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Diversity in Engineering Technology Students

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Abstract

In the US, there are two academic pathways to a career in engineering: Engineering and Engineering Technology (ET). Engineering Technology attracts more African American and Latin American students than traditional engineering programs. Nationally, African American students are more than twice as likely to enroll in an ET program versus Engineering. We suspect it may be due to traditional Engineering programs' requirement of higher levels of math and science classes, often lacking in under-privileged or underserved urban or rural high schools. Recently published research by the New York Equity Coalition supports this supposition. Understanding the reasons for the higher representation of these students in ET can provide insights on the background of these students for developing effective practices and programming to improve retention of this cohort. It would also provide useful information for increasing the diversity of traditional engineering programs. This paper presents initial findings from a work in progress that is part of a multi-institution study to understand the factors that influence initial matriculation into and retention in engineering technology programs.

Introduction

The lack of diversity in US engineering programs has been a persistent and troubling problem which has resulted in a traditionally homogeneous engineering workforce. The lack of diversity in engineering presents a pressing national issue for several reasons: the United States is losing its advantage as the world's leader in research and development, the lack of potential contributions from diverse perspectives for the development of innovative technologies, and the principle of social equity stipulating that careers should be open to all people, unconstrained by factors such as gender or race. [1-3] Innovation in the science, technology, engineering and math (STEM) fields are key contributors to the US global competitiveness. With predictions that the growth rate of many science and engineering occupations will be faster than average in the near future, [4] failure to strengthen the STEM pipeline has potential to further erode the U.S. ability to remain competitive in a global economy. Increasing the participation of underrepresented populations in engineering will allow the U.S. to fully tap the human potential of its citizens while enhancing and diversifying the STEM workforce.

Recruiting more underrepresented minorities into engineering programs is a way to diversify and grow the engineering workforce. However, despite an increase in the number of women and minorities pursuing higher education, little progress has been made in recruiting and retaining these students in engineering programs. [5] The percentage of engineering degrees going to

African, Latino and Native Americans has increased steadily from 3% in the early 1970's to just over 10% in 2016. [6, 7] This is still less than half of the combined representation of these underrepresented minorities in the U.S.[6]

Compounding the problem of low enrollment of minority students is lower retention of these students in engineering programs. Minorities in STEM programs have lower rates of five-year degree attainment compared to their majority counterparts. Thirty-three percent of whites complete their degree in five years compared to 18% of African American and 22% of Latinos. [8] Reichart reported in the 1990's, the retention gap between minorities and non-minorities in engineering programs. While over half of non-minority freshman graduated in engineering, only a third of minority engineering freshman persisted to graduation. [6] Major factors affecting retention included feelings of isolation, a competitive academic environment, lack of effective advising, negatives classroom environments, lack of role models and mentors, and feelings of self-doubt. [5] Research has shown financial aid is another major factor for minority students and is correlated to degree attainment. [9, 10]

Although retention of minority students continues to lag majority students, there are research based practices for improving the climate in the engineering classroom. This includes wide spread adoption of learner-entered pedagogical approaches. [11] Problem based learning (PBL), cooperative learning, case-based learning, and service learning are examples of these approaches. These approaches result in improved student learning and social integration for all students. [12] These practices have also been found to improve retention of women and minority students. [13] Other high impact practices that have proven successful include use of learning communities, first-year seminars, and capstone projects. All of these promote student interaction with faculty and their peers. [5] Outside of the classroom, strategies that promote retention of minority students include personnel dedicated to tracking persistence, undergraduate research opportunities, participation in internships, and access to minority focused organizations, such as the National Society of Black Engineers. [5, 14]

Perceptions of racism and discrimination have been correlated to lower grade point averages and graduation rates of Black engineering students. [15] Evidence of institutional awareness of these issues and programs in place to promote a positive climate that supports diversity, can assist with improving persistence of diverse students. Brown additionally noted that institutions should strive to have a critical mass of Black student to prevent the isolation that has been noted to as a factor contributes to lower graduation rates.[22]

