

Grand Challenge Scholars Program



WPI

Application

National Academy of Engineering

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1 Vision and Goals of the Grand Challenge Scholars Program at WPI

1.1 Background

Motivated by the National Academy of Engineering (NAE) vision for the future, and also by the increasing call from the NAE for a new engineering platform, WPI enlisted the help of the Teagle Foundation to initiate this application to the Grand Challenge Scholars program so that we may award eligible students the designation of being an NAE Grand Challenge Scholar. This designation provides WPI students with the opportunity to address pressing challenges facing the globe. WPI students who complete the program will achieve the distinction of Grand Challenge Scholar, a designation which will be recognized officially on their transcript by WPI and the NAE, and which indicates their intentional preparation to collaborate and succeed in a transdisciplinary and global environment.

The WPI Grand Challenge Scholars Program (GCSP) provides undergraduate students with a more intentional learning opportunity and experience within the curriculum and co-curricular activities while being mentored by faculty and staff, and includes four important objectives. These objectives are unique to the WPI GCSP:

1. **Integrity**

Scientists and engineers have a direct and vital impact in the quality of life of all people both here and abroad. They, along with humanists, bring both beauty to the world and maintain the highest standards of honesty and integrity. Engineering and science are the backbone of informed decision-making and decisions are dependent on the integrity of the science. As a community of Grand Challenge Scholars, the community will participate with faculty and the co-directors in discussions with examples as to what a learned professional's obligations are in both the engineering and science fields. Values such as promoting a culture of scientific integrity without fear of retaliation, an open environment of peer review and transparency, and adherence to constant improvement of best practices serve as the foundation of our discussions.

2. **Interdisciplinarity**

Both on a macro scale, where the world's natural resources will be stressed by population increases, to the micro scale, where engineers need to work in interdisciplinary teams to be effective, consideration of social issues is central to engineering. Political and economic relations between nations and their peoples will both enable and constrain engineering practice in the future, probably to a greater extent than currently. Attention to intellectual property, project management, multilingual influences and cultural diversity, moral/religious repercussion, global/international impacts, national security, and cost-benefit constraints will continue to drive engineering practice.

3. **Social Responsibility**

Every one of our Grand Challenge Scholars will participate in their junior year in our IQP (Interactive Qualifying Project) project. The IQP is an interdisciplinary project experience that challenges students to examine the impact of science and technology on society to address social issues and human needs. Students immerse themselves in problems of societal importance with the intent of building the passion, proficiency, and certainty that their life's work can change the world. WPI's goal is to develop socially responsible undergraduates of all majors—students who understand how their work can benefit society at large—as well as students in the arts and humanities who fulfil the WPI GSC requirements. Each IQP project represents coursework equivalents to 3 courses or one full term of work. Sustainability serves

as a common theme for IQPs, many of which address problems related to energy, environment, sustainable development, education, cultural preservation, and technology policy. Projects such as storm water management to improve surface quality, addressing consequences of climate change, planning for Massachusetts drinking water, earthquake alarm sensors, and design of a solar-powered housing project for impoverished Native American communities are just a few examples where students work together. Students pool their areas of nascent expertise while learning about how to listen and respond constructively to the real world experiences and perspectives of members of another community (often another culture). Each project involves some hands-on implemented action, and generates a significant written report.

4. **Integration of Engineering and the Liberal Arts & Sciences**

To augment WPI's requirements structure, a Teagle-grant supported small scale decentralized curricular redesign effort has also been launched in the context of launching Grand Challenges Scholars Programs (GCSP) under the aegis of the National Academy of Engineering (NAE). This involves pairings of liberal arts and engineering faculty who are working together to revise elements of engineering courses and humanities and arts or social sciences courses. There are several ways to meet this objective to integrate disciplinary content as part of the process of creating a proposal to earn the designation of a Grand Challenge Scholars School by the NAE. Dissemination of the curricular models developed along with related tools and assessment findings will be used for continued improvement.

WPI's project-based emphasis and balanced curriculum (which requires all technical majors to pursue a depth area of interest in the humanities and arts, and experience a modicum of exposure to the social sciences) already provides all of its undergraduate students with a solid basis for considering entry into the Grand Challenge Scholars Program. In addition, WPI offers all of its students a healthy variety of opportunities beyond its formal curriculum (student organizations, clubs, social action events, etc.) to explore their interests in the kinds of issues that naturally emerge from a serious engagement with any one of the Grand Challenges. The proposed WPI GCSP can help us to leverage all of these components together into a more coherent experience that perfectly embodies one of WPI's strategic planning initiatives – to support the fulfillment not only of a Major but also a "Mission" by every undergraduate student. Although there are similarities between WPI's curriculum and the GCSP, the GCSP is different in that it combines several individual elements that you might find on WPI's campus and offers them in a coordinated and strategic way that addresses one of the grand challenges. For example, service learning is not required at WPI but can be found independently within a course or within a club or student service organization. What we propose through the GCSP is service learning in support of exploring one of the grand challenge areas. This reflects a new approach for WPI. Thus, the GCSP provides a framework to plan and reflect upon not only curricular experiences, but also for each student to seek out and coordinate co-curricular component activities which match the GCSP requirements, all the while being mentored by faculty and staff.

The heart of the program focuses on the Grand Challenges of Engineering through the themes of health, energy, sustainability, security, and education. The program's goal is to prepare tomorrow's technical leaders to solve the challenges facing society during the next century. Through completion of the five components of the program, students will have the opportunity to engage in research relating to their selected Grand Challenge, explore interdisciplinary coursework, gain an international perspective, engage in entrepreneurship, and give back to the community through service learning. Once the program is established on campus, WPI may be able to support up to 100 new participants each year. We envision attracting 30-40 students in the first year, and ramping up thereafter until we reach the 100 student goal (which represents less than 10% of our entering class size). WPI has a long history of

blending theory and practice (as exemplified in our institution's motto). WPI has approximately 5,000 undergraduate students, of which 75% are majoring in Engineering or Sciences, and 14 academic departments of which 10 are in Science and Engineering. WPI is consistently ranked among the top tiers of colleges and universities. *The Wall Street Journal/Times Higher Education College Ranking* ranked WPI as first in the nation for combining teaching and research. *The Princeton Review* recognized WPI for having the most popular study abroad program in its 2017 rankings. In 2016, the NAE recognized WPI with the 2016 Bernard M. Gordon Prize for Innovation in Engineering and Technology Education for "The WPI Plan," the university's revolutionary project-based approach to education.

