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Background Factors Affecting Student Success in Aerospace Engineering: A Survey of Sophomore and Senior Students

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Abstract

There are numerous opportunities for K-12 students to participate in pre-college engineering experiences, such as university sponsored summer engineering programs, high school engineering courses, extra-curricular activities, and summer internships. Program administrators often report that these pre-collegiate engineering experiences are successful in increasing students' motivation to pursue an engineering degree. This is consistent with self-efficacy theories, which tell us that when a student perceives an experience as positive, it can encourage the student to continue participating in that subject area. While we do know that these programs can encourage students to enroll in engineering, the lasting impact of these programs on engineering students is less clear. With this research, we provide some clarity by examining background factors of retained aerospace engineering students.

The goal of this mixed-methods investigation is to identify the factors that increase student success in engineering in order to inform future programs and curricula. Research questions guiding this study include: *1) How do retained aerospace engineers describe the impact of participation in a pre-engineering program on university major choice? and 2) Which background factors affect student retention and success in Aerospace Engineering students?* We surveyed sophomore and senior aerospace engineering students and analyzed the students' self-reported background factors, engineering identity, and engineering self-efficacy. Student information such as GPA, retention information, demographics, SAT/ACT scores, and initial major of study were acquired from the university and analyzed with the self-reported data to determine significant measures of success. The results of our investigation can inform the design and implementation of pre-college engineering programs.

Introduction

The workforce demand for engineers is increasing, but student retention and graduation rates are staying constant which means that soon the need for engineers in the United States will surpass the engineering population. Only 57% of engineering undergraduates complete their degree and graduate as engineers, and every year, a higher percentage of students transfer out of engineering majors more than any other major[1]. Universities and state governments work hard to fund, organize, and recruit students into pre-college engineering programs with the expectation of creating both more engineers and better engineers, but the effectiveness of these programs to retain students in engineering and promote student success has not been widely documented[2].

The purpose of this research is to investigate the factors that motivate students to choose Aerospace Engineering (ASE) and the background features (e.g. engineering parents, summer programs, etc) that encouraged student success and fostered an aerospace engineering identity. To achieve this, we developed a survey to determine which background factors affected student retention and success in ASE students at a large public university in the southeast United States.

The two highest dropout rates for engineers are in their first and third semesters[3]; thus, surveys were given to sophomore ASE students midway through the fall semester. Seniors were also included in this study to provide a data point to which we can compare the response of the sophomore students and give an example of successful retention. To further investigate how student perception of success correlated to academic success and retention, student GPA and retention data were gathered at the end of the semester. The data collected in this study will aid in the determination of programs, events, and factors that promote retention and student success in ASE.

Related Work

Recent studies have studied background factors, but none have specifically looked at how background factors affect Aerospace Engineering students. Most research studies used self-efficacy theory to evaluate success, so we used a similar process and investigated background factors, identity, and success with self-efficacy theory. Pre-college courses such as technology and engineering courses, as well as some hobbies (i.e. programming, electronics, video game development, robotics, and rocketry) have been shown to increase student self-efficacy in engineering. Self-efficacy is important to engineering success because it has repeatedly been tested as an indicator for student achievement and academic success.[4]

An engineering identity is comprised of many parts creating the system of beliefs that a person holds about themselves and their community in the past, present, and future. Identity is the set of beliefs that people have about themselves and their paths in life.[5] Ever changing, the formation of identity occurs over the course of a lifetime[6]. Formative experiences, like internships and research opportunities, have been shown to inform a student's development of identity, affecting it either positively or negatively, depending on the experience. Some research indicates that a situated learning framework may be the best way to inculcate identity in engineering students. By immersing students in the culture and community of engineering and having them develop first a belonging in the local community of their departments, then the greater communities, including the community of engineers all over the world.[7]

Engineering identity has been a difficult thing for researchers to define and measure, though several researchers have tried. The development of a student's engineering identity is often assessed through self-efficacy theories[6], and many researchers assume that if a student has a high self-efficacy for engineering, then they have developed their identity as an engineer. Unfortunately, identity is much more complex than just self-efficacy[6].

Researchers have also examined background characteristics such as students' parents' education level and number of high school extracurricular, but these factors show no statistically significant correlation to students' retention in engineering. The background characteristics that did have significance appeared in engineering non-persisters, who had lower high school science and mathematics grades and higher SAT verbal scores.[8] While some research is being done in the field of student backgrounds, there is still significant need for more research to determine why students choose to major in engineering fields[6,9]. Specifically, there is a need for more valid and detailed measures of capturing and assessing students' reasons and motivations for choosing an engineering major[10].