Reichart at al looked at which schools who have strong records in graduating Black engineers. [6] These schools have a greater than 50% graduation rate of black students. Common factors included a "message from the top" that minority students are valued. Most of these schools had retention efforts centered in the dean's office, a director of a minorities in engineering program (MEP) and minorities in engineering centers. [6] It was noted that it is not only important what the MEP programs do for the students but the care at which this is done. Programs seen as demeaning can do more harm than having no program at all. Support was given by the universities to maintain active student run engineering societies that support minority students. Summer bridge programs to prepare the students for the rigors of college academics was also a common offering at these universities. It was noted that these programs are enrichment programs and are not remedial in nature as to avoid stigmatization. Efforts are also made to not isolate minority students in their classes. All schools had accessible tutoring, academic support

and academic advising available to all students. A commitment to adoption of effective pedagogical practices that promote student learning compared to the long-standing practice of "weeding-out" students in introductory engineering classes, is crucial. A comparison of the three higher education programs represented by the authors are described in the following materials.

The goal of this paper is to describe initial findings from a study to better understand the higher representation of underrepresented minorities (URM), specifically Black and Latino students, in Engineering Technology programs in the US. The study includes reviewing enrollment and graduation rates by ethnicity at several universities, current programs at place in ET programs to increase graduation rates, and preliminary findings from a survey that aims to develop a better understanding of motivations to enroll in ET programs and factors that impact graduation rates.

Diversity in Engineering Technology at the Rochester Institute of Technology

There are two pathways to a career in engineering: Engineering and Engineering Technology. The engineering profession is very broad with engineers within a discipline performing varied functions within the public or private sector by solving problems for the overall benefit of society. As summarized by American Society for Engineering Education (ASEE) and the American Society of Mechanical Engineers (ASME), four year BS Engineering Technology programs are another pathway to the engineering career with a more applied or practice oriented engineering lens. [16, 17] The distinction between a Bachelor of Science degree in Engineering Technology and a Bachelor of Science Degree in Engineering is more academic in nature and there are very few distinctions between the careers graduates of these programs enter in the workforce. The difference between the programs is largely irrelevant to the industries that hire these graduates. [18] Engineering Technology programs have a higher percentage of minority students, particularly Black and Latino students. In 2017, Rochester Institute of Technology's (RIT) population of African American, Latin American and Native American (AALANA) was 15.6%. In RIT's Engineering Technology programs, 18.4 % were AALANA compared to 9.8 % of engineering students. [19]

Table 1: Engineering and Engineering Technology Degrees by Ethnicity [7, 20]

	Black	Hispanic
US Engineering Technology	9%	13%
US Engineering	4%	11%
RIT Engineering Technology	5%	7%
RIT Engineering	2%	4%

STEM Preparation in New York State schools

A 2018 report from the New York Equity Coalition of civil rights, education, parent, and business organizations presented data on access to high quality STEM coursework in middle and high school. [21] The study found that Black and Latino students in New York State are:

- Under-represented in gatekeeper courses that prepare students for college and career opportunities.
- Less likely to attend schools where these courses are offered compared to their White counterparts.
- Under-enrolled in these courses even in schools where they are offered and
- Disproportionately enrolled in schools with no or too few school counselors, who could help them navigate course selection for progress into college STEM programs and careers.

The classes the coalition defined as "gatekeeper" classes as rigorous college preparatory courses that prepare students for college and career opportunities. These courses included Algebra I and Earth Science in middle school, Calculus, Physics, Advanced Placement (AP), Computer Science, Foreign Language and Music. The STEM courses included in this study are required or are stepping stones into required coursework for entry into college engineering programs. Table 2 shows the differing entry requirements for high school math and science coursework at RIT. Students who have not taken Physics and Pre-calculus in high school would not receive admission into RIT's engineering programs. With forty-one percent of RIT's undergraduate students coming from New York State, access to required coursework in New York State will impact enrollment in engineering programs. Fifty-six percent of RIT's engineering technology students and 50 % of RIT's Engineering students are from New York State.

