Measuring Achievement Goal Orientations of Freshman Engineering Students

Megan K. France [1], Olga Pierrakos[2], Javarro Russell[3], and Robin D. Anderson[4]

Abstract – Student engagement and motivation are central areas of concern in education. In fact, motivation, specifically achievement goal orientation, has received a lot of attention in educational research but not in engineering education research. Not only are various achievement goals linked to better use of learning strategies, persistence, and help-seeking behaviors, but exploring the various achievement goal orientations of engineering students may be important for recruitment and retention. Herein, we investigated freshman engineering students' achievement goal orientation, both generally and specific to engineering courses. We examined differences in achievement goals for freshman male and female engineering students, as well as differences in freshman students who persisted in engineering versus those who transferred out. Preliminary results suggest that engineering students differ in their general versus engineering course specific achievement goal orientations. However, there did not appear to be any difference in general achievement goals for freshman engineering persisters versus switchers.

Keywords: achievement goal orientation, engineering students, retention, group differences

INTRODUCTION

It is well-known that recruitment and retention in engineering must be improved in order to promote a more diverse student body and to ultimately increase the number of students majoring in engineering. Numerous studies have shown that despite efforts to recruit and retain students within the engineering major, fewer students are going into the field [CSEPP, 4; NAE & NRC, 7; Beam et al., 3]. In particular, less women and minorities are entering and being retained in engineering programs and this is of critical importance.

Although we can identify various demographic groups who are not being retained (e.g., women, minorities), we know very little about why these students are not persisting within the field of engineering. Simply identifying who is not persisting is only the first step in addressing issues of retention. There are still questions of why these students are not persisting. Therefore, it would be beneficial to explore additional characteristics, other than demographic variables, of engineering students. These characteristics, such as student motivation, may be related to retention and success. These characteristics may also vary among groups (e.g., males and females). Finally, knowing more about

[1] Ph.D. Candidate, Center for Assessment and Research Studies, James Madison University, 821 S. Main St., Harrisonburg, VA, 22801, francemk@jmu.edu.

[2] Assistant Professor, School of Engineering, James Madison University, HHS Building, Room 3227, Harrisonburg, Virginia 22807, pierraox@jmu.edu.

[3] Ph.D. Candidate, Center for Assessment and Research Studies, James Madison University, 821 S. Main St., Harrisonburg, VA, 22801, russe2ja@jmu.edu.

[4] Associate Director, Center for Assessment and Research Studies, James Madison University, 821 S. Main St., Harrisonburg, VA, 22801, ander2rd@jmu.edu.

student characteristics can help engineering faculty be better educators and foster values of lifelong learning within their students.

Background on Achievement Goals

One area that has received a lot of attention within educational research is motivation, specifically achievement goal orientation. Not only are various achievement goals linked to better use of learning strategies, persistence, and help-seeking behaviors, but exploring the various achievement goal orientations of engineering students may be important for identifying potential non-completers (i.e., switchers) of engineering programs. Also, the classroom environment can influence students' achievement goals. Thus, knowing students' achievement goals provides information about the class structure and can help faculty know where to focus their efforts. For example, if students demonstrate high performance goals, faculty can deemphasize normative comparisons. In this situation, faculty can modify their teaching approach to promote mastery goals over performance goals. Likewise, faculty can be proactive in addressing their classroom's structure and strive to positively impact students' achievement goals.

Achievement goals are defined as the goals or purposes that motivate students within the academic setting [Wolters, 9]. Much of the literature on achievement goals focuses on the distinction between mastery goals and performance goals. Specifically, students who adopt mastery goals (i.e., learning goals) are motivated to understand the material and develop their skills. On the other hand, students who adopt performance goals are concerned with comparing themselves with others. These students evaluate their ability in relation to others in order to determine their self-worth; that is, they are concerned about being judged based on their performance [Ames & Archer, 2]. In addition to this distinction, mastery and performance goals are related to different patterns of learning. Mastery goals are associated with a number of positive learning strategies and attributes; for example, the belief that effort leads to success, a preference for challenging work, interest and positive attitudes toward learning, increased time on tasks, persistence, liking the class, and effective learning and problem-solving strategies [Ames, 1; Ames & Archer, 2]. Conversely, performance goals are associated with avoidance of challenging tasks, the belief that one lacks ability in the face of failure, and the use of superficial learning strategies [Ames, 1; Ames & Archer, 2].

