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Minority Graduates in Engineering Technology: Trends in Choice of Major

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Abstract

The paper presents a demographic analysis of college graduates in engineering technology (ET). The paper intends to investigate the graduates' background, population, and choice of major.

Graduates in ET are a much smaller population than those found in other Science, Technology, Engineering, and Mathematics (STEM) programs. Little publishing exists about who they are and how long it took to pursue their degree while examining other available demographic data. The delineation of this paper does not include computer science and computer technology programs. Several opinions exist about who these students are, where they come from, and what interests them. The paper presents a view of existing data of the most extensive undergraduate ET programs at a Midwestern university. The authors aimed to clarify a number of these opinions and determine if further study is warranted, mainly providing direction and form of that future work. The authors built their conclusions on the processed data results in such categories as basic demographics, gender, ethnicity, program changes, and graduation majors.

The authors analyzed the University-provided demographics data as reported by college graduates in ET. The authors established gender and ethnic patterns and then addressed two research questions. The authors used ethnicity as a lens to explore the undergraduate experiences of female and minority graduates in ET. The first research question allowed the authors to establish the proportion of ET graduates' ethnicities and compare it to the proportion of ethnicities in the United States population. The development of a response to the second research question uses ethnicity as a lens, investigating how female ET students navigate and establish their major, while focusing on representation in their respective ethnic groups.

Future research can include examining the data for insight into who applies for funding, scholarships, and other means to support themselves while pursuing a degree in technology. The paper provides the readers with the foundational elements to further explore the ET student population and determine what funding or financial needs may encourage more students to pursue a degree in ET. Using this more extensive institutional database will provide a means to further the authors' understanding of student perception, needs, and those factors that influence their education decisions at a bachelor's degree level. The result of this work will begin to lead educators and administrators in their quest to diversify and increase student populations in ET.

Keywords – STEM, engineering technology, graduates, diversity, minority, gender, ethnicity.

Introduction

Graduates in engineering technology are far less in number than traditional engineering students and those in other STEM fields. Little publishing exists about who they are and how long it took to pursue their degree. The paper presents a review of existing data from the undergraduate engineering technology program at a Midwestern university, one of the most extensive in the country. Studying the demographics and program changes will help understand the student dynamics and backgrounds while pursuing their degrees. The paper investigates engineering technology graduates through the demographics of gender and ethnicity, and program changes and graduation majors. The results will be useful for engineering technology researchers, practitioners, and administrators in their quest to study, diversify and increase student populations in the field.

Literature Review

The discipline of engineering technology originated in 1955, as the Committee on Evaluation of Engineering Education (CEEE) from the American Society for Engineering Education (ASEE) in the Grinter report [1]. The report defines and outlines engineering education, as suggested a "bifurcation" in engineering curricula [2]. The creation of this division proposed a "general professional category" emphasizing engineering sciences, focusing heavily on theory, though engineering educators were unreceptive [1, 2]. The space race of 1957 proved the need for a wide range of technical talent, and engineering technology emerged outside the curriculum track of engineering programs as theorized by the CEEE [1, 3].

Vocational and two-year associate programs focus on the applied theory, providing a foundation for engineering technology education. The programs aimed to raise technical support professionals to work along with practicing engineers [1]. Industry saw benefits from the separate curriculums and areas of specialization as engineers studied theory and conceptualized design, while engineering technologists held the technical skills to apply theory to practice [3]. Four-year baccalaureate engineering technology programs developed from two-year programs in the 1960s, as professional engineers personally showed the need for practical and applied skills [1]. Institutions with engineering technology programs expanded associate programs to include baccalaureate curricula, which included mathematical theory, alongside technical skills, mimicking traditional engineering programs before the 1950s [1].

One issue in the formation and growth of four-year engineering technology programs was a naming convention. With the reluctance of engineering faculty to adopt the bifurcated curricula, engineering programs were, and still are unwilling to adopt engineering technology programs as engineering [1]. Ideas for naming this new baccalaureate degree program included "Applied Engineering" and "Engineering Science" [4]. Academic institutions ultimately accepted the naming convention of engineering technology, with graduates taking on the title of "engineering technologist" as the Accreditation Board for Engineering and Technology (ABET) endorses the position [4]. The distinctions between the traditional engineering programs and engineering technology programs remain ill-defined at best, colloquially, academically, and professionally [1, 5]. The shortfall in the programs' distinctions has led to the following problems. Institutional recruitment has difficulty describing the engineering technology program to prospective students and parents [1]. Industry aimed at filling engineering positions also faces similar qualms, wondering if the program is an engineering or technician education [1, 5].

