Female and Female Underrepresented Engineering Technology Students: Background, and Influences

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***Abstract*—** In this Research to Practice Full Paper it is recognized that four-year engineering technology programs include far more African American students than four-year engineering programs. Comparisons of studies focused on engineering technology or engineering programs or both programs indicate that this difference is considerable and is evident over a period of at least a decade. These findings support the need for research on the underrepresented engineering technology student population.

There is a great deal of diversity research in engineering, and some of the other fields often associated with Science, Technology, Engineering, and Math (STEM). However, this is not the case with the student population in engineering technology. Studies on engineering technology students often focus on students in the majority, which proves to be white male students. This results in the lack of focus and understanding of whom the underrepresented students are and their formal and informal learning influences. Learning in the formal and informal community and family environments have been shown by research to support and influence student choices as well as their future success. Thus, the influence of the underrepresented engineering technology student's past and current environments is significant but relatively unknown.

Researchers intended to gather data from underrepresented engineering technology student populations with a survey they developed. The survey queries student demographics, community and school support and preparation for the university experience, as well as their plans for the future. The original survey distribution resulted in responses from the students in the majority. The responses resulted in an understanding of the students in the majority, again leaving underrepresented students out of the study results. The survey has been re-distributed to primarily female and female underrepresented groups with the intent of furthering our understanding of the female and female underrepresented engineering technology students, their demographic, their past, and future. Thus increasing our knowledge of the contrasts of these students will support recruitment and retention efforts by these universities' administration.

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Keywords—engineering technology; female students; female underrepresented students

I. INTRODUCTION

Reports issued in 2016 noted that there were more Bachelor's Degrees earned by African American students in engineering technology than in engineering fields [1, 2]. This trend was noted as unusual and the reason for it not known. Engineering technology is often ignored or combined into engineering, technology, or other areas perceived to be similar. This creates a dearth of research on engineering technology and does not expose the rationale for the disparity in the number of African American and other underrepresented minority (URM) or female students in engineering and engineering technology.

II. LITERATURE REVIEW

Researchers question the reason for the decisions made by female underrepresented minority students as well as female students. They make decisions similarly to the rest of our population, based on things they know and understand. This work will begin exploration in this area in an attempt to provide guidance to further research, the path, and methodology best suited to uncover the reasons for these differences.

Engineering technology students are students that learn engineering concepts and apply them [3]. While a number of these students matriculate directly into engineering technology programs, they frequently move in from other majors such as engineering, sciences, or related associate level degrees. These students rely on intuition and perceive the world around them as it exists, they often find abstract concepts difficult to understand and apply [4]. Little literature exists that explores the cognitive domain of engineering technology students [5],

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which would provide a greater understanding of these students. More importantly further exploration of where engineering technology students come from and those things that influence their choices.

The majority of students in engineering technology are white males [6]. Since the number of female underrepresented and female students overall is limited, obtaining data on these students is a challenge. This study is looking at that very small population to find what little exists on these female underrepresented and female students in engineering technology.

Underrepresented Students. The United States has been referred to as the "melting pot," suggesting that the country is not as diverse as it was fifty or more years ago.[7]. Over the last century the population as assimilated, resulting in constant change. The population found in engineering technology have not kept up with these changes [1, 2]. The majority of students in these programs are white male, with very low populations of URM and female students.

Influences on underrepresented students in engineering technology affect matriculation and persistence rates. This is true in any field is it important to understand the formal and informal influences on these students. As noted, due to the shortage of these students obtaining this information and interpreting it correctly is a challenge.

Female Students. Further issues exist with female students, URM or otherwise. Studies have shown that female students normally choose majors that interest them and that they have demonstrated aptitude [8]. If a field is associated with being "smart" or exhibiting strengths, male students are attracted to those majors [9]. Malgwi [8] asserts that they found that men choose majors that will allow career advancement, future job opportunities, and good compensation. While most female students are not always considerate of these factors as they choose a major field. Thompson [10] asserts that the advisors gender will prompt a choice of major.