Building on the dichotomy of mastery and performance goals, Elliot and McGregor proposed a more complex conceptualization of achievement goals to incorporate approach and avoidance orientations into a 2X2 framework [Elliot & McGregor, 5]. That is, they described achievement goals in terms of competence, and the outcome can either be a desirable possibility (i.e., success) or an undesirable possibility (i.e., failure) [Elliot & McGregor, 5]. Thus, when a student adopts an approach orientation, they are expecting success, whereas a student who expects failure adopts an avoidance orientation. Following this 2X2 framework, a *mastery-approach* (MAP) goal orientation is manifested in a student's desire to learn as much as possible, to be persistent, and develop their skills. A student who fears losing skills and the inability to master all the material defines a *mastery-avoidance* (MAV) goal orientation. Students who exhibit a *performance-approach* (PAP) goal orientation compare themselves with others and are motivated by their desire to demonstrate their ability and achievements publically. Finally, a *performance-avoidance* (PAV) goal orientation describes a student who does not want to appear incompetent or lacking in ability relative to others [Elliot & McGregor, 5; Wolters, 9]. In addition to these four goal orientations, a fifth orientation has been suggested and is included in our study. A *work-avoidance* (WAV) orientation describes a student that tries to do as little work as is necessary to get by [Pieper, 8].

Purpose of Current Study

The purpose of this study was to investigate achievement goals for freshmen engineering students at a large, rural university with a mid-size engineering program. These students completed two different instruments measuring achievement goals, a measure of general goals (General Achievement Goal Questionnaire) and a measure of goals specific to engineering courses (Engineering Achievement Goal Questionnaire; see Methods). We had three overarching research questions:

(1) How do students' achievement goals toward engineering compare to their achievement goals toward all their courses in general?

(2) What differences exist in achievement goals for male vs. female students or for freshman persisters (engineering students who persisted within the major during the first year) vs. freshman switchers (engineering students who dropped out of the major during the first year)?

(3) How are students' engineering achievement goals changing over time?

First, we compared students' reported general achievement goals to their engineering-specific achievement goals. We expected MAP and PAP to be lower at the general level than at the specific level. Students chose to be engineering majors, most likely due to some intrinsic interest in the topic; therefore, they should report higher levels of MAP for the engineering major. Students also may feel that their performance is more important in their engineering courses and therefore report higher PAP. It could also be expected that MAV and PAV would be higher for the engineering specific courses than generally, due to the amount of pressure students may feel about succeeding in this potentially competitive and challenging major [Ames, 1]. However, we would expect WAV to be lower for students' engineering courses. Again, if students are interested in the engineering profession, they should report lower levels of WAV than they do on a general level.

Second, we wanted to investigate differences in various groups for general achievement goals. Specifically, we wanted to investigate differences between males and females on MAP, PAP, MAV, PAV, and WAV. For example, are males, who are generally seen as more competitive than females, higher than females on PAP. In addition to gender, we also wanted to investigate differences on general achievement goals for freshman persisters vs. switchers (that is, students who persisted in the engineering major compared to students who dropped out of the major during the first year). Given that data were collected for all students at the beginning of their first year, we have knowledge of who persisted in the major their sophomore year. Therefore, we compared the general achievement goals scores for these two groups. It may be that a student's achievement goal profile is predictive of whether he or she will persist in the engineering major. Perhaps, the students who are retained are significantly higher on MAP and PAP and significantly lower on MAV, PAV, and WAV.

Finally, we wanted to investigate how engineering achievement goals change over time. Researchers have found that classroom environments can influence the achievement goals students adopt depending on the learning tasks, perceptions of authority, and evaluation processes [Ames, 1]. As students progress through the engineering program, it is expected that they develop a strong interest in engineering and value life-long learning. This would be reflected by an increase in MAP over time. However, if performance-type goals are emphasized in the classroom more or in addition to mastery goals, performance goals could increase over time as well. This would be a less desirable outcome as performance goals are not related to adaptive learning strategies. As students develop their skills, relationships, and an understanding of their place within the engineering profession, it is expected that PAV, MAV, and WAV would decrease over time.

METHODOLOGY

The Achievement Goal Questionnaire (AGQ) is an instrument that purports to measure students' achievement goal orientation [Elliot & McGregor, 5; Finney et al., 6] and work-avoidance [Pieper, 8]. Students completed two versions of the AGQ. One was general (G-AGQ) in that the items referred to the semester's courses as a whole (i.e., *I want to do as little work as possible this semester*). The other measure (E-AGQ) employed items specific to students' engineering classes (i.e., *I want to do as little work as possible in my engineering classes*). Furthermore, the AGQ consists of five subscales: Mastery-Approach (MAP), Mastery-Avoidance (MAV), Performance-Approach (PAP), Performance-Avoidance (PAV), and Work-Avoidance (WAV).

