

Massachusetts Institute of Technology
School of Engineering

**National Academy of Engineering
Grand Challenge Scholars Program**

Proposal

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Proposal

School of Engineering at the Massachusetts Institute of Technology NAE Grand Challenges Scholars Program

Vision

Comprised of an exceptional community of students, scholars, researchers, educators, and engineering practitioners, the MIT School of Engineering's (SoE) mission is to educate the next generation of engineering leaders, to create new knowledge, and to serve society. By cultivating and training the students who will help create solutions to the greatest technological and social problems of the 21st century, and by directly contributing innovative ideas and practical technologies to society, the MIT School of Engineering demonstrates its position as a world-leading institution.

Founded in 1861, MIT has a proud history of influencing the world through technological leadership and research innovation. MIT is one of the world's preeminent research universities: renowned for rigorous academic programs in science, technology, and other areas of scholarship; cutting-edge research; a diverse campus community; and a longstanding commitment to working with the public and private sectors to bring new knowledge to bear on the world's complex challenges. The School of Engineering's Grand Challenge Scholar Program (GCSP) will leverage the existing platform of educational excellence in the SoE to provide undergraduate students with an additional layer of engineering experience and skills to solve the Grand Challenges as outlined by the National Academy of Engineering.

Led by the Department of Civil and Environmental Engineering (CEE), the School of Engineering's GCSP will work with faculty in the broad domains of their research, as well as collaborate with fellow faculty from across the School. Further, the SoE's GCSP will work with existing framework and educational opportunities across MIT to add depth to the Grand Challenges Scholars program including, but not limited to, MIT's Undergraduate Research Opportunities Program, the Gordon Engineering Leadership Program, MIT's Innovation Initiative, the Sandbox program, MIT's International Science and Technology Initiative, and MIT's Public Service Center. This sampling of existing opportunities is described below.

Undergraduate Research Opportunities Program (UROP) cultivates and supports research partnerships between MIT undergraduates and faculty. UROPs offer undergraduates the chance to work on cutting edge research—whether it is joining an established research project in a lab, a group, or pursuing one's individual ideas. [source: <http://web.mit.edu/urop/index.html>]

The **Bernard M. Gordon---MIT Engineering Leadership Program (GEL)** aims to develop next generation, technical leaders with the values, attitudes, and skills necessary to understand and address engineering problems. The GEL supplements MIT's technical education with the leadership skills that prepare young engineers for effective careers in engineering. A key outcome of this program is working in teams and developing leadership skills. [source: <https://gelp.mit.edu/>]

MIT's Innovation Initiative (MITii) works with all five MIT schools to strengthen the educational pathways and networks for students, alumni, and partners to move ideas from conception to impact. In MIT's tradition of *Mens et Manus*, MITii combines hands-on, global opportunities for building expertise in the innovation process with insights developed from the evidence-based science of innovation. [source: <https://innovation.mit.edu/about>]

The **MIT Sandbox Innovation Fund Program** provides meaningful seed funding, up to \$25,000, for student-initiated ideas, mentoring from within MIT and from a broad network of committed partners, and tailored educational experiences. The opportunity is open to all MIT students, who may work as individuals or in teams, and offers a flexible, mentor-based model, which allows students to take the spark of an idea and implement the concept outside of the Institute. [source: <http://sandbox.mit.edu/about/>]

MIT International Science and Technology Initiatives (MISTI) is MIT's flagship international education program. Rooted in the *Mens et Manus* tradition, MISTI matches MIT students with tailored internships, research and teaching opportunities abroad. They also facilitate international faculty collaborations and develop partnerships with leading companies, research institutes and universities around the world. [source: <http://misti.mit.edu/about---misti>]

MIT's **Public Service Center (PSC)** helps students with hands-on experiences that serve communities and the students themselves in life-transforming ways. [source: <http://web.mit.edu/mitpsc/whatwedo/esg---psc/index.html>]

The School of Engineering intends to spring board from this existing framework, and others at MIT, to easily connect scholars with the resources to assemble their undergraduate portfolio to answer the five main calls as outlined by the NAE: **1) Research, 2) Interdisciplinary Curriculum, 3) Entrepreneurship, 4) Global Dimension, and 5) Service Learning.**

Oversight of the program will be held by a steering committee that includes faculty from across the Department of Civil and Environmental Engineering, and led by a chair of the steering committee, who will report to the MIT GSCP Director. We plan to have CEE lead the inaugural program, but anticipate that other departments may join in future years. The role of the steering committee is to lead and innovate the dynamic MIT GSCP curriculum – keeping it current and in-line with both NAE and MIT. This includes but is not limited to reviewing the subject selection for the interdisciplinary curriculum to ensure cohesiveness and connectivity as it relates to NAE grand challenges; annually updating the entrepreneurship, global dimensions and services options; and similar tasks.