A great deal of literature exists on gender differences. All provide evidence or substantive discussion regarding the differences. Competition is one of the more prevalent differences, either the like or dislike of competitive situations[11]. Some students have suggested preferred working enviornments influcence thieir choice of career[12], often reasons for the differences also has to do with perception of problems and the world around them.[13] Further, the interaction of instructors, based on genders also influences how students perceive subjects, and their interaction/successes in one or another.[15] Lacking diversity in genders, similar to what is evident in the general population also impacts student choice and perception of suitable careers for themselves.

First Generation Students. Outreach programs designed to target URM and female populations are often all one gender or ethnic background [11, 12]. The one factor, generally ignored, is the fact that many of these students ar3e first generation college students. To successfully broach what can be a wide divide, further understanding of the differences of these students from one another and those already in programs is essential for success in recruitment and encouraging matriculation. Further, understanding the differences between students, their developmental environments, and community interactions limits the ability to develop pedagogy and outreach that encourages students to reach past what they and their families know and understand.

Formal Influences. Formal influences such as in the classroom influence children and adults [13]. The learning, methods of instruction and general comfort affect students and the way they learn. Less discussed is the informal environment in which they live. The impact of family dynamics, social and cultural influences impact the way a student thinks and reacts as they move through life [14]. This is not only important in the pre-career choice, but also in general living in college and beyond.

III. RESEARCH QUESTIONS

In previous work with this dataset, the primary student respondent was the white male. A concerted effort was made to solicit students that are in engineering technology and are an underrepresented minority and/or female student. That data will be extracted and shared in this document. The researchers, while using similar research questions in other studies believe the outcome in this work to be much more focused and they will be able to develop a sound direction to begin their larger work while disseminating these important findings.

Who are the female and female underrepresented students in engineering technology?

- *What are their demographics?*
- *What influences – either formal or informal are in their past?*

IV. METHODS

The researchers originally developed a survey[6] to extract information supporting their desire to learn more about the

demographics, home environment, preparation for higher education and future plans of underrepresented engineering technology students. Rather than obtain the desired data, they had more data on the majority population of white male students. For this research, the survey was distributed to a more diverse, focused under-represented population of engineering technology students. The result was more female underrepresented and female responses overall was obtained. The data was cleaned and the data sorted by gender, then race, for review. The data was then analyzed.

Data Analysis Methodology. Responses to the Qualtrics survey resulted in 176 responses to 48 questions, those that are applicable to this work are noted in Appendix A. After removing unwanted data, there are 36 responses from female engineering technology students to review. The results found in this data are noted in the findings section, using the best method to display the results of the survey with the desired groups of students.

V. FINDINGS

Two sorts of the data are displayed in this section. First using the data sorted by gender is reviewed to respond to the first question, and then the data sorted by race is shared using the means appearing most appropriate.

Demographics. There were 36 responses reviewed for this section – all of these students are female engineering technology students. Figure 1 shows the distribution of female students by race.

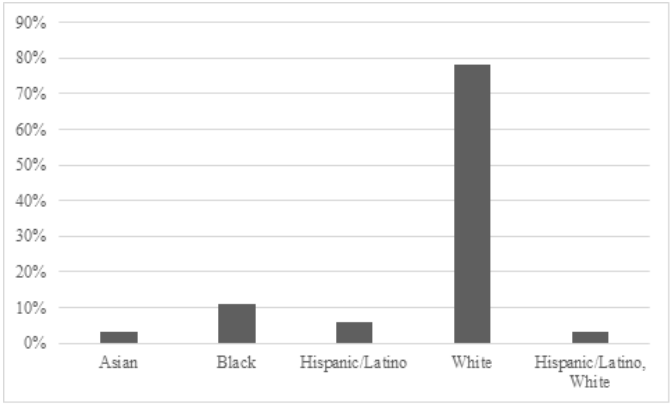


Figure 1. Female Engineering Technology Student Racial Distribution

Of the black students represented in the sample all four were in mechanical engineering technology, the Asian student was also in this major. Of the Hispanic/Latino students, one was Electrical, one other said other, and the third that is also noted as Hispanic/Latino also included white and noted they were in mechatronics. All of the other respondents where white female consisting of a well-distributed list of majors.