Prior researchers have used surveys to investigate perceptions, self-efficacy, and identity of engineers and those teaching potential engineers. A previous researcher, Yasar, used an iterative method in his development of a survey to assess K-12 teachers' perceptions of engineers and familiarity with teaching design, engineering, and technology.[2] However, Yasar's participants were all pre-college level students and professionals. This process consisted of a literature search to find items for the survey and multiple field tests and revisions to come to the final survey instrument. In this work, we adapted Yasar's method and directly surveyed undergraduate engineering students.[2]

In order to inform universities about which experiences work best for ASE, we developed a survey in order to extract information from students about which background factors have influenced their choice in selecting ASE as a major. The survey was used to collect data regarding background factors that may have affected student success, including retention in engineering, engineering self-efficacy, academic success, and the development of students' engineering identities.

Instrument Development

First, we investigated the background factors that lead students to choose ASE. Factors were identified during a literature search as well as from personal experience and suggestions from recent alumni. We also researched engineering student retention and the factors that affect students' decisions to remain in engineering, or change majors.

Using two primary theories we created a two-part survey to distribute to students. The two themes we used to create questions for this survey included success and background factors. We operationally defined student success using four metrics, illustrated in Figure 1: retention in engineering, a high self-efficacy in engineering, academic achievement and the development of an engineering identity. Retention was assessed by the students' enrollment into the next course in the aerospace curriculum. Academic achievement was assessed using the within-institution GPA. Self-efficacy was measured using previously validated likert-scale statements used by Fantz.[4] Our instrument was evaluated by engineering education experts at two universities to provide feedback and to ensure clarity and completeness of questions. Identity development or the development of an engineering identity was measured in two ways. First, we compared the responses to the questions "Are you an engineer?" and "Is there any reason that you might want to leave aerospace or engineering now or at some time in the future?" Then, we looked at the organizations that the students listed. Participating in engineering-related organizations illustrates participation in the engineering community, which is indicative of a developed identity as an engineer. After a final review with local experts, a finalized survey was created and distributed to the senior and sophomore students. Appendix A contains the first portion of the survey, which was distributed to the participants within a classroom. Appendix B contains an example of the online portion of the survey.

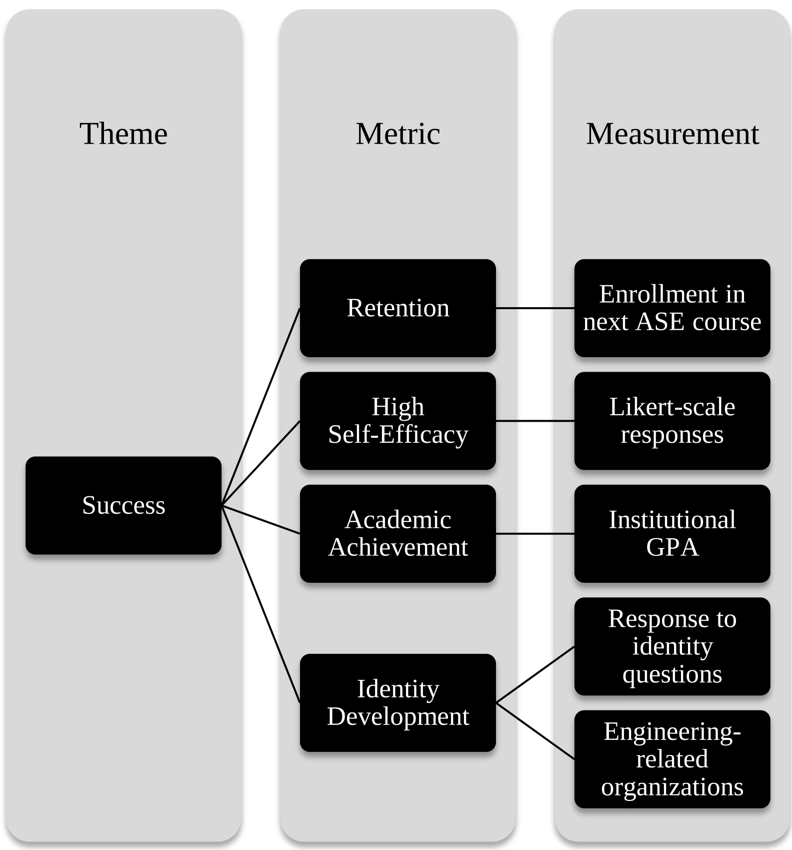

Figure 1. Success Metrics and Measurement. *This figure illustrates the relationship between the success metrics and their methods of measurement.*