Data were collected at various time points (see Table 1) from students enrolled in a first-year engineering course. First, freshmen engineering students were required to attend a campus-wide assessment day at the start of their first semester where students completed the General Achievement Goal Questionnaire (G-AGQ) instrument. Of the 114 freshmen enrolled in the engineering major in 2008, 99 had complete data on the G-AGQ. Of that 99, 14 were female, 78 were Caucasian, 10 were minority, and 11 did not specify their ethnicity. The average age was 18.43 (*SD* = .39). Of the 110 freshmen enrolled in the engineering major in 2009, 89 had complete data on the G-AGQ. Of that 89, 14 were female, 64 were Caucasian, and 25 were minority. The average age was 18.47 (*SD* = .37) Second, freshmen engineering students were asked to complete the Engineering AGQ (E-AGQ) at the start of their second semester (January 2009). Of all the freshmen engineering students, only 29 (7 females) completed the E-AGQ at this time point. Finally, freshmen engineering students were asked to complete the E-AGQ at the end of their first year (May 2009). Of all the freshmen engineering students, 71 (11 females) completed the E-AGQ in May. Across those two time points, 26 students took the E-AGQ both in January and in May. Of the 71 students who completed the E-AGQ in May, 55 also completed the G-AGQ in August.

Table 1. Summary of data collection.

Instrument	General AGQ	Engineering AGQ	Engineering AGQ	General AGQ
Time of Data Collection	August 08	January 09	May 09	August 09
N a	99 students	29 students	71 students	89 students

Note. [a]A total of 188 students took the General AGQ. 55 students took the G-AGQ in August 08 and the E-AGQ in May 09. [b]26 students took the E-AGQ in both January 09 and May 09.

RESULTS

The results from this study are preliminary. Due to the small sample sizes, the meaning of the results should be interpreted with caution. Yet, the results herein give us insight into the use of AGQ scores in a variety of settings and purposes in engineering education.

According to the achievement goal theory, it would be hoped that students have high levels of MAP – as it is related to more adaptive learning strategies – moderate levels of PAP, and low levels of MAV, PAV, and WAV (see Table 2).

Table 2. Ideal score ranges for the five achievement goals.

Achievement Goal	*Score Range*	*High Score*	*Low Score*
Mastery-Approach (MAP)	3 - 21	Adaptive	Maladaptive
Performance-Approach (PAP)	3 – 21	Somewhat Adaptive	Neither Adaptive nor Maladaptive
Mastery-Avoidance (MAV)	3 – 21	Maladaptive	Adaptive
Performance- Avoidance (PAV)	3 – 21	Maladaptive	Adaptive
Work-Avoidance (WAV)	4 – 24	Maladaptive	Adaptive

Engineering students reported high levels of MAP both generally and in relation to their engineering courses (see Table 3). MAP scores can range from 3 to 21; the midpoint of the scale is 11.50. Students reported MAP scores at the high end of this scale, indicating an orientation toward learning goals. These scores are slightly higher than MAP scores reported by an earlier cohort of freshmen students at this university (mean of 17.76) [Finney et al., 6]. These high levels of mastery-approach may be an indication of the type of student this university recruits or it may be that college students in general have high levels of mastery-approach orientation. Students also reported relatively high levels of PAP, again falling above the mid-point of the scale, indicating that students also approach their courses with performance goals. This too may be indicative of college students in general, and these means are comparable to PAP scores (mean of 15.22) from an earlier cohort of freshmen students at this university [Finney et al., 6]. Both MAV and PAV scores fell closer to the mid-point of the scale, indicating moderate levels of mastery-avoidance and performance avoidance orientations. These scores are comparable to MAV and PAV scores from an earlier cohort at this university (means of 13.09 and 13.67 respectively) [Finney et al., 6]. Finally, WAV scores were the lowest, falling below the mid-point of the scale (the WAV scale ranges from 4 to 24, thus the mid-point is 12.50), indicating that students do not avoid their work. Again, these low WAV scores may be a result of the population, that is, college students in general may be less work-avoidant and therefore more successful academically (i.e., get into college). Unfortunately, the WAV subscale was not given in the previous study [Finney et al., 6]; therefore, we could not compare our results.