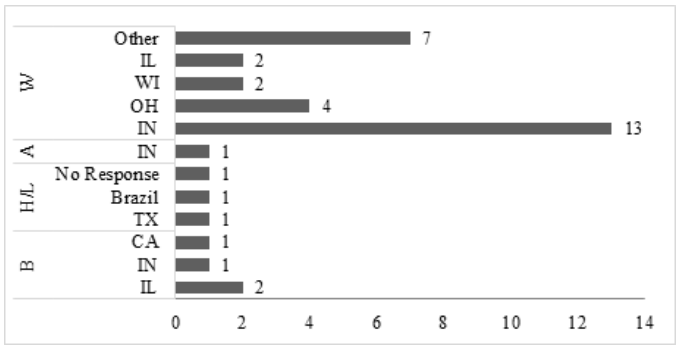


Figure 2. Female Engineering Technology Student Racial Distribution by Home Location

Female students responding to the survey were all from the United States, with the exception of the one respondent from Brazil.

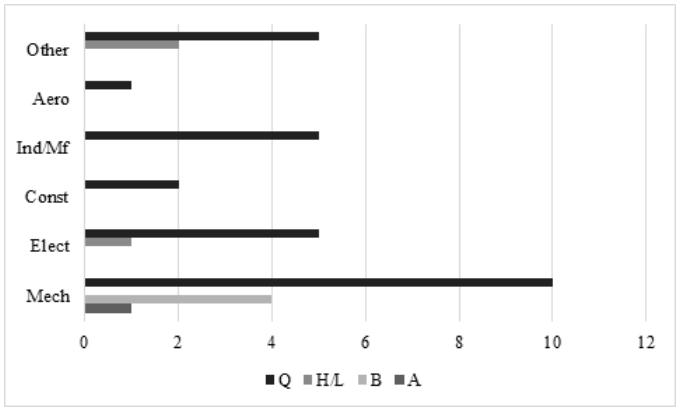


Figure 3. Female Engineering Technology Student Distribution by Race and Major

Female engineering technology respondents indicated their major at matriculation. All of the female URM students began in engineering technology, while of the female white students 21% indicated that they initially matriculated into engineering with the balance matriculating directly into engineering technology.

Information on Past – Influencers. The survey asks respondents to share the number of semesters they spent in HS in mathematics courses. Figure 4 shows that data, however it should be noted that all female engineering technology students that first matriculated into engineering completed 8 semesters of math in high school.

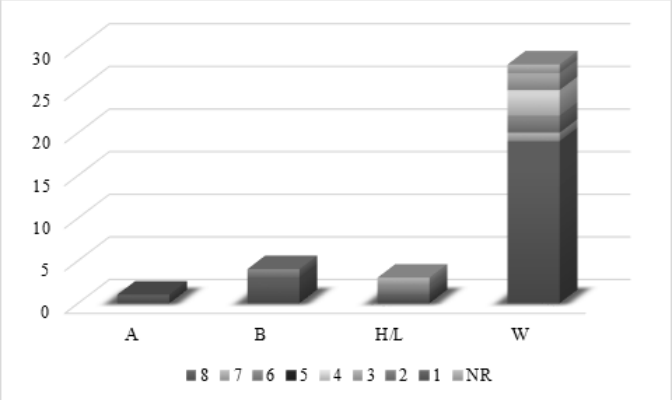
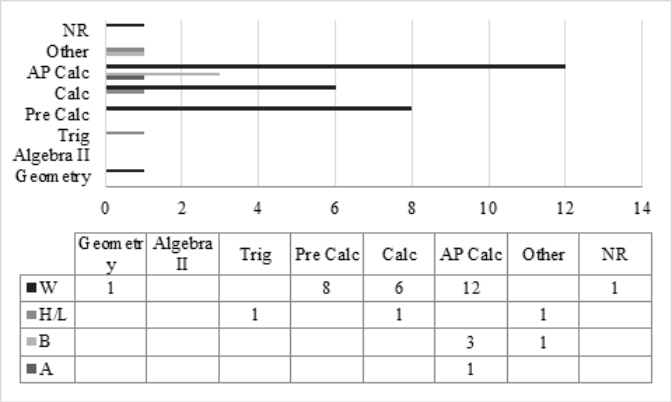