The WPI Plan was launched more than forty years ago to replace the traditional rigidly-prescribed curriculum — typical of conventional engineering education at the time — with a flexible, exciting, and academically challenging program aimed at helping students to learn how to learn. All WPI students complete two major projects in addition to requirements in general education and in their major fields. The Major Qualifying Project (or MQP) challenges students to solve problems typical of those to be encountered in their professional discipline. The Interactive Qualifying Project (or IQP) presents an issue at the intersection of science, technology, and culture, and emphasizes the need to learn about how technology affects societal values and structures. Students also achieve intellectual breadth through degree requirements in the social sciences and humanities and arts. In addition, students achieve some depth within the Humanities and Arts by completing an Inquiry Seminar or Practicum on a theme emerging from a self-selected series of courses.

1.2 Overview of Program Components

The five components of the Grand Challenge Scholars Program are embodied at WPI by integrating our mission and philosophy to prepare the next generation of engineers.

1. **Research experience.** WPI has for the last 42 years incorporated junior and senior research projects as a graduation requirement for all students. The institutional commitment to a project-based curriculum was exemplified by moving from semesters to 7-week terms, to dedicate full time research and study into an independent project manifested by a product and a substantial written report with reflections. Both projects and an undergraduate research experience are elements of the WPI approach. WPI is nationally recognized for its leadership in providing undergraduate students with numerous hands-on and community-based project opportunities, as well as requiring a capstone project research experience in every major. The GCSP at WPI builds upon this fundamental strength by offering Grand Challenge Scholars the chance to strategically integrate their research and project experiences around a particular Grand Challenge, if they so choose.
2. **Interdisciplinary curriculum.** WPI is fully committed to preparing its students to work at the intersection of science, public policy, engineering and business as well as beyond these disciplines to integrate ethics, behavior and social justice. WPI's interdisciplinary curriculum emphasizes the scientific, technical, societal, and humanistic contexts in which knowledge is applied and constructed. The core values that guide WPI's interdisciplinary curriculum include the beliefs that educational activities should challenge students to make connections between disciplines, to consider multiple viewpoints, and to appreciate the consequences of their actions. This is the approach taken in our Great Problems Seminars which are team-taught by pairing an engineer or science faculty with a faculty from social science, business, or the humanities and arts. Additionally, we have created eight course modules integrating STEM with

the humanities and arts and social science content (these modules are discussed in further detail in section 1.3). Through these kinds of commitments and curricular initiatives, WPI has already taken initial steps to cultivate among our undergraduates a basic recognition that multi-disciplinary teams play an important role in real world problem solving. The GCSP takes this another step by supporting individual students who wish to acquire their own repertoire of interdisciplinary skills and to enhance not only their appreciation but their effectiveness in work on cross-disciplinary problem areas. Specific courses that are recommended to complete this component include:

We strongly suggest that students use one of the Great Problem Seminar (GPS) courses to fulfil the interdisciplinary curriculum requirement. The following represents five GPS courses that students can choose from. These courses are examples and are not an exhaustive list. Grand Challenge scholars can identify other courses with the mentorship and guidance of their advisors:

Great Problem Seminar: Heal the World

Starting with the biology of an infectious disease and moving on to the management of disease control, students study the costs of research and regulation required to bring new drugs to market and learn to examine problems with local complexity and global scale.

Great Problem Seminar: Food Sustainability

Students work in teams with the support of faculty (and potentially community sponsors) to research and develop technological, chemical, biological, policy driven, and other types of solutions to help examine factors of chronic hunger, malnutrition, and feeding rising populations across the globe.

Great Problem Seminar: Ignorance is Not Bliss

Should where you grow up and go to school determine how well you do in life? This course examines educational systems around the world and explores how factors like nature and nurture, opportunity and outcome, and the availability of educational technology affect a person's life.

Great Problem Seminar: The World's Water

With a changing climate and growing global population, the availability and sustainability of fresh clean water is in question. In this course, students work in teams to identify

Sarah, a Grand Challenge Scholar of Water

Sarah, an aspiring Environmental Engineering major at WPI, takes The World's Water (a GPS course) in her first term at WPI. She is hooked! Sarah applies to become a Grand Challenge Scholar.

When they meet in the spring, her GCSP faculty mentor points out how to explore and expand her interest in water by spending a term completing her Humanities and Arts requirement in Morocco. Sarah learns about the Moroccan people, Arabic culture, Islam, and the desert environment of that North African country during the fall of her sophomore year.

Equipped with these experiences and her sustained passion about water issues, Sarah is well-positioned to compete for a highly coveted spot at an off-campus Project Center (such as Namibia, Paraguay, or even Santa Fe, NM) to complete her junior year IQP. She and her interdisciplinary project teammates assess and ameliorate a remote village's water supply difficulties.

As a senior Environmental Engineering major, Sarah brings all these rich and varied human and global perspectives on water issues into her MQP (Major Qualifying Project).

a specific water problem and research and develop technological, policy driven, ecological, and other types of solutions.

Great Problem Seminar: Recover, Reuse & Recycle: Building a Lasting World

Focused on material resources and reusing and recycling them, students blend engineering with humanities, collaborate with the NSF Center for Resource Recovery and Recycling (CR3), and work on projects sponsored by leading global corporations.

In addition, students are encouraged to propose to the committee for approval a course that may be particularly appropriate for their specific Grand Challenge.

3. **Entrepreneurship.** WPI is fully committed to preparing students to translate invention to innovation; to develop market ventures that scale to global solutions in the public interest. As an institution we have recently developed a new student entrepreneurship club, new activities around innovation, and new course development. Our recent heavy involvement in the Keen Fellows program now introduces entrepreneurship in multiple classes and in out of class activities. The GCSP provides yet another framework for entrepreneurship and innovation to be cultivated and integrated into the undergraduate experience at WPI. The following represent specific courses that are recommended to complete this component. These courses are examples and are not an exhaustive list. Grand Challenge scholars can identify other courses with the mentorship and guidance of their advisors:

Leadership Practice (BUS 1010)

This course explores how the concepts of creativity, entrepreneurial and critical thinking, emotional and self-awareness, passion, diversity, communication, and ethics inform and affect leadership practice. The course considers a variety of contemporary leadership challenges including how leaders work effectively across cultural, technological, and disciplinary boundaries, how leaders foster new ideas and bring them to fruition, how they communicate effectively and persuasively to diverse stakeholders, and how they make decisions that are both ethical and effective.