Difficulty in Defining Engineering Technology Graduates

Limited literature focused on engineering technology graduates is available in comparison to their engineering colleagues. In addition to the smaller number of engineering technology students [6], the Integrated Postsecondary Education Data system (IPEDS) does not collect numeric data for engineering technology programs, only awarded degrees [5]. Program-specific information is available from ABET, the foremost educational accreditation organization for engineering and technology programs [7]. Furthermore, the information collected by ABET is only available for engineering technology programs, which they accredit [7].

Another difficulty of qualifying and quantifying student data is the lack of standard terminology used to describe engineering technology program graduates. In postsecondary education, those who earn two-year engineering technology degrees are referred to as "technicians," while those who earn a four-year degree are "technologists" [5]. However, in federal data collection, the terms technician and technologist are used interchangeably while referring to work done by those with either a two- or four-year degree [5]. The title of "technologist" also holds little currency in industry. The job titles held by engineering technology graduates link to their work roles rather than the name of their degree. Thus, those who have four-year engineering technology degrees self-identify job titles, reporting as engineers or managers [1, 7].

Engineering Technology vs. Engineering Graduates Roles in Workforce

Graduates in engineering technology are fewer in number than their engineering graduate counterparts [6]. As lack of available literature and indistinguishable definitions confound, engineering technology students are misidentified both colloquially and professionally. While closely related and sometimes similar in occupation, engineering and engineering technology are separate areas of academic training [5]. The misidentification of engineering technology graduates creates inaccuracies and blurs the degree's distinct and unique differences [6]. Traditional engineering disciplines emphasize advanced mathematics, theory, and conceptual design [7]. According to ABET, engineering programs require higher-level mathematics, including numerous semesters of calculus and theoretical science courses [7].

Engineering technology programs focus on the application of traditional engineering theory. The degree course work focuses on applied calculus, algebra, and trigonometry [7]. This area of study includes practical, laboratory, and problem-solving skills, giving engineering technology degree programs an “implementation” minded focus of engineering theory [5].

Figure 1 depicts the hands-on-continuum of engineering technology [8]. Engineering programs study coursework geared towards science, theory, and foundational analysis, while engineering technology programs study coursework geared towards industrial application and hands-on implementation in the workplace [5, 7]. Engineering graduates pursue careers in theoretical design, and research and development [1]. Meanwhile, engineering technology graduates often enter construction, product design, manufacturing, or testing [7].

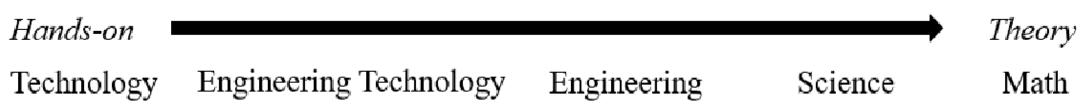


Figure 1. Hands-on Continuum for Engineering Technology [8].

Despite the curriculum differences, graduates of ABET-accredited four-year engineering technology programs in several states are qualified to become licensed professional engineers with verifiable proof of competency [7, 9]. One earns licensure upon passing the Fundamentals of Engineering (FE) exam and the Principles of Practice of Engineering (PE) exam through the National Council of Examiners for Engineering and Surveying (NCESS) alongside providing proof of engineering work experience [9].

Diversity in STEM

Academic programs in STEM lack diversity in the student body [5, 10]. In 1950 as the United States government and industry leaders recognized STEM fields fostered innovation and strengthened global competitiveness [10, 11], the National Science Foundation (NSF) formed "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense" [12]. A core mission of the NSF is to “cultivate a world-class, broadly inclusive science and engineering workforce” [13]. The NSF efforts focused on supporting education and workforce promotion for STEM careers, providing federal funding [11]. While STEM education efforts grew, the labor market filled with young White males [11].

While there is an increase in females and underrepresented minorities perusing postsecondary education, recruitment and retention in engineering technology programs have seen little progress in equal workforce representation [14, 10]. According to engineering technology Degrees, 2009-2018, the percentage of females pursuing engineering technology bachelor’s degrees has increased from 9.4% in 2009 to 14.5% in 2017 [15]. Reported by ethnicity, Black and African American engineering technology bachelor's degrees saw a decrease from 8.5 to 6.9% in 2017, Hispanic saw an increase from 6.7 to 10.6%, with White male students dominating the field [15]. Alongside low enrollment, ethnic minority students also show lower retention rates and a longer completion time in STEM programs [10]. Thirty-three percent of White students completed their degree in five years, while 18% of African Americans and 22% of Latino were able to do so [16]. A significant retention gap also exists in minority students [10]. According to Reichart, in the 1990s only one-third of minority freshmen, but more than half of non-minority students finished their degree [17].