Table 2: Math and Science Admissions Requirements for Engineering and Engineering Technology programs at RIT [22]

Admissions	**Engineering**	**Engineering Technology**
Required High School Math	4 years including Algebra, Geometry and topics in Trigonometry and Pre-calculus	3 years including Algebra, Geometry and topics in Trigonometry; Pre-calculus recommended
Required High School Science	4 years including Physics and Chemistry	3 years including Chemistry or Physics

In New York, sixty-eight percent of New York high schools offer Calculus and 74 percent offer Physics. Only 34 % offer Computer Science courses. The study found Latino and Black students are under enrolled in these courses because they disproportionately attend schools where these classes are not offered. One reason for this is they are concentrated in high need school districts that do not offer this coursework. White students have greater access to AP coursework. This course work can make them more attractive applicants to engineering programs. White students successfully compete 280% more AP coursework that Black and Latino students in New York State, however Whites only account for 8 % more students. [21]

Black and Latino students are under enrolled in STEM courses even when the schools they are attending offer this coursework. [21] For example, in schools that offer Calculus, Black students represent 13 percent of all students but only 7 percent of Black students take Calculus. Only 12

percent of Latino students are enrolled in Calculus at these schools despite representing 21 percent of all students.

In New York, eighty-four percent of Black students and 78 percent of Latino students and are enrolled in the Big 5 school districts (made up of New York City and the four large city school districts—Buffalo, Rochester, Syracuse, and Yonkers).[21] At RIT, Engineering Technology programs have a higher percentage of students than RIT's engineering programs from many of the counties that include these Big 5 districts and from the Bronx (Table 3). This indicates that the ET programs are admitting more students from these counties that include the school districts that include a high proportion of Black and Latino students. This is especially true for the counties and school districts in the New York City area.

Table 3: Enrollment in RIT's Engineering and Engineering Technology Programs by County and Related School Districts

County	Included Urban School district*	Eng.Tech	Eng	Comparison of ET to Eng
Monroe	Rochester	24.8%	21.5%	+15%
Erie	Buffalo	8.1%	10.4%	-22%
Onondaga	Syracuse	6.7%	7.0%	-4%
Westchester	Yonkers	2.6%	2.4%	+12%
Bronx	Bronx	2.3%	0.9%	+156%
Kings	New York City	4.5%	2.5%	+79%
Queens	New York City	4.5%	2.4%	+84%
New York	New York City	1.7%	1.1%	+63%
Richmond	New York City	0.9%	0.4%	+145%
	TOTAL New York City	11.6%	6.4%	+82%

*Note: The data available for RIT is based on enrollment by county, not by school district. School districts that are included in the New York Equity Coalition report are indicated by the county in which these districts reside.

In 2018, 53% students who were admitted into an RIT Engineering Technology (ET) programs had applied to an engineering or other STEM program (not ET) at RIT as their first choice. In 2018, 64% of African American students and 56% of Latino admitted ET students did not select Engineering Technology (ET) as their first choice. [19] This indicates that these students are less likely to meet the requirements for entry into RIT's engineering program. It also indicates that there could be higher representation of students of color in the engineering programs at RIT if more of these students were accepted into these programs.

Retention of Diverse Engineering Students – Rochester Institute of Technology

While RIT's Engineering Technology programs enroll a higher percentage of Black and Latino students, retention of these students remains a concern (Tables 4). To graduate more Black and Latino engineers, it is important to improve retention of these students.

