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Academic Success and Retention of Underprepared Students

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Academic Success & Retention of Underprepared Students

1.0 Introduction

The Academy of Engineering Success (AcES) program, founded in 2012 and operating with NSF S-STEM funding since 2016, implements literature-based strategies to support and retain underprepared (non-calculus-ready) and underrepresented first-time, full-time undergraduate students in engineering with the goals of increasing the number of graduating engineers and diversifying the engineering workforce [1], [2]. A total of 71 students, including 21 students supported by renewable S-STEM scholarships, participated in the AcES program between 2016 and 2019 in the Fundamentals of Engineering Program of the Benjamin M. Statler College of Engineering and Mineral Resources at West Virginia University, a large R1 institution in the mid-Atlantic region. Requirements to renew the scholarship include: (1) continued enrollment in an engineering or computer-science related major in the engineering college while maintaining a cumulative GPA of at least 3.0 and (2) participation in periodic surveys and individual and focus group interviews [1], [2]. AcES participants who are not scholarship recipients are not invited to participate in individual and focus group interviews, but are invited to take the surveys.

Three instructional elements comprise the AcES program: (1) a structured week-long pre-fall bridge experience, (2) a fall professional development course, and (3) a spring course focusing on engineering developments throughout history. In addition, AcES students have a common academic advisor in their first year and also participate in co-curricular activities. During the first year, AcES students have opportunities for: (1) faculty-to-student, student-to-student, and engineering professional-to-student interaction, (2) academic support and student success education, and (3) major and career exploration – all designed to facilitate cohort formation and help students develop feelings of institutional inclusion, engineering self-efficacy and identity, and academic and professional success skills [1], [2].

Research using data from the 2017 and 2018 cohort supported the Kruger-Dunning Effect, "a cognitive bias in which unskilled people do not recognize their incompetence in specific areas and often overestimate their abilities" [3], [4], [5]. Students who ultimately leave engineering before their second year often begin their engineering journey with unrealistic views of their ability and the difficulty of the journey. Typically, they underestimate the demands of the major (and career) and overestimate their ability to succeed in the major with little extra effort [2], [3], [5]. This paper compares pre- and post-measures of characteristics believed to be influential or related to academic success and student retention in STEM fields for three cohorts (2017, 2018, and 2019) of the AcES program.

2.0 Methodology

Three survey instruments: the Grit assessment [6], [7], the Longitudinal Assessment of Engineering Self-Efficacy (LAESE) survey [8], [9], and the Motivated Strategies for Learning Questionnaire (MSLQ) [10], [11] are used to measure students' attitudes, characteristics and beliefs related to engineering and their ability to succeed in their chosen major and career. Each of these assessments include sub-scores relating to student characteristics including: Engineering

career expectations; engineering, math or coping self-efficacy; feelings of inclusion; test anxiety [8], [9]; self-regulation; and strategy use [10],[11]. These characteristics are believed to be influencing factors in student retention.

Students who retain past their first year in engineering are expected to demonstrate "grit," defined as "passion and sustained persistence applied toward long-term achievement, with no particular concern for rewards or recognition along the way" [6], measured by the Grit survey in which students rate each of 12 statements using a 5-point Likert scale, ranging from "very much like me" to "not at all like me." Based on their responses, survey completers are assigned a "grittiness" score from 1 to 5 in which 1 is "not gritty" and 5 is "very gritty."

The LAESE survey uses a 7-point Likert scale in which students indicate their level of agreement with statements as well as, for a subset of items, the level of importance of the statement to measure six characteristics (measured using sub-scales): (1) Engineering career expectations; (2)Engineering self-efficacy 1 (ability to earn an A or B in math, physics, and engineering courses and succeed in an engineering curriculum while not giving up participation in outside interests); (3) Engineering self-efficacy 2 (ability to complete engineering requirements such as math, physics, chemistry, as well as their general ability to succeed in any engineering major); (4) Feeling of inclusion; (5) Coping self-efficacy; and (6) Math outcomes efficacy [8], [9].

The MSLQ provides a measure of students' motivation and beliefs related to their ability to succeed in engineering. The MSLQ uses a 7-point Likert scale in which students indicate the level that the statement is "true" of them, with 1 representing "not at all true of me" and 7 representing "very true of me" to measure five traits, divided into two categories: motivational beliefs – which include intrinsic value of engineering, self-efficacy, and test anxiety; and learning strategies – which include learning strategy use and self-regulation [10], [11].