Retention of Minorities in STEM

Rates of females and underrepresented minorities pursuing postsecondary education have generally risen since the 1980s [11]. Across STEM majors in their entirety, student retention rates are similar regardless of ethnicity, while female retention rates skew higher than both White and Asian males' [11]. However, the recruitment of females and underrepresented minorities in engineering-based programs saw little progress [11]. Increasing classroom diversity has been shown to enhance academic achievement and productivity, though the experiences of females and underrepresented minority students differ from those of a majority of male students [11]. Lichtenstein reports that female and underrepresented minority students face the same obstacles as first reported in postsecondary education more than 50 years ago. These feelings include self-doubt, feelings of both social and cultural isolation, poor classroom environments, lack of representation in mentors or role models, and competitive academic environments [11].

Reichart studied institutions with high graduation rates of Black engineering students, those at or above 50%. Recurring factors in those schools' success included an emphasized effort of valuing minorities. Value started from the top, with retention programs beginning in the dean's office [17]. Education support systems were also made available through the use of tutoring and academic advising. Those schools also included a Minorities in Engineering (MEP) program and active engineering societies run by students [10, 17]. Impactful retention efforts for females and underrepresented minorities include the use of learning communities, undergraduate research opportunities, and internships and minority support organizations, such as the National Society of Black Engineers [10]. Lichtenstein claims that targeted academic programs and other efforts help minority students build confidence in problem-solving skills, professional skills, and interpersonal relationships [11].

Recruitment

The United States has an increasing demand for science, technology, engineering, and math education to compete in a global economy [8, 18]. The Committee on Equal Opportunities in Science and Engineering (CEOSE) explains that broader participation in STEM education is necessary to improve the STEM competitiveness of the United States. The country has a growing minority population, retention and recruitment of underrepresented minorities is pivotal [18]. The committee of Underrepresented Groups and the Expansion of the Science and Engineering Workforce states that "minorities are seriously underrepresented in science and engineering, yet they are also the most growing segment of the population" [19, pp. 1-2]. The committee also expands on reasons to support and invest in the diversification of STEM education, including uncertainty in the future workforce, the racial and ethnic shifts in the domestic population, and using diversity as an asset [19].

Federal programs exist to recruit and retain underrepresented minorities in STEM, such as the Historically Black Colleges and Universities Undergraduate Programs (HBCU-UP) and the Louis Stokes Alliance for Minority Participation (LSAMP) [18]. The federal agencies, National Institute of Health (NIH) and National Science Foundation (NSF) have aided in funding for programs such as Advancement of Women in Academic Science and Engineering Careers (ADVANCE), Alliance for Broadening Participation in STEM (ABP), Research Experience for Undergraduates (REU), and Tribal Colleges and University Programs (TCUP), showing results in underrepresented minorities persisting in STEM education [18]. Thirty-four percent of HBCU-UP participants pursued graduate degrees, an increase from African American students nationally at 20.5 percent [18].

STEM education recruitment is also relevant outside of structured or federally funded efforts. The study, Examining Recruitment and Retention Factors for Minority STEM Majors Through a Stereotype Threat Lens, conducted interviews with minority students persisting in STEM fields [20]. Students reported influencing factors in their interest to pursue STEM included teachers, guidance counselors, peers, and familial support [20]. Students indicated that patience, encouragement, and adversity throughout high school influenced their decisions to pursue STEM.

The review of the literature provides support to the statement that underrepresented minorities are often the focus of STEM education research. However, most of the available research is in engineering, with a limited number of publications on engineering technology. The targeted study of engineering technology students provides educators and administrators with an opportunity to recruit and retain female students and those from underrepresented minority groups in STEM. For educators and administrators to use that opportunity and facilitate change, they need to understand the current representation of minorities among engineering technology students and the obstacles minority students face while working towards their degrees.

Research Questions

The authors aimed to further knowledge about engineering technology graduates with the two following goals. The first goal was to show that female and ethnic minority graduates are underrepresented in engineering technology programs. The second goal is to investigate if females were more likely to change their major than the males for each ethnic group among engineering technology graduates. The following are the research questions the authors formulated to address the research goals.

