Work in Progress: Openness, Conscientiousness, Self-Direction, and Mindset in First-Year Engineering Students

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Introduction

Starting in 2004, the College of Engineering and Applied Sciences at Western Michigan University (WMU) began placing most incoming first-year students into cohorts based on their preferred major. Students placing into at least Pre-Calculus as their first math class are designated as 'Pre-Mechanical', 'Pre-Electrical', etc. After successfully completing 1.5-2 years of foundational coursework, the 'Pre-' is removed and they can take upper-level courses in their major. First-year students who wish to major in engineering, engineering technology, or computer science but who place into Algebra II as their first math class are classified as 'Engineering Preparatory' and assigned to a common cohort (a mix of potential majors). The class schedule for this cohort includes an optional, but strongly recommended, academic success course. Member of each cohort typically share at least three classes and are assigned a faculty mentor. The cohort structure and associated student success programs like tutoring, social events, and an associated living-learning community have led to significant gains in retention and graduation rates. However, increases in these metrics have plateaued and we are actively seeking ways to supplement previous gains and to help more students successfully complete their degree programs. The current study is based on promising results in the literature related to the potential impacts of various personality traits on engineering student success.

A variety of personality tests and inventories are available to characterize individuals. Most have strong proponents as well as detractors. The Big Five personality inventory [1] appears to be one of the most well-received, in large part because it does not classify respondents into specific 'boxes' but assigns them a score along continua of behavior. Multiple studies have investigated the potential links between personality traits and student success (e.g., [2-7]). For university students and engineering students, in particular, two of the five factors most commonly identified as related to student success are Openness and Conscientiousness.

There has also been great excitement in recent years around concepts like grit, resilience, and mindset with regards to their potential role in student success (e.g., [8-11]). While a recent meta-analysis cast doubt on the universal applicability of mindset interventions for improving student outcomes [10], researchers did point out that the impact of mindset is potentially significant for students at the lower end of the socio-economic spectrum or those who were under-prepared for their program of study [10,11]. Separate research has also identified the potential for self-directed learning to play a role in student success [7,12,13].

Taken together, there seem to be several potentially distinct aspects to student personality and behavior that may either be interconnected or may separately play a role in student success. We also know that specific behaviors such as forming study groups can have an impact on student success [14]. In the current work, we are attempting to tease out the unique factors and interrelations between these various research approaches to identify the best path forward for effective student interventions.

Experimental Methods/Materials/Project Approach

All first-time in any college (FTIAC) students in the College of Engineering and Applied Sciences were invited to participate in an online survey for the project. Students were invited and the consent forms administered during the first two weeks of the semester by giving short presentations in various classes. Students were told that participants who completed both a start- and end-of-semester version of the survey would be entered into a random drawing for one of three $50 gift cards. Three hundred forty-eight FTIACs were eligible to participate. One student died during the Fall 2019 semester and four others made complete withdrawals from the university for unknown reasons. These students were removed from the analysis, leaving a potential pool of 343 participants. One hundred four completed the start-of-semester survey (30.3% response rate) and 42 completed both the start- and end-of semester surveys (12.2% response rate). Only results from the start-of-semester survey are included in the current work. Table 1 shows the demographics of respondents for the survey and Table 2 shows the demographics of all Fall 2019 FTIACs. Female students and white students were overrepresented in the respondent pool compared to the overall student population.