Table 4: 2017 Retention and Graduation rates of African American, Latin American, and Native American (AALANA) Engineering Technology Students

Rochester Institute of Technology – Retention and Graduation Rates		
RIT ET 1-year retention rates	83.00%	80.90%
RIT ET 2-year retention rates	72.30%	65.30%
RIT ET graduation rates	59.00%	53.30%

RIT's College of Engineering Technology is working to improve retention. In 2018, the college hosted an on-site offering of the National Effective Teaching Institute (NETI) for the faculty in the Engineering Technology programs. NETI is a workshop for engineering educators focused on improving student learning. In 2017, a journal club was formed for ET faculty interested in educational research. RIT's Women in Technology program coordinator is transition from soft funding to hard funding over the last two years and the director's role expanded to focus on under-represented minorities, and not just women in Engineering Technology. As a university, RIT is committed to recruiting, retaining and graduating more students of color. RIT has a Vice President of Diversity and Inclusion who oversees the Division of Diversity & Inclusion. The mission of this division is to "work collaboratively with academic and administrative units to provide a holistic range of services that enhance access and success for historically underrepresented students, faculty and staff, support education and scholarship, and ensure a welcoming, inclusive, vibrant and accessible environment for everyone."[23] RIT's 2015-2025 Strategic plan, Greatness through Difference, outlines goals of becoming the largest producer of female and under-represented male STEM graduates for private colleges, calls for a ten year plan ti increase representation form these groups and eliminate the achievement gap between minority and majority students.[24]

Retention of Diverse Engineering Students – Purdue University, Purdue Polytechnic Institute

Similar data to that provided by RIT is shown in Table 5. Data for the college which includes construction management, computer science, and other related programs of study in the Purdue Polytechnic is provided along with data from the School of Engineering Technology (SoET).

Table 5: 2018 Retention and Graduation Rates of Black, Latin American, and Native American (AALANA) Engineering Technology Students

Purdue University – Overall and School of Engineering Technology				
	Overall	**SOET Overall**	**AALANA**	**SOET AALANA**
1-year retention rates	83.00%	93.20%	80.90%	87.00%
2-year retention rates	72.30%	84.80%	65.30%	84.60%
ET Graduation Rate (4-year)	59.00%	59.00%	53.30%	47.10%
ET Graduation Rate (5-year)		76.40%		50.00%
ET Graduation Rate (6-year)		76.30%		76.20%

Utilizing a multi-tiered methodology Purdue University – Polytechnic Institute (PPI) works to engage students at all levels in ways that engage the students in a personal non-intrusive manner. They begin with the STEM Academic Boot camp. This camp is a 5-week summer program intended to bridge an incoming student's high school experience with what they can expect as a matriculating freshman. Underrepresented minority (URM) students are targeted with the intent of simulating the fall semester. During the 5-week period, these students take courses in math, English, design thinking, and programming. Coursework includes quizzes, exams, and homework. In the summer of 2018, 15 incoming PPI students attended the program.

A peer mentoring program, Boiler Mentors Peer Mentoring consists of freshman mentored by upper-class students. All students are encouraged to work together to overcome some of the issues encountered in that first few months of freshman year. The Minority Technology Association (MTA) supports the Boiler Mentors Peer Mentoring program as well as has programming throughout the school year. They work together to encourage each other in their studies and other factors impacting their lives. It is a club sponsored by the college, and the membership includes URM students from all backgrounds. A course TECH 100 – "Technology Freshman Seminar" is one credit hour course available to all freshman where they learn about the support services available at Purdue University. They also learn skills to help them get through their courses and learn more about success at the university.

An academic support program called BEST – Building Excellence for Students in Technology is a tutoring program for all students, those that are struggling are encouraged to attend. Further support is provided to students if they want to interact with a faculty mentor. Sophomores and Junior level students often request the support of a faculty member in non-academic issues. Students choose if they want to be a part of this program and if they want the faculty member to have attributes such as gender or race. The college aides students in finding mentors for them. There are other programs that students and faculty are encouraged to participate in with the intent of increasing interaction and a sense of community. Each student and faculty member is given a "Techie" T-shirt, and if they wear them on Techie Tuesdays, they can get a free donut or other giveaways. All of these programs and the faculty and staff strive to support the diversity statement, these programs and others developed as we move into the future support the following:

