Rethinking Engineering Diversity, Transforming Engineering Diversity (REDTED)

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Abstract

The research project described in this paper is titled "Rethinking Engineering Diversity, Transforming Engineering Diversity (REDTED)," which is part of the National Science Foundation, Revolutionizing Engineering Department (RED) grants. The project is in its first year and therefore what is described in this paper will be a brief overview of the project and some of the work done during the first year. The proposed research is to explore how the representation of women and Underrepresented Minority (URM) students and historically underserved groups will be increased in an engineering department by deploying a multi-pronged approach. Our definition of diverse student populations includes both visible differences such as gender and racial minorities, but also includes invisible differences such as poor, LGBTQ, disabled, veterans, and others. The approach includes curricular and extra-curricular reform, which is targeted at the Civil and Environmental Engineering (CEE) Department at Rowan and includes:

a) Radically changing admission standards to promote excellence;
b) Enhancing the perception and understanding of diversity and equality among students, faculty and administrators to create a more inclusive environment;
c) Developing Advocate and Allies Mentoring Program for first year, and transfer students;
d) Transforming existing engineering curriculum of second and third year from a narrow sub-discipline based approach to a more inclusive, system-based approach;
e) Enriching students' aspirations by providing successful and diverse role models from industry and academia; and
f) Developing a model for inclusion of diverse students.

The study is unique in that the definition of diversity is expanded to include both visible and invisible aspects. It also takes a comprehensive approach in seeking to attract a more diverse population into engineering while also making sure that the diverse students who do choose to pursue engineering find an inclusive and welcoming climate. The first year of the study has included conducting surveys of students and faculty to get baseline data on the attitudes to inclusivity. It will also include faculty workshops to begin the process of modifying our curriculum. In addition, the peer mentoring program and its structure is also being discussed and student workshops will be conducted to develop peer mentoring skills.

Introduction

The College of Engineering at Rowan University was created through a $100 million gift from Henry and Betty Rowan in 1992 to the then former Glassboro State College (Chandrupatla et al., 1996). Four engineering departments of Chemical, Civil & Environmental, Electrical & Computer and Mechanical Engineering were established originally in 1996. Two additional departments have since been added to the College: Biomedical Engineering (fall 2014) and the Engineering Entrepreneurship Program (to begin fall 2016).

The College implements the use of innovative methods of teaching and learning to prepare students for entry into a rapidly changing and highly competitive marketplace (Marchese et al., 1997; Newell et al., 1999; Dahm and Newell, 2001). The major hallmark of our Rowan

engineering program is a unique common class known as the *Engineering Clinics*. The engineering clinic class is integrated throughout the entire curriculum for eight semesters. All five engineering departments of Biomedical, Chemical, Civil, Electrical and Mechanical Engineering have this common clinic class throughout their program of study. The overall learning objectives of the Engineering Clinics are outlined in Sukumaran et al. (2006).

After nearly two decades since the College was established, it is evident that our innovative curriculum especially, the Engineering Clinics, was able to meet the demands of stakeholders based on feedback from employers and alumni as well as other external sources. A critical analysis of our performance however indicates that the visible aspects of diversity in our student population such as race, gender, and ethnicity are below the national average while the invisible aspects of diversity, such as socioeconomic status, disability, sexual orientation, and gender identity are not addressed nor counted. A detailed assessment of the demographics of the students and faculty will be discussed in the following sections. It is important to note that the University and Department are at the cusp of change and have seen dramatic growth in the last 3 years. The University has been recently reclassified as a research institution in the State of New Jersey and has also acquired two medical schools. The enrollment at the University climbed from about 12,000 students in 2012 to 16,000 students in 2015; the enrollment in the College of Engineering has increased from about 830 to 1307 students during the same time period.

Glassboro (Permanent Population 18,897) is located in Southern New Jersey and is considered part of the larger Philadelphia metropolitan area. Camden (population 87,500) is the fifth largest city in New Jersey, and an economically distressed area. It is located in a New Jersey Federal Empowerment Zone (EZ). The city has a predominantly minority population. Southern New Jersey counties such as Cumberland County, Salem County and Atlantic county also have high minority populations.