Figure 4. Semesters Female ET Students Spend in Math in HS by Race

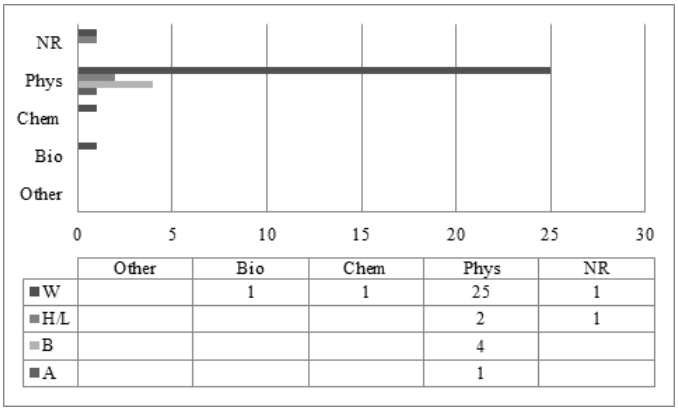
The following Figure 5 shows the highest level of math completed by the responding student population. The majority of students have taken calculus and AP calculus. However, there are outliers that the highest math course taken was geometry, trigonometry, and pre-calculus.



	Geometry	Algebra II	Trig	Pre Calc	Calc	AP Calc	Other	NR
W	1			8	6	12		1
H/L			1		1		1	
B						3	1	
A						1		

Figure 5. Highest Level of Math Female ET Students Completed in HS

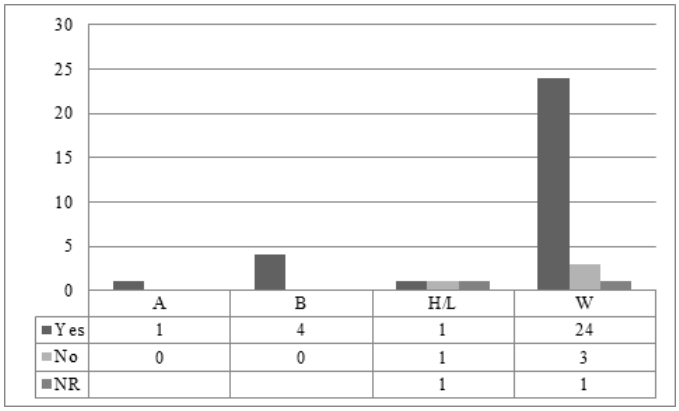
Figure 6 shows the highest science course taken in high school and it is evident that for those responding most took physics in preparation for their future studies.



	Other	Bio	Chem	Phys	NR
W		1	1	25	1
H/L				2	1
B				4	
A				1	

Figure 6. Highest Level of Science Female ET Students Completed in **HS**

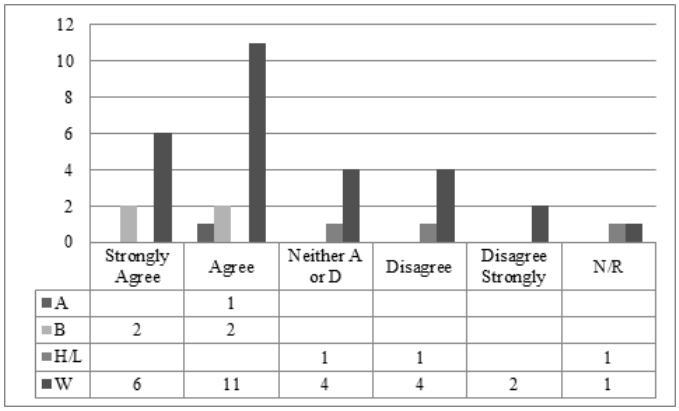
The following Figure 7 shows the availability of advanced placement (AP) courses in their high school. Of the students responding, those URM students that indicated they were black or Asian had AP courses at their high school. The Hispanic/Latino students were not consistent in their response to this question.