Part one of the survey was completed in class. It consisted of two questions: 1) *Draw an engineer and describe your drawing* and 2) *Why did you choose to major in aerospace* *engineering? Tell me the whole story. Who was most influential in your decision and why?* (Why ASE?) These were open-ended questions, to allow for creativity and candor from the participants. Part two was an online survey that contained a series of multiple choice questions and likert-scale items about the students' histories, pre-college experience, and self-efficacy. The second part of the survey was administered via email using Qualtrics survey tool. The purpose of the multiple methods of delivery for this survey was to increase the response rate. As shown by Wilson et al., paper surveys administered in class provide a nearly 90% response rate, compared to the online administered surveys' response rate of just 20%. By initiating the survey in class with a face-to-face presentation, the students were more likely to complete the electronic portion.[11] Furthermore, students were asked to complete the self-efficacy and demographics portion of the survey online in order to allow some questions to be hidden if they do not apply to students. There was concern that asking students several questions about how much or little experience they have in engineering may damage their self-efficacy. Using the online tool allowed for lead-in questions like "was gifted education available to you?" If the question was answered "no", then no more questions about gifted education would be asked. If the answer was "yes", then the student could continue to the follow-up questions involving gifted education. For the same reasons, it was important that the students not be able to change their answers to the self-efficacy questions (at the beginning of the survey) after they see the other questions. The online platform allowed the researchers to control the question navigation.

Participants

All research procedures were conducted with the approval of our Institutional Review Board. The participants used for this study were recruited for the study during a regular class meeting of either the sophomore Aircraft/Spacecraft Performance class or the senior Aircraft Design class. These classes represent required coursework in the Aerospace Engineering curriculum, so the sample should be representative of the ASE population. The students were chosen because they had been positively retained beyond their freshman year. The researchers received initial responses from 19 out of 24 enrolled ASE seniors and 40 out of 50 enrolled ASE sophomore students. The surveys were distributed in class, but the students were made aware that the survey participation was completely voluntary. Each participant was asked to complete a consent form, which allowed them to opt-out without adversely affecting their grades. Consenting students completed part one of the survey and then were emailed a link in order to complete the second part of the survey. Finally, the consent form allowed the researcher to access the participants' student records, which provided some potentially sensitive data that may not be properly self-reported, like GPA.

Data Analysis

We used the qualitative and quantitative data to determine common themes among the students. At the beginning of the spring semester, we received the participants' GPA and enrollment information. Declared major and date of enrollment in ASE 1013 (first-semester freshman introductory course) was used to determine which students were successfully retained. The date of enrollment in ASE 1013 marks the beginning of the ASE curriculum, so the number of semesters since that date provides us with the number of semesters that the student has been successfully retained in Aerospace Engineering. Also, we collected information from the students' records, including their demographic data (race, gender, hometown), SAT/ACT scores, enrollment information (incoming freshman or transfer), and initial major. We compiled this data with the student's survey response data to re-analyze and determine which background factors lead to successful ASE students. This two-part survey included qualitative and quantitative data; therefore, the data analysis included two methods for analysis.

Qualitative

First, we eliminated incomplete surveys from the data set, so as to ensure that all the data could be fully tested. The first portion of our survey was the qualitative portion distributed to students in their classes. In the preliminary analysis of part one of the survey responses, two researchers used open-coding and thematic analysis to determine salient themes. Two researchers coded the responses separately using MaxQDA, and then discussed their responses for consistency and to reduce bias in the data.

The resulting codes, or keywords, were put into groups that followed a central theme. For the Draw and Engineer annotations, words like "problem", "challenge", "solution", "research", "logic", and "variation in engineering" were grouped into the same category: Problem Solving. Table 1, below illustrates all of the keyword groups.

Table 1

Code Categories Found from Drawings

Group	**Code**
Problem Solving	Problem, challenge, solution, research, logic, variation in engineering
Big picture	Save the world, larger impact, effect on community
Stereotypes	Recognition of stereotypes, dismissal of stereotypes, can be anyone, gender, he/she
Build	Building things, hands-on, maintenance, machinery
Hard work	Long hours, tired, hard work, time
Clothes	Professional dress, comfortable clothes, hard hat
Innovation	Thinking of different ways to explore, open-minded, designing, "not artist"
Benefits	Rewards, money, benefits, boat

Math/Science	Math, calculator
Heart	Happy, Passion, hardworking, determination
Programming	Computer, laptop, programming
High Stress	Stressful

For the Why ASE Narratives, codes like “money”, “get a job”, “practical”, and “real job” were grouped into the same category: Practical. Table 2, below illustrates the keyword groups.