It is thus a shortcoming that the college has been unable to attract and boost its student body in terms of diversity. It is apparent that an innovative curriculum is not enough to attract a diverse student body, but requires a multi-pronged approach, which will be discussed in more detail in the following sections. This proposal describes transformative changes that include curricular and extra-curricular reform, which is targeted at the Civil and Environmental Engineering (CEE) Department at Rowan University. The department has seen tremendous growth in student numbers. From 2013 to 2015, incoming CEE freshmen saw a growth of 30%. The number of freshmen rose from 58 students to 74 students over these two years. This presents an opportunity for the department to focus on increasing its diversity, since there are an increased number of faculty being hired, an increased number of students enrolling, and a willingness to change how things have been done in the past so that an increased access to a diverse student body can be provided. The department will serve as a test bed for the College of Engineering and has willing faculty and a Department Head who sees this as the top priority.

The traditional approach to measuring diversity in engineering involves counting racial and ethnic minorities and women, while measuring gains in representation as reflected by the numbers. We believe that this traditional approach needs to consider other important aspects of diversity, in addition to the traditional approaches, to maximize the inclusiveness within the field. Decades of educational policy and practice have under-considered the existence of groups

such as LGBTQ, poor, and disabled, thereby perpetuating exclusionary social patterns (Riley et al., 2014). Our multi-pronged approach to increasing diversity and inclusion begins with expanding the fundamental definition of diversity to include visible and invisible difference.

Institutional and Departmental Demographics

All data presented in this section was obtained from the Office of Institutional Effectiveness, Research and Planning (IERP) at Rowan University (IERP, 2014). Relevant to the need to expand the definition of diversity, we note that institutional demographic data are available only for racial and ethnic minorities, men and women.

Women comprise about 19.5% of the CEE student body, which is close to the national average of 20% for Civil Engineering (NAE, 2014). The numbers of Underrepresented Minority (URM) students comprise about 9.5% of the student population in CEE with African Americans, Asian Americans and Hispanic Americans at 2.3%, 3.2% and 4.1% respectively compared to 2.6%, 10.9% and 3.5% nationally (NAE, 2014).

The retention rates in the 2nd to 3rd year range from 80 to 100%, while nationwide retention rates average 77% for 1st to 2nd year and lower in the 2nd to 3rd year (IPEDS, 2014). For Civil and Environmental Engineering students, the 2nd to 3rd year retention rate hovers between 85 to 100% for male students and 100% for female students, which is excellent compared to national averages as stated above. The CEE department does better in retaining women students than male students.

The University transfer student retention rates are consistently around 85% to 89%. CEE transfer student retention rates are 100%. *With the increased commitment to admitting more transfer students, these numbers should increase during the duration of the grant.* The 5-year graduation rates are cumulative rates in that the rates include the students who graduate in 4 years and 5 years. The graduation rate for Rowan University students differs by gender with male students having a lower graduation rate than female students. The 5-year graduation rate for 2009 and 2010 is 59% and 41% for male students who were traditional admits and about 70% for male transfers and 73 to 76% for female transfers. In comparison, CEE has a 5-year graduation rate of 69 to 86% for male traditional admits and 71 to 100% for female traditional admits. The transfer population was too small to make any meaningful analysis possible. The national average 6-year graduation rate is around 55% (IPEDS, 2014; Chronicle of Higher Education, 2014).

Data for underserved groups including disability data, LGBTQ and socio-economic status (SES) data is not available through the IERP and hence it is not provided. Graduate data is also not provided because the numbers have been very small until now.

