

National Academy of Engineering Grand Challenge Scholars Program (GCSP)
An Operational Document for Proposing a GCSP at Your School
July 29, 2009

1. National Academy of Engineering Grand Challenges. Designing and creating solutions is the DNA of engineering. On the whole, engineering solutions are judged by whether they are practical, cost effective, and get the job done. However, the world is now a much more complicated place, and engineering is called upon to address complex and interrelated problems that require more than just practical solutions. The new engineer also has to be mindful of the intended value and unintended impacts of an endeavor, especially where society is most vulnerable (e.g. removing grain from the food supply to make biofuel).

The National Academy of Engineering (NAE) recently released a list of fourteen “Grand Challenges for Engineering” that must be addressed if we hope to achieve a sustainable, economically robust, and politically stable future for our children and our children’s children [<http://www.engineeringchallenges.org/>]. These challenges range from the most basic to the extraordinary, and encompass four Grand Challenge themes.

Energy and Environment

- Make solar energy economical
- Provide energy from fusion
- Develop methods for carbon sequestration
- Manage the nitrogen cycle
- Provide access to clean water

Health

- Advance health informatics
- Engineer better medicines

Security

- Prevent nuclear terror
- Secure cyberspace
- Restore urban infrastructure

Learning and Computation

- Reverse engineer the brain
- Enhance virtual reality
- Advance personalized learning
- Engineer the tools of scientific discovery

These are ambitious tasks that will require a new generation of engineers that will collectively

- Create new capabilities
- Provide pragmatic solutions for basic human needs
- Develop new entrepreneurial opportunities
- Reinvent human interactions
- Transform systems thinking
- Be the architects of a sustainable society
- Be mindful of unintended consequences
- Connect technology with society

2. Grand Challenges Scholars Program (GCSP). At the NAE Grand Challenges Summit held at Duke University in March 2009 [<http://summit-grand-challenges.pratt.duke.edu/>], a consortium of founding institutions – Duke University’s Pratt School of Engineering, The Franklin W. Olin College of Engineering, and the University of Southern California’s Viterbi School of Engineering – jointly

announced the NAE Grand Challenges Scholars Program (GCSP) to educate engineering students who will play leading roles in the NAE Grand Challenges [<http://www.grandchallengescholars.org/>].

Addressing the NAE Grand Challenges over the next 20-plus years will require the efforts and talents of many men and women educated in a range of engineering disciplines, the majority of whom are currently high school age or younger. ***The explicit objective of the national GCSP is to develop a nation-wide network of Grand Challenge Scholars Programs within participating schools that will educate the future leaders of the NAE Grand Challenges.***

3. Joining the Nation-Wide Network of GCSPs. The first step for schools interested in starting a GCSP is for the dean of engineering to join the “GCSP Update List” by using the “Join the GC Scholars Program” link available on the GCSP website <http://www.grandchallengescholars.org/>. Schools that join the update list are automatically sent an invitation to perform the second step of proposing a program for educating a select group of diverse engineering undergraduates to address a Grand Challenge theme or a specific Grand Challenge problem.

Institutions approved for the GCSP designation will be permitted to display the National Academy of Engineering Grand Challenge Scholar logo on their web site, official publications and press releases. Students who successfully complete a GCSP, as certified by their home institution, will receive a Grand Challenge Scholar certificate endorsed by the National Academy of Engineering and a Grand Challenge Scholar designation on the student’s transcript.

Programs approved for GCSP designation will become an essential part of the NAE Grand Challenges network of engineering schools. Member institutions will have access to an online community of GCSPs as well as workshops and programs intended to support the development and ongoing work of the GCS community. These electronic and face-to-face networks will allow GCS program directors, faculty, staff, and students to exchange ideas and research progress and to present best practices to further refine the program (see Assessment).