Table 2

Code Categories Found from Why ASE Narratives

Group	**Code**
Problem Solving	Problem, challenge, solution
Arbitrary	Alphabetical, random choice
Practical	Money, get a job, real job
Background research	Career quiz
Interesting	Cool, unique, fast, not boring
School	High school courses, high school, middle school
Transfer	Previous major, business oriented, non aero goals, bakery
Curiosity	Natural talent, intelligence
Engineering Class	Robotics
Math/Science	Math, physics
Fascination	Airplane love, personal interest/history, pilot, happiness, passion
Mentor	Family history, no mentor
Marketing	Recruiter, engineering program
Challenge	Seeking a challenge, hard, challenging
Experience	Previous experience, summer program
Build	Design, make, building things, take things apart, fix things, innovative
Big Picture	Helping larger community
Cultural inspiration	Video game, Star Trek

Some codes, such as “problem solving”, “big picture”, and “build” overlapped both sections, illustrating the concept’s strong connection to engineering expectations.

Quantitative

Using a multivariate analysis of variance (MANOVA) approach, the researcher compared the effect of five primary background factors and four success measures, shown in Table 3 and Table 4. The “mentor” code was chosen from the qualitative survey responses because it is a background factor that could be affected. If mentorship correlated with a higher success factor, then this study could be used to advocate for increased mentorship within the STEM community.

Table 3 shows the 5 background factors used as dependent variables in the MANOVA. Two nominal variables, one scale variable, and one ordinal variable were used. Each factor was tested for statistical significance at a P value less than .05.

Table 3

Background Factors

Factor	Measure	Description
1.Mentor	Yes/No	Students were categorized by whether or not they indicated a mentor as the reason they chose engineering.
2.ACT	17-35	Students' raw ACT scores as reported by the university.
3.STEM Parents	Yes/No	Students indicated if they had a parent who worked in a science or engineering related field.
4.Experience Score	0-3	Based on a series of questions about their pre-collegiate engineering experience, the students received one point for each type of engineering experience they had prior to the start of college.
5.Any Experience	Yes/No	Students were categorized by whether or not they indicated ANY pre-collegiate engineering experience.

Table 4 shows the four measures of success: identity, self-efficacy, academic achievement, and retention. Each factor was measured individually. The identity score was a combination of three questions from the online survey: "14. Is there any reason that you might want to leave aerospace engineering or engineering now or at some time in the future?", "16. Are you an engineer?", and "17. Are you involved with any clubs or on-campus groups? If yes, then which ones?". First, if the participant answered "yes" to "Are you an engineer?", they get one point. Indicating that, no, they do not want to leave aerospace engineering gains another point. Finally, one point was given to each student who indicated participation in an engineering related student organization on campus. Such participation illustrates a participation in the community and an increase in engineering identity.

Table 4

Success Measures

Factor	Measure	Description
1.Identity Score	0-3	+1 "Are you an engineer?" = Yes +1 "… leave engineering?" = No +1 Participation engineering related organizations on campus (AIAA, EcoCar, etc)
2.Self-Efficacy Score	0-5	Average of the scores from the 9 self-efficacy statements
3.Academic Achievement	0-4	University-reported institutional GPA
4.Retention Score	0-4	+0.5 points for each semester enrolled in ASE

The other three measures of success are more straightforward. The self-efficacy score was determined by the participants' responses to the nine self-efficacy statements at the beginning of the survey. Academic achievement is indicated by the institutional GPA, as reported by the university. Finally, the aerospace degree program is four years or eight semesters long, and we are looking at retention on a semester basis. As previously mentioned, enrollment in ASE 1013 marks the beginning of the aerospace curriculum, so we calculated the number of semesters since the student first enrolled in order to determine the number of semesters that each student was enrolled in the aerospace degree program. The retention score was determined by adding 0.5 points for each the number of semesters the student has been enrolled in aerospace engineering (e.g., 7 semesters = 3.5 points).

Results

Survey Part 1 Results

Participants

Overall, almost 82% of the students in the classes participated in the paper survey, drawing an engineer, annotating their drawing, and writing the story of how they chose to major in aerospace engineering. As shown in Table 5, 59 students: 19 seniors out of a class of 24 and 40 sophomores out of a class of 48, completed the paper survey during class. The participation rates were high, 79.1% of the senior class and 83.3% of the sophomore class agreed to participate in our study. The participation in the online survey was lower than that of the paper surveys with 14 seniors and 21 sophomores participating and only 13 seniors and 19 sophomores completing the entire survey. The online surveys required work outside of the classroom, so a lower participation was expected.