Global Environment of Business Decisions (BUS1020)

This course introduces students to the complexity of the global environment and adopts a multi-dimensional view (cultural, economic, social, legal, political, and technological) of world economy. It promotes understanding the global environment as integrative forces affecting the success or failure of today's businesses and fosters a global perspective.

Risk Analysis for Decision Making (BUS 2070)

Financial and operational risks are omnipresent in small entrepreneurial enterprises and in the corporate world. This course introduces students to enterprise risk and prepares them to act in the presence of risk. The course will sensitize students to two significant types of risk (namely, financial and operational risk), provide students with tools for assessing risk and minimizing risk exposure, and prepare students to take risk into account when making decisions as leaders, managers, and individuals.

Creating Value through Innovation (BUS 3010)

This course focuses on the ways value can be created and captured through innovation. Focusing on the assessment of customers, organizational capabilities, and competition, students will consider a variety of different types of innovations and their associated ethical and financial

value propositions. Students will learn analytic tools to successfully assess and commercialize technology, product, and service innovations in a variety of contexts.

Achieving Strategic Effectiveness (BUS 4030)

Every successful business has a strategy for how it provides value and earns profit within its particular industry. Focusing on the contexts of technology, innovation and entrepreneurship, this course develops analytic approaches for assessing the various aspects of strategy such as the competitive environment, the network of stakeholders, ethical implications, investor motivation, operational execution, and financial projections that are necessary to create a complete business plan.

In addition, students are encouraged to propose to the committee for approval a course that may be particularly appropriate for their specific Grand Challenge.

4. **Global dimension.** WPI is fully committed to developing the students' global perspective, which we understand is necessary to address challenges that are inherently global as well as to lead innovation in a global economy. Currently through our First Year Program's Great Problems Seminars, our junior year Interactive Qualifying Projects (which more than 60% of all students now complete at an overseas Project Center), along with our on-campus coursework offered through the International Studies program within the Humanities and Arts, as well as our Interdisciplinary and Global Studies Program (which prepares students for and manages all of the off campus Project Centers), WPI currently provides a multitude of ways to connect science and engineering education to a global challenge. In addition to the Project Centers, WPI offers a limited number of study abroad immersion and exchange programs for select programs of study (for example, an immersion program in Konstanz, Germany for students studying German). These study abroad experiences may be used in lieu of the Global Dimensions requirement. The GCSP offers WPI undergraduate students the chance to integrate another dimension or purposeful learning onto this wealth of global opportunities that they already have. [See sidebar example on this page.] Specific courses that are recommended to complete this component are described below. These courses are examples and are not an exhaustive list. Grand Challenge scholars can identify other courses with the mentorship and guidance of their advisors:

Introduction to International and Global Studies (INTL 1100). An introduction to the main concepts, tools, fields of study, global problems, and cross-cultural perspectives that comprise international and global studies.

Approaches to Global Studies (INTL 2100). This course examines the major theoretical and methodological approaches that characterize global studies. Since the end of the Cold War, new forms of transnational integration, interdependence and conflict have been considered examples of globalization. Yet this period is not the first to undergo such transformation, and the "global" is often experienced in disparate ways around the world. This course examines the diverse ways of understanding globalization in the past and present.

Topics in Global Studies (INTL 2910). This seminar course takes an interdisciplinary approach to historical and contemporary topics in global studies. Topics vary each year and may include international development, global inequality and justice, global public health, war and terrorism, international organizations and governance, humanitarianism and human rights, travel and tourism, the Anthropocene, climate change.

Senior Seminar in International and Global Studies (INTL 4100). This course is designed to integrate each student's international courses, projects, and experiences in a capstone seminar in International and Global Studies. Students will reflect on what they have learned in their previous courses and international experiences. They will assess what happened to them overseas, why it happened, and how it might be understood. They will also prepare a paper with an instructor in their area of International and Global Studies that integrates their previous academic courses.

In addition, students are encouraged to propose to the committee for approval a course that may be particularly appropriate for their specific Grand Challenge.

5. **Service learning.** Developing and deepening students' social consciousness and their motivation to bring their technical expertise to bear on societal problems. Programs such as Engineers Without Borders, or Engineering World Health may be adapted to satisfy this component. In addition, WPI has over 200 different clubs and organizations with a full 100 of them providing a service component.

1.3 Detailed Illustration of Program Components

1. **Research experience.** The research challenges found in our Interactive Qualifying Project and our Major Qualifying Project research program (similar to a senior honors research paper) convey in human and societal terms what engineering and science can contribute to global well-being. All WPI Grand Challenge Scholars will engage in a term long (equivalent to a three course load) research project experience that is connected to one of the NAE Grand Challenges, while utilizing the four major themes of sustainability, security, health, wellness of being (education).
2. **Interdisciplinary curriculum.** Every WPI graduate completes the equivalent of a minor in the Humanities and Arts area by fulfilling a six course sequence, the last portion of which is usually a project experience centered within a chosen depth area of the Humanities and Arts. This is a requirement. During the last decade, additional opportunities for interdisciplinary learning have evolved such as our Great Problems Seminar, minors in Liberal Arts & Engineering, and our intentionally developed IQP projects. Each IQP project must investigate, situate, and address a technical problem in its human, social, political, and cultural contexts. Currently, students simply go through all these graduation requirements, but have no structured way of reflecting upon or lining together the threads of coherence and personal growth that may be happening. The WPI GCSP will be able to take advantage of ongoing institutional investments on e-portfolio software and expertise. Our initial cohort of Grand Challenge Scholars are likely to be among the first WPI students who will enjoy a new advising and documentation infrastructure that consciously encourages planning and periodic reflection opportunities for those students who see the pursuit and study of a coherent Grand Challenge thread to be their "Mission."