4. Three Essential Characteristics of a GCSP. Each institutional program must possess the three essential elements of a GCSP: (a) selecting a diverse cohort of outstanding engineering students, (b) educating them with an appropriately innovative and institutionally tailored GCSP curriculum, and (c) building curricular connectivity into each student’s scholarly plan. No one-size-fits-all program will be imposed, and each GCSP must be inherently flexible to achieve intellectual breadth and inclusiveness. However, ***it is recommended that applications for an institutional GCSP adhere to the following criteria.***

(a) Grand Challenge Scholar selection. *Objective: Identify a diverse cohort of domestic and international students that will be educated to design and create solutions to the NAE Grand Challenges.* Each GCSP will determine how student selection is best accomplished within the mission and character of the individual school. In general, students selected for a GCSP should (1) be an engineering student in good standing, (2) be committed to engineering of the Grand Challenges, and (3) have an awareness of social and/or global consciousness. The three founding GCSP schools exhibit the breadth of programmatic approaches. USC’s Viterbi School of Engineering expects to designate GC scholars in their senior year. Duke’s Pratt School of Engineering plans to identify GS scholars as mid-undergraduates, e.g. in their junior year. The Franklin W. Olin College of Engineering views the GC scholars as an overall engineering immersion experience.

Each of the founding GCSPs is required to establish institutionally tailored criteria and mechanisms for assuring that all Grand Challenge Scholars comply with goals and spirit of the program. This must include an institutional GCSP director and should include an institutional GCSP oversight committee.

(b) GCSP curriculum. *Objective: Acquire and integrate the engineering and non-engineering curricular and meta-curricular expertise necessary to engineer a Grand Challenge theme or specific Grand Challenge problem.* The five curricular components of a GCSP are listed below. Substantial flexibility is given in how these five components are implemented at each partner engineering school, but mechanisms should be in place to track and assess student performance on each component in each individual program (see Assessment). Well-designed and well-documented meta-curricular activities could satisfy a number of the curricular components, particularly components for entrepreneurship, global dimension and service learning.

1. Project or research activity engaging a GC theme or challenge: Working to solve the NAE Grand Challenges is the motivation for the GCSP. Each GC scholar must participate in a substantial team or independent project relating to a Grand Challenge theme or specific Grand Challenge problem. Examples: formal undergraduate research programs, senior theses, graduation with distinction, on-site internships, or cap stone design projects.

2. Interdisciplinary curriculum: Bridging engineering to other disciplines is essential for solving the NAE Grand Challenges. An “Engineering-Plus” curriculum should be devised that prepares engineering students to work at the boundary between an engineering and non-engineering discipline, such as public policy, international relations, business, law, ethics, human behavior, risk, medicine and the natural sciences. However, this must be more than simply double majoring or picking up a minor in a non-engineering discipline. Specifically, each GCSP should have an institutionally tailored mechanism that thematically draws together the engineering and non-engineering curricular components of each student’s course of study. Examples: an explicitly interdisciplinary course, a GCSP seminar series or presentation sequence.

3. Entrepreneurship: Implementing innovation is central to technology development. Each GC scholar must participate in a curricular or meta-curricular component on the process of translating invention and innovation into market ventures. This may be either risk-taking ventures for business or introducing technology for not-for-profits in the public interest. Examples: submitting an invention disclosure, participating in start-up competitions, campus or community engagement, and/or formal classes in marketing, patent law, intellectual property.

4. Global dimension: Global awareness is necessary for working effectively in an interdependent world. Students may participate in a curricular or meta-curricular component that instills elements necessary to develop innovations in a global economy, or address ethical issues of global concern. Domestic activities that stress global or cross-cultural implications may satisfy this component. Examples: completing formal classes, participating in internships, or conducting research in global health, global environmental challenges, non-profit marketing or low-cost manufacturing, study and/or internships abroad.

5. Service learning: Working for the benefit of others is the foundation of a civil society. Students may participate in a curricular or meta-curricular component that deepens their social awareness and to heighten their motivation to bring their technical expertise to bear on societal problems. Examples: completing formal classes in social action, participating in internships, global service organizations such as Engineering World Health or Engineering without Borders, or conducting research in an area with a clear component of improving the human condition, or participation in an institution’s community service or tutoring program.

(c) Curricular connectivity. *Objective: Ensure intellectual and thematic connectivity across the five curricular components and a Grand Challenge theme or a specific Grand Challenge problem.* A well-connected curriculum would be one where a single component can be linked to one or more of the other components; e.g. interning and/or performing research on global health or clean energy.

Awareness of unintended consequences, responsible conduct in research, and professional ethics should be embedded across the five components. It is recommended that each GC scholar select or be assigned a GC advisor to monitor student progress and ensure thematic continuity and connectivity.

5. Assessment. The Grand Challenge Scholar Program has two levels of organization and thus two levels of assessment are needed to ensure consistency with the core principles set forth by the founding committee.