Table 1: Demographics of start-of-semester survey respondents

Male	Female	White	Non-white
77 (74.0%)	27 (26.0%)	92 (88.5%)	12 (11.5%)

Table 2: Demographics of all Fall 2019 FTIACs

Male	Female	White	Non-white
290 (84.5%)	53 (15.5%)	280 (81.6%)	63 (18.4%)

The survey was created by incorporating 20 questions each related to Openness to Experience and Conscientiousness, eight questions related to Mindset, and 10 questions related to Self-Direction. Questions were randomized and included both positive and negative factors for each topic. Openness to Experience and Conscientiousness questions were drawn from the open-source question bank of the International Personality Item Pool at the Oregon Research Institute [15]. The full 20-item scale for each trait (10 positive, 10 negative) was used. Mindset questions were obtained from the National Mentoring Resource Center and the work of De Castella and Byrne [16,17]. Self-Direction questions were pulled from the work of Lounsbury and co-workers [13]. Each screen of the survey presented a random selection of questions (+ and -) from each personality aspect. Three additional questions related to student's confidence in completing their degree program were also included at the end of the survey. On all questions, students submitted a response from 1-5 (does not describe me at all to describes me very well or not at all confident to extremely confident).

After the start of the Spring 2020 semester, GPA from Fall 2019 (overall GPA as well as grades in math courses) and enrollment data from Spring 2020 were gathered for all Fall 2019 FTIAC students. 'Success' in the present context is measured in terms of continuing enrollment at Western Michigan University (either in the College of Engineering and Applied Sciences or in another college) and in terms of the Fall 2019 GPA. One-way ANOVA analyses were performed between each of the personality traits (for example, all 10 positive Openness to Experience responses were averaged to yield a single O+ score, and all 10 negative responses

were averaged to yield a single O- score, etc.), students' high school GPA, and their confidence in completing their degree and in having chosen the correct major to determine if any of the factors appear to significantly affect 'success'. All reported 'statistically significant' relations are at the 95% level or higher.

Results and Discussion

Cohort – All FTIACs

For FTIAC students who did not respond to the survey, the only pre-semester data that has been analyzed is their high school GPA. Data on permanent address and expected family contribution (EFC) is available but has not been included in the modeling at this point. Previous academic success has been shown to be predictive of future achievement by other researchers [e.g. 18]. A comparison was made between 1) all Fall 2019 FTIACs, 2) Fall 2019 FTIACs who did not complete the online survey, and 3) Fall 2019 FTIACs who did complete the online survey to see if high school GPA was statistically significant to the success of one or more of these groups. One-way ANOVA predicted that high school GPA is indeed statistically significant to the first semester GPAs of all three groups to a 95% confidence level. In fact, high school GPA was found to be a statistically significant factor in first semester GPA for all cohorts that were analyzed except two (explained below). No other factor was found to be as near-universally significant at the 95% confidence level.

Cohort – FTIACs Completing the Online Survey

In addition to high school GPA, both students' confidence that they would graduate from college and confidence that they would graduate from Western Michigan University (WMU) were found to be statistically significant factors for first semester GPA in the cohort of students who completed the online survey. Students reporting a confidence level of 1 out of 5 in either measure achieved statistically lower GPAs in their first semester than students reporting confidence levels of 2 or higher. Both confidence in graduating from WMU and positive self-direction score were statistically significant factors relative to whether or not the students were enrolled at WMU for Spring 2020. Students who were very confident in graduating (4 or 5) were statistically more likely to be enrolled at WMU for Spring 2020 than those who responded 2 or 3 out of 5. Students reporting a self-direction score of 3 or lower were statistically less likely to be enrolled than those reporting 4 or 5.

Sub-cohorts: Male vs. Female

High school GPA and confidence in graduating from college were found to be statistically significant relative to the first semester GPA for male students. Students reporting a confidence level of 1 out of 5 relative to graduating achieved statistically significant lower GPAs in their first semester than students reporting confidence levels of 3 or higher. Confidence in graduating from WMU and the positive self-direction score were found to be statistically significant to whether a male student was enrolled for Spring 2020. Male students reporting positive self-directions scores of 4 or 5 had statistically higher GPAs than those reporting scores of 3 or lower. Male students with confidence in graduating from WMU of 3 or higher had higher GPAs than

those with a confidence level of 2. In contrast to the male students, no factors were found to be statistically significant relative to first semester GPA for female students. Only the positive mindset score was found to be statistically significant for female students' enrollment for Spring 2020, the only time this factor was found to be significant for any cohort or sub-cohort. However, it should be noted that the relatively low number of female respondents (27), may call into question the validity of the statistical analysis for this group.