The WPI Plan, which began in the 1970s, established the importance of having every student develop some interests and capacities outside of their major (particularly through the Humanities and Arts, and Social Sciences course requirements). Unfortunately, conversations among disciplinary perspectives and experiences that bridge the science/humanities divide have not typically occurred for WPI underclassmen unless they enroll in a GPS course, and so

relatively few students anticipate the high premium on interdisciplinary thinking and teamwork, which undergirds the junior year IQP experience.

In 2014, WPI participated in a Teagle-funded project called “Integrating the Liberal Arts through the Grand Challenge Scholars Program Framework” to address this curricular need. We have used this grant to support the design and implementation of new interdisciplinary course activities which integrate engineering and science content with social science and humanities content, at the local level of regular courses that students might experience within each program. Students in classes whose instructors have participated in this interdisciplinary course development work will have, in effect, another inspiration/entry point to consider becoming Grand Challenge Scholars.

Details on ongoing Teagle grant-funded work and assessment at WPI:

For 2016-17, the initial cohort of Teagle-supported faculty pairs included:

- A Biomedical Engineer and a specialist in Science, Technology, and Policy have developed a module for a Politics of Plague (GOV) course that focuses on scientists’ role in the creation and testing of a new vaccine to treat a sudden, deadly disease. Students will be assigned the role of scientists who serve as advisors to American public officials. They will work in groups to explore the science behind vaccine creation, the laws surrounding drug testing, and the public health policies in place to protect citizens. The module will culminate in each group presenting a prevention and control proposal that addresses these key topics.
- A Philosopher of Religion and a Mechanical Engineer have developed a module for an Introduction to Static Systems course in which students design a cable system to constrain a floating balloon wind turbine. Students have to calculate payback time as well as a social impact score based on the construction locations that they choose on a map. These social regions include animal migration routes, religious burial grounds, private land, etc. This activity allows the students to evaluate the

Jim, a Grand Challenge Scholar of Solar Energy

Jim, a sophomore Management major at WPI, takes Introductory Microeconomics. His instructor teaches a module integrating economics concepts with technical data on rare metals, which he co-developed with an Aerospace Engineer. Jim learns about the GCSP program in passing, and decides he wants to be a Grand Challenge Scholar to explore entrepreneurship around the economics of solar energy.

Jim signs up for the Economics and Entrepreneurship class the next term, and completes a major in-class project on marketing solar batteries. He applies to join the GCSP on the strength of this project.

With the help of his GCSP advisor Jim immediately lines up an internship at the Solar Energy Industries Association (SEIA) in Washington DC the summer before his junior year. He gets himself elected president of the Tech Entrepreneurs club (a WPI student organization) that fall.

As a senior, Jim joins a team of Electrical Engineers whose Major Qualifying Project (MQP) focuses on multi-junction solar cells. For his Management MQP, Jim provides marketing analysis and user-friendly recommendations for their design.

technical and social aspects of developing industrial infrastructure within a community setting.

- The Director of Environmental and Sustainability Studies and a Mechanical Engineer have jointly designed a module to be incorporated into an Introduction to Environmental Studies course and an Introduction to Dynamic Systems course. From the social science perspective, the module will examine the “mechanics” of ideas and how they affect nature-society relations. Why do seemingly good ideas, or technological advances, hit resistance in the social sphere? How can the concepts of force and torque be understood as metaphors for nature-society relations?
- A Systems Engineer and an artist in the Interactive Media & Game Development (IMGD) program have developed a module that will introduce IMGD students to a weapons disarmament systems engineering exercise in relationship to police firearm violence. Another module was created to introduce into an systems engineering course an alternate reality game that incorporates systems engineering exercises into a contained game world

All eight faculty are currently implementing the materials and the activities they co-designed in courses being taught this year. Four more teams are gathering to create eight more modules to test in courses next year. We will begin to measure and document the desirable impacts of these efforts (starting in the summer of 2017):

- At a fundamental human level, inducing such conversations between faculty members from Engineering versus the Arts and Sciences builds respect and constructive relationships.
- Next, the students in the respective classes enjoy the fruits of these collaborations when liberal arts-infused topics are taught in an engineering setting, and when technically-informed topics are taught in humanities and social science courses. That is, the students gain a valuable opportunity to see how real issues in the real world are not typically neatly defined in terms of just one disciplinary approach or another.
- Finally, these interdisciplinary course activities and modules serve as leavening to support and sustain a broader cultural change at WPI toward the fulfillment of our strategic planning’s “Major and a Mission” goal. We want every undergraduate student to fulfill not only a “Major” (acquire disciplinary expertise) but also a “Mission” (some coherent set of interests, skills, or concerns that motivate the student’s education but which cut across the various aspects of curricular and co-curricular activity that comprise the entire undergraduate experience at WPI).

3. **Entrepreneurship.** Over the last two years, WPU has secured a full time intellectual property expert, an Entrepreneur in Residence, and has made available to students an alumni group called TAN (Technology Advisors Network). The TAN activities are designed to help students develop their project ideas that have potential into a viable product. This active group of alumni and friends serve as additional advisors to the GSC. In addition, within the kinds of multidisciplinary project teams that pervade the WPI curriculum, elements of the “entrepreneurial mindset” play an essential role in student success. Real world problems that can be tackled in a rich project experience require that student teams develop and assemble a shared understanding of the material, economic, social and political constraints that prevail in the problem space, and then generate a situation-specific mix of humanistic values, creative possibilities, and analytical approaches in order to produce one or more potential solutions to

the specific challenge they have been presented. This complicated mix of research, communication, imagination, comparative methodological, and assessment behaviors amounts precisely to the same blend of activities and skills applied in open-ended problem situations that are otherwise widely touted as the essence of “innovation, creativity, and entrepreneurship.”