(a) National level. The deans and directors of the institutional GCSPs collectively govern the national organization through the national steering committee (See below). The steering committee membership will be appointed by the deans and directors of the member institutional GCSPs.

The primary roles of the steering committee are to promote the GCSP to U.S engineering schools, recruit new GCSP partners, review proposals for membership, and prepare the annual report to the NAE. The steering committee also will be responsible for organizing periodic GCSP summits as well as an electronic community for exchange of programmatic best practices and the results of student scholarship, research and outreach. Regular participation in the workshops and annual submission of programmatic accomplishments are essential for continued membership in the national body.

(b) Institutional level. The deans and faculty that comprise each school's GCSP are charged with institutional program governance. Each institutional program must have a GCSP director and is recommended to have a GCSP committee that provides advice and programmatic oversight. The selection of the director and/or the organization of this committee are at the institution's discretion.

The primary roles of the institutional director and oversight committee are to establish the GCSP curriculum, select students, monitor student progress, and approve students who have successfully completed the program. Each program director must compile the names and accomplishments of students who receive Grand Challenge Scholar designation upon graduation and convey this information to the national steering committee. Acquiring the names of GC scholars and descriptions of their accomplishments is essential for the annual report submitted by the national steering committee to the NAE. Cooperation of the institutional GCSP committees is also sought in longitudinal tracking of Grand Challenge Scholars.

6. Submitting a GCSP Proposal. Schools that join the GCSP Community through the GC Scholars web site will be invited to submit a proposal for an institutional program. These proposals should be concise descriptions of the following information.

1. Cover page with the name of the candidate school, name and signature of the engineering dean, name and signature of the GCSP director, and the GCSP director contact information.
2. Describe the GCSP vision for your school, noting GC-related activities.
3. Describe how GC scholars will be selected, including anticipated number of students involved.
4. Describe how the five GC curricular components will be met at your school.
5. Describe how GC scholars will be assessed and tracked at your school. Also include in this section how you will promote early student engagement in GC-related activities, as well as how you will foster intramural and extramural networking among GC scholars.

Examples of approved institutional GCSPs can be viewed at <http://www.grandchallengescholars.org/>.

Submit your proposal to reichert@duke.edu for distribution and review by the GCSP steering committee. Please feel free to contact any of the steering committee members for further information.

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7. Proposed Steps for Year 1. The NAE Grand Challenge Scholars program is in the very early stages having been announced in March 2009 <http://www.grandchallengescholars.org/>. While the response since the announcement has been strong, it is important that the next steps build upon this momentum.

(a) Establish the GCSPs at the three founding schools. Work to build the GC curricula at Duke, Olin and USC with the goal of designating the first group of GC scholars at these schools in 2009-2010 the GCSP community. This experience will be used to refine the guidelines for other GCSPs.

(b) Grow GCSP national membership. The national membership currently consists of the founding GCSPs Duke, USC and Olin. A letter will be sent out from the founding engineering deans announcing the NAE Grand Challenge Scholars Program to all U.S. engineering deans, and inviting them to join. The announcement refers to a web-based mechanism for engineering deans to add their name and contact information to the list of GCSP community members. Schools that sign on to the GCSP list serve automatically receive an email that thanks them for joining and instructs them on how to submit a proposal for a GSCP at their school. It is likely that the majority of the initial proposals will be approved to build the membership.

(c) Conduct a GCSP workshop. The national steering committee will be approaching the National Science Foundation, corporations and member schools to sponsor a workshop to further develop the principles and practices of the GCSP initiative. The first step is to prepare a letter of intent to the NSF and potential corporate partners to generate enthusiasm and garner buy-in for the effort. Participants in the workshop should include administrative, faculty and student representatives from the partner GCSPs, key members of K-12 education, and critical industries associated with the fourteen grand

challenges. Olin College has been proposed as the workshop site. It is hoped that many participating schools will be able to develop their own GCSP implementations in anticipation of or at this workshop

(d) Establish a national GCSP funding base. Each individual GCSP is expected to maintain its own operational funding base. However, it would be a clear advantage if a central funding source was available to support innovative initiatives, underserved institutions, and the work of particularly meritorious scholars. A critical goal of the GCSP workshop will be to establish the criteria, proposed objectives and desired outcomes for a proposal to the NSF and corporate partners to support the national program. These funds would be awarded to individuals and programs according to a yet to be determined application process.