> "The Purdue Polytechnic Institute is committed to creating an inclusive and intellectually stimulating environment where its faculty, staff and students, from many diverse backgrounds and life experiences, are treated equitably and with respect." [25]

Retention of Diverse Engineering Students – Indiana University/Purdue University, Indianapolis

The programs to increase diversity of students in the School of Engineering and Technology at Indiana University/Purdue University, Indianapolis (IUPUI) do not target specific programs, but support all the school's programs, including engineering, engineering technology, computing technology, leadership, technical communication and music technology. Even though the recruitment and retention efforts are for all programs, enrollment data from IUPUI supports the national data that the percentage of underrepresented minorities in Engineering Technology is double that in Engineering.

Table 6. Percentage of Under-represented minority students currently enrolled in the School of Engineering and Technology at IUPUI [26]

IUPUI	Black	Hispanic	Native American
Engineering Technology	9%	8%	0.07%
Engineering	4%	4%	0%

Graduation rates are lower for underrepresented minority students in engineering technology than in engineering. Figure 1 is graduation rates for Black and Hispanic Engineering students and Figure 2 is Black and Hispanic Engineering Technology students. Published numbers for graduation rates only consider full-time students who enter as freshman and stay in the same major. Because of this, no transfer students or students who switch majors are included in the data. At IUPUI, over 30% of ET students have greater than 30 hours of transfer credit, and an unknown number switch majors. The graduation rate data is not including a substantial portion of students. At first glance, Figure 2 shows an extremely high graduation rate (100%!) for the 2009 cohort of ET students. However, because of the data being limited to full-time, non-transfer students, the 2009 cohort of underrepresented minority students had an N of only one student. Similarly, the N for the 2011 class was only two, and the 50% statistic only represents one successful student. Thus, the data does not give an accurate picture of the total graduation class.

Survey of Engineering Technology Students and Graduates

In February of 2017, National Academies of Engineering (NAE) published a study entitled "Engineering Technology in the United States." [27] This document made several recommendations regarding further study with the intent of developing an understanding of students, their characteristics, academic progression beginning in grade school, and furthering our understanding of why different groups graduate at higher rates than others and issues encountered in the workplace.

A committee was formed from engineering technology faculty interested this subject and developed two surveys to investigate graduate and undergraduate engineering technology students background, to see what type of student enters STEAM programs, the support the receive in their homes and communities, why some graduate at higher rates than others, and problems that occure in the workplace. These surveys were developed using well respected techniques[28-30] to address these issues, with the anticipation that further studies will be inspired from the results.