The Grit, LAESE, and MSLQ surveys are administered to AcES students three times during the first year: at the beginning and end of the fall semester and at the end of the spring semester. The data is compared to understand patterns of attitude change over the first year. Previous research based on the combined survey results of all three surveys for the 2017 and 2018 cohorts indicated support for the Kruger-Dunning Effect. This paper and poster compare the early fall and late spring measures for the combined 2017, 2018, and 2019 cohorts on the Grit and LAESE surveys.

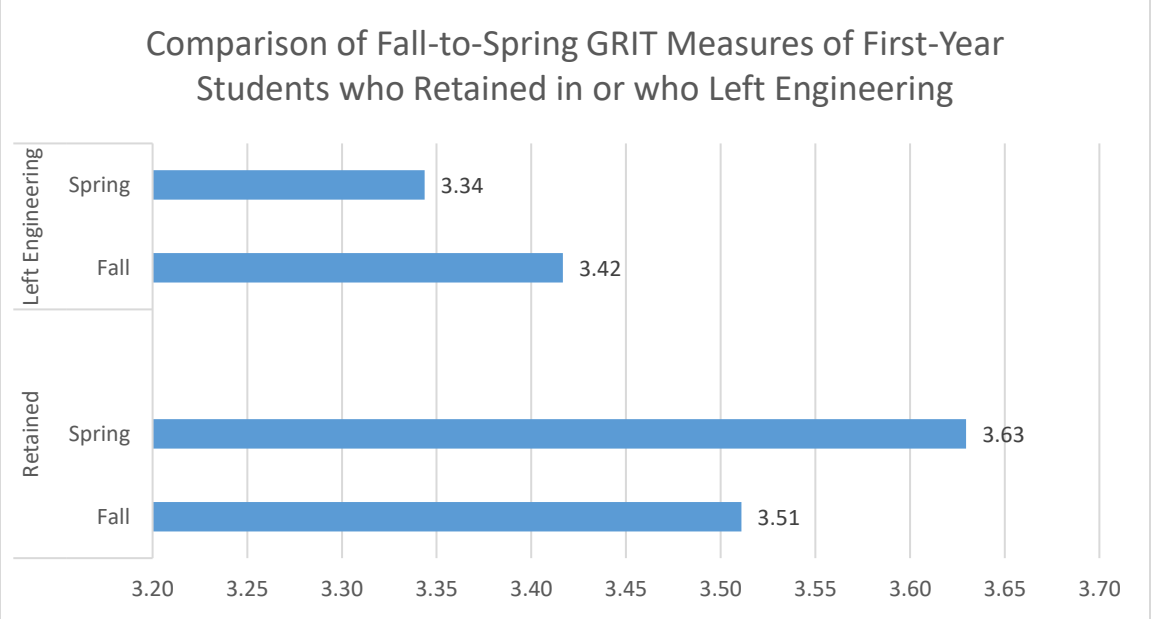
The COVID-19 pandemic and its associated restrictions limited some of the activities of the AcES program in 2020 and early 2021; however, efforts and adaptations were made to remain connected with the students during that challenging time. Advising appointments as well as individual and focus group interviews for all cohorts were held virtually. Unfortunately, those students from the 2019 cohort who chose to leave engineering for a different major did not complete the surveys in spring 2020. GPA scholarship renewal guidelines were waived for the fall 2020 semester to accommodate those students who took advantage of the (one-time only) Pass/Fail grading option or who earned lower grades due to the unique challenges of completing courses in an online environment in which many of the faculty were learning to use the educational technology along with the students. Additional scholarship opportunities were

offered to AcES scholars to pursue summer school opportunities. Some students used the opportunity to remediate from a difficult spring term and others used the opportunity to get ahead on their academic plan.