- *What is the proportion of ethnicities of engineering technology graduates, and how does it relate to the proportion of ethnicities in the United States population?*
- *How does the number of female engineering technology students of each ethnicity who changed majors relate to their representation in the respective groups, and what majors do they graduate with?*

Methodology

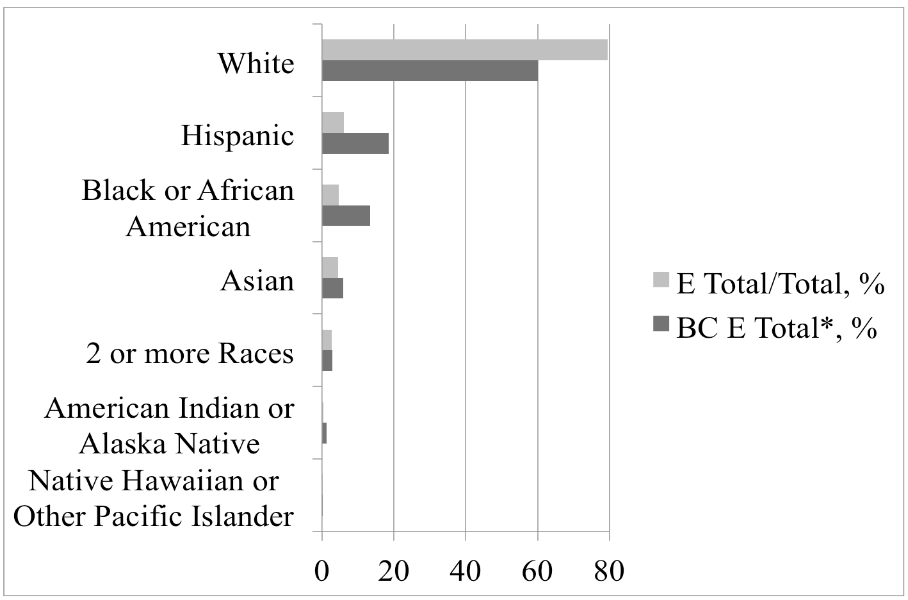
The authors used graduation data for ABET-accredited undergraduate engineering technology programs at a large Midwestern university. The university provided the data for the research. The authors cleaned the data by excluding the graduates who identified themselves as "International" or "unknown." The subsamples of American Indians or Alaska Natives and Native Hawaiians or Other Pacific Islanders are small compared to other ethnicities. Due to the extremely low number of these individuals compared to other groups, the authors considered them as outliers when addressing the research questions. The authors utilized Microsoft Excel to work with the sample and determine the appropriate answers to the research questions.

Findings

After completing the data analysis, the initial sample size was 1444 graduates, who were awarded Bachelors of Science degree across eleven engineering technology programs. Among a variety of parameters, graduates reported their ethnicity as defined by the United States Bureau of the Census (BC) [18] and, alternatively, as "International" and "unknown." This brought down the final sample size to 1333 graduates. The following comparisons were made and utilized to respond to the research questions.

The engineering technology graduates are predominantly male students, representing 90.2% of the total number of graduates. White male graduates represent 92.1% of the total number of students who identified themselves as White. Notably, the remaining 7.9%, White female graduates is below the female graduate average and is the smallest proportion of females per ethnic group. In opposite, Black or African American female graduates represent 29% of the total number of graduates of this ethnic group, which is the biggest proportion of females per ethnic group. Hispanic female graduates represent 17.1% of the total number of graduates of this ethnic group, the *second* biggest proportion of females per ethnic group. However, in absolute numbers, both White males and females constitute the majority of graduates of the respective genders for all the remaining ethnic groups combined.

The engineering technology graduates of White ethnicity exceed the United States population representation of this ethnicity by almost 20%. The engineering technology graduates of Hispanic and Black or African American ethnicity relate to the United States population representation of this ethnicity as 1:2 or constitute one-third of the representation of the respective ethnic groups in the United States population. Figure 2 shows the percentage of engineering technology graduates of each ethnicity and its relation to the proportion of ethnicities in the United States population. In Figure 2, E stands for Ethnicity, and BC E stands for Bureau of Census Ethnicity.



Note: *E – ethnicity of engineering technology graduates, BC E – ethnicity distribution in United States population as per United States Bureau of the Census.

Figure 2. Engineering Technology Graduates: Ethnic Distribution in United States Population.