Details on Kern Foundation-funded work and assessment at WPI:

- In its broader strategic efforts to foster the entrepreneurial mindset at WPI, the college has embarked upon an ambitious multiyear effort (supported financially by the Kern Foundation to the tune of more than \$2 million so far). This funding enables dozens and dozens of WPI faculty members to participate in KEEN or other innovation workshops, to develop new “Innovation and Entrepreneurship” (“I and E”) courses and materials, and to stimulate rich conversations across the disciplines and throughout the campus about “value creation” in all its senses (not just monetary).
 - “Stimulating Innovation and Entrepreneurship” was another of the WPI Strategic Planning process initiatives that came out of the new President’s first two years of work (2013-15) and an entirely new wing of the college’s administration has been hired and organized to support ongoing Institutional Research efforts.
 - Tracking and documentation of the impact of the Kern grant falls into the category of high profile investment in “I and E” activities. Institutional Research functions will help to provide assessment data: WPI will surely keep close track of how many faculty undergo the KEEN training, how many undergraduate students experience “I and E”-themed activities in their courses, and, longer term, keep an account of what kinds of longitudinal impact this effort may have on WPI graduates and alumni.
4. **Global dimension.** Every entering student has the opportunity to participate in the Great Problems Seminar, a course which is specifically designed to introduce our students to one or another of the NAE Grand Challenges. Currently, about 25-30% of entering students take advantage of this option. Courses such as *Feed the World*, *Power the World*, *Heal the World*, and *The World’s Water*, are co-taught by a pair of faculty members (one from a technical field and one from either humanities, social sciences, or business). A menu of course titles like these is offered every year. These Great Problems Seminars introduce first year undergraduates to the complexity of global problems, but also help those students to begin to frame tractable aspects of these problems into projects that they can tackle at a more local level.

Our required Junior Year Interactive Qualifying Project (IQP) and the required Senior Year Major Qualifying Project (MQP) may be completed at one of our international or off-campus domestic Project Center sites (shown on the map provided below). These projects build upon the institutional commitment at WPI to provide uniquely intensive experiences in research, teamwork, and integration of engineering, science and the humanities. When a student goes away from campus for 7 weeks to complete one of these intensive 3 course-equivalent project experiences, they fulfill WPI’s gigantic institutional commitment to provide profound and meaningful opportunities to engage in global learning.



All students prepare for these projects by enrolling in a course prior to the experience, which introduces them to the culture, people, language, and history of their destination project site. This course also 1) introduces students to research design, methods for social science research and analysis; 2) provides practice in specific research and field skills using the project topics students have selected in conjunction with sponsoring agencies; and 3) discusses how to develop social science hypotheses based upon literature reviews in the students' topic areas and apply concepts drawn from social psychology, anthropology, sociology, economics and other areas as appropriate. Students make presentations, write an organized project proposal, and develop a communication model for reporting their project findings.

Grand Challenge Scholar applicants are likely to emerge from the first year GPS courses, but they are not required to take one of those. They may just as easily be inspired to apply for the GCSP because of an interdisciplinary liberal arts module they experienced in a first year engineering class, or a technical module experienced in a humanities and arts or social science class. Once a student has been designated a Grand Challenge Scholar candidate, they will have access to a GCSP advisor/mentor, who will help that student to think through the remainder of their undergraduate experience (courses to register for, project experiences to apply to, even clubs and extracurricular activity opportunities to explore) that might enhance the student's particular "mission" interest. For all those that have a significant global component, the GCSP-advised student will be steered not only toward off campus project opportunities, but also to associated coursework in non-major fields that might improve the student's eligibility for those opportunities [see sidebar on page 6]. Additionally, a newly revised minor in International Studies will also be available to all WPI students (including the Grand Challenge Scholars).

5. **Service learning.** The physical location of WPI presents an ideal environment where our students can continue to put the values of community engagement, diversity, and service learning into action. Our urban setting fosters an environment where the city becomes the classroom and academic programs can move beyond the campus buildings and into the

surrounding neighborhoods. Within a short walk of the center of campus one encounters a rich tapestry of art museums, restaurants, and businesses bustling with people speaking dozens of languages, all calling Worcester home. We take seriously our role in improving the community through responsible stewardship of our environment, the people, and culture of our town. This is part of the mission of WPI and as such will be fully integrated into the Grand Challenge Scholars Program.

Most of the junior year Interactive Qualifying Project (IQP) projects entail a substantial service-learning component, since the IQP is primarily intended to situate student work at the threshold where technical capabilities can be applied to address a specific social or community need. WPI's approach to IQPs is consistent with the goals of service learning. The activities are 1) designed to meet the needs of that community and occurs within that community, 2) coordinated between the institution and the community, 3) fosters civic responsibility, 4) is integrated into and enhances the academic curriculum, 5) allows time for students to reflect on the service experience. For example, a team that spends a term in Bangkok, Thailand spends 7 weeks working directly with a team of Thai national university students. Together, this group of WPI and Thai students might assess and redesign math and science instructional materials at a Bangkok elementary school. Alternatively, they might all be sent to some village in the hinterland where electricity infrastructure is so unreliable that some solar power generation capability is desired to enable the villagers to be more connected to government services and the outside world. Working with and for other members of communities around the world, WPI students cannot help but come into a new awareness of the challenges of real world problems. They experience the joys and difficulties of negotiating cultural differences, and learn that "solving problems" is not just an abstract activity that can be done successfully in isolation, but one that requires serious openness to learn about local conditions and respect localized expertise. The outcomes of these projects have real consequences for the real people who are depending on WPI students.

All WPI students participate in this graduation requirement, and the project experience that they each contribute to provides (though clearly there is a wide spectrum here) an often life-changing opportunity to become engaged personally in the challenges and needs of persons or communities. Additional service learning opportunities beckon through various curricular and co-curricular activities, whether through courses being taught in engineering, biology, social sciences, or arts and humanities courses, or through voluntary participation in student-led organizations. GCSP students will be encouraged to record and deliberate upon these various opportunities through the periodic composition of reflective essays that will populate the student's e-portfolio (for more on this tool see Section 3.2).

Incidentally, since not all WPI students go off campus to complete their IQP, the Worcester Project Center organizes project opportunities for WPI students that specifically focus on service to the greater Worcester community. The Worcester Project Center supports 6-10 individual and unique projects each year centering on the local needs of the Worcester community. Our students will have the opportunity to work with the Worcester Project Center to fulfil a service learning experience. Like any other WPI student, a Grand Challenge Scholar might find the perfect IQP opportunity for his or her "mission" area of interest is right here, and that happy circumstance affords an even greater chance for longitudinal involvement in service learning and meaningful follow-up and reflection on the impact of that experience.