	A	B	H/L	W
Yes	1	4	1	24
No	0	0	1	3
NR			1	1

Figure 7. AP Courses at HS Attended by Race

While asking if preparation for math courses is opinion based, students generally agreed that they were prepared. However, an examination of responses from students that did not feel they were prepared shows that white and Hispanic/Latino female students do not believe they are as prepared as their counterparts indicated they were.



	Strongly Agree	Agree	Neither A or D	Disagree	Disagree Strongly	N/R
A		1				
B	2	2				
H/L			1	1		1
W	6	11	4	4	2	1

Figure 8. Adequate HS Preparation for First College Math Courses

Influencers. The responses to two questions regarding perception by students and faculty of the engineering technology major are examined here. A 5-point Likert scale was used and the analysis is shown in Figures 9 and 10 below.

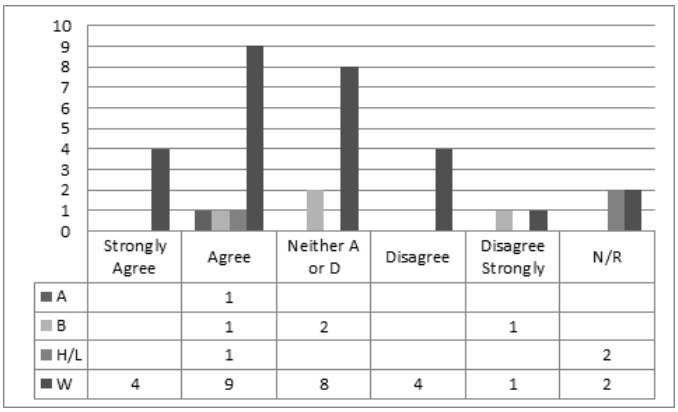


Figure 9. Perception of Students Varies by Major – By Faculty

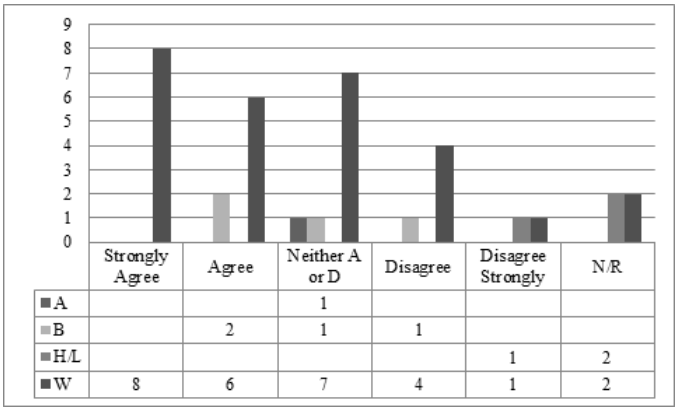


Figure 10. Perception of Engineering Technology Students – By Students

VI. Discussion

Based on the respondents to this survey that were female examined by race, a number of things were found.

Demographics. In general, most of the students were white; however, there were a few black students as well as Hispanic/Latino students providing additional information. The data was reviewed in aggregate and by race to determine similarities and differences. Most of the students were in the 18-24 year age range, while 1/3 of the students were white and from Indiana. The balance were from other Midwestern states, with one no response, 1 foreign country, and nearly 1/5th of the respondents not indicating. In all categories, most students were mechanical engineering technology with an even distribution of majors throughout all races except the black female engineering technology students who were all mechanical engineering technology students. Of note is that all URM female students responding to the survey matriculated directly into engineering technology, while the white female students matriculated into engineering and then transferred to engineering technology later in their studies.