On average, 45.2% of the total number of engineering technology graduates changed their major while at school. At the same time, for females only, the average is 54.6%. From the ethnic perspective, 38.9% of Black or African American females changed their major, which is less than any other ethnic group and below both the total and female-only averages. Seventy-one point four percent of Hispanic females changed their major, which is more than any other ethnic group and above the total and female-only averages. The difference between Black or African American and Hispanic females is significant because both combined subsamples are twice as small as the White female subsample. With White females dominating in numbers among female engineering technology graduates, the percentage of White females who changed their major is close to the female average and equal to 58.3%. The subsamples of female engineering technology graduates of Asian and two or more races are small compared to the remaining ethnicities. The authors considered them as outliers when addressing the research question. Figure 4 shows how the number of female engineering technology graduates of selected ethnicities who changed majors relates to their representation in the respective groups. In Figure 3, FM stands for Females, and M stands for Males.

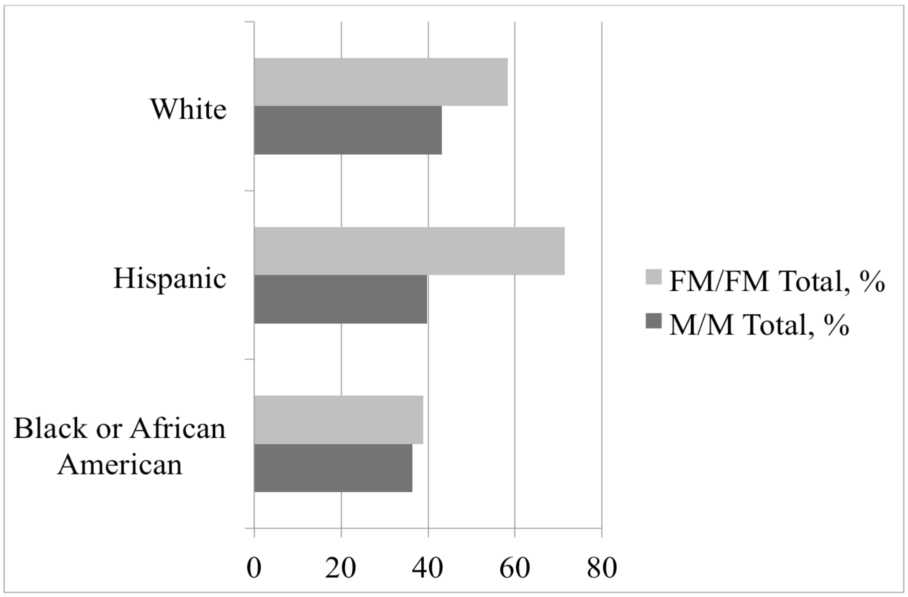


Figure 3. Engineering Technology Graduates: Change of Major Distribution.

The percentage of female engineering technology graduates in the first four graduation majors is inversely proportional to the graduates' percentage of the respective graduation majors. In other words, the less "popular" the major is, the higher percentage of females who graduate with that major. The smallest percentage, 6.5%, of female graduates is in Mechanical engineering technology. The biggest percentage, 33.3%, of female graduates is in Automation & Systems, and Mechatronics. Figure 4 specifies the engineering technology degrees earned by males and females.

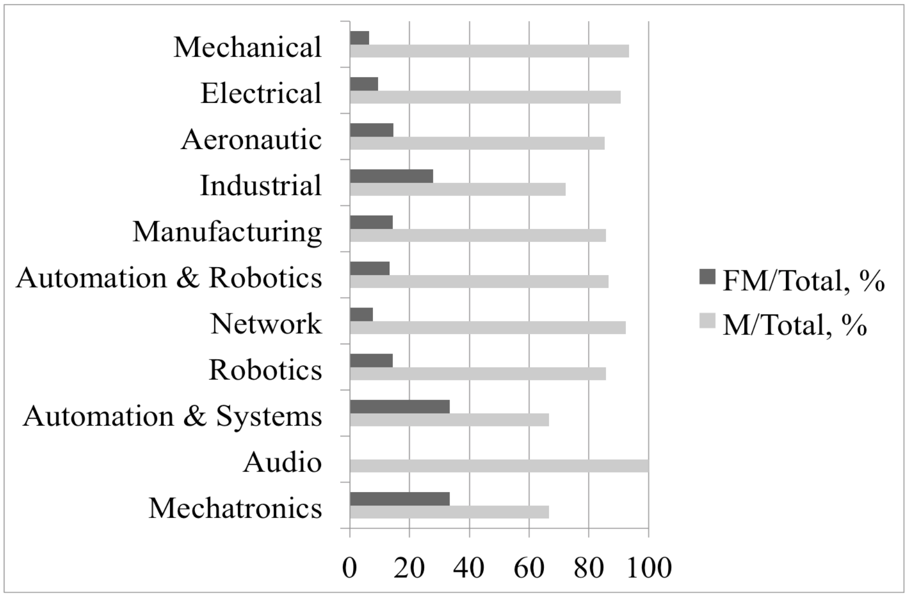


Figure 4. Engineering Technology Graduates: Distribution of Majors.