Table 3.Test of statistically significant differences in scores from General AGQ to Engineering AGQ ($N = 55$).

Achievement Goal Orientation	General AGQ Mean (SD)	Engineering AGQ Mean (SD)	*t*	*p*-value	Cohen's *d*
MAP	18.15 (2.28)	18.36 (2.26)	.73	.47	.01
PAP	16.00 (4.13)	15.18 (4.74)	-1.70	.10	-.18
MAV	13.44 (4.09)	12.55 (4.60)	-1.61	.11	-.23
PAV	14.18 (4.34)	13.38 (4.13)	-1.68	.10	-.19
WAV	10.85 (4.44)	10.29 (4.37)	-.779	.44	-.13

Research Question 1: How do students' achievement goals toward engineering compare to their achievement goals toward all their courses in general?

In order to compare the General AGQ to the Engineering AGQ, scores on the Engineering AGQ administered in May were compared to those same students' scores on the General AGQ. Dependent samples *t*-tests were conducted for each subscale. Although the means changed slightly from the General AGQ to the Engineering AGQ, none of the differences were statistically significant (Table 3). However, because tests of statistical significance are impacted by sample size, we also calculated an effect size. Cohen's *d* was calculated as a measure of practical significance. Generally, a Cohen's *d* ranging from .20 to .49 is considered a small practical difference, .50 to .69 is considered medium, and .70 or greater is considered a large practical difference. Yet, these differences should be interpreted relative to the context or phenomenon under investigation. Other than MAP, all other achievement goals had small negative effect sizes.

We expected students' engineering mastery-approach goals to be higher than their general mastery-approach goals, given their interest in the major. This was not supported; however, because students are already reporting high levels of MAP, we may not have been able to find a difference due to a ceiling effect. We also expected students' engineering performance-approach goals to be higher than their general performance-approach goals. Conversely, there was a small practical decrease in PAP from general to engineering. Although this was not expected, it is good that students' engineering courses do not elicit as much performance goals as general courses. We also expected higher engineering MAV and PAV scores compared to general MAV and PAV scores. However, there was a small practical decrease in MAV and PAV from general to engineering. Again, although this was unexpected, it indicates that engineering courses may elicit lower avoidance goals. This is a positive outcome because avoidance goals are associated with fear and anxiety toward academics [Elliot & McGregor, 5]. Our hypothesis regarding WAV was supported. Students reported higher levels of WAV generally than they did for their engineering courses. That is, students avoid more work outside of their engineering courses.

Research Questions 2: Are there differences in achievement goals for male vs. females or for persisters vs. switchers?

Group differences on the AGQ subscales were also investigated. Significance tests were not conducted due to the small sample sizes of some of the groups. First, differences on the General AGQ between males and females were examined. Overall, males and female scored similarly on performance goals (PAP and PAV). However, females appeared to score slightly higher on MAP than males, indicating that females may be more mastery-approach orientated toward all their courses than males. Females may adopt this orientation because they have more diverse interests than males or they may value learning from all their courses. Females also scored higher on MAV than males, suggesting that females may be more worried about making mistakes and losing skills compared to males. Conversely, males scored higher on WAV than females. This would suggest that males avoid work more than females. It is possible that males are more selective about which courses they put a lot of work into, only working hard in the courses that are of greatest interest to them. The means for these two groups are presented in Figure 1.

