

Improving the Diversity of Faculty in Electrical and Computer Engineering (iREDEFINE ECE)

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I. WHY? MOTIVATION

As women faculty in electrical and computer engineering (ECE), we have been involved in several efforts targeted at increasing the participation of women in ECE departments. For example, at Rutgers University, we have organized presentations and workshops for first year students that highlighted the societal aspects of ECE, such as bioelectrical engineering applications. Such focus did bear fruit; between 2010 and 2016, the sophomore female enrollment in ECE at Rutgers rose from 11% to 19%. At the University of San Diego, we have conducted research on the demographics and outcomes of undergraduate students in ECE, facilitated workshops to help faculty teach in more inclusive ways, and are currently

working on a National Science Foundation (NSF)-funded effort to revolutionize engineering education [1]. Also, as chairs, we have been considering ways to diversify our faculty carefully considering the overall hiring process including innovative approaches such as cluster hires [2], paying close attention to the language used when advertising faculty positions, the discussions during the review of the candidates, the candidate selection criteria, and the interview process [3]. However, the number of diverse graduate students is small to begin with, and in an era in which companies have realized the value of diversity, academia has to compete with companies such as Google and Microsoft for the best Ph.D. graduates. Without a diverse faculty, we cannot sustain a diverse student body.

At the annual Electrical and Computer Engineering Department Heads Association (ECEDHA) meetings, there had been sessions discussing ways to diversify faculty and students. In 2015, as part of a more general ECE branding effort, organized by a group of chairs, some of us decided to create a branch of the bigger effort and focus on diversity. Then, an idea was conceived; what if we brought to the ECEDHA conference graduate students from diverse backgrounds,

Table 1 Degrees Awarded to Women in the United States in 2015. (Source: ASEE)

	BS		PhD	
	% Female	Rank	% Female	Rank
Environmental	49.7%	1/23	39.1%	2/23
Biomedical	40.9%	2/23	38.9%	3/23
Biological & Agricultural	34.4%	3/23	25.8%	11/23
Chemical	32.4%	4/23	32.7%	4/23
Architectural	30.1%	5/23	42.9%	1/23
Electrical Engineering	13%	20/23	15%	17/23
Electrical & Computer Engineering	14%	22/23	17%	19/23
Computer Engineering	11%	23/23	15%	18/23
Engineering (all)	20%		23%	

who are not exactly sold on an academic career, but would be willing to find out more? And what if we involved the ECE chairs in educating those students about the positive aspects of academic careers? After all, as women who have navigated successful careers in academia, we believe that being a faculty member is the most rewarding job in the world. What if the chairs also offered tips on the process of seeking a faculty position? Who knows better than the chairs who most often are the ones conducting the faculty searches? What if we could enable the students to showcase their work, and thus build contacts with chairs for future reference? We started a diversity committee with women and men and “Improving the Diversity of Faculty in Electrical and Computer Engineering” (iREDEFINE ECE) emerged.

One of our colleagues who is also an ECE chair, recently wrote a compelling piece for the PROCEEDINGS OF THE IEEE titled “Our Hidden Figures” [4] about the critical need in ECE to enhance diversity. At the end, she challenges the ECE community, particularly the “elders,” to take action to change the culture of ECE and “get to work.” In this piece, we respond to that call.

Note that there have been many significant efforts to increase diversity in engineering at different points in the educational pathway but little overall change in the culture. There are opportunities for the ECE com-

munity to be involved on all levels and role models are critical for the success of these efforts. In the United States, those interested in precollege education might consider becoming involved with the Next Generation Science Standards (NGSS) [5], which include engineering for the first time potentially dismantling some of the elitism associated with engineering. At the undergraduate level, the 50k Coalition brings together professional societies, universities, and companies to aim for 50 000 diverse engineering graduates by 2025 (an ambitious goal since the current number is about 30 000) and is looking for partners [6]. In this Point of View article, we describe iREDEFINE, which helps diverse ECE graduate students transition to academic careers. This addresses a weakness of ECE, the lack of diversity in the faculty, with a strength of ECE, a strong community of department heads who meet annually.