3.0 Results and Discussion

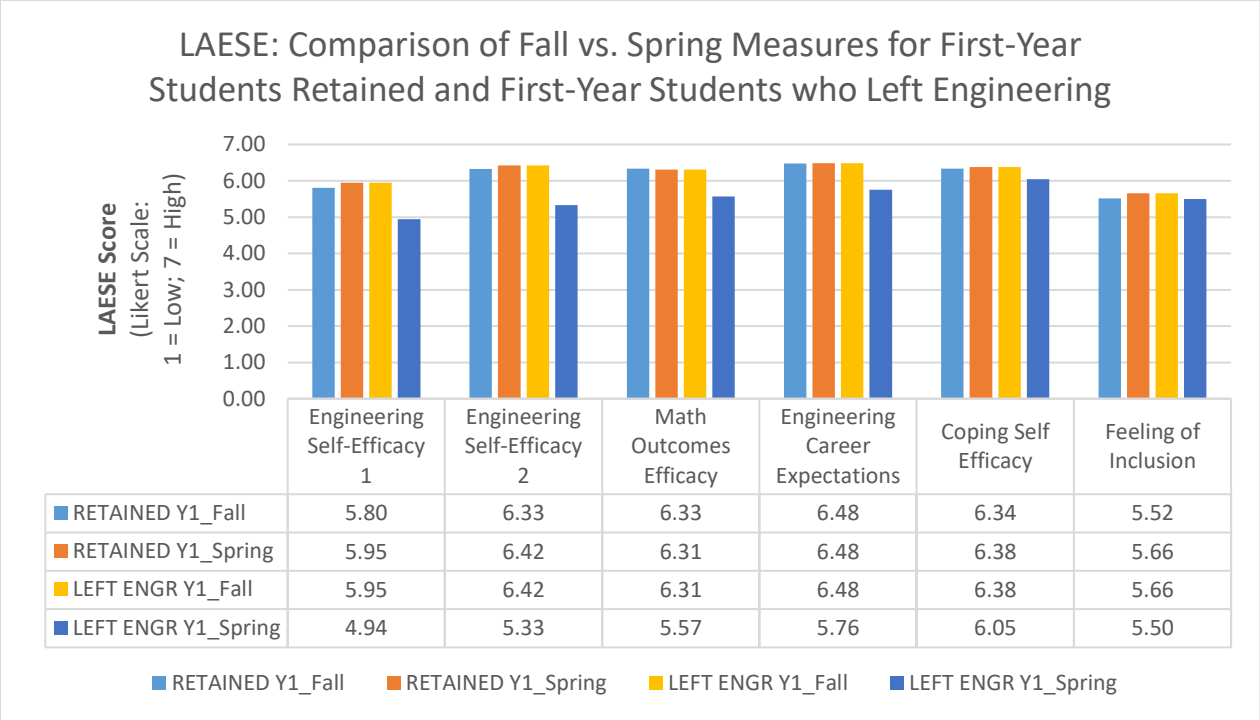
Results from the survey responses of 59 students in the combined 2017, 2018, and 2019 cohorts are presented and discussed below. Of the 59 students in the study, 42 (71.2%) retained and 17 (28.8%) left engineering before the beginning of their second year in college, which is slightly higher than the retention of non-calculus-ready students in the college during these years.

As shown in Figure 1, below, Grit scores of retained students increased 0.12 points (2.4%) from 3.51/5.00 in fall to 3.63/5.00 in spring while the Grit scores of students who left engineering decreased 0.08 points (-1.6%) from 3.42/5.00 in fall to 3.34/5.00 in spring.



These results suggest that students who retain in engineering gain grit during their first year, while students who ultimately leave engineering before their second year lose grit.

Similar comparisons of fall and spring LAESE results, as presented in Figure 2 below, suggest that students who retain in engineering increase in engineering and coping self-efficacy and feeling of inclusion measures while students who leave engineering before their second year decrease in measures of all characteristics assessed by the LAESE instrument.



	Engineering Self-Efficacy 1	Engineering Self-Efficacy 2	Math Outcomes Efficacy	Engineering Career Expectations	Coping Self Efficacy	Feeling of Inclusion
RETAINED Y1_Fall	5.80	6.33	6.33	6.48	6.34	5.52
RETAINED Y1_Spring	5.95	6.42	6.31	6.48	6.38	5.66
LEFT ENGR Y1_Fall	5.95	6.42	6.31	6.48	6.38	5.66
LEFT ENGR Y1_Spring	4.94	5.33	5.57	5.76	6.05	5.50

Not surprisingly, the largest difference between retained and not retained students relate to engineering self-efficacy. The LAESE *Engineering Self-Efficacy 2*, a measure of students' perceptions of their "ability to complete engineering requirements such as math, physics, chemistry as well as their general ability to succeed in any engineering major" [2], [8], showed the largest decrease (-1.09 points/7.00 point scale representing a 15.57% decrease) in scores from fall to spring in students who left engineering for different majors. The second largest decrease in scores of students who left engineering was in the LAESE *Engineering Self-Efficacy 1*, a measure of students' perceptions of their "ability to earn an A or B in math, physics, and engineering courses and succeed in an engineering curriculum while not giving up participation in outside interests [2], [8]." Interestingly, students who left engineering started their first year with engineering self-efficacy scores higher than students who retained in engineering. The average early fall *Engineering Self-Efficacy 1* score was 5.95/7.00 and the early fall *Engineering Self-Efficacy 2* score was 6.42/7.00 for students who ultimately left engineering compared to 5.80/7.00 and 6.33/7.00, respectively, for students who retained in engineering after the first year. These results suggest that the students who ultimately left engineering may have underestimated the amount of effort that is required to successfully complete the first-year engineering-related course work or were overconfident in their own ability to be successful in those courses without expending "extra" effort.