Faculty mentors for the program will be selected from a pool of faculty advisors in the SoE who focus on one or more of the grand challenges in their current research. The steering committee will meet with mentors at the beginning of each academic year to review the program and responsibilities. A program guide will be developed and provided to each mentor. Mentors will be matched with prospective scholars through the application process to work with students to put together a track and will be expected to meet with their students at least once per term, to monitor and document progress, as well as to ensure NAE thematic connectivity and continuity. Documented progress will be provided to the steering committee by the end of each

term through an e-portfolio and at the end of the student's senior year. Depending on availability of funds, we hope that faculty mentors will receive discretionary funds from their respective departments for their participation and dedication to this program. A full description of faculty mentors and responsibilities is included in [Appendix I](#).

Selection of Scholars

The program steering committee will implement a communications strategy, which will involve reaching out to freshmen learning groups at MIT – Interphase, Terrascope, Concourse, Experimental Study Group (ESG), and Media Arts and Sciences (MAS); host information seminars; and work with the Undergraduate Advising and Academic Programming Office (UAAP) to inform freshmen of the opportunity, benefits and application process for the GCSP.

Upperclassmen will be identified through MIT's Undergraduate Research Opportunities (UROP) program, particularly those involved in research that relates to one of the fourteen global challenges. We anticipate an enrollment of 10---20 students in the initial years of the program.

The department of Civil and Environmental Engineering will implement an application and selection process that incorporates an advising model where students are matched with a mentor when beginning the application process to work together to select a program of coursework that fulfills the requirements of the GCSP while also fulfilling the degree requirements for their declared major. Students will work with their mentor to identify a grand challenge and build a "track" of study that will include the interdisciplinary curriculum necessary to successfully complete the program. This plan will be included in their portfolio, which will be submitted with their application to the GCSP. The proposed portfolio will include a completed Academic Program Form noting all Grand Challenge related curricular and co-curricular activities, including their proposed Research (UROP, senior capstone/design project), Interdisciplinary Curriculum plan, Global Dimension (MISTI, study abroad), and Entrepreneurship plan and Service Learning (Public Service Center program) activities. The portfolio will also include a narrative that outlines the Grand Challenge(s) the prospective scholar wishes to address.

Scholar selection will take place at the end of each academic year. The applications will be reviewed by the steering committee and make recommendations accordingly. All admitted students will be matched with a faculty mentor, most likely the mentor that worked with the student through the application process.

Scholars will meet at least once per term with their Grand Challenge mentor. The mentor will document their progress and achievements through an online version of their GCSP portfolio. In addition, the GCSP steering committee will meet periodically with the faculty mentors to review the progress and ensure that all scholars continue to meet program requirements.

Application and Selection Timeline

Fall Academic Year

- Steering Committee works with the CEE Academic Programs Office and SoE and

- relevant MIT offices to promote scholars program and application
- Online portal is completed

Independent Activities Period [IAP] Academic

- Online portal opens – January 1

Spring Academic Year

- Applications (with contents noted below) due March 15
- Selection of scholars by April 15
- Student identifies Grand Challenge and builds a track of study for application
 - Track must include: Research proposal (UROP, senior capstone/design project), Interdisciplinary Curriculum plan, Global Dimension (MISTI, Study Abroad), Entrepreneurship plan and Service Learning (Public Service Center program) activities
- Student writes narrative that identifies the Grand Challenge s/he would like to address and how the proposed track links to solving that objective
- Student works with faculty mentor to request a letter of support and mentorship
- Student selects degree program coursework that fulfills GCSP requirements, reflecting the Grand Challenge of choice

CEE anticipates that in the first year of the program, the department and SoE will focus on additional outreach and information sharing through the various communication channels at MIT.

Curricular Components

Detailed curricular requirements are listed in [Appendix II](#), and a sample program form is included as [Appendix III](#).

In regards to time commitment, the goal is for the program to be completed through the subject and activities that a typical MIT student completes but curates these activities into a more formal and cohesive track of study that addresses the NAE Grand Challenges.

Interdisciplinary Curriculum “Engineering Plus”

At MIT, all undergraduate students must complete the General Institute Requirements (GIRs), which include a freshman science core with foundational subjects in biology, math, chemistry and physics; fulfill a rigorous communication requirement; and a lab requirement and coursework in humanities and social sciences. At the end of a student’s freshman year they select their major. Using the proposed application portfolio, students can plan long-term about both their major and how the GCSP would be a natural complement to the existing MIT requirements, both at the Department and Institute level.