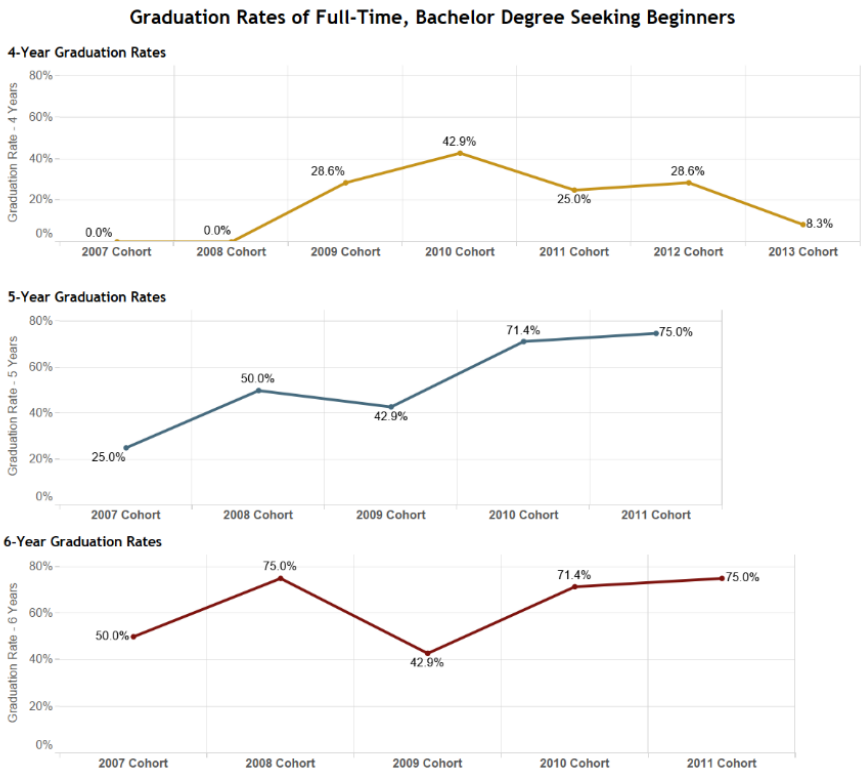

Figure 1: Graduation Rates for Black and Hispanic Engineering Students at IUPUI [26]

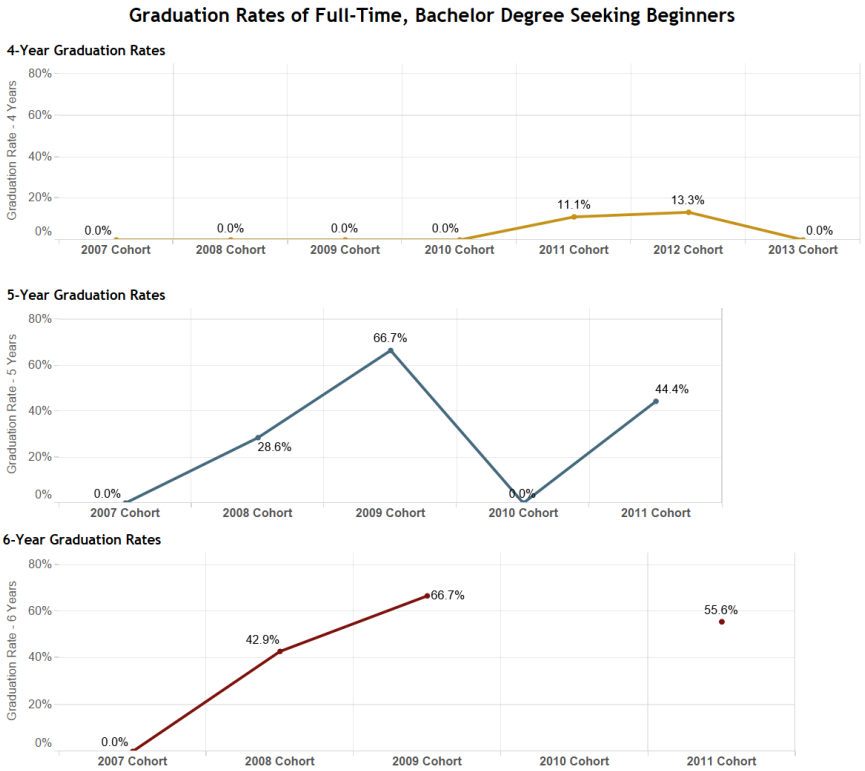

Figure 2: Graduation Rates for Black and Hispanic Engineering Technology Students IUPUI [26]

The preliminary results of the survey show that respondents are near par with the general population. 18% of those responding are in technology programs, with slightly less in engineering technology. This was anticipated as the number of engineering technology students as related to other programs tends to be much lower in overall number[31]. Most of the responding students are attending 4-year institutions, and the clear majority attended public elementary and secondary schools. Many of these students did not belong to a community or religious group and indicated that they received pre-matriculation support from other organizations, although there are some that did receive such support. Nearly 16% of these students are the first in their family to attend college, and they indicated that they received familial support as they prepared to matriculate into their chosen program. These factors and others that were illuminated by the survey results indicate that ET students, in general, need more support as they are introduced and make choices regarding their future. Interviews with these students will also provide greater insight into who is helping them prepare if they are not religious or community organizations. It is anticipated that greater investigation into the collected data and these discussions will provide the input needed to develop and implement interventions. Thereby encouraging higher numbers of URM students choosing to enroll in engineering technology programs. The result of these findings and subsequent actions would increase diversity in engineering technology programs throughout the United States.[31]