2 Grand Challenge Scholars

2.1 Recruitment of Students

As a polytechnic institute, WPI has over 50% of all undergraduates (approximately 5,000) studying in the engineering fields. Additionally, 35% study in science, math or computer science. We aim to provide multiple pathways to allow a diverse group of students to participate in the Grand Challenge Scholars Program. One common pathway into the GCSP will be facilitated through our freshman Great Problems Seminars. The co-directors to the GCS program will make a special invitation to students in the Great Problem Seminar to attend a specific information and sign-up session. The Great Problem Seminars focus on interdisciplinary topics are taught by faculty pairs, with students engaged in team projects and culminates in a research experience. Current topics (2016) include: *Power the World, Heal the World, The World's Water, Feed the World, and Building a Lasting World*. Students can choose to take one of the above courses their freshman year. Each course culminates in a research poster that is presented to the university on a specifically designated all-campus event. Last year, over 500 freshman science and engineering students took at least one of the Great Problem Seminars. We anticipate that GPS alumni will self-select into GCSP as a result of taking these courses because those courses will now include specific discussions, round-tables, debates, or activities that expose students to the GCSP. We expect students to have a good idea as to the particular Grand Challenge they want to focus on after they complete the Great Problem Seminars. The Great Problem Seminars provide students with an opportunity to explore the Grand Challenges in their freshman year. This is not to say that a student's interest won't change later. However, based on experience with WPI students, we believe that most students will have identified a focus by the end of their freshman year. We are open to a scholar changing his or her focus if an opportunity exists and they have the passion to do so.

An alternative route to recruit students is through our sophomore level required humanities and arts capstone project. Project experiences generally take the form of an inquiry seminar organized around a particular theme, or a practicum experience applying some area of arts or humanities-focused skills. Examples of a typical humanities project can therefore range widely in form and content. For example, a student who pursues music as her depth area in the humanities and arts might prepare and perform a solo recital of works; or instead participate in a small group of students writing distinct research papers that examine the intersection of music, culture, and society by focusing on the issues of gender, sexuality, race, and class. By working in a seminar setting those students can share as they explore the interconnected nature between these socio-political issues and music from historical, social, and cross-cultural perspectives. Students interested in health and society issues could pursue philosophy as their depth area to examine contemporary questions of medicine, health care, and ethics: asking what issues medicine addresses or does not, who receives care, how healing takes place, and comparative notions of healers; whereas another approach might be to pursue depth in the history of science in order to examine how and why new knowledge gained through the life sciences may translate into the improvement of public health very slowly, while at other times it suddenly spawns revolutionary medical practices.

A third and alternative route of entry to Grand Challenge Scholars Program could arise through designated course experiences developed by a team from Engineering and the Liberal Arts working together. Eight such course modules have already been developed through the first year of our Teagle grant work.

2.2 Application Process & Selection

Students interested in participating in the Grand Challenge Scholars program will submit an application as early as the end of their second term (halfway through the first year), but no later than 8th term (end of sophomore year). WPI does not have an honors program, however we view those who elect to be in the GCS Program to have both the capacity and commitment that reaches beyond the degree (major and a mission).

According to the Strategic Plan, every WPI student will have the opportunity to fulfill a Major and a Mission. This means not only a degree, but a means of adding value and passion to their degree. Therefore, any student can enter the program throughout their time at WPI but must remain in academic good standing (defined as a GPA of 3.0 or higher) once in the program. Students must also maintain their active engagement in the program's calendar of advising, documentation, and reflections, and pursue appropriate curricular and co-curricular activities in the meanwhile.

To apply students must submit:

- An official transcript
- Response to a short essay question about the Grand Challenge's social and global awareness and diversity. Students will be asked to describe why they want to be a Grand Challenge Scholar and to explain how participating in the GSCP program will enhance their current plan of study. They will also be asked to identify a specific problem they hope to solve and why that issue is of interest to them.
- Identify two endorsers: one from engineering or science and the other from humanities and arts or social science and policy studies departments.

The standard application deadlines are twice a year, January 15th and May 15th. Notification of acceptance will be February 1st and June 1st. Students not accepted will receive prompt feedback and help to remediate their application for the next deadline. Application will be housed in the Dean's offices of Engineering and Arts and Sciences. They will be directed to the program director.

3 Program Administration

3.1 Steering Committee & Leadership

Faculty and Administrators form the Grand Challenge Scholars Program steering committee. The committee will consist of eight members of which two are appointed by the Dean of Arts & Sciences, two from Engineering, and two from the Dean of the School of Business. These members along with the two co-directors will constitute the steering committee. Faculty will have direct oversight of the curriculum, advising, and responsibility for a year end retreat to review past successes and future initiatives. The initial group of faculty will be appointed by GCSP taskforce as they have been working on the program through FY 15 and FY 16. The role of the committee will be to:

1. Create Grand Challenge Scholars information sessions,
2. Collect and screen applications,
3. Maintain the integrity of the program – review e-portfolio on a yearly basis (see below),
4. Identify learning opportunities that support the structure of the GCSP,

5. Review changes in structure due to new course development or new opportunities as they present themselves, and
6. Develop the year end retreat agenda

Co-director appointments will be for 2 year terms (staggered to avoid any disruption of leadership) which can be renewed.

3.2 Mentorship & Support

The GCSP students will each be assigned an advisor who is well-versed in the goals of the program and what is needed to complete the requirements. The advisor will be chosen from our Teagle cohort of faculty who are themselves involved in the transformative activities associated with engineering for the future. WPI will engage in a multifaceted approach to mentorship and support of GSCP advisors. WPI will support advisors to attend the GSCP Annual Meetings in order to network with other advisors. WPI will provide additional institutional support by appointing each GSCP advisor to its Teaching and Learning Center, which is a faculty-led unit that maintains and strengthens instructional effectiveness and student learning by offering programs, services, and resources in the areas of training, development and funding to new and existing faculty. The Teaching and Learning Center also supports innovation in the curriculum and in teaching practice, and fosters campus-wide dialogue on teaching and student learning. Finally, WPI will hold regular meetings with the advisors and academic leadership to discuss progress with the program, troubleshoot any challenges, and to continue to grow the program.

