

A Proposed Grand Challenges Scholars Program in the Lyles College of Engineering

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Abstract

There has been a growing concern regarding traditional engineering education - for not adequately preparing future graduates who will be able to address society's increasingly complex problems. Future engineers will need a new set of skills in the context of the global economy. Additionally, the retention of engineering students, especially underrepresented students, is another cause for concern. Approximately, 50% of students majoring in engineering graduate within six years. This challenge intensifies considering that fewer incoming students, specifically underrepresented ones, are attracted to the field of engineering and construction management.

The National Academy of Engineering's (NAE) Grand Challenges Scholars Program (GCSP) intends to address the preceding concerns. It will provide the framework for educating the future engineers and construction managers who will be equipped with the necessary skills to solve the Grand Challenges of the 21st century. In 2008, NAE identified fourteen Grand Challenges for the 21st century to highlight the areas of engineering that will have great potential to improve mankind's quality of life. The overarching thematic areas include energy and environment, health, security, and learning and computation. The GCSP has five components: (1) interdisciplinary curriculum, (2) hands-on projects or research experience, (3) entrepreneurship, (4) service learning, and (5) global perspective. The aforementioned roadmap will not only enhance students' skills and knowledge needed to solve complex societal problems, but will provide realistic and exciting opportunities for students to get engaged.

There is an increasing number of engineering programs worldwide adopting the GCSP roadmap within their existing undergraduate and/or graduate education. The details of a proposed GCSP in the Lyles College of Engineering at California State University, Fresno will be discussed in this paper.

Keywords: Grand Challenges, interdisciplinary, entrepreneurship, energy, environment, security

Introduction

There has been much debate concerning the shortcomings of the conventional engineering education in recent years^{1, 2}. The culmination of these deliberations has resulted into several landmark publications including: The Engineer of 2020³, Educating the Engineer of 2020⁴, Changing the Conversation⁵, Grand Challenges for Engineering⁶, Raising the Bar: America's Challenge to Higher Education⁷, and The Vision for Civil Engineering in 2025⁸.

In the Engineer of 2020 (3), the National Academy of Engineering (NAE) poses an important question: *“Does it serve the nation well to permit the engineering profession and engineering education to lag technology and society? Rather, should the engineering profession anticipate needed advances and prepare for a future where it will provide more benefit to humankind? Likewise, should engineering education evolve to do the same?”* In response, the NAE makes a number of recommendations in the Educating the Engineer of 2020 (4). Accordingly, the characteristics of a successful future engineer will entail: *“strong analytical skills, practical ingenuity, creativity, good communication skills, business and management knowledge, leadership, high ethical standards, professionalism, dynamism, agility, resilience, flexibility, and the pursuit of lifelong learning.”*

Furthermore, in 2008, the NAE identified fourteen global challenges for the 21st century. Grand Challenges are key initiatives fostering innovations to solve the world’s problems in relation to sustainability, health, vulnerability, and human wellbeing. Subsequently, in 2009, the NAE Grand Challenges Scholars Program (GCSP) was announced at the GC Summit in Durham, North Carolina^{9, 10}. The intent of the GCSP is to prepare students via a combination of curricular and extra-curricular activities so that future engineering graduates will be able to tackle the 21st century grand challenges.

Initially, only a handful of universities adopted the GCSP. Over the years, a growing number of universities worldwide have been incorporating the GCSP in their undergraduate/graduate education in different ways¹¹⁻¹⁴. Recently, the Lyles College of Engineering (LCOE) at California State University, Fresno (‘Fresno State’) has submitted a preliminary proposal to join the GCSP Community. At this time, the LCOE’s proposal focuses on the Construction Management (CM) program as a pilot. It is envisioned that the proposal will expand to encompass the remaining five LCOE engineering programs in the future. Following is the outline of the CM’s proposed Grand Challenges Scholars Program.

Overview

The undergraduate curriculum for the Construction Management program in the Lyles College of Engineering at Fresno State was overhauled nearly three years ago. The unique features of the revised curriculum comprised an interdisciplinary approach with a business minor as an integral element of the CM major. Service learning was incorporated at all levels in the form of “S” designated courses. At the freshman level, CM 1S, the orientation course; in the mid-level, CM 7S, the construction materials and assembly course; and at the senior level, the capstone course, CM 180S provide the experiential learning opportunities with one or more community based organizations (CBOs) in the field of construction. Each student is obliged to spend a minimum of 20 hours community service learning in construction related jobs as part of the requirement for the an individual “S” designated course, thus, a total of 60 hours by the time of graduation. Furthermore, an internship became compulsory for students enrolled in the new curriculum. Students are required to work in the construction industry for minimum 600 hours to fulfill the internship requirement. A hallmark of the new curriculum is the entrepreneurship component, implemented via seminar series, capstone sequence of courses, and extra-curricular activities.