Discussion and Conclusion

The study showed the following patterns among engineering technology graduates and minority engineering technology graduates.

White (W) engineering technology graduates showed the smallest proportion of females per ethnic group, 1:9, than any other ethnic group. The result surfaced a problem of deep underrepresentation of females among W engineering technology graduates that did not appear in the existing research as per the literature review. The result indicates that engineering technology researchers, practitioners, and recruiters must consider specifically targeting W females along with ethnic minority females. Black or African American (BAA) and Hispanic (H) engineering technology graduates showed the biggest proportions of females per ethnic group. BAA and H females have a significant share in representing their ethnic groups in the engineering technology field, 1:2 and 1:3, respectively. The result can indicate certain success in the University's recruitment and retention work among the groups as related to females. The authors propose additional research to look into the possibility of validating the latter statement.

That said, in absolute numbers, even proportionally underrepresented W female graduates outnumber all ethnic minority female graduates combined. Moreover, BAA and H ethnic groups as a whole are heavily underrepresented among engineering technology student graduates compared to the respective ethnic group proportion in the United States population; specifically, they relate as 1:2. In other words, the University had three times fewer BAA and H graduates than it potentially could at minimum. The result correlates with the existing research per the literature review. The authors believe that engineering technology researchers, practitioners, and recruiters have a long path to recruiting ethnic minorities in the field.

When it comes to the change of major parameters, the data is in favor of BAA graduates. The graduates of the BAA ethnicity showed the lowest major change rates as compared to other ethnic groups. Both BAA females and males showed similar major change rates, as well as the lowest major change rates per ethnic group. The result could imply that BAA students are more determined to complete their studies than those in other ethnic groups. The authors are particularly interested in learning if BAA students participate in outreach clubs with targeted mentorship and if they can link it to low major change rates among BAA graduates. Also, for BAA females alone, low major change rates indicate an opportunity for their continued proportional growth in the overall BAA engineering technology student body. At the same time, H graduates in general and H female graduates, in particular, showed the highest major change rates. The result, together with a smaller proportion of females in the overall H engineering technology student body compared to BAA (1:3 vs. 1:2), must become a concern of engineering technology researchers, practitioners, and recruiters.

Nevertheless, females across all ethnic groups change their majors more often than males in the respective groups. While establishing the reasons for that phenomenon is out of the scope of the paper, some could be a lack of encouragement from family and peers and a feeling of isolation in college. The change of major is a significant parameter for tracking student retention. One of the key factors is the information about student background prior to the change of major. Learning these patterns is another opportunity for future research.

As for the choice of major parameter, the fact that female students tend to fill the discipline niches less popular among students as a whole is interesting and requires further investigation. One reason could be that female students feel less pressure from their families and peers that they “would not succeed” in the presently male-dominated majors. Another reason could be that the smaller popularity of the major among applicants creates an opportunity for recruiters to successfully promote the major among non-dominated audiences. One can compare the newly emerged end product-oriented majors, such as Robotics, with new market niches. According to Michaelson, the first rule of niche marketing is “to offer the customer a clearly differentiated product that fills (or creates) a need" [22, p. 23]. When offering additional majors, an academic institution might be creating an alternative sufficient to attract and sustain female undergraduate students from the marketing perspective. An alternative approach to investigating the problem is to see the list of subjects for the majors popular among females and link to their interests at the K-12 level. The authors left the distribution of majors across different ethnic groups for future research.

Overall, the results show that potential and current female and minority engineering technology students are being left behind in many ways. The future recruitment tactics may include promoting the discipline among females, including W females and minority students at the K-12 level. The future retention initiatives may include the following. Firstly, higher education institutions can develop first-year engineering technology programs in college similar to the programs that already exist in engineering as per the literature review. Secondly, higher education institutions can create student support systems within each major. The latter would provide targeted mentoring that supports the students academically and in other areas of their lives.

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