Background and Influence. In review of the answers to questions more focused on background and influence on a student's choices. Most students spent eight semesters of high school in math, while others spent as low as 2 semesters in math during the same time. These same students indicated that pre-calculus, calculus, or AP calculus was the highest levels of math they had taken. Thus providing at least a basic understanding that these students anticipated taking a math based major once they applied for and matriculated into their chosen college major. The outliers were one student whose highest math was geometry, another trig, and two that indicated other. This was only 13% of the overall responding population. Further review of the responses indicated that the vast majority of students took physics as their highest science in high school. All of the female URM engineering technology students responding to the survey indicated that physics was their highest science take in high school. This same group indicated that AP courses were available at their high school with both female white and Hispanic/Latino students providing a mixed level of response to this question.

When asked if they thought they were adequately prepared for their math courses upon matriculation into college the responses were mixed. Most indicated that they did not disagree or agree or were positive with their experiences. While the Hispanic/Latino students didn't respond, either disagreed, or didn't agree or disagree, this indicates that further research into these students backgrounds should provide better understanding of the opportunities available to these students. While female white engineering technology students varied in their responses, most students were positive, however the distribution of these student experiences indicate more research and investigation into the quality of math preparation is required.

VII. Conclusion

The researchers were interested in the perception these students had about the faculty they interact with, and how they perceive students by major. In particular, if students have an experience indicating one major is better than another. Their responses indicated that faculty response to student major varies, and is fairly well distributed given the responses by the students. They shared that most faculty were not biased. The female engineering technology students indicated that their peers were generally not biased against engineering technology students. However, it should be noted from Figure 10 nearly 18% of the students indicated that there was a bias. Thus providing an indication those students in other majors may benefit from further understanding of engineering technology majors.

Since this population is so small, the number of respondents that met the criteria of female engineering technology students was not expected to be large. However, the 36 students that responded provided interesting information, which can be used to encourage further questioning and research. This research could be used to inform practioners regarding their actions in and out of the classroom and for those involved in recruitment and retention activities. Further research, activities, and teacher education to encourage and improve programs throughout STEM preparation at the high school and earlier levels would be warranted. This would provide students with the exposure to and potential choice of engineering technology as a career choice. Further, it would provide a basis for filling the pipeline with female students of all races preparing them for success in STEM programs, including those in engineering technology

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Appendix A - Engineering Technology Student Survey – Applicable Questtions

Demographics

- What gender do you identify as?
- How old are you in whole years?
- Did you attend high school in the United States or a US territory?
- What race do you identify with?
- What engineering technology degree program are you currently in?
- Where Did You Start College?
- What year do you anticipate graduating with your engineering technology degree?
- Hometown:
- Current City:

High School Preparation

- How many semesters of mathematics did you complete in high school?
- What mathematics courses did you complete in high school?
- What science courses did you complete in high school?
- Were Advanced Placement (AP) courses offered at your high school?
- Please list any AP mathematics or science course you took in high school.
- High school prepared me adequately for my first college mathematics courses.
- Clarify your answer to the question: "High School prepared me adequately for my first college mathematics courses."

Path to Major

- What is your current engineering technology major?
- Including the current academic year, how many years have you been enrolled in engineering technology?
- Which best describes your path to your current major?
- I applied to this program/major directly from high school and was admitted to my current major.
- Why did you choose your current major?
- How did you first hear about engineering technology in general and your current major in particular?

Institution and Curriculum

- At my institution there is a perception among engineering students that one's major is an indicator of academic ability (e.g. 'Smart' students do Major X.)
- At my institution there is a perception among engineering technology students that one's major is an indicator of academic ability (e.g. 'Smart' students do Major X.)
- At my institution there is a perception among faculty and staff that one's major is an indicator of academic ability (e.g. Major X would be a better fit for you. It is not as rigorous or challenging).