Conclusion

The data presented in the New York Equity Collation report and RIT enrollment data supports the hypothesis that the higher enrollment of Black and Latino students in Engineering Technology programs at RIT is because these students are more likely to come from underserved schools that lack the availability of gatekeeper coursework for these students to enter Engineering program. While Engineering Technology programs attract more Black and Latino students into their programs, it is important that ET programs have targeted activities and practices for these students be retained and graduate. Improving campus climate, adoption of student based learning strategies, tracking retention data and minority engineering programs are some research proven practices that can be adopted to achieve student success. Data suggests that Black and Latino students are more likely to come from under-served school with less exposure to rigorous college preparatory coursework. Attention should be given to the schools that incoming ET students are coming from and their academic preparation in the design and development of programming for these students. This programming would be to the benefit of all students coming from under-served schools. Findings from the survey will provide additional information about ET students and assist with development of strategies to improve graduation rates for underrepresented minorities in these programs.

This paper, along with others currently in preparation are intended to delve into previous research and search for additional information to provide an insight into students that are often in the minority. This will provide us with recommendations for future work and enhance our current work to extract as much as possible from recently acquired data. It is anticipated that more papers will be generated that focus on identified issues that provide a basis for recommendations and support future work to move us forward in our understanding of these students. Efforts are currently taking place that include obtaining support for interviews of these students followed by an expansion of the project to a more complete national scope.

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Biographical Information

ELIZABETH DELL is a Professor of Mechanical Engineering Technology at the Rochester Institute of Technology. She is the Faculty Associate to the Provost for Women Faculty. She served as Director of Women in Technology from 2010-2013. She received RIT's Edwina Award in 2012 for significant contributions to gender diversity at RIT and Isaac L. Jordan Faculty Pluralism award in 2016.

ANNE LUCIETTO is an Assistant Professor of Engineering Technology at Purdue University. She spent twenty-six years in industry in progressively responsible roles. She moved into academia to work with students so their transition into both industrial and academic careers is smooth without a long transition period. Her research focuses on engineering technology students and their differences from students in other STEM fields. Her interests also include renewable energy, those that teach STEM students, and other areas of research related to the materials, building and maintenance of equipment. Dr. Lucietto is a Fellow in the Society of Women Engineers, a Senior Member of IEEE, a member of ASME, and ASEE.

ELAINE M COONEY is a professor and program director for Electrical Engineering Technology in the Purdue School of Engineering and Technology at IUPUI. She is a Senior IDEAL Scholar with ABET, which affords her to present program assessment workshops around the world with other Senior IDEAL Scholars. She has been an AAC&U Indiana LEAP Faculty Fellow focusing on tuning of engineering technology curriculum and assessment of student work, and continues to provide leadership to the ET community in Indiana and nationally.

LIZA RUSSELL is a Junior pursuing a Bachelor's of Science in Mechanical Engineering at Purdue University. She began working under Dr. Lucietto in the summer of 2017 as a part of Purdue's Summer Stay Scholars program and has thus far continued as an Undergraduate Researcher. In addition to her Mechanical Engineering coursework, Liza is pursuing minors in Physics and Anthropology.

EMILY SCHOTT is a junior in Aeronautical Engineering at Purdue University. She is currently researching under Dr. Lucietto as part of Purdue's 2018 Summer Stay Scholar program. Emily is also pursuing her certificate in Entrepreneurship and Innovation. She is a member of the Purdue Society of Professional Engineers Rube Goldberg Team and the American Institute of Aeronautics and Astronautics.