Texas Tech University
Grand Challenges Scholars Program
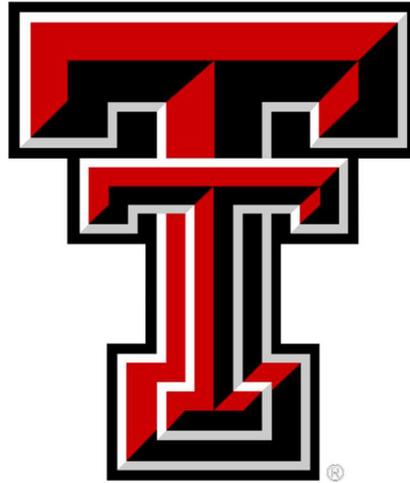
Operational Document
National Academy of Engineering

Al Sacco Jr., Dean, College of Engineering
al.sacco-jr@ttu.edu

Michael San Francisco, Dean, Honors College
michael.sanfrancisco@ttu.edu

Danny Reible, GCSP Director
danny.reible@ttu.edu

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1. Vision and Goals of the Grand Challenges Scholars Program at TTU

1.1 Background of The National Academy's GCSP

Motivated by the National Academy of Engineering's (NAE) 14 Grand Challenges and increasing calls for a new engineering education paradigm, Texas Tech University (TTU) has developed a new education model within the Edward E. Whitacre College of Engineering to prepare engineers to be the leaders of tomorrow. The Grand Challenges Scholars Program (GCSP) will provide eligible students at TTU the opportunity to be a part of a global alumni that bears the distinction of a Grand Challenges Scholar (GC Scholar) by the NAE and universities across the globe. This will indicate their intentional preparation to collaborate and succeed in a transdisciplinary and global environment. The GCSP is a combined curricular, co-curricular, and extra-curricular program with five competencies that are designed to prepare the next generation of students for addressing the 14 Grand Challenges facing society. These 14 Grand Challenges, listed below, constitute a strategic calling for engineers across the world to use their unique strengths and training to make a lasting difference for our global society in the 21st century.

The NAE's 14 Grand Challenges:

1. Advanced Personalized Learning
2. Make Solar Energy Economical
3. Enhance Virtual Reality
4. Reverse-Engineer the Brain
5. Engineer Better Medicines
6. Advance Health Informatics
7. Restore and Improve Urban Infrastructure
8. Secure Cyberspace
9. Provide Access to Clean Water
10. Provide Energy from Fusion
11. Prevent Nuclear Terror
12. Manage the Nitrogen Cycle
13. Develop Carbon Sequestration Methods
14. Engineer the Tools of Scientific Discovery

The fourteen challenges can be sorted into the four different themes:

1. Sustainability
2. Health
3. Security
4. Joy of Living

The details of the GCSP at TTU, described herein, are 3-year outcomes-based program that gives wide flexibility to faculty and students on the best ways of offering appropriate and relevant experiences to prepare students for the road ahead. Texas Tech University, having multiple NAE faculty members, AAAS, AIChE, ASCE, ASME, and IEEE fellows across the breadth of disciplines within engineering, will be uniquely positioned to have a transformative effect on both future engineering professionals and the non-engineers with whom our engineering workforce must engage to successfully address these problems. Initially, the program will be offered to engineering students of the TTU Honors College but may potentially be expanded more broadly to other engineering students and students of other colleges in the future.

Today, the College of Engineering at Texas Tech has more than 4,500 undergraduate students across 11 engineering disciplines with studying abroad in campuses held within 14 different countries. Paired with state-of-the-art research facilities (e.g. The Maddox Engineering Research Center, Texas Tech Innovation Hub, National Wind Institute, The Climate Science Center, Nano Tech Center) Texas Tech aims to make the GCSP a diverse learning experience for engineering students to receive a revolutionary project-based solution to next generation education.

1.2 Overview of Program Components

Each student will choose a specific grand challenge to focus his/her GCSP experience. These can be in the area of one of the 14 Grand Challenges identified by the NAE or in a related area within one of the four themes. In order to complete the GCSP the student will need to expand his/her knowledge and experience in the chosen challenge/theme through the five competencies: research, multidisciplinary learning, business/entrepreneurship, multicultural experience, and

social consciousness. The general requirements and expectations for developing the five competencies include:

- **Research:** Mentored research or project-based experiences related to one of the 14 chosen Grand Challenges to enhance technical competence and creativity by unifying the skills and knowledge the student has acquired from the diverse courses and extracurricular experiences.

- **Multidisciplinary:** Coursework outside of the student's specific engineering discipline to provide him/her with the skills to address the interdisciplinary nature of the Grand Challenges.

- **Business/Entrepreneurship:** Enhance the necessary skills of creativity, ingenuity, teamwork, and communication and understand that viable business models are necessary for successful implementation of a Grand Challenges solution. The Innovation HUB (3.14 below), provides guidance and support.