Table 5
Student Participant Sample and Population Data

	Total	Seniors	Sophomores
Students Enrolled in course	72	24	48
Part 1 Participants	59	19	40
Part 2 Participants	32	13	19
Average GPA	3.29	3.31	3.28
Transfer Students	7	2	5

1. *Draw an engineer.*

The qualitative analysis indicated several recurring themes in the “Draw an engineer” drawing annotations. Overall we found that students describe engineers as possessing problem solving skills, intelligence, dedication, professionalism, innovativeness, and passion. Also, engineering students expect to have long hours, high stress, significant monetary rewards, and a large impact on the community or galaxy.

The most frequently depicted quality of engineers was problem solving ability or the desire for a challenge, mentioned in twenty-seven percent of the drawings. Students described engineers’ use of logic, research, and machinery, as well as the variation of tasks of which engineers are capable. Furthermore, building and fixing things, independent of problem solving, came up eleven times. Students cited fixing things around the house, working as back yard mechanics, and “throwing together” rockets in their free times as activities indicative of engineers. Students depicted intelligence, math and science ability, and an affinity for programming as important characteristics in their drawings, pointing out calculators, mathematical equations, and MATLAB as important features of engineers.

Six drawings specifically pointed out male qualities in their engineers or specifically used male pronouns whereas no drawings referenced the female gender. However, four drawings outwardly rejected gender stereotypes, specifically using “no specific gender” or “he/she” to reference their drawings. Furthermore, almost twenty-nine percent of students outwardly rejected engineering stereotypes, noting “an engineer could look like anyone” or “wouldn’t be picked out of a line-up”. Students’ drawings also illustrate their expectations of their future as engineers. Eighteen percent of students included the larger impact or big picture of the benefits of engineering, and two students included the salary they expected as a result of their engineering career. About a quarter of students accept that engineering comes with hard work, long hours, and high stress, by including “coffee stains” and “blood-shot eyes” in their drawings. Finally, and most reassuringly, students noted innovation, passion, exploration, and happiness twenty-five percent of the time.

2. Why ASE?

In the narrative responses, we found many recurring themes with more than half (59.3%) of the students discussing a fascination with flight or the love of airplanes as their motivation to pursue a degree in ASE. The most interesting recurring theme came from popular culture references such as Star Trek and Doctor Who.

As illustrated in Figure 2,almost half (47.4%) of the students expressed that they were guided to choose engineering either because they were good at math and science or because of their experience in a math or science class. High school physics classes, particularly, garnered a lot of support for engineering, cited by 9 students as a reason they chose aerospace engineering. High school was the most popular time for students to choose engineering (25 students), but at least 9 students decided their majors in middle school. Seven students mentioned participating in engineering classes before attending college, and only three mentioned having attended engineering summer programs. Just over a third (33.9%) of students indicated that a family member either was an engineer or pilot, serving as their mentor or the reason they chose ASE. Around 30% of students indicated that they chose ASE because it sounded like the most interesting option, especially out of the other engineering disciplines; these students mentioned they wanted something "unique" or "interesting".

Eight students, interestingly all seniors, also conveyed a desire to make a difference in the world (and beyond), listing "space travel", "human space flight", and "advancing aerospace into a new era of flight" as motivations. Additionally, 13.5% of students mentioned engineering instances in pop culture as their initial inspiration to choose aerospace engineering (e.g. Kerbal Space Program (video game), WWII TV shows, and Star Trek (movie)). While some students had grand plans and eccentric influences, nine students took a practical approach, asserting that they want to make "lots of money" and have a "real job" as their motivations. Seven students decided on ASE after doing background research including career quizzes and job shadowing experiences. Some students identified qualities in themselves that they felt were indicative of engineers: problem solving, curiosity, intelligence, innovation, and the ability to build and fix things. Not surprisingly, these qualities matched directly to some of the qualities students depicted in their drawing response in question one. Finally, two students confessed to choosing aerospace engineering "by random", specifically choosing ASE because it "came first alphabetically".

