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Advancing Engineering Education Using a Teaching Focused Plan For Creating an Inclusive Classroom

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Dr. Jacques C. Richard, Texas A&M University

Dr. Richard got his Ph. D. at Rensselaer Polytechnic Institute, 1989 and a B. S. at Boston University, 1984. He was at NASA Glenn, 1989-1995, worked at Argonne National Lab, 1996-1997, taught at Chicago State University, 1997-2002. Dr. Richard is an Instructional Associate Professor, Aerospace Engineer and NSF REU Program Director at Texas A&M since 1/03. His research focuses on computational plasma modeling using particle methods with spectral methods on Maxwell and Boltzmann equations. He has applied the lattice Boltzmann method to study plasma turbulence and plasma jets. He also studies engineering enculturation to better quantify and understand what in a classroom develops the engineering student into an engineer, building critical, computational and algorithmic thinking, with respect to cultural, ethnic, racial, gender, sexual, nationality, socioeconomic diversity. Past research includes modeling ocean-air interaction; reacting flow systems; modeling jet engine turbomachinery going unstable (received NASA Performance Cash awards). Dr. Richard is involved in many outreach activities: tutoring, mentoring, directing related grants (e.g., a grant for an NSF REU site). Dr, Richard is active in professional societies (American Physical Society (APS), American Institute for Aeronautics and Astronautics (AIAA), ASEE, ASME). Dr. Richard has authored or co-authored about 35 technical articles (about 30 of which are refereed publications). Dr. Richard teaches courses ranging from first-year engineering design, fluid mechanics, to space plasma propulsion.

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Mr. Robert Harold Lightfoot Jr, Texas A&M University

Robert Lightfoot received his master's degree in software engineering from Southern Methodist University and his bachelor's degree in computer science from Texas A&M. Before joining Texas A&M, he worked at Ericsson (now Sony-Ericsson) in the network development and Digital Switch Corporation, and Motorola in cellular infrastructure development, project management and technical marketing. He also owned a company that developed custom networked and computer-controlled automation equipment.

Dr. Karan Watson P.E., Texas A&M University

Karan L. Watson, Ph.D., P.E., is currently a Regents Senior Professor of Electrical and Computer Engineering, having joined the faculty at Texas A&M University in 1983 as an Assistant Professor. She is also serving as the C0-Director of the Institute for Engineering Education and Innovation. She has served in numerous roles at Texas A&M University, including: Provost and Executive Vice President(2009-2017), Vice Provost (2009), Dean of Faculties and Associate Provost (2002-2009), Interim VP for Diversity (2009 & 2005-2006), Associate Dean of Engineering (1996-2001), and Assistant Dean of Engineering (1991-2006). Dr. Watson is a fellow of the Institute of Electrical and Electronic Engineers (IEEE), the American Society for Engineering Education, and the Accreditation Board for Engineering and Technology (ABET). Her awards and recognitions include the U.S. President's Award for Mentoring Minorities and Women in Science and Technology, the American Association for the Advancement of Science mentoring award, the IEEE International Undergraduate Teaching Medal, the WEPAN Bevlee Watford Award, the College of Engineering Crawford Teaching Award, and two University-level Distinguished Achievement Awards from The Texas A&M University Association of Former Students—one in Student Relations in 1992 and in Administration in 2010, and the Texas Tech College of Engineering Distinguished Alumni. In 2003–2004, she served as a Senior Fellow of the National Academy of Engineering Center for the Advancement of Scholarship in Engineering Education. Since 1991, she has served as an accreditation evaluator, commissioner, Board of Director, then President of ABET, and is currently Secretary/Treasurer of the ABET Foundation Board of Directors. She has also served as a program evaluator for J.D. programs for the ABA, for universities' regional accreditation for SACSCOC, and for Business Schools for AACSB. She also has served as the Chair of the ECE division of ASEE, the President of the Education Society of IEEE, and the chair of the Women in Engineering of IEEE. She served as the Treasurer and a Board of Directors member for WEPAN.