Interdisciplinary Curriculum

The foundation of MIT’s General Institute Requirements (GIRs) lays the groundwork for a robust interdisciplinary curriculum for our scholars. Students will work with their faculty mentor to

select **four subjects** that are inherently interdisciplinary in nature. These subjects may also be used to satisfy a departmental degree requirement or an institute degree requirement. Suggested subjects, which address certain **Grand Engineering Challenges**, are noted below, but the list is not exhaustive, and will be updated by the steering committee and the mentors as the program evolves. A sample of current scholar's course selections will be summarized on our website, for future students' reference.

Energy and Environment	
1.071J Global Change Science	2.013 Engineering Systems Design
1.020 Principles of Water and Energy Sustainability	2.60J Fundamentals of Advanced Energy Conversion
1.021J Introduction to Modeling and Simulation	2.500 Desalination and Water Purification
1.044J Fundamentals of Energy in Buildings	2.612 Marine Power and Propulsion
1.072 Groundwater Hydrology	3.032 Mechanical Behavior of Materials
1.085 Air Pollution	4.447J Design for Sustainability
1.74 Land, Water, Food and Climate	5.60 Thermodynamics and Kinetics
1.731 Water Resource Systems	12.021 Earth Science, Energy and the Environment
Security	
1.056 Building Structural Systems I	1.101 Intro to Civil and Environmental Engineering Design Lab I
1.020 Principles of Water and Energy Sustainability	1.102 Intro to Civil and Environmental Engineering Design Lab II
1.153 Transportation Policy, the Environment, and Livable Communities	
1.044J Fundamentals of Energy in Buildings	
Health	
10.443 Future Medicine: Drug Delivery, Therapeutics, and Diagnostics	3.96J Biomaterials: Tissue Interaction
10.585 Engineering Nanotechnology	
10.962 Seminar in Molecular Cell Engineering	
20.201 Fundamentals of Drug Development	
20.363J Biomaterials Science and Engineering	
Joy of Living	
6.803 The Human Intelligence Enterprise	9.15 Neural Circuits, Neuromodulatory, and Neuroendocrine Systems
9.01 Introduction to Neuroscience	9.33 Your Brain: A User's Guide
9.12 Experimental Molecular Neurobiology	9.40 Introduction to Neural Computation
9.14 Brain Structure and its Origins	

Research

Project or Research Activity Engaging a GC Theme or Challenge – MIT's Undergraduate Research Opportunities Program (UROP) is a robust program that provides undergraduate students with the opportunity to work on cutting edge research with faculty throughout the Institute. This program would provide a GCSP candidate with the hands-on experience

identified in the Grand Challenges. The UROP office requires an evaluation and end of term report from each student that details their research experience as well as their work and results. The opportunity to participate in a SuperUROP is available to juniors and seniors, providing them with the chance to engage in more involved research with results that could ultimately lead to a paper.

Alternatively, in departments like Civil and Environmental Engineering, a student can pursue research in a Grand Challenge as part of their senior capstone project. These projects involve hands on research in an area of interest to students or selected by a faculty member, utilizing the skills and knowledge they have acquired in their undergraduate academic career and apply them in design projects that solve real world problems.

Research projects must be pre-approved by the scholar's faculty mentor before the research begins. All research, regardless of whether it is a UROP, SuperUROP, capstone, etc., will be presented at a GCSP symposium in the spring term.

Entrepreneurship

Many engineering students take subjects in the Sloan School of Management, and have career interests in start-ups. MIT's Innovation Initiative has recently developed a minor in Entrepreneurship and Innovation that naturally supports this feature of the GCSP by building skills in business development, leadership, management, and innovation, among other areas.

In addition, there are several entrepreneurship focused competitions held on campus, like the MIT \$100K Entrepreneurship Competition, Water Innovation Prize, and the Clean Energy Prize. These types of competitions encourage MIT students to act on their talent, ideas and energy to produce tomorrow's leading firms.

Global Dimension

We will institute a curricular and meta-curricular approach to meeting the global dimension requirement. One avenue for completing this criterion would be through an internship abroad with MIT's International Science and Technology Initiative (MISTI). An international education program, MISTI matches students with tailored internship, research, and teaching opportunities abroad in as many as twenty-two countries. There are also entrepreneurial opportunities through MISTI's MIT Global Startup Labs that cultivates, supports and empowers generations of young tech-entrepreneurs in emerging nations.

Service Learning

Our program would utilize a number of undergraduate opportunities through MIT's Public Service Center and MIT's Edgerton Center. The opportunities at these centers represent a wide range of public service projects close to home and far away. Previous opportunities include helping build technical, organizational or design resources for an emergency water-supply start-up in Chile and working with an MIT Inspirational Teacher Award winner in the physics class of a local high school. The numerous opportunities abroad could also be used to satisfy both the service learning and the global dimensions components.