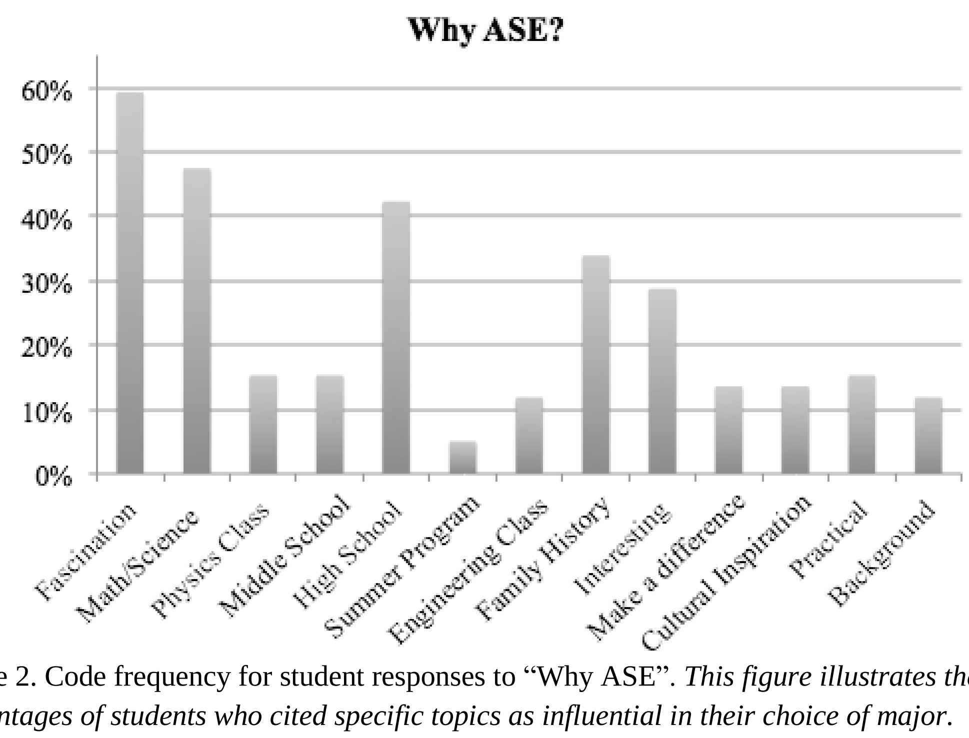

Figure 2. Code frequency for student responses to "Why ASE". *This figure illustrates the percentages of students who cited specific topics as influential in their choice of major.*

Survey Part 2 Results

Participants

A total of 32 students, 13 seniors and 19 sophomores as shown in Table 5 above, completed Survey Part 2. For the data analysis, the researchers only used the responses from the students for which complete data sets exist: paper survey, Qualtrics response, and student record information. The final data set consisted of 32 students. Two sophomores transferred out of Aerospace engineering after the fall semester. Both students moved to Mechanical Engineering.

Multivariate Analysis of Variance

We used SPSS, a software package used for statistical analysis, to compare the relationships between each of the background factors and success factors. Testing the background factors, we found that mentorship, ACT score, and STEM parents showed to have no significant difference on success. Pre-collegiate engineering experience, however, did show to have an effect on success, shown in Table 6. Using the MANOVA approach, we found that only two success factors were significantly different: identity score and retention score.

Table 6

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[d]
BF_ExpScore	Pillai's Trace	.781	2.375	12.000	81.000	.011	.260	28.494	.943
	Wilks' Lambda	.316	3.016	12.000	66.435	.002	.319	31.056	.957
	Hotelling's Trace	1.858	3.664	12.000	71.000	.000	.382	43.969	.996
	Roy's Largest Root	1.683	11.358[c]	4.000	27.000	.000	.627	45.432	1.000

a. Design: Intercept + BF_ExpScore

b. Exact statistic

c. The statistic is an upper bound on F that yields a lower bound on the significance level.

d. Computed using alpha = .05

Using Wilks' Lambda, shown in Table 6, we can reject the null hypothesis that pre-collegiate engineering experience has no effect on success. Based on a MANOVA-derived combined dependent variable by combining the four dependent variables together, partial eta squared value is .323, indicating that about 32% of the variability in success across all four success variables is being accounted for by the four group values. With an F statistic of 3.075 and a power of .961, there is a 96.1% chance of rejecting the null hypothesis. Using Levene's test, the homogeneity assumption is satisfied across all four variables, as shown in Table 7. This is of particular importance because of the differences in sample sizes.

Table 7

Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
S_SEscore	.735	3	28	.540

S_msuGPA	2.143	3	28	.117
S_RetentionScore	1.886	3	28	.155
IDscore	2.835	3	28	.056

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + BF_ExpScore

As shown in Table 8, Retention (S_RetentionScore), p value less than .001, and Identity (IDscore), p value = .049, are the only two success factors shown to be significant with a p value less than .05. Additionally, the observed powers for these two variables are relatively high: .999 and .638, respectively. GPA and self-efficacy scores were not found to be statistically significant.