Randy Hugh Brooks, Texas A&M University

Howdy,

After 23 years in Telecom building LD, internet, and email platforms and networks, I observed that the front line personnel that I was hiring didn't have what I considered to be skills that they should be bringing to the table. I began investigating why, and that led me to high school.

Alas, I began my journey in Education in 2010 inhabiting the classrooms of Lovejoy High School, where my two daughters attended.

I redubbed my PreCalculus course as Problem-Solving with Brooks and was also afforded the opportunity to lead an impactul Project Lead the Way (PLTW) Principles of Engineering (PoE) course, a project-based learning survey of the engineering discipline.

Since the Summer of 2015 I have been privileged to work with the Texas A and M Sketch Recognition Lab (TAMU SRL) to evaluate a couple of online tutorial tools (Intelligent Tutoring Systems (ITS)) currently under development, Mechanix and Sketchtivity, that provide immediate constructive feedback to the students and student-level metrics to the instructors. I presented on this work at the state and national PLTW Conventions and at CPTTE in 2016.

I also spent 5 semesters beginning the Fall of 2015 taking online courses learning how to construct and deliver online courses. This resulted in a MSEd from Purdue University in Learning Design and Technology (LDT).

This widely varied background prepared me well for my next big adventure. Beginning in August 2018 I became the Texas A and M Professor of Practice for the Texas A and M Engineering Academy at Blinn College in Brenham. Texas A and M Engineering Academies are an innovative approach to providing the planet with more Aggie Engineers.

I am focused on enhancing the high school through first-year college experience and am an engaged member of the Texas A and M IEEI (Institute for Engineering Education and Innovation).

My foundations were set by an upbringing on the family ranch near Joshua, Texas and 4 memorable years at Texas A and M where I met my wife, I led Bugle Rank #7 in the Fightin' Texas Aggie Band (Class of '86 Whoop!), and dove into Telecom Engineering. Once in Telecom, my learning continued at MCI, Vartec, and Charter.

Ms. Donna Jaison, Texas A&M University

Donna Jaison is a PhD student under Dr. Karan Watson and Dr. Tracy Hammond in the Multidisciplinary Engineering Department at Texas A&M College Station. She is a Graduate research assistant at the Institute of Engineering Education and Innovation(IEEI) at Texas A&M University under director Dr. Tracy Hammond. She completed her MEng. in Computer Engineering with specialization in VLSI from Texas A&M University, College Station. She completed her Bachelors in Electrical Engineering with a Minor in Mathematics from Mississippi State University.

Advancing Engineering Education: A Teaching Focused Plan For An Inclusive Classroom

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Abstract

Texas A&M University has recently started several initiatives within its newly created engineering education faculty group to support faculty in creating a more inclusive classroom where diversity and inclusion can be safely discussed in the context of current events and course topics. These initiatives include 1) a weekly teaching fellows program where faculty experiment with inclusive practices and watch videos of their implementation and reflect on their success, 2) a weekly meeting with the faculty of engineering education as a whole where faculty regularly share the techniques that have been successful, and 3) a weekly reading group for students and faculty discussing how race and inclusion can be better integrated into the classroom. This paper will discuss the techniques tested, their results across multiple classrooms and engineering disciplines, the successes of faculty trying these techniques in their classroom for the first time, and the results of an analysis of qualitative and quantitative data analysis on these events. Qualitative data includes interviews describing experiences in the classroom as well as feedback from students in the classroom about their experiences. A particular focus will be attending to the experiences of faculty teaching first-year students. Results show that the initiative has been quite successful and a large number of faculty have attempted previously considered risky methods of creating an inclusive classroom with excellent success. Results also demonstrate that success breeds success, and the more faculty that attempt changing their engineering classroom to be more inclusive, the more other faculty are willing to attempt similar techniques in their own classrooms.

