level learning attributable to compulsive preparation and studying before major exams [58, 76]. Higher levels of anxiety about academic performance can, in some instances, negatively affect academic performance [39], although this is not identified in the present study. Engineering programs are known to utilize standardized examinations as one of the most important evaluation approaches to determining grades for courses. Frequent examinations and quizzes might contribute to anxiety and distress associated with test taking. Therefore, engineering programs should be aware that this personality trait is common within their student population and may choose to provide additional resources to assist these students to gain a deeper learning of the content and to help them with decreasing their negative emotions. These resources can include tutoring and counseling centers where students can obtain help with content areas, time management, and organizational and note-taking skills. For educators who are involved in developing and designing assessment tools to evaluate student performance, there might be different and innovative ways of assessing students for deep, as opposed to surface learning. Programs may choose to differentiate instruction and evaluation approaches for these individuals by changing the format of the classes to incorporate more hands-on

projects rather than paper-and-pencil examinations, which can lead to surface-level learning of materials and increased test anxiety due to pressures of memorization [77]. As a result of such differentiated instruction and evaluation, students may feel more supported in their programs and experience higher academic success. Lower level of negative emotions associated with Neuroticism could contribute to greater satisfaction/well-being with the college program and lead to higher retention rates.

Although many examinations associated with different levels of engineering courses emphasize independent learning and technical details with content knowledge, engineering educators should recognize that the abilities to work in teams (groups) and multi-disciplinary settings and effective communication skills with society at large are now specifically required by many professional accreditation bodies. Engineering educators and program designers need to recognize the variety of personality traits that their students may display and explore innovative educational and evaluation approaches to encourage engineering students to progressively develop people-centered tendencies in conjunction with individual study behaviors. Many professional accreditations bodies actually require such training components. As engineering students are progressing through engineering programs, they will leave the programs with solid and comprehensive engineering content knowledge and technical skills. It is critical that they could utilize their effective communication and team-work skills to apply and disseminate their cutting-edge engineering knowledge and skills to the larger community, making a broader societal impact.

7. Limitations

This study has a number of limitations. First, we recruited our participants from a specific college due

to convenience. Our participants' current term and cumulative GPAs and SAT Math scores represented a wide range of variance, indicating that the sample was representative of all ability levels within the participating school. In addition, the gender statistics within the participating program was consistent with national norms for engineering programs. However, due to the participants being selected from a small urban college, the findings might not be generalizable to other types of universities in other U.S. geographical areas. Second, given that the NEO-PI-3 is self-report instrument, there could be measurement issues such as rater bias related to the nature of self-report measures. Future researchers might consider the use of qualitative approaches such as semi-structured interviews or discourse analysis to explore the influence of students' personality traits and understand human behaviors from the informant's perspectives, allowing a dynamic and negotiated processing. Third, GPA was used as the sole indicator of academic performance. Students' overall satisfaction with their engineering programs depend on many factors such as academic engagement, personal interaction with instructors and classmates, sense of belonging in engineering programs, and adjustment to an academic program. Other indicators, such as sense of belonging, college adjustment, class attendance, teacher evaluations, and performance on undergraduate projects, should be considered in future studies that evaluate academic success through multi-dimensional approaches.

8. Conclusions

Overall, our findings confirm the important role of general personality traits in relation to academic performance in college engineering students. In this particular sample, engineering students who had higher scores on Neuroticism tended to have higher GPAs. This finding indicates that some combination of Neuroticism attributes might motivate students positively to study more and obtain higher grades. On the other hand, the findings could suggest that some high-achieving engineering students might be prone to mental health issues such as anxiety and impulsiveness that could affect college retention. Extraversion and Agreeableness had negative association with GPAs. The findings indicated that personality characteristics of individuals with people-centered tendencies (e.g., the willingness to socialize, consideration of others, sympathy, and concern for others) might not be highly represented in the engineering fields, which often require independent work and self-directed problem solving. Engineering often requires professionals to work with technical details rather than with

people, thus the ability to work with people might be less critical. However, civil engineering projects in the practical fields often require the ability to work as a team and communicate effectively (e.g., design engineers working with architects and construction engineers to complete a project). It is plausible that such communication and social skills are not explicitly measured by the examinations or projects in the participating civil engineering program as a training site. Second, three of the Big Five personality domains measured by the NEO, Neuroticism, Agreeableness, and Conscientiousness, were significant predictors of GPA measures. This study underscores the importance of exploring the predictive power of personality factors to explain the variance in academic achievement among undergraduate engineering students. Future studies should extend personality assessment in engineering students with considerations of gender differences, program differences, and racial and ethnic differences. In addition, future researchers should consider academic success more holistically and explore the interplay between personality traits and a broader definition of success through not only a quantitative approach, but also a qualitative approach or a mixed method.

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