It is evident from the preceding brief overview that several elements of the GCSP are embedded within the existing CM's undergraduate education. It is the guiding principle of the proposed initiative to further reform the curriculum and incorporate additional extra-curricular activities, as needed, to realign the CM education in the Lyles College of Engineering at Fresno State with the NAE's Grand Challenges Scholar Program. Following is our vision for developing and incorporating the proposed GCSP roadmap.

Interdisciplinary Curriculum

The NAE's recommendation is to complement the engineering/construction fundamentals with non-engineering/construction courses from other fields to provide a breadth of knowledge in communication, public policy, business, law, ethics, human behavior, risk, and the arts, as well as health care/sciences. The CM curriculum at Fresno State entails a high rigor including calculus courses, a course in statistics, a calculus-based physics course, earth sciences, and all the construction management/science courses required by the accreditation board, the American Council for Construction Education (ACCE). The curriculum is complemented with the required series of courses for a business minor. Furthermore, the curriculum is enriched with variety of courses in communication, public policy, ethics, law, etc., as part of the general education requirement. There are also opportunities available for students to select other minors, certificates, and additional pre-requisite business courses to become "MBA-ready."

Furthermore, it is well known that non-engineering/construction courses are taught in colleges/programs outside the college of engineering. As a result, students see little or no relevance between non-engineering/construction courses and their major field of study. As a part of our proposed GCSP curriculum innovation, we intend to establish a closer partnership with non-engineering/construction programs to bridge these disconnections. One such example is the first author's experience in seamlessly integrating the geology and geotechnical engineering courses via a project-based learning (PBL). Moreover, there will need to be more discussions and presentations introduced at different levels within the program to highlight the Grand Challenges projects. In the past, our case studies in construction failure, incorporated in various courses, have provided broad perspectives of the global infrastructural challenge. We intend to expand the case studies application in other areas of grand challenges in the future.

Hands-On Projects or Research Experience

Multiple courses taught in CM are project-based, especially the capstone series. The selected projects have been at small scale, yet present real world challenges and sharpen students' problem solving skills, which are critical, as they take on greater scale projects in their future career. To enrich students' experiential learning, the CM faculty design these projects with built-in research components such as building performance analysis, sustainability design strategies, lean concepts, etc.

Entrepreneurship

In relation to the entrepreneurship component of the GCSP, the NAE (7) suggests that students should be prepared to translate invention to innovation and "to develop market ventures that

scale to global solutions in the public interest.” As mentioned previously, entrepreneurship constitutes a hallmark of the CM program in the Lyles College of Engineering. Two of the faculty members serve as the Coleman Fellows for Entrepreneurship and are actively involved with the Lyles Center for Innovation and Entrepreneurship. The CM program has been offering courses in relation to entrepreneurship as technical electives as well as a joint certificate program in entrepreneurial real estate in collaboration with the Craig School of Business-Gazarian Real Estate Center. In the past, CM students were exposed to the entrepreneurial activities via seminar and speaker series and by taking relevant courses. They will be engaged at a larger scale dealing with grand challenges as part of the proposed GCSP in the future.

Service Learning

In addition to the required “S” designated courses that provide opportunities for CM students to become engaged in community service activities in construction, we have introduced an award-winning Eco-Village project, in collaboration with a local architect, as an integral part of the senior level capstone courses. A global phenomenon, the Eco-Village movement promotes humane housing, a green and sustainable solution to homelessness. Originally, spearheaded by Mr. Art Dyson, a world-renowned architect, the Eco-Village Project of Fresno will provide safe, sanitary, uplifting and dignified housing for the homeless people locally and emergency shelter for disaster stricken communities globally. Furthermore, the Eco-Village Project is an environmentally sustainable community that provides a holistic safe haven that “gives the mental, emotional and physical tools necessary to escape the endless cycle of homelessness¹⁵.” A multi-disciplinary project, CM students have taken the lead in the past to collaboratively design and build the Eco-Village sustainable modular units. Other members of the team represent interior design, real estate, anthropology, planning, and engineering. Our vision is to scale up the Eco-Village project to the global level for emergency shelter applications.

Global Perspective

The NAE states that the global dimension component of the GCSP should develop and deepen “students’ social consciousness and their motivation to bring their technical expertise to bear on societal problems through mentored experiential learning with real clients.” The preceding Eco-Village Project, once implemented as emergency shelters globally, will provide an excellent experiential learning opportunity. CM students have also been involved in Engineers Without Borders projects in the past. We envision that students in the GCSP may be able to fulfill their internship requirements working for construction companies overseas, as prescribed in the above statement by the NAE. Moreover, we are in the process of developing study abroad programs, which will provide ample opportunities for students to immerse in another culture and gain global perspective.

Conclusions

The vision of the NAE’s GCSP is to advocate a new engineering education paradigm that will prepare engineers who will be “world changers.” The proposed GCSP in the Construction Management Program at Fresno State, a pilot program in the Lyles College of Engineering, already possesses several features of the GCSP’s five components. The CM education in LCOE,

realigned with the GCSP's vision, will move to a global context and will provide tremendous opportunities for students to collaboratively solve global grand challenges.

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