Introduction

The vast majority of attrition appears in the freshman year [1–6]. Retention rates for underrepresented minority (URM) engineering students are often lower than those of the majority group [7–8], even when financial resources are similar between URM and majority students [9]. URM and women undergraduates in engineering face challenges that may hinder their sense of belonging and consequently deter their persistence in STEM higher education. Even the differences in school districts can create large differences in the sense of belonging in secondary school STEM education based on district constructs in support of STEM students [10]. These tensions have been amplified in the wake of current events, e.g., the murder of George Floyd [11–12], making students more cognizant of social issues outside of the classroom and aware of implicit and explicit biases within it.

At Texas A&M University, there is a goal in the College of Engineering (CoE) to reach a first year retention rate of 90% for all students. While there is no current available retention data for first year retention of students for the 2020 to 2021 year, the 2019 cohort data is available and is as follows: 87.8% for all students enrolled in the COE, 88.4% for Female students, 89% for Black students, 87.7% for Hispanic students, and 85.2% for first generation students [13]. Improving these retention rates is vital to support and grow a diverse student population; a strategy to achieve this goal involves developing an inclusive environment to promote a sense of social belonging, especially among minority students [14], and enable all students to learn more effectively [15]. This paper discusses the efforts being made at Texas A&M university to better prepare first-year engineering faculty to serve URM students by creating more inclusive classrooms.

Motivation and Methodology for Change

We seek to understand how and why current educational approaches fail to create an inclusive learning environment so that we may address these inequities. As noted in analyses of other STEM fields, some major factors include:

1. A deficit model by the "in-group" about the "out-group" where through the hoarding of opportunities and access stereotyped assumptions and beliefs are constructed and perpetuated to justify the exclusion of the "out-group" [16–17].
2. The head start model where faculty members, consciously or unconsciously, teach to and reward the students who come into the class with a head start on the competencies to be taught in the course. Indeed, some prior research points to racial/ethnic differences in academic preparation as a prominent explanation for subsequent disparities in STEM persistence [18–21].
3. The lack of persistence, in unique proportions, in STEM fields versus other college majors. Black and Latinx students are significantly more likely to change majors than White students, and while socioeconomic status can account for much of the Latinx difference, it is not a significant contributor to the differences for Black students [22].
4. A lack of a sense of belonging causes women and underrepresented minorities to not enter or leave STEM majors [23] and STEM professions.
5. Compounding previously mentioned factors, many STEM courses require previously existing higher order mathematics proficiency to understand the course content. However, students may have negative attitudes toward mathematics due to not having a sense of what the mathematics mean in the context of their fields. Consequently, these students struggle in STEM courses regardless of their skill levels [24].

The systemic change needed to broaden the participation of diverse students will depend on faculty demonstrating authentic concern and prioritization of the needs of all engaged learners. We propose the need to address the five inhibitors above in the following strategic efforts.

1. Unteach faculty members the deficit model whenever and wherever we can.
2. Expose faculty to the fundamental unfairness of advantaging participants who had a head start in the subject matter, then give the faculty the tools to avoid this unfairness.
3. Address the pedagogical factors that fail to scaffold students to the engineering materials being taught with experiences from their background experiences and knowledge.
4. Address the faculty roles in ensuring all students have a sense of belonging to the field of engineering.
5. Provide materials that faculty and students can access to demystify and motivate students in difficult concepts.

The first step for addressing all of the strategies to create a more diverse engineering workforce can be, at least partially, addressed by helping faculty members to create a more inclusive engineering classroom that encourages students from diverse perspectives to persist and develop robust engineering identities. To this end, Texas A&M University has recently started several initiatives within its newly created engineering education faculty group (EEFG), an organization of faculty from multiple colleges that choose to collaborate regularly regarding advances in the engineering education arena. The EEFG supports faculty in creating more inclusive classrooms where diversity and inclusion can be safely discussed in the context of current events and course topics. These initiatives include 1) a weekly teaching fellows program where faculty experiment with inclusive practices and watch videos of their implementation and reflect on their success, 2) a weekly meeting with the faculty of engineering education as a whole where faculty regularly share the techniques that have been successful, and 3) a weekly reading group for students and faculty discussing how race and inclusion can be better integrated in the classroom. These initiatives established communities of practice [25] where faculty modeled what they were doing in the classroom to create a more inclusive classroom. This modelling allowed other faculty to identify techniques that they might be able to use in their own classrooms and give them the confidence to use them.