Assessment, Tracking and Recognition

Upon admission to the program, scholars will meet with their faculty mentor once per term to connect and review program benchmarks. An e-portfolio will be created by each scholar to post his or her work for review by his or her faculty mentor and will be accessible to the steering committee for periodic review.

After each year of the program, the Department of Civil and Environmental Engineering, working with the School of Engineering will host a poster presentation to showcase the work of the students recognizing their contributions to the important issues laid out by these challenges.

Final evaluations of the individual student's program will be conducted by that student's faculty mentor and the steering committee.

Appendix I

Faculty Mentor: Roles and Responsibilities

The goal of the faculty mentors is to connect students with engaged advisors who are working in the broad domains that address the NAE's Grand Challenges. Students may work with their faculty advisor when crafting their application or they may be assigned after being accepted to the Scholars program.

Faculty mentors are expected to:

- Attend a training session with the steering committee in the beginning of the fall term
- Work with prospective scholars when putting together their application
- Meet regularly (at least once per term) with their GCSP scholar
- Ensure that their scholar is meeting the program requirements
- Attend the research poster session of their GCSP scholar
- Connect their scholar to resources and opportunities across the Institute

Appendix II

Summary of the Grand Challenge Scholars Program's Required Components and Options for completion

Curricular Components	Requirements
Research Experience	Participate in an academic---year UROP (9 months, can be SuperUROP) or completion of a capstone project on one of the global challenges. Project must be pre---approved before the research begins and presented at a GCSP symposium (internal) following completion of their project.
Interdisciplinary Curriculum	Complete: An approved set of four subjects related to the student's focus Grand Challenge and that are interdisciplinary in nature
Entrepreneurship	Complete ONE of the following activities: 1) Take 2-3 subjects from the entrepreneurship & innovation (EI) minor. It is recommended that one of the subjects be a Foundational subject and then 1-2 from either the Contexts, Leadership of Teams and Organizations or Experiential domains from the EI list. The Full list of class options found here: https://innovation.mit.edu/education-practice/eiminor/ 2) Participate in MISTI Global start up labs 3) An approved internship or other experience that explicitly involves a high degree of innovation, invention or related activity 4) Approved involvement with a venture initiated by student 5) Participate in StartMIT, StartIAP, MIT Global Founders' Skills
Global Dimension	Complete ONE of the following activities: 1) Approved MISTI program 2) International Program (CME, MIT Madrid, or Departmental Exchanges, e.g., ETH Zurich, Imperial College London, Oxford, etc.) 3) An approved global dimension trip proposed by the student
Service Learning	Complete ONE of the following activities (logging a minimum of 30-120 hours): 1) Approved program through the MIT Public Service Center (local, national, or abroad) 2) Approved program through D-LAB at MIT 3) Engineers without Borders project 4) GlobeMed project

Appendix III

Sample GCSP Program Form

GCSP ACADEMIC PROGRAM FORM												
Advisee/Mentor _____			Major: _____				Date SB expected: _____					
GLOBAL CHALLENGE: Provide access to clean water												
RESEARCH			Semester Taken:									
Year			1		2		3		4			
Term	Number	Units	F	Sp	F	Sp	F	Sp	F	Sp	F	Sp
Senior Civil and Environmental Engineering Design	1.013	12									X	Capstone project
INTERDISCIPLINARY SUBJECTS			Semester Taken:									
Year			1		2		3		4			
Term	Number	Units	F	Sp	F	Sp	F	Sp	F	Sp	F	Sp
Principles of Energy and Water Sustainability	1.020	12				X						
Groundwater Hydrology	1.072	12								X		
Engineering Nanotechnology	10.585	12						X				
Your Brain: A Users Guide	9.33	12			X							
ENTREPRENEURSHIP			Semester Taken:									
Year			1		2		3		4			
Term	Number	Units	F	Sp	F	Sp	F	Sp	F	Sp	F	Sp
Water Innovation Prize									X			Entrepreneurship based competition in the area of water resources
GLOBAL DIMENSION			Semester Taken:									
Year			1		2		3		4			
Term	Number	Units	F	Sp	F	Sp	F	Sp	F	Sp	F	Sp
MISTI						X*						Research contaminants in the Cutzmalá watershed which provides drinking water to Mexico. *Sophomore summer
SERVICE LEARNING			Semester Taken:									
Year			1		2		3		4			
Term	Number	Units	F	Sp	F	Sp	F	Sp	F	Sp	F	Sp
D-Lab Internship									X**			Summer internship in the developing world related to water. **Junior summer