In addition to being provided with an advisor, students will be mentored through regular contact with other students, faculty and administrators. The Dean of Engineering along with the Dean of Arts & Sciences will host three gatherings and networking sessions with the advisors with a focus on one of the Grand Challenge Problems. We will also provide them the opportunity to be one of our first students to use a new e-portfolio and engage in a reflection of e-portfolio material with their advisor. The Electronic Portfolio (e-portfolio) project at WPI is a collection of electronic evidence assembled and managed by a student on the web. The electronic evidence may include input of text, electronic files, images, multi-media, and hyperlinks to projects and written text.

The e-portfolio may include:

- A copy of poster presentation from the Great Problem Seminar.
Each year in December the students present their research project related to the Grand Challenge in poster form. Each participant has an opportunity to talk with the wider faculty about the research presented in an afternoon, university wide event.
- A copy of written text from the humanities project.
An important part of the WPI Plan is the humanities project. This requirement has the goal for every student to graduate with a broader perspective than is provided solely by the study of science & technology. Each student after completion of 5 related courses in humanities in arts is assigned an inquiry seminar that integrates the material into a written synthesis of the material. The written text allows students to reflect on their responsibilities to others in local, national & global communities (goals of Humanities & Arts project).
- Personal Reflection on both the above.

GPS programs will require a written reflection on the Great Problem Seminar & Humanities project (if these are modes of fulfilling the GC Program requirement) into their electronic portfolio.

- Creation of an IDP – Individual Development Plan.
Each GC Scholar will complete with their advisor an individual development plan. An Individual Development Plan is a tool that helps facilitate one’s personal and professional goals. It is a two way communication between student & their advisor. IDPs are often used to drive leadership goals on & off campus as well as thinking about goals for the next few years. There are many different templates available. We have not made a decision on the template we plan to use. This decision will come as the GCS advisors meet at the onset of the program.
- Documentation of activities.
The e-portfolio has the capacity to chronologically display co-curricular activities including events, club sponsored programs and the various organizations & leadership activities of our Grand Challenge Scholar.

3.3 Tracking

As a key part of its strategic plan, WPI has begun the process of investigating and investing in the establishment of an e-portfolio capability. One of the two currently funded Faculty Learning Community groups is focused precisely on “ways of integrating reflection on values, interests, skills, and life/career direction into the student experience, connecting curricular and co-curricular learning; investigate how e-portfolios might be utilized toward that end; and think big about how students make meaning from their WPI experiences.” [2016 Morgan Teaching and Learning Center Teaching Innovation Grants announcement] Over the past year and a half, e-portfolio expert Professor J. Elizabeth Clark (Dept. of English, LaGuardia Community College) has come to WPI for workshops, consultations, and as a partner in our Institute for Project Based Learning, to help us think through how the ePortfolio can be framed as a developmental approach to project based learning or as a capstone signature work product. Faculty have learned about scaffolded, collaborative, and reflective activities at the center of effective ePortfolio pedagogy, and gained her perspective about various ePortfolio models and implementation at a diverse range of campuses.

Beyond the qualitative and reflective eportfolio evaluation, a simple assessment tool to track student advancement through the program will be created. This tracking tool will be part of the e-portfolio of each student.

Student Tracking Check List	
A minimum of one activity must be completed for each component of the GCSP program (Research, Interdisciplinary, Entrepreneurship, and Global Dimensions, and Service Learning) in order for a student to graduate as a GC Scholar. Students may not use the same activity to demonstrate completion for more than one component. This tracking list is monitored and approved by the student’s advisor, and found in their ePortfolio.	
Research	<input type="checkbox"/> Completion Date _____ <div style="text-align: center;">Check All That Apply (minimum of one)</div> <input type="checkbox"/> IQP Date: _____ <input type="checkbox"/> Faculty Sponsored Summer Research Date: _____

	<input type="checkbox"/> Faculty Sponsored Academic Year Research Date: _____ <input type="checkbox"/> Faculty MQP Date: _____ <input type="checkbox"/> Corporate Sponsored Research Date: _____
Interdisciplinary	<input type="checkbox"/> Completion Date _____ <p style="text-align: center;">Check All That Apply (minimum of one)</p> <input type="checkbox"/> Great Problem Seminar List: _____ Date: _____ <input type="checkbox"/> Modules Supported List: _____ Date: _____ by Teagle Team <input type="checkbox"/> IQP Written Report Name: _____ Date: _____ <input type="checkbox"/> Interdisciplinary Minor List: _____ Date: _____
Entrepreneurship	<input type="checkbox"/> Completion Date _____ <p style="text-align: center;">Check All That Apply (minimum of one)</p> <input type="checkbox"/> Course on Entrepreneurship Date: _____ <input type="checkbox"/> Participation in Tech Advisors Date: _____ Shark Tank Network <input type="checkbox"/> Participate in Keen Fellow Program Date: _____ <input type="checkbox"/> Minor in Entrepreneurship Date: _____
Global	<input type="checkbox"/> Completion Date _____ <p style="text-align: center;">Check All That Apply (minimum of one)</p> <input type="checkbox"/> Participate in Global Project Date : _____ Center Activities <input type="checkbox"/> Complete at least one Great Date: _____ Problems Seminar <input type="checkbox"/> List Appropriate Coursework List: _____ <input type="checkbox"/> Participate in <u>Global</u> Project Center Date: _____ <input type="checkbox"/> Study Abroad Immersion Program Date: _____
Service Learning	<input type="checkbox"/> Completion Date _____ <p style="text-align: center;">Check All That Apply (minimum of one)</p> <input type="checkbox"/> Member of Club or Organization Date: _____ with Service Requirements <input type="checkbox"/> Provide Leadership to Community Date: _____ Based Group or NGO <input type="checkbox"/> Lead an Engineers Without Date: _____ Borders Project

3.4 Assessment

A focus of WPI's Teagle grant funds were to support a program of **assessment**. We ultimately evaluate the impact of these interdisciplinary partnerships, and of the experiences that they afford to the participating faculty and students. All pairs of supported faculty provided baseline assessment data prior to the initiation of their collaborations, and will be assessed again before the end of the year. This process is built in the WPI GCSP.