Methodology for Evaluation

Eight faculty members teaching freshman classes were interviewed to learn what techniques they implemented in the classroom. These qualitative data were analyzed with a grounded theory approach [26] and coded using NVivo, allowing us to group common themes together and identify top coded techniques. The interviews contained the following questions:

1. How has your understanding of diversity, equity, and inclusion changed over this past year?
2. Looking back on your past first year engineering classrooms, do you recall there being much discussion amongst your students related to diversity, equity, or inclusion?
3. How have the events of the past year impacted the discussions your first year engineering students have in class regarding diversity, equity and inclusion?

4. How do you feel your participation in the EEFG and the book discussion and readings this past year has prepared you for discussing social justice or diversity, equity, and inclusion topics with your students?
5. Have you found yourself discussing these social justice or diversity, equity, and inclusion topics more with your peer first year engineering faculty?
6. What techniques or practices have you adopted in your classroom to address diversity, equity, and inclusion through discussion or other means for these first year engineering students?

Results

Several themes were found when interviewing the participants in the focus groups. The awareness and understanding for diversity, equity, and inclusion (DEI) topics was much higher for these participants over this past year. Several faculty began considering having DEI discussions in their classrooms more often, and some did integrate DEI topics into their own classes. Participants reported that in the past DEI was not something that was considered in their classrooms with the exception of specialized circumstances. Several participants mentioned how this past year changed the discussions they saw in their lives, however, these faculty were often hesitant to bring up current events and hot button topics with their students for a variety of reasons. Often the source of the hesitation was that their identities might either discredit them when discussing the topic, that their identities might be too closely related to the current events, or that they felt students would find it inappropriate to discuss these topics in the classroom.

These participants unanimously agreed that their participation in the EEFG group and for some the book discussion helped them become more comfortable to discuss DEI topics in their classrooms and with their peers, giving them more ability to frame an approach to discuss some topics. They also felt that having a group to discuss DEI topics gave them the sense that they had a community and that they were not alone in their feelings and experiences. However, participants still felt it difficult to find opportunities to discuss DEI topics in their work lives, with some only having the EEFG meetings and book discussions as outlets. Some found that it is difficult to have discussions over Zoom, citing body language as a barrier that remote meetings have difficulty overcoming. Techniques that were particularly useful for these participants were introducing DEI topics in direct relation to the engineering discipline and design considerations, along with integrating important historically diverse engineers related to national heritage months throughout the year, e.g., Black History Month or Hispanic Heritage Month. Participants were also more mindful of the graphics they use in their presentations and examples they use in their classrooms to be more inclusive.

Example of Technique for First Year General Engineering Course

The first engineering course that engineering freshmen take at Texas A&M University is not department-specific and encompasses all first-year students. The course is an introduction to

programming and consists of one hour of lecture and three hours of a programming lab per week. The students enter the course with varying levels of technical background, maturity, and adjustment to college life. The instructor seeks to relate to the students' personal experiences to connect engineering computations to human needs/realities.

An example lesson involves building programs to analyze data downloaded from a local weather data station. The instructor highlights that data may often help myriad populations view circumstances from many perspectives filtered by their own personal experiences and situations. Students may also notice that the instructor is from another country and a member of an under-represented group, without the instructor necessarily having to explicitly highlight personal characteristics as a living example of the experiences presented before them. Students learn to humanize engineering analysis to include consideration of their experiences as well as those of the intended audience. To wit, consider software designed without forethought of a broader population, i. e., face-recognition software that is not inclusive of all races.

Discussion

The success of the EEFG thus far and other universities who have established communities of learning and practice [27] encourages the possibility of pedagogical change toward more inclusive engineering classrooms. Faculty can help advance the change with continued institutional support. While discussing DEI topics intimidates many instructors, having a group to discuss and share resources with helps them overcome that barrier. Students learn best in an inclusive environment which can be fostered by showing empathy, communicating with students on a personal level, and showing that you care about how you are teaching engineering.

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