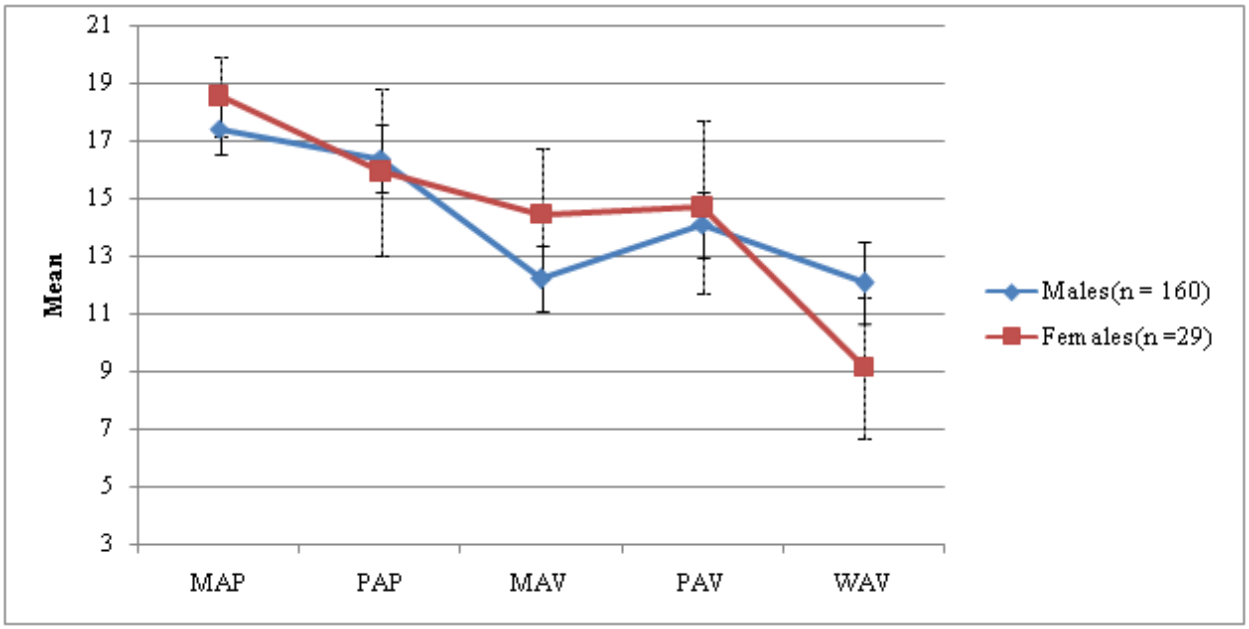

Figure 1. Differences in General AGQ (Aug. 08 and 09) by Gender (black bars represent 95% confidence intervals).

Differences between males and females were also examined for Engineering AGQ scores. Compared to the General AGQ, males and female scored similarly on PAP and PAV and females scored higher on MAV, indicating again that females may be more afraid to make mistakes in their engineering courses than males. Unlike the General AGQ however, females scored similarly on MAP compared to males, indicating both groups endorse high levels of MAP. In fact, female MAP scores stayed constant across the General AGQ and Engineering AGQ, but male MAP scores increased from the General AGQ to the Engineering AGQ. Thus, males appear to adopt more of a mastery-approach orientation with respect to their engineering courses than to their courses in general. It may be that males are more interested in their engineering courses than their general courses and value the learning that occurs in these courses more than in their courses overall. Interestingly, compared to the General AGQ, males are not showing the same work-avoidant patterns on the Engineering AGQ, scoring lower on WAV for engineering courses. That is, females and males scored about the same on WAV for their engineering courses. The means for these two groups are presented in Figure 2.

This preliminary evidence suggests that males and females may differ in their general and engineering achievement goal orientations; however, more data from female students is needed. In particular, females and males differed on their general MAP, MAV and WAV goals. Females' higher scores on MAP and lower scores on WAV may indicate that females have diverse interests, or interests outside of engineering. This could be supported by the fact that males' engineering MAP scores were comparable to females' general MAP scores. Females were also higher on MAV scores generally and possibly for engineering, indicating that females are more mastery-avoidant – afraid to lose knowledge or make mistakes. Students who endorse mastery-avoidant goals have been compared to the "perfectionist" student [Ames, 1].