Implementation

This project uses a mixed-methods cyclical research-action plan grounded in critical theory of education. Critical education theory examines the ways in which educational policies and practices are shaped to maintain existing regimes of privilege and power and espouses an ideology in which education is a means to social transformation that brings cultural, social, and economic equity (Popkewitz and Fendler, 1999). The action plan describes activities to create cultural change in the Civil Engineering Department that will result in an inclusive environment

and greater student diversity. Research is needed to advance our scholarly understanding of the factors that impede and promote diversity and inclusion in engineering education, which in turn will allow us to contour our activities to be more effective. Our research aims to answer critical questions such as:
(1) Which changes in recruitment strategies and admission standards most effectively increase URM and women's enrollment in engineering?
(2) What are the aspects of engineering culture that serve as barriers to inclusion and participation of women and URMs?
(3) What are the effects of inclusive practices on engineering culture and minority participation?
(4) Does hierarchical mentoring affect recruitment, retention, and identification in engineering?
(5) How can workshops on diversity and inclusive pedagogy be tailored to be most effective in engineering?
(6) How can inclusivity be integrated into an ongoing evaluation model for engineering?

Building on previous research, we recognize that transforming engineering diversity is not just a matter of increasing the numbers of diverse students in the program. At every stage of the pathway to professional practice, human, social, and cultural capital (Bourdieu, 1977) play a role which must be addressed to provide a sustainable model for engineering diversity. Social capital is the accumulation of resources based on networking and personal relationships; cultural capital is characterized as certain forms of knowledge, education or skill; and symbolic capital is explained as prestige that accumulates as a result of possessing more cultural capital relative to another (Bourdieu, 1977). While we focus on the middle years of undergraduate education for the transformative change, we recognize that there are links to both previous experiences and future output and performance that must be taken into account in each of these respects. We respectfully acknowledge that a multi-pronged approach to transforming diversity, which deals with the problem from a systems perspective, has met with the greatest success in previous attempts. To cite just two examples: Oklahoma University's Research Institute for STEM Education continually refers to the need to consider social and cultural capital's input into human capital achievement (OU RISE). Carnegie Mellon's transformation of gender underrepresentation in computer science encompassed a multi-pronged approach encompassing human, social and cultural capital (Margolis and Fisher, 2003).

Our objectives represent stages along the pathway to promote our vision of Transforming Engineering Diversity as shown in Figure 1.

Adopt a more holistic admission evaluation process for first year and transfer students.
We will adopt an SAT-optional admissions standard for CEE. We will also change the evaluation process for transfer students and offer an academic bridge program for freshmen admits who are identified as needing additional support for integration into the academic program. For this past year, we have been assessing our admissions data to understand where we draw our prospective students from and how we might improve recruiting. In addition, we also assessed how our current admission criteria impacts who is admitted and who is not.

Enhance the perception and understanding of diversity and inclusion among students, faculty and administrators.
Faculty, staff and students will participate in workshops on inclusiveness, with the goal of developing a "collective intentionality" across the departmental culture, which will be self-perpetuating and address all forms of difference. The research group completed a climate and classroom pedagogy survey to understand how we develop the "collective intentionality." The first faculty workshop will be conducted soon.