II. HOW BAD IS IT? SOME NUMBERS IN ELECTRICAL AND COMPUTER ENGINEERING

Academic and nonacademic entities often state that valuing diversity is necessary for accessing the best available talent and ideas. However, as a field,

ECE suffers from a lack of diversity, even when compared to other engineering disciplines. For example, data from the American Society for Engineering Education (ASEE) shown in Table 1 shows that the percentage of women getting B.S. and Ph.D. degrees in the United States in computer (CE), electrical (EE), and electrical and computer engineering (ECE) is lower than the percentage for engineering as a whole [7]. In fact, for B.S. degrees, these fields are among the lowest percentages in engineering with only small improvement at the Ph.D. level. Other engineering disciplines have considerably higher percentages of women at the undergraduate and Ph.D. level, as seen in Table 1.

In a multi-institution longitudinal study of undergraduate students, Black men and women were reported to be strongly attracted to EE and CE compared to other engineering majors but not retained at high rates particularly in CE [8]. Trajectories of EE and CE students vary by race [8]. When comparing among EE, mechanical, civil, industrial, and chemical engineering, EE students had the lowest “stickiness” defined as the number of students graduating in a major divided by the number ever declaring that major [9], [10].

At the professoriate level, Table 2 shows that ECE ranks 17th out of 21 engineering disciplines considered

Table 2 Tenured/Tenure-Track Faculty in the United States, 2015. (Source: ASEE)

	Engineering	ECE	ECE Rank (out of 21 engineering disciplines)
Female	16%	12%	17
African American	3%	3%	4
Asian American	27%	31%	2
Hispanic	4%	4%	7

in the percentage of female faculty [7]. The percentage of female faculty lags behind the percentages of females obtaining Ph.D. degrees in all engineering fields. Environmental engineering has the highest percentage of women faculty at 23.9% followed by biomedical at 22%, civil/environmental at 20.1%, general at 19.4%, and chemical engineering at 18.8%. Percentages of African American and Hispanic faculty are low but comparable for ECE and engineering as a whole. The percentage of Asian American faculty is slightly higher in ECE than engineering.

Research has shown that the percentages of women undergraduate science and engineering majors and graduates

is associated with the percentage of women on the faculty [11]. Increasing the percentages of women and under-represented minorities (W-URM) on the faculty may increase the W-URM enrollment in ECE departments, as more diverse faculties will be better positioned to tap into a talent pool that has traditionally avoided ECE and serve as role models and mentors [12]–[14].

So what can be done to improve the situation? A group of ECE department heads decided to take action and collaborate on a program to proactively motivate and prepare some W-URM PhD students to consider tenure track faculty or postdoctoral positions in ECE departments of U.S. universities.

This iREDEFINE ECE project is supported by the NSF [15].

III. WHO? iREDEFINE TEAM

The iREDEFINE team included nine chairs of ECE departments across the United States, a representative from industry, and the Executive Director of the Electrical and Computer Engineering Department Heads Association (ECEDHA). The project is directed by Prof. A. Petropulu, a past ECE chair and past president of ECEDHA. ECEDHA has been in existence for more than 50 years and maintains an active membership of nearly 300 chairs from across the United States and Canada. The four-day annual conference brings together prominent figures from academia, government, and industry to deliver presentations and facilitate discussions on emerging key technologies, teaching innovations, and pressing issues facing ECE, such as lack of diversity and shifting enrollment trends. For more information

**Fig. 1.** 2017 iREDEFINE attendees and faculty mentors.

on past programs, visit <http://www.ecedha.org/conferences/meetings>.

IV. WHAT? iREDEFINE PROJECT

The iREDEFINE project offers a model for improving diversity at the ECE postdoctoral and professorial levels, and capitalizes on a unique opportunity to bring ECE department heads together with W-URM graduate students. The project includes the iREDEFINE annual workshop and followup mentoring activities. The iREDEFINE Workshop is held in conjunction with the ECEDHA Annual Conference and ECExpo and provides a glimpse of the life and career of an ECE faculty, information on different types of schools, tips on how to prepare for a successful academic position interview, and opportunities for networking with department heads and peers. The unique opportunity here arises due to the high concentration of ECE department chairs attending the event, many of whom are investing great efforts on increasing the diversity of their faculty, and who are interested in helping with the goals of the project. The project was funded for two years. Activities are being evaluated and will be improved based on participant feedback to maximize impact.

Note that a series of workshops with similar aims to iREDEFINE is RISING STARS in EECS (held at the University of California Berkeley in 2014 [16], Massachusetts Institute of Technology in 2015 [17], and Carnegie Mellon University in 2016 [18]), which aims to connect female graduate students with the most prestigious research institutions. However, iREDEFINE is broader as it addresses academic careers at the wide variety of institutions represented by ECEDHA members including those focused on teaching as well as research institutions. In addition, iREDEFINE aims for a broader range of participants including underrepresented men of color as well as women.