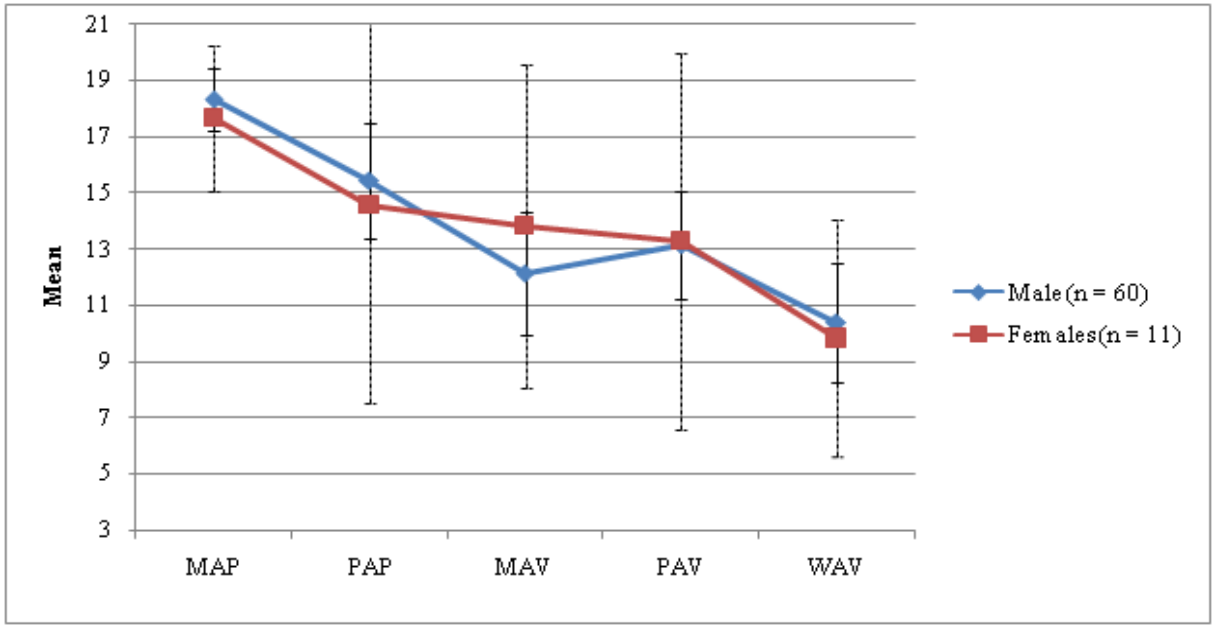

Figure 2. Differences in Engineering AGQ (May 09) by Gender (black bars represent 95% confidence intervals).

In addition to gender difference, switcher scores on the General AGQ were compared to persister scores. Interestingly, there were very little differences on MAP, PAP, MAV, PAV, or WAV for these two groups. The means of these two groups are presented in Figure 3.

These results suggest that knowing a student's general achievement goal profile does not seem to provide any predictive information about whether that student will persist in the first year of the engineering major or not. That is, there does not appear to be a relationship between general achievement goals and retention within the engineering major at least in the first year.

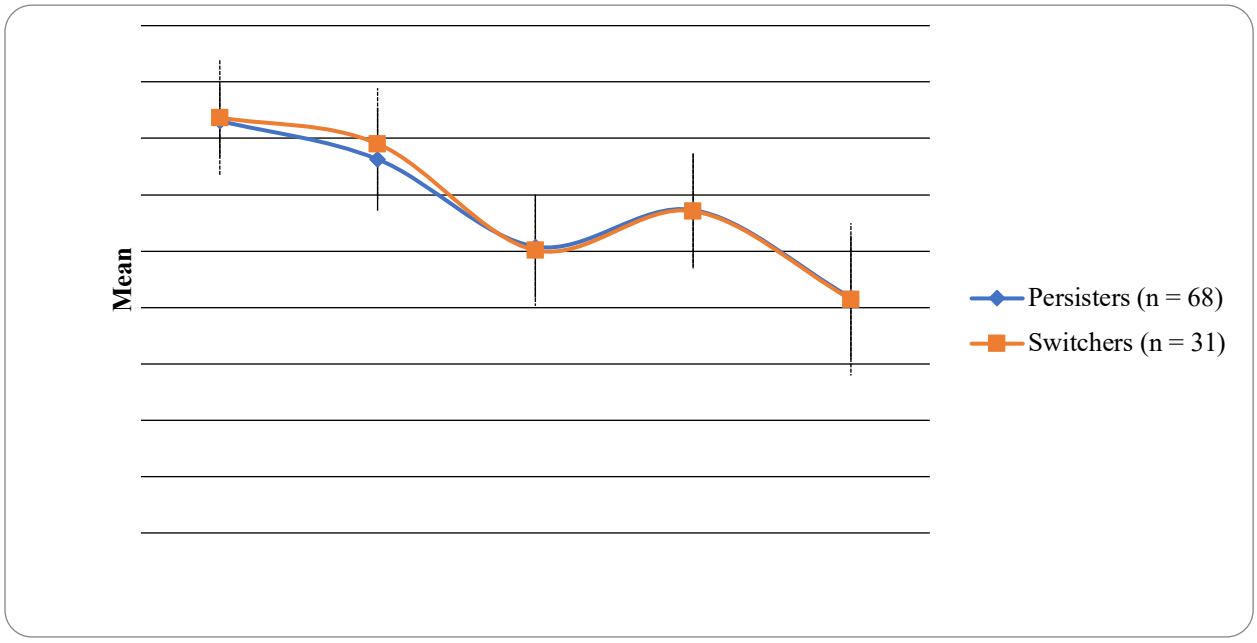

Figure 3. Differences in General AGQ by Retention (black bars represent 95% confidence intervals).