Students who ultimately retained in engineering started the fall with slightly higher *Math Outcomes Efficacy* (6.33/7.00) than students who left engineering (6.31/7.00). Both groups, however, decreased in *Math Outcomes Efficacy* measures from fall to spring. The average score of students who retained decreased by 0.02/7.00 (-0.29%) while the average score of students who left engineering decreased by 0.74/7.00 (-10.57%). While both groups lost confidence in

their ability to succeed in math courses, those who left engineering seem to have had their confidence shaken much more that those who stayed.

Students who left engineering after their first year also decreased in *Engineering Career Expectations*. The average score for *Engineering Career Expectations* was the same (6.48/7.00) for both groups at the beginning of the fall term. Those who retained in engineering showed essentially no change in that measure at the end of spring semester, but those who left engineering showed a -0.72/7.00 (-10.29%) change in *Engineering Career Expectations* between fall and spring terms.

Similarly, the *Coping Self-Efficacy* measure increased slightly (0.04/7.00, 0.57%) from fall to spring for retained students while it dropped (-0.33/7.00, -4.71%) from fall to spring for students who left engineering. The average score for *Feeling of Inclusion* also increased (0.14/7.00, 2.00%) from fall to spring for retained students while it decreased (-0.16/7.00, -2.29%) for students who left engineering. Interestingly, both *Coping Self-Efficacy* and *Feeling of Inclusion* average scores were higher in the fall for the not-retained students.

4.0 Conclusion

The LAESE measures suggest that the Kruger-Dunning Effect may explain student behavior. Students who ultimately left engineering started the fall with higher scores in 4 of the 6 measures (*Engineering Self-Efficacy 1* and *2, Coping Self-Efficacy*, and *Feeling of Inclusion*) than their peers who retained in engineering. Perhaps they "didn't know what they didn't know" which may have caused them to overestimate their abilities and underestimate the challenges they would face and the amount of effort it would take to be successful in an engineering major or career. The "leavers" also started out with slightly lower *Math Outcomes Efficacy* scores, on average, than those who persisted to their second year in an engineering major.

The data support the Kruger-Dunning Effect in the students who ultimately leave engineering. Some AcES students appear to have overestimated their incoming abilities and underestimated the challenges that pursuing an engineering degree would present. Other AcES students did not. The majority of AcES students – those who retained in engineering – appear to have risen to meet the challenges presented by the engineering-related first-year curricula and have developed increased abilities to meet those challenges. These students not only increased in "grittiness," but increased in their engineering and coping self-efficacy and felt more included in the engineering field than when they started their engineering education. This observation emphasizes the need for more early education about positive career expectations and the work it takes to achieve the valued engineering career. While programs, like AcES, often focus on helping students use academic resources, building cohorts to facilitate feelings of inclusion, and interacting with faculty, mentors, and practicing engineers to facilitate the development of positive career expectations, perhaps there are additional characteristics that students need as well. Perhaps first-year engineering programs should also consider ways to help students to adopt a growth mindset [12] and a strong work ethic to prepare them for the workload they will likely experience. Students need to understand that the level of effort expended to earn good grades in high school is not sufficient to earn good grades in STEM courses in college. Those students who learn to "raise their game" early (during their first year), expect a higher level of

work, and learn to use their resources effectively to meet the challenges presented appear to retain in engineering, at least to the second year.

5.0 Future Work

Data collection and analysis will continue and will focus on retention not only to the second year, but on persistence to graduation. Future work will focus on longitudinal trends related to measures of grit, self-efficacy, career expectations, and feeling of inclusion, and will include additional measures from the MSLQ including measures of motivational beliefs and learning strategies. Qualitative data collected from individual interviews and focus groups is being coded and analyzed to provide a more complete understanding of what helps students persist to graduation in an engineering major. Recommendations for future work include investigations into the role student mindsets (growth vs. fixed) and student workload expectations play in their retention.

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