Sub-cohorts: White vs. Non-white/Underrepresented Minority (URM)

When survey respondents were aggregated according to race, only high school GPA was found to be statistically significant relative to first semester GPA for white students. Both positive self-direction and students' confidence in graduating from WMU were found to be statistically significant relative to white students' enrollment for Spring 2020. White students with positive self-direction scores of 4 or 5 were statistically more likely to be enrolled in Spring 2020 than students with scores of 3 or lower. White students with confidence levels in graduating from WMU of 3 or higher were statistically more likely to be enrolled than white students with confidence levels or 2. For non-white or underrepresented minority (URM) students, no factors were found to be statistically significant relative to Spring 2020 enrollment. High school GPA, students' confidence in graduating from college, confidence in graduating from WMU, confidence in having chosen the correct major, and positive conscientiousness score were all found to be statistically significant relative to first semester GPA for URM students. For confidence in graduating (both categories), URM students reporting levels of 1 had statistically lower GPAs than students with levels of 2 or higher. URM students with confidence levels of 3 or higher that they had chosen the correct major had statistically higher GPAs than students with confidence levels of 1. Positive conscientiousness scores of 4 or higher were statistically related to higher first semester GPAs for URM students than for students with scores of 3 or lower. With only 12 students in this sub-cohort, however, these results are potentially suspect.

Sub-cohorts: Pre-Calculus or higher vs. Algebra II

For students who placed into at least Pre-calculus during their first semester, confidence in graduating from college, confidence in graduating from WMU and high school GPA were all found to be statistically significant relative to first semester GPA. Pre-calculus students with graduation confidence levels (both categories) of 1 had statistically lower GPAs than students with confidence levels of 2 or higher. Confidence in graduating from WMU and positive self-direction score were found to be statistically significant relative to Spring 2020 enrollment. Pre-calculus students with self-direction scores of 4 or 5 were statistically more likely to be enrolled for Spring 2020 than students with scores of 3 or lower. Confidence in graduation from WMU of 3 or higher was related to a statistically higher likelihood for Spring 2020 enrollment than a confidence level of 2. For students who placed into Algebra II for their first semester, only positive conscientiousness score and negative openness to experience score were found to be statistically significant factors to first semester GPA. Algebra II students with positive conscientiousness scores of five had statistically lower first semester GPAs than students with scores of 4. Negative openness scores of 3 or higher for these students were statistically related to higher first semester GPAs than scores of 2. Only negative mindfulness score was found to be statistically significant for Algebra II students' enrollment in Spring 2020, with students

reporting mid-range scores (3), being less likely to be enrolled than students at either extreme. Students in Algebra II are under-prepared for a course of study in engineering, so the statistical significance of a mindfulness factor is consistent with previous work [10,11]. This was the only time that negative mindfulness score was found to be statistically significant.

Conclusions

In addition to the relationship between high school GPA and first semester GPA that was found to exist for most student cohorts, confidence in graduating (both from college in general and from WMU specifically) as well as the positive self-direction score were found to be the most common statistically significant factors in this analysis. The relatively low number of URM and female participants increases the uncertainty of the validity of the results for those groups of students, but the relationship between confidence or commitment to graduating and student success has been noted in retention models such as that of Tinto [19,20]. Very few personality traits were found to be consistently related to either first semester GPA or second semester enrollment. This is somewhat surprising given other results available in the literature. However, it may be related to the consideration below.

Student attrition from the College of Engineering and Applied Sciences at WMU is typically higher between the end of the first year and start of the second than it is between the first two semesters. For this reason, classification of students retained to Spring 2020 as 'successful' is likely somewhat premature. The addition of retention data to Fall 2020 into the statistical analysis, as well as the incorporation of financial and residential data, will likely provide a more robust view of factors that influence engineering student retention and success.

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