Students will be required to maintain a portfolio that documents their progress through the programs. Each student will be urged to use our new e-portfolio platform. The e-portfolio will become a requirement by FY19. Faculty mentors will have access to the portfolio which includes a variety of learning experiences and activities related directly to the 5 pillars: research, interdisciplinary, entrepreneurship, global dimensions and service learning. The program review committee will review student applications received during the GCSP registration process and work with the Registrar's Office to provide a final GCSP award approval check as part of the degree completion review process. They will also support faculty advisors who support and monitor student progress. The program review committee working with the Registrar will compile the names and accomplishments of students who receive Grand Challenge Scholar designation on their transcripts upon graduation and convey this informational to the national steering committee.

Our Grand Challenge Scholars Program asks students to think about important problems as the motivation for their disciplinary education is at the core of one key part of our new Major with a Mission initiative (part of WPI's strategic plan). WPI faculty advisors will receive orientation regarding the requirements of the GCSP program and will advise students from first to fourth year regarding choices made with respect to projects and courses for those wishing to attain the GCSP designation. A GCSP planning/tracking sheet will be made available to provide guidance to the advising process, and to capture the information and intent needed to complete the GCSP registration form that is used to identify the cohort. The planning/tracking sheet and the GCSP registration form would be included in the student's e-portfolio.

In addition, we document a change management approach by administrating and assessing faculty interactions through the following questionnaire to our engineering and liberal arts teams. In each team, the engineering faculty curriculum designer will receive the following reflective questions before and after course design.

The engineering faculty curriculum design team asked: on a scale 1 (least) to 10 (most highly) rate pre and post the following:

1. I do not know what is comprised in Liberal Arts Curriculum. ____
2. Liberal Arts are best taught as stand-alone discipline and subject manner. ____
3. I am not interested in integrating connections to Engineering in my Liberal Arts courses. ____
4. I have a great respect for the power of Engineering in Liberal Arts courses. ____
5. Liberal Arts should be found only as an extracurricular activity for Engineering students. ____
6. We have on our campus "Engineering Faculty Champions" for the integration of Liberal Arts in Engineering courses. ____

7. We have on our campus “Liberal Arts Faculty” for the integration of Liberal Arts into Engineering courses. ____

The Liberal Arts faculty curricular designer will receive a similar set of reflective questions.

On a scale 1 (least) to 10 (most highly) rate pre and post the following:

1. I do not know what is comprised in an Engineering Curriculum. ____
2. Liberal Arts are best taught as stand-alone discipline and subject manner. ____
3. I am not interested in integrating connections to Engineering in my Liberal Arts courses. ____
4. I have a great respect for the power of Engineering in Liberal Arts courses. ____
5. Liberal Arts should be found only as an extracurricular activity for Engineering students. ____
6. We have on our campus “Engineering Faculty Champions” for the integration of Liberal Arts in Engineering courses. ____
7. We have on our campus “Liberal Arts Faculty” for the integration of Liberal Arts into Engineering courses. ____

3.5 Recognition

Students who successfully complete a WPI project and demonstrate their commitment to solving the challenges for society’s benefit will receive public recognition. WPI currently recognizes award winners for project work. WPI will introduce a new GCSP prize into each project award event, recognizing the execution of work that befits a GCSP scholar. Thus, four GCSP prizes will be awarded in each school year in association with each of the four WPI project recognition events. WPI will place a brief video presentation by each of the above GCSP project students/groups on the WPI website to share the importance with which we hold the principles of the GCSP with our community and with our prospective students.

3.6 Funding & Support

The sustainability and quality of programs is of great importance to WPI, as the values, mission, and objectives of the Grand Challenge Scholars Program is congruent to our strategic plan which emphasizes interdisciplinary work, project work, global initiatives, and the integration of engineering and science with human need. Support for the values of NAE – Grand Challenge Scholars Program is universal at WPI. Specific aspects of our strategic plan and overall philosophy at WPI include: (do) More in Four, Major and a Mission, and Research for all. We support the program director with a stipend plus a course release and support the GCSP advisors with training and networking opportunities. The University makes available to every NAE Grand Challenge Scholar a stipend of \$150 to be used for projects. These funds are available through the Office of Undergraduate Studies by a written request that is supported by the student’s GCS advisor. In addition, students have access to limited funds for travel to GSCP events. These funds will be held with the three Deans who are signatories of this proposal.

Students wishing to study abroad have a variety of funding mechanisms available to them through WPI’s Interdisciplinary and Global Studies Division (IGSD). Through the generosity of its alumni, WPI supports global scholarships each year. The University cannot guarantee that all NAE Global Challenge Scholars

will receive a scholarship. However, last year’s entering class (Class of 2020) received 340 Global Scholarships. IGSD has additional resources to supplement financial aid for students with unmet needs who have been admitted to the Global Program in their sophomore year. Those resources go to about 60 more students. Therefore, roughly 400 members of the junior class receive financial aid to support their participation in the Global Program. WPI’s goal is to add to this volume of aid so that all members of the class entering in 2018 (class of 2022) will have at least \$5,000 to support their participation in the Global Program. Each year WPI matriculates 1,100 entering freshman.

Budget Estimates (Yearly)	
Co-Director Stipend	\$8,000
Director Course Buy Out (0.50 FTE/year, as or if needed)	\$0-\$6,000
Director (or designee) Travel	\$1,000
Project Funds \$150/student @ 100 students, starting at 30-40 students	\$6,000-\$15,000
Stipends for Advisors 3 Major Advisors @ \$1,000 each	\$3,000
Attendance at NAE GSC national meetings/faculty development (8@\$1000 each)	\$8,000
Total Estimated Budget Variance with new needs and scaling up from 100 students to many more.	\$26,000-\$41,000

4 Conclusion

WPI is honored to present our application to be an active, dynamic member of the National Academy of Engineering’s Grand Challenge Scholars program. WPI has set into place the infrastructure to support and sustain the program long term. Each of the three academic Deans are contributors and supporters of our program. Our institutional strategic plan also supports the GCSP as outlined. We aim to educate the future leaders from all disciplines to the National Academy of Engineering Challenges.