Table 8

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[e]
BF_ExpScore	S_SEscore	1.044	3	.348	1.252	.310	.118	3.755	.298
	S_msuGPA	.286	3	.095	.192	.901	.020	.576	.081
	S_RetentionScore	18.459	3	6.153	11.874	.000	.560	35.622	.999
	IDscore	9.269	3	3.090	2.963	.049	.241	8.888	.638

e. Computed using alpha = .05

Finally, a post hoc test was done to look at the individual mean differences between the two variables that were statistically significant, shown in Table 9.

Table 9

Multiple Comparisons

LSD

Dependent Variable	(I) BF_ExpScore	(J) BF_ExpScore	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
S_RetentionScore	0	1	-1.362*	.3582	.001	-2.096	-.628
		2	-1.762*	.4443	.000	-2.672	-.852
		3	-1.762*	.4443	.000	-2.672	-.852
	1	0	1.362*	.3582	.001	.628	2.096
		2	-.400	.5257	.453	-1.477	.677
		3	-.400	.5257	.453	-1.477	.677
	2	0	1.762*	.4443	.000	.852	2.672
		1	.400	.5257	.453	-.677	1.477
		3	.000	.5878	1.000	-1.204	1.204
	3	0	1.762*	.4443	.000	.852	2.672
		1	.400	.5257	.453	-.677	1.477
		2	.000	.5878	1.000	-1.204	1.204
IDscore	0	1	-1.27*	.508	.019	-2.31	-.23

		2	-1.00	.630	.124	-2.29	.29
		3	-1.00	.630	.124	-2.29	.29
	1	0	1.27*	.508	.019	.23	2.31
		2	.27	.746	.723	-1.26	1.79
		3	.27	.746	.723	-1.26	1.79
	2	0	1.00	.630	.124	-.29	2.29
		1	-.27	.746	.723	-1.79	1.26
		3	.00	.834	1.000	-1.71	1.71
	3	0	1.00	.630	.124	-.29	2.29
		1	-.27	.746	.723	-1.79	1.26
		2	.00	.834	1.000	-1.71	1.71

Based on observed means.
The error term is Mean Square(Error) = 1.043.
*. The mean difference is significant at the .05 level.

Retention was shown to be significant at an experience score of 0, but it was shown to be significantly different than each of the experience levels. Identity was shown to be significant at an experience score of 0, but was only shown to be significantly different from the ID scores of the students with an experience score of 1. As shown in Figure 3 and Table 9, the students' retention score increased significantly with exposure to at least one pre-collegiate engineering experience; however, the findings did not indicate a continued increase with more experiences.

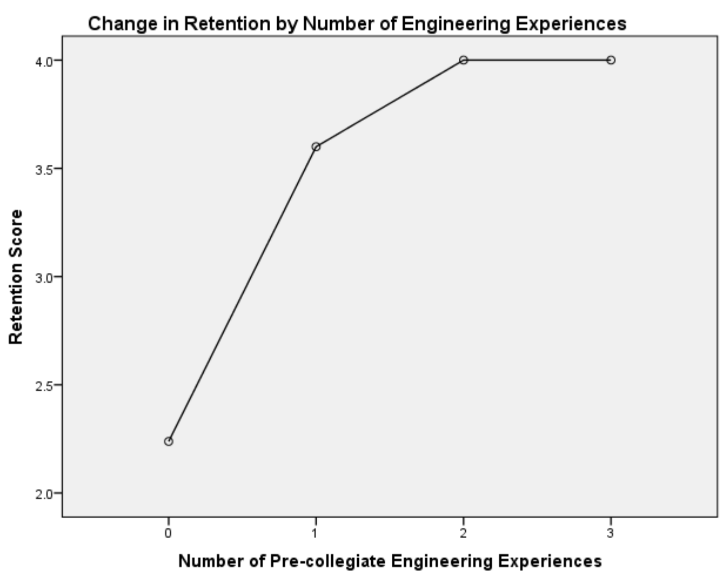

Figure 3. Change in retention by number of engineering experiences. *This figure illustrates the increase in retention as it relates to the number of pre-collegiate engineering experiences.*