Research Question 3: How are students' engineering achievement goals changing over time?

Finally, student scores on the Engineering AGQ were compared over time. Significance tests were not conducted due to the small sample size. However, some trends can be noted. Although these are preliminary results and our interpretations are limited due to the small sample size, there was a slight increase for MAP, PAP, PAV, and WAV. There was a slight decrease in MAV (see Table 4 and Figure 4). If these changes are real, it would suggest that the engineering classroom environment is promoting both mastery-approach and performance goals. The decrease in MAV may indicate students are not fearful of losing their skills or making mistakes within their engineering courses. The increase in WAV may be an indication of the times in which that data was collected. That is, the second time point was collected at the end of the semester, close to finals. Also, students may not have had a realistic understanding of their goals and coursework when data was first collected, thus the second time point may be a more realistic reflection of where they fall on these achievement goal scales.

Table 4. Pre-Post Scores for Engineering AGQ (N =26*).

Achievement Goal Orientation	Pre-Mean	SD	Post-Mean	SD	Mean Change
MAP	18.35	2.67	18.62	2.16	0.27
PAP	13.69	5.20	14.12	5.11	0.43
MAV	12.27	4.29	11.62	4.32	-0.65
PAV	11.77	4.97	12.35	4.66	0.58
WAV	8.96	4.04	9.96	3.92	1.00

*Interpret with caution due to small sample size

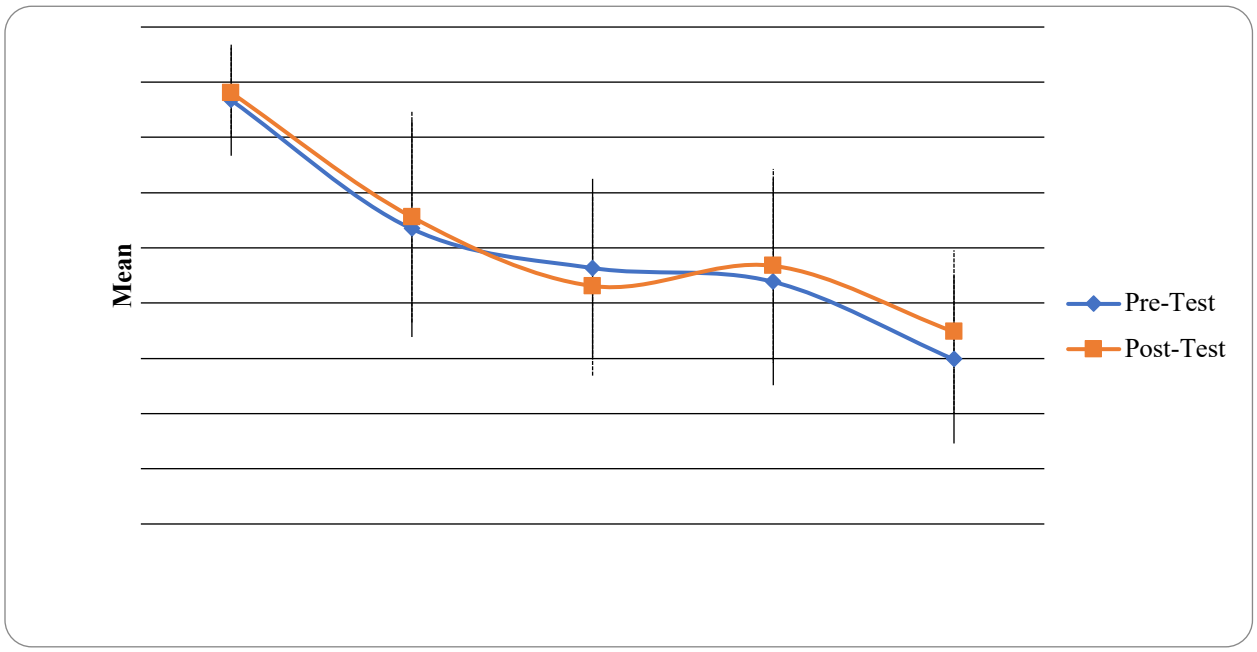

Figure 4. Differences in Engineering AGQ Pre- and Post-tests (n = 26)
(black bars represent 95% confidence intervals).