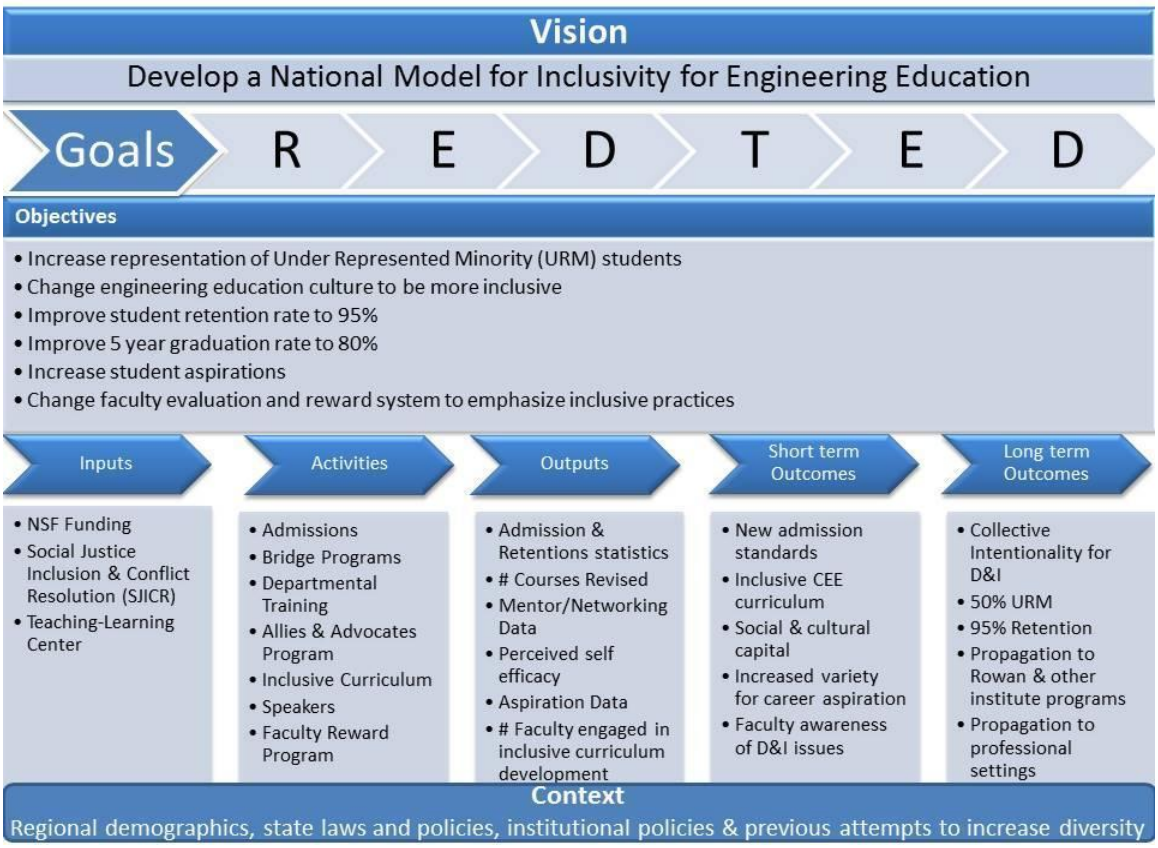

Figure 1: Logic Model articulating the research plan

A major challenge was operationalizing the climate for diversity in the college. Our baseline questionnaire aims to gauge the diversity climate in the College of Engineering. We decided to ask all engineering faculty and students to answer the survey, rather than just the CEE faculty and students. We will then be able to gauge whether interventions in the CEE specialization make a significant difference not only from their own baseline but also from other specializations. We will also be able to measure whether there is a spillover effect from one specialization to the next. The latter is a distinct possibility, since students are integrated across specialties in the core clinic courses, and faculty collaborate at least on this one class across disciplines.

There are some models for measuring diversity climate, but they are limited in terms of the extent that they touch on curriculum design, classroom experiences, professional and personal experiences. Inspired by Ferdman's work on diversity (2013) and Jost's (2004) work regarding

how diversity is expressed in curriculum design and practice, we operationalized levels of policy and practice regarding the following forms of institutionalizing practices supportive of diversity:

- For each of the following, please assign a number from 1-5 to indicate the level you think corresponds to your experiences in your engineering courses. Examples of the extremes (levels 1 and 5) were given for responders' guidance.
- To what extent do learning environments in your curriculum foster sharing of ideas, exploring concepts and working collaboratively?
- To what extent do you feel comfortable sharing ideas, discussing beliefs, and expressing incomplete or incorrect ideas in the learning environment?
- How is discrimination and harassment in the classroom environment dealt with if it occurs?
- How are different experiences and levels of confidence with laboratory work addressed in your courses?

We then asked more specifically about particular types of diversity. While University of Washington's PACE study (2011) included some perceptions of diversity climate, their questions were confined to gender and race/ethnicity; the Australian Learning and Teaching Council also had operationalized some good measures of experienced diversity regarding gender. But, as mentioned above, our definition of diversity expands the traditional foci to religion, socio-economic background, and sexual orientation. For some questions we repeated the questions used in these previous surveys and added parallel questions for other types of diversity, but we limited the extent to which we did so for fear that the repetitive questions would lead to survey fatigue or response bias. One solution we hope will be effective is using a matrix which asks respondents to rate frequency across the various kinds of bias (Table 1).