V. iREDEFINE WORKSHOP

The project was launched in 2017 with the first iREDEFINE workshop held with great success on March 17–18, as part of the 2017 ECEDHA Annual Conference and Expo, in Miramar Beach, FL, USA [19] (see Fig. 1). The workshop provided students with a glimpse of the lives and careers of ECE faculty members, helpful tools for an academic job search, and opportunities to network with their peers and the ECE chairs. The workshop started with a 3-h course on basic negotiations, problem solving, and conflict resolution delivered by a professional company with experience in supporting women scientists and engineers [20]. In the remainder of the first day, the program featured sessions on teaching methods for active learning by Prof. John Booske of University of Wisconsin—Madison, funding agencies and how to seek funding by Dr. Elliot Douglas, Program Director of Engineering Education at NSF, and unconscious bias by Prof. Nayda Santiago of the University of Puerto Rico at Mayaguez. This was followed by a panel discussion on different types of schools by Profs. Stella Batalama, University at Buffalo; John Booske, University of Wisconsin—Madison; Susan Lord, University of San Diego; and Miguel Velez-Reyes, University of Texas at El Paso. There was also a presentation by Teresa Kostenbauer, Arrow Electronics, on how to build ties with industry. Throughout the day, there were networking breaks, and in the evening there was a networking reception for workshop attendees and ECE chairs. During the second day, the workshop attendees had the opportunity to attend the sessions of the ECEDHA conference, and also presented posters on their work to ECEDHA attendees.

Invitations to apply for the iREDEFINE project were sent to all ECEDHA members. There was an enthusiastic response of 54 applications. The NSF grant provided travel funding for 13

students, referred to as iREDEFINE Fellows. The Fellows were selected from a pool of applicants by the project organizing committee, based on their potential to be an academic as gleaned from their academic accomplishments and personal statements about an academic career. In addition to targeting students who are already seeking academic positions, the project also includes junior students, in an effort to motivate them to think about a career in academia. In response to very strong interest in attending the workshop by a large number of applicants, 30 additional students were invited to attend, while the project director invited their chairs to cover their students' expenses. The majority of the chairs responded positively; 27 chairs supported one or more of their students. It is interesting to note that one student, whose chair did not have enough funds for her, came with her own funding. However, when this was brought to the attention of the NSF director, the director committed additional support for that student increasing the total number of Fellows to 14. In total, 28 schools were represented by one or more graduate students each including a mix of types of universities.

This first cohort included ten women and three men as iREDEFINE Fellows with 30 women and five men in the larger group who responded to a survey given right after the workshop. Participants self-reported race/ethnicity was 18 Asian/Pacific Islander, 13 White, five Hispanic or Latino, and three Native American or Other. Note that participants could choose more than one category.

Overall, students were very pleased with the program. In a survey given after the workshop, participants said that the most beneficial part was networking with the ECE chairs and with peers from other schools. This supported the idea of the project committee that bringing students to the ECEDHA conference would be valuable.

VI. iREDEFINE MENTORING

To establish a community of support and reinforce the lessons learned at the workshop, iREDEFINE also has a mentoring component which extends beyond the workshop to include quarterly post-workshop e-meetings. The mentoring committee includes members of the original project team as well as other ECE chairs from departments across the United States. In order for the e-meeting to provide a meaningful experience, a list of topics is distributed to the student participants ahead of time. Each student is asked to share their thoughts on each topic. The e-meetings are monitored by the Project Director and members of the mentoring committee, who comment on the student responses and provide additional information as

needed. Examples of topics of discussion include:

- preparing application materials for a faculty position tailored to the particular opportunity;
- how to prepare for an interview;
- understanding the differences between various types of institutions;
- mock interview for a faculty position;
- preparing a research proposal;
- how to navigate the NSF website, look for solicitations on a specific topic, how to check for projects funded under a specific program;
- guide on funding agencies;
- guide on new teaching approaches and technologies.

In addition, topics are solicited from the students.

VII. CONCLUSION

Recognizing the need for something to be done to enhance the diversity of the ECE postdoctoral population and professoriate, this iREDEFINE project serves as a good example of collaboration and action. By sharing this with the larger IEEE community, the authors hope that others in the IEEE community will be inspired to consider and act on other creative efforts to enhance the profession.

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