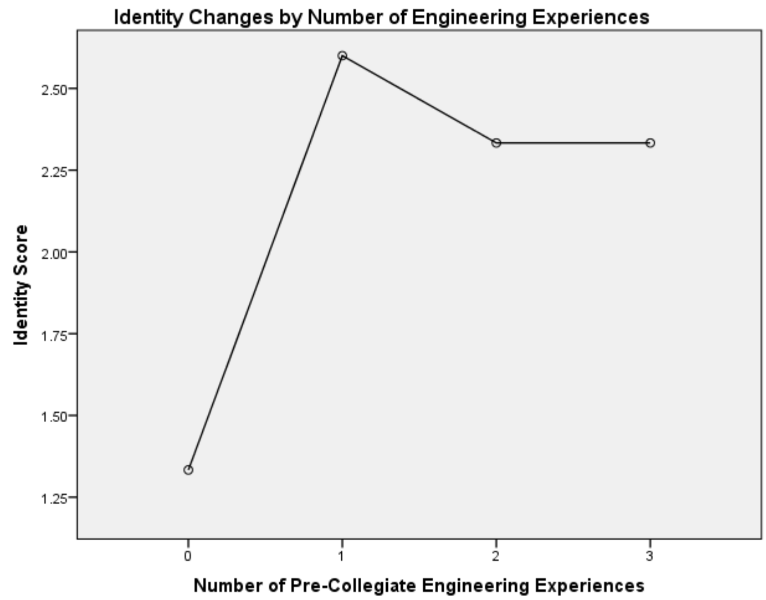

Figure 4. Identity change by number of engineering experiences. *This figure illustrates the increase in identity scores as it relates to the number of pre-collegiate engineering experiences.*

Similarly, the identity score increased with the students' exposure to at least one pre-collegiate engineering experience, but additional experiences did not show significant increase. Furthermore, the specific types of engineering experiences that were the most beneficial were unable to be identified with statistical significance with this data set.

Discussion

This study revealed that students who have any pre-college engineering experience will be retained at a higher rate than the students who do not have an engineering background. Examples of engineering background include participating in a summer engineering program, taking advanced math, science, or engineering courses in high school, and participating in engineering related extra curricular activities.

We also found that the three primary factors influencing Aerospace Engineering students at Mississippi State University in their choice of major were a fascination for flight, an affinity for math and science, and the influence of a mentor. Thus far, we have found that students point to engineering experience and mentors as key factors that initially lead them to choose ASE.

Additionally, we found that participating in at least one pre-collegiate engineering experience, such as science and engineering fairs or robotics competitions is correlated with an increase in engineering identity and retention. As expected, we found that these students are more likely to participate in engineering organizations, and plan to stay in engineering.

Limitations and Future Work

One limitation of this study is that it was given at only one university as a pilot. Some of the programs that we are investigating are highly selective, serving as few as eight students in a year. In order to get sample sizes large enough for decisive results about individual programs, this study needs to be performed in aerospace engineering departments at multiple universities. In future studies, additional cohorts will be included to provide the sample sizes required for significance in individual background factors.

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Appendix A

Student Backgrounds Survey Part #1

Name: ____ NetID: __________________

Thank you for your participation. Initial here if you are willing to be interviewed about your responses at some future date: _______

Question 1: Draw an engineer. Describe your drawing.

Question 2: Why did you choose to major in aerospace engineering? Tell me the whole story. Who was most influential in your decision and why?

Appendix B

Student Backgrounds Survey Part #2

NetID: _______________

1. Please rate the following 9 statements indicating how much you agree with each statement. Consider all of your aerospace courses.
    1. I'm confident I can understand the basic concepts in my aerospace engineering classes.
    2. I expect to do well in my aerospace engineering classes.
    3. I’m certain I can master the skills being taught in my Aerospace engineering classes.
    4. I’m confident I can do an excellent job on the tests in my aerospace engineering classes.
    5. I’m confident I can do an excellent job on the assignments in my aerospace engineering classes.
    6. Considering the difficulty of my engineering courses and teacher, and my skills, I think I will do well in my aerospace engineering classes.
    7. I’m confident I can understand the most complex material presented by the instructors in my aerospace engineering classes.
    8. I’m certain I can understand the most difficult material presented in the readings for my aerospace engineering classes.
    9. I believe I will receive excellent grades in my aerospace engineering classes.
2. Did your elementary, middle, or high school have a gifted studies program? Did you participate in gifted studies?
3. Did you have any engineering experience before attending college? Where did you get this engineering experience?
4. Did you take any Project Lead the Way classes?
5. Have you participated in any advanced curriculum? Describe your experience.
6. Does either of your parents work in engineering or science related field? Explain.
7. Is there any reason that you might want to leave aerospace or engineering now or at some time in the future? Explain.
8. Are you an engineer?
9. Are you involved with any on-campus groups? If yes, then which ones?
10. What are your hobbies?
11. What are some of the qualities that you look for in your dream job?
12. Is there anything else that you would like for me to know?

By submitting this survey, you agree to allow the researchers to use your responses to this survey in their research project.