Incorporating Grand Challenges and Developing a Grand Challenges Scholars Program at a Large Land Grant University

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Abstract

This work in progress paper describes incorporating the NAE Grand Challenges for Engineering into the undergraduate experience through coursework and outreach, and the initiation of a Grand Challenge Scholars Program (GSCP) at a large land grant university. In the late 2000s, the National Academy of Engineering (NAE) published two reports aimed at enhancing the public's perception of engineering; Engineering Messages and the Grand Challenges for Engineering (GCE). These efforts have sparked an international movement that is capturing the imagination of established engineers, engineering students, and the public in general. While the origin of the GCEs was as an aid to enhancing the public's perception of engineering the movement it sparked is focused on solving the GCEs. Recognizing that addressing the GCEs would require skills not normally focused on in a traditional engineering program; the NAE developed the concept of a Grand Challenge Scholars Program. Individual colleges develop their own cocurricular programs, following NAE guidelines, which are then approved by the NAE GCSP committee. The structure of the Grand Challenge Scholars Program at Auburn University is described.

Keywords

Grand Challenges, co-curricular, extra-curricular

Introduction

In 2008 the National Academy of Engineering announced a list of 14 challenges facing society in the 21st century.[1] These challenges (Table 1), if solved, would have a profound societal impact. Since that time, the list has fostered an international movement within the engineering community to tackle the challenges. In addition to inspiring practicing engineers, the list of challenges can also serve to inspire and motivate the next generation of engineering and STEM students. Several studies have found millennials and younger students are particularly motivated when STEM content is put in a real-world context and related to societal impact.[2-5] At the 2016 Forum on the NAE GCes, one speaker (Dr. Jackie Ying) stated that "Young people become excited when they realize that STEM fields are building blocks to have a positive impact on how

Table 1. National Academy of Engineering Grand Challenges for Engineering

Engineer the Tools of Scientific Discovery
Provide Access to Clean Water
Provide Energy from Fusion
Make Solar Energy Economical
Reverse-Engineer the Brain
Prevent Nuclear Terror
Engineer Better Medicines
Enhance Virtual Reality
Restore and Expand Urban Infrastructure
Secure Cyber Space
Develop Carbon Sequestration Methods
Advance Health Informatics
Advance Personalized Learning
Manage the Nitrogen Cycle

people live."[1] On March 23, 2015 a letter outlining the commitment to produce more than 20,000 engineers specially prepared to lead the way in solving large-scale problems by 2025 was formally presented to President Barak Obama.[6] The deans of 122 U.S. Engineering Schools signed the letter and each pledged to graduate a minimum of 20 students per year who had completed special training. Students receiving this training participate in the Grand Challenge Scholars Program (GCSP). This program was proposed at the first Summit on the NAE Grand Challenges for Engineering held at Duke University and endorsed by the NAE in 2009. The GCSP is a combined curricular, co-curricular, and extra-curricular program with five competencies that are designed to prepare the next generation of students for addressing the grand challenges facing society in this century. The five core components to all GCSPs are: A mentored research or creative project to enhance technical competence and creativity, a multidisciplinary experience, a business/entrepreneurship experience, a multi-cultural experience, and experiences that deepen social consciousness and motivation to address societal problems, often gained through service learning. All programs are approved by the GCSP steering committee. However, each institution creates its own specific realization implementation and which activities meet the goals of the program. Implementation can include experiences and expectations such as courses, extracurricular activities, research experiences, entrepreneurship, mentoring, travel, study abroad, and participation in outreach activities.

Activities and Findings

Research done by the author and collaborators has shown that incorporating grand challenge related activities into the freshman experience improves knowledge and attitudes about engineering, especially among students traditionally underrepresented in STEM.[7-14] Similar results have been obtained for outreach activities including open houses and summer camps. Efforts at Auburn University began with the incorporation of the GCE into the engineering curriculum. Introduction to Engineering classes taught by the author included projects and hands on activities based on the GCE. Since that initial effort, additional faculty teaching other sections of this course have also begun to include discussions, projects, and activities based on the GCE in their sections. Efforts extended outside the classroom through the development of outreach activities based on GCE. These outreach activities were designed to be presented by faculty or university students in a range of settings including high school summer camps hosted at Auburn University, evening enrichment programs for elementary students, and at afterschool programs in the area, Figure 1. Students participating in this effort as presenters reported that the experience was positive for them and fostered a sense of duty and responsibility to give back to the community.

The results of incorporating the GCE into curricula and outreach efforts motivated the desire to establish a GSCP at Auburn University. The program is now in its second year. Auburn University's Grand Challenge Scholars program was initiated in 2018 with the first cohort of students entering the program in the spring of 2019. The program supplements and enhances the engineering school's vision of (1) being the best student-centered engineering experience in America, (2) leading research that improves the quality of life and fosters economic competitiveness,

Figure 1. High school students building a dye sensitized solar cell as part of a GCE motivated summer camp activity.

and (3) empowering a dynamic faculty that exemplifies excellence and innovation. It further contributes to the college's goal of enhancing student engineering experiences through continuous improvement of our programs, facilities, and student opportunities. The GCSP at Auburn University was designed to build on the existing infrastructure and opportunities. The program is supported by the college and is guided by a steering committee with representation from alumni, faculty, administrators, and leaders of the various programs that GCSP scholars participate in as part of the overall GCSP experience.

As a large Land Grant University, a multitude of cocurricular and extracurricular opportunities for students exist at Auburn University. Therefore, Auburn's GCSP program does not seek to recreate opportunities to address the core competencies. Instead, it recognizes that students may participate in numerous activities and experiences through the university and beyond. Therefore the program seeks to provide context and unification for students so that they can reflect on these experiences in relation to the GCE. For example, Auburn recognizes that there is a multitude of avenues that students can pursue to develop their research skills. Examples of activities that students utilize to fulfil the GSCP research component at Auburn include, (1) participation in an Auburn Undergraduate Research Fellowship (AURF) GCE related project, (2) participation in a summer Research Experience for Undergraduate (REU) program, (3) conducting an Honors College research and thesis project related to the GCEs, (4) independent study with a faculty member related to a GCE, and (5) other undergraduate research opportunities, in which the project is related to a GCE, subject to GCSP steering committee approval. Potential experiences to develop social consciousness include the completion of a study abroad program. (1) an internship in another country, (2) participating in Engineers Without Borders as a travel team member, (3) conducting another project with a global component, subject to steering committee approval, (5) serving as a host buddy in the International Buddies Program or similar mentoring program through the Office on International Studies, and (6) participation in a student organization with global and multicultural focus. A similarly broad list of options is available for students to develop the remaining three components of the program. It is important to note that none of these opportunities are controlled or managed by the Auburn GCSP and several are managed externally to the College and University.

Of the 12 students participating in the first cohort of students, 30% are female and 20% are African American; both are higher rates than the engineering student body at large. These numbers mirror those of other programs that have attracted a higher proportion of underrepresented minorities in general. Several students in the first cohort have reported that company interviewers showed particular interest in their activities in the GCSP. One student was offered an internship based in part on his involvement with the program. Another has received an offer to conduct research with faculty at another university based on their GCSP involvement. The second cohort of students will be inducted in January of 2020.

Conclusions

The GCSP and the GCE offer significant synergy between the altruistic values of students and the traditional college engineering program. Several years of research at Auburn have shown the benefits of emphasizing societal impacts on the knowledge and attitudes of middle school students through college freshman. The GCSP is in a nascent stage but participants have already

expressed enthusiasm and received positive benefits such as internships in industry and research labs.

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