CONCLUSIONS AND FUTURE WORK

The purpose of this study was to provide an example of how engineering programs can examine additional student characteristics, beyond demographic variables, to possibly better understand recruitment and retention in engineering education. For this study, the researchers gathered preliminary information on students' achievement goal orientations. Although preliminary, these results do provide some information about how engineering students' achievement goals differ (or do not differ) generally and specific to their engineering courses, by gender, by retention, and across time. In general, students MAP orientation is very high, their PAP orientation is high, their MAV and PAV orientation is moderate, and their WAV orientation is low.

Engineering faculty from a variety of institutions can easily use the AGQ to investigate their own students' achievement goals. Although these current results indicate that knowing a student's general achievement goal profile is not helpful in determining whether or not a student will be retained, these results do provide valuable information that can be applied to an engineering program. For example, it appears females are higher on MAV than males; therefore, faculty can emphasize to female students that trying and effort is more important than perfection and attempt to create a safe environment where students know they can make mistakes. Engineering faculty can try to foster mastery-approach goals by developing diverse learning tasks that are likely to engage students and hold their interest, as well as rewarding student effort [Ames, 1]. For example, the freshmen course in this study developed a curriculum with a problem based learning (PBL) focus. PBL is likely to foster student interest and engagement, which could lead to the development of mastery-approach goals. Engineering faculty can discourage performance goals by deemphasizing the importance of correctness, absence of errors, and normative success [Ames, 1]. By adopting these procedures, faculty would be encouraging values of life-long learning and the belief that effort leads to success.

Researchers should consider comparing groups (e.g., males vs. females, persisters vs. switchers) on their achievement goals specific to their engineering courses in future studies. It may be that switchers and persisters do not differ on general achievement goals but do differ on engineering specific goals. Unfortunately, we did not have a large enough sample size to make these comparisons on the engineering AGQ using significant differences analyses techniques. It is necessary to collect and aggregate data over a number of years to investigate these comparisons. Furthermore, researchers should compare engineering students' achievement goals across programs. Based on the nature of the program, students' achievement goals could vary. For example, a highly competitive program that promotes comparison and rewards high performers would be expected to drive performance goals. However, a collegial program that encourages effort and teamwork should drive the development of mastery goals. This in turn should lead to varying outcomes in students' learning strategies. That is, students who endorse mastery goals should value learning and develop adoptive learning strategies, whereas students who endorse performance goals should use more shallow learning strategies and evaluate their self-worth relative to their performance.

Researchers may also want to gather qualitative data from students about their achievement goal orientations or their perception of the goals their engineering program promotes. Qualitative data can be collected through interviews or focus groups. Purposeful sampling can be used to collect data from various groups (e.g., females, switchers) or those students with extreme patterns of achievement goals (e.g., students low on mastery goals vs. students high on mastery goals).

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Megan K. France

Megan France is a doctoral student in the Assessment and Measurement program at James Madison University. She serves as a graduate assistant to the Center for Assessment and Research Studies (CARS). Her research interests involve examining non-cognitive constructs in various college populations. She is also interested in working with university programs and majors to improve the learning and development of students.

Olga Pierrakos

Dr. Olga Pierrakos is an assistant professor in the School of Engineering at James Madison University. Dr. Pierrakos holds a B.S. in Engineering Science and Mechanics, an M.S. in Engineering Mechanics, and a Ph.D. in Biomedical Engineering from Virginia Tech. Her interests in engineering education research center around recruitment and retention, understanding engineering students through the lens of identity theory, advancing problem based learning methodologies, assessing student learning, as well as understanding and integrating complex problem solving in undergraduate engineering education. This latter project is funded through her recent NSF CAREER award. Her other research interests lie in cardiovascular fluid mechanics and K-12 engineering education.

Javarro Russell

Javarro Russell is a doctoral student in the Assessment and Measurement program at James Madison University. He also serves as a graduate assistant to the Center for Assessment and Research Studies (CARS). His research interests include assessment practice and public policy, as well as working with various programs and majors to improve the learning and development of students.

Robin D. Anderson

Dr. Robin Anderson is the Associate Director of the Center for Assessment and Research Studies (CARS) at James Madison University. She also is an Associate Professor of Graduate Psychology at JMU, where she teaches in the Assessment and Measurement Ph.D. program and coordinates the Higher Education Assessment Specialist Graduate Certificate Program.