Table 1: Survey questions used to assess bias

Using a scale of 1-5, please indicate the extent to which you have observed each of the following in Rowan Engineering (1=Never, 2=seldom, 3=sometimes, 4=often, 5=always)

	Race/ ethnicity	Religion	Gender	Sexual orientation	Socio-economic background
Bias in the classroom/lab related to:					
Tension in the classroom around issues of:					
Student resentment of others who are different than they are with respect to:					
Separation between _____ groups					
Conflict between _____ groups					

Given that the population of responders, both faculty and students, are savvy at deciphering and using statistical tables in similar format, we expect this to be a concise and manageable format. We also asked them to respond to their own experiences, as shown in Table 2.

Table 2: Survey questions to assess student experiences with respect to bias inside and outside the classroom

On a scale of 1-5, please indicate to what extent you agree with the following statements about your experiences in Rowan Engineering (1=Strongly Agree, 2=Agree, 3=Neutral, 4=Disagree, 5=Strongly Disagree)

	Race/ ethnicity	Religion	Gender	Sexual orientation	Socio-economic background
I feel I need to minimize or downplay various characteristics of my _____to be able to fit in					
I feel I am expected to represent my _____ group in discussions during class or official meetings					
I feel there are expectations (positive or negative) about my performance because of my_____					

We also asked them to rate their own comfort in situations of diversity, their own behavioral practices, and more. The questionnaire also collects demographic data, background experiences related to engineering success and comfort, self-confidence in engineering, engagement with both college and university extra-curricular activities (some of which are specifically focused on diversity), and their intentions to pursue engineering in the future.

In addition to being asked parallel questions (to the student questionnaire) about their own experiences with diversity, faculty were also queried about curriculum design (both in terms of explicit focus on individuals from diverse backgrounds and in terms of the extent to which social impacts are considered in the presentation of theory, assessment of learning, and the application of technology); the extent to which non-technical professional skills are taught which would enable multidisciplinary and multicultural teams to function at a high level; the ethical and professional responsibilities of an engineer are communicated in a way which promotes social, global, cultural and environmental considerations; and the extent to which assessment values communication, creativity and interpersonal skills. Faculty were also asked to describe various manifestations of tolerance, attention to treatment and opportunities for diverse faculty in various formal and informal settings.

Develop Advocate and Allies Program for high school, community college, first year, and transfer students for efficient transition, retention and graduation.
We intend to train junior and senior students to be effective Advocates and Allies (NDSU) for incoming freshmen and transfer students and maintain an Advocates and Allies mentoring program. In addition, we will establish an engineering living-learning community for mentors and mentees. We have obtained student input on what they would like to get from a peer mentoring program and we are in the process of setting it up for the new academic year.

Transform existing engineering curriculum of second and third year for next generation workforce development including changing testing and assessment procedures.
Faculty will attend workshops on designing an inclusive curriculum, which will result in re-design of core sophomore/junior CEE courses to incorporate inclusive content, pedagogy, and testing. Students will also engage in inclusive curriculum design, outreach efforts and peer mentoring through Junior/Senior clinics. The workshop on inclusive curriculum will be conducted soon. Meanwhile the project coordinator and members of the research team have been working with individual faculty to assess their course syllabus and determine changes that can be made to the course content to make it more inclusive.

Enrich students' aspirations and strengthen their identity as engineers by providing successful and diverse role models from industry and academia.
We will invite CE speakers who are role models of difference and who have impacted society and policy through professional practice. The first in a series is a panel of diverse role models, who are also CE alumni and will emphasize the importance of diversity and inclusion in the CE profession.

Develop a national model for recruitment and retention of diverse students.
We intend to create a model for recruitment and retention of diverse students that can be adapted and changed for different institutional contexts.

Conclusions
This National Science Foundation funded study is in its first year. The results presented in the paper are preliminary and discusses strategies to achieve the objectives of the study moving forward. There are already several positive outcomes of the study including a preliminary climate study of the students and faculty in the College of Engineering at Rowan University. There has also been some changes in recruitment and admissions that has resulted from some preliminary assessment of admissions methodology that is producing positive outcomes.

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