- **Multicultural:** Special understanding and awareness gained through experience that these Grand Challenges impact populations around the world and require a global mindset when forming a solution.

- **Social Consciousness:** Deepen social consciousness and motivation to address societal problems, often gained through service learning, because serving people is the vision served by the Grand Challenges.

2. Grand Challenges Scholars
2.1 Recruitment of Students

The GCSP at TTU will be open to all undergraduate engineering students, so long as the student has a minimum of 4 semesters remaining in their degree plan. Texas Tech University plans to

provide multiple pathways to allow a diverse group of students participate in the Grand Challenges Scholars Program. Initially, however, the program will be limited to Engineering Honors Students, (approximately 350), to initiate and assess the program effectiveness. The main pathway for students to become acquainted with the program will be by recruiting students from the Honors program although it is envisioned that as the program grows, a course introducing the Grand Challenges and the program may be offered as an elective course to the university (Appendix A). This course will walk the students through the expectations, application process, and each of the 5 competencies within the 14 Grand Challenges. There is no prerequisite for this course, although the student must be in good standing with their major department and have the desire to apply for the GCSP at TTU.

Another pathway for recruitment will be through the *Introduction to Engineering* course that all undergraduate engineers are required to take their first year. The faculty leading the course will be given promotional information about the program and be asked to set aside time to discuss the importance of joining the GCSP at TTU. Various other pathways of exposure will be implemented around the college of engineering to prepare students for the worthwhile experience of becoming a GC Scholar. *RaiderReady* (IS 1100) is a one hour, freshman seminar course designed for students to successfully manage the transition from high school to Texas Tech. Multiple engineering faculty participate in this course and will be given a brochure of the GCSP to promote the course. The Honors College has a First Year experience program and an associated 8-week Responsible Conduct of Research workshop to prepare students for research as well as effectively transition into the university. The university-wide Program in Inquiry and Investigation (Pi^2) also prepares first year freshmen for research and is offered through a series of five broad cohorts. Engineering Ambassadors (EA's) who are representatives of the Whitacre College of Engineering typically communicate with prospective students, give tours of the engineering facilities, speak to civic groups and high school students, as well as assist in the Job Fairs. The Engineering Diplomats represent the interests and policies of the College of Engineering regarding international affairs and connections. Diplomats also assist in promoting and recruiting students for international programs through information sessions, workshops and office hours. Giving the EA's and the Diplomats information about the GCSP will be

instrumental in providing awareness of the program throughout the student body.

2.2 Application Process & Selection

Students interested in participating in the Grand Challenges Scholars Program will apply as early as the end of their 2nd term (end of Freshman year), but no later than the beginning of their 5th term (beginning of Junior year). Interested students will submit an online application through the TTU website that includes;

- A brief essay (no more than 250 words) or short video submission on why the student wishes to join the GCSP and what they hope to accomplish within the program, relevant to one or more of the 14 Grand Challenges
- GPA (minimum GPA of 3.5, required by the Honors College) and Academic Transcript
- Resume
- Identification of the Grand Challenge they wish to pursue within the four themes that will improve life on this planet (Sustainability, Health, Security, and Joy of Living)
- Identification of a faculty GC mentor. This can be a research advisor or other faculty member that can oversee the development and implementation of plans to achieve the five competencies. If a mentor has not been identified at the time of application, the student has 2 semesters to identify a mentor. The mentor should be identified no later than the end of the first semester of the junior year.
- A plan for demonstrating the five competencies that can be updated and revised in cooperation with the faculty mentor or program director

The standard application deadlines are twice a year, November 15th and May 15th and notification of acceptance will be February 1st and July 1st. Applications will be submitted to the Program Director, and accepted students will be given the opportunity to meet with the Program Director to discuss implementation strategies. Students may apply multiple times to the program in hopes to gain admittance at a later date if not selected previously. Students are required to maintain the minimum GPA requirement throughout the remainder of the program to remain a GC Scholar.

3. Program Implementation at Texas Tech

3.1 The 5 Competencies

3.1.1 Research Experience

Research is a vital part of the Grand Challenges Scholars Program. To fulfill the research competency, the GCSP will provide students with the opportunity to conduct original research to increase the GC Scholar's own knowledge relevant to a Grand Challenge. The student will develop a report on their research and present a poster or make an oral presentation to summarize the research and the conclusions or findings. This poster and the report must be included in the student's ePortfolio.

A student can complete his/her research experience with a faculty member, through a research abroad program, or a company sponsored project. To propose a new research project the GC Scholar must submit an abstract to the Program Director and their own GC Mentor providing information on what the student plans to achieve from the research project and how it relates to the GC Scholar's chosen Grand Challenge.

3.1.2 Multidisciplinary Curriculum

The multidisciplinary curriculum complements engineering fundamentals with courses in other fields related to the chosen Grand Challenge topic. Each GC Scholar should demonstrate the connections of engineering to one or more of the areas of business, law, public policy, ethics, human behavior, medicine, and risk. Grand Challenges Scholars in consultation with their GCSP Mentors, will identify interdisciplinary courses most appropriate for their personalized plan. The TTU GCSP requires a minimum of 6 approved credit hours and a minimum 3.5 GPA both overall and within the GCSP courses to fulfill this component. Some of these courses may be offered as Honors Seminars.

3.1.3 Global Awareness

Texas Tech currently requires all undergraduate engineering majors to spend at least 6 weeks in another country to fulfill their study abroad degree requirement. This aims to make students at Texas Tech more culturally aware "world citizens", a skill fundamental to understanding the serious consideration of various issues that are mandatory for all viable Grand Challenges solutions. There are multiple funding opportunities for students to apply for within the Honors College as well as *Raiders Abroad* to ensure all students meet this requirement. The GC Scholar can also overlap multiple components. Within this experience some examples include;

- Research Abroad
  - Linking a study abroad experience with laboratory work or field studies in another country. Many study abroad programs have an independent research component or are structured entirely around an ongoing research project.
- Intern Abroad
  - No matter what your post-graduate plan are, you will benefit by having a variety of experiences to help you develop personally and professionally. Interning abroad is the perfect way to accelerate your career path through exploration of the Grand Challenges and cultivation of new ideas.
- Learn Abroad
  - Texas Tech faculty teach courses in locations around the globe. Students enroll in catalog courses taught specifically for the integration of our GC Scholars to understand the world around them.
- Serve Abroad
  - Service learning links academic study and civic engagement through thoughtfully organized service as a means for students to practice the theory that they are learning in the classroom.

3.1.4 Business/Entrepreneurship

The Business/Entrepreneurship requirement will enable GC Scholars at Texas Tech to gain a deeper insight into how innovation occurs by incorporating the importance of business models. To develop an understanding, gained through experience, that practical business models are necessary for successful implementation for Grand Challenges solutions. A list of possible opportunities is below;

- Approved entrepreneurial experience by GC Director
- Internship with a significant entrepreneurial focus (approved by GC Director)
- Courses (minimum 6 credit hours) which focus on entrepreneurship (Appendix C)
- Receive a Rawls College of Business Undergraduate Certificate
  - Accounting, Energy, Finance, Information Technology, International Business, Leadership, or Joint Business/Engineering Undergraduate Certificate in Technology Entrepreneurship
- Participate in an Entrepreneurial Program at the Innovation HUB
  - Red Raider Startup
  - Red Raider Idea Competition
  - BaseCamp & Rapid Prototyping Lab
  - Young Entrepreneur Academy
  - iLaunch Competition
  - TTU Accelerator & Startup

Texas Tech has many opportunities to help students in the GCSP achieve their full potential. These opportunities will give GC Scholars the ability to take the manifested ideas and understand the necessary steps needed to bring change to the global society.

3.1.5 Social Consciousness

The Grand Challenges affect people all around the world—not just in the United States. The Texas Tech University GCSP will work hand in hand with the Whitacre College of Engineering Outreach and Engagement Program to provide quality opportunities for engagement with

students, teachers and the community. Several examples of programs/activities that will fulfill the social consciousness component are listed below:

- Whitacre College of Engineering (WCOE) Robotics Initiative
  - Get Excited about Robotics (GEAR) for grades K-8
  - Boosting Engineering, Science and Technology (BEST) for grades 6-12
  - FIRST□ Tech Challenge (FTC) for grades 7-12
- Junior Engineer Clubs are provided at no cost to participating schools and allow 5th grade students to explore different fields of engineering
- Enroll in a service learning engineering course
- Hold an executive role within TTU Service organizations. Some organizations are listed below, but not all. Must provide proof of service/participation
  - Engineers Without Borders
  - Society of Hispanic Professional Engineering
  - Society of Women Engineers
  - National Society of Black Engineers

Any other possibilities presented by a student must be approved by the program director.

With the help of the Teaching, Learning and Professional Development Center (TLPDC), the Service Learning Faculty Fellows program fosters a community of scholars who integrate the philosophy, pedagogy, and process of service learning into each component of their professional lives - research, teaching, and service. The fellowship is a viable option that plans to incorporate the role of service learning to all permanent, full-time faculty all while helping the GCSP at TTU gain attention.

3.2 Tracking & Assessment

Each student will be required to create an ePortfolio that will present the student's experience throughout the GCSP. After completing one of the five competencies, the student must create a visual/verbal representation of the experience to add to the ePortfolio. Visual/verbal representations can include:

- PowerPoint
- Paper(s)
- Poster
- Video
- Journal Entries

To gain the official title of a Grand Challenges Scholar, the ePortfolio must be completed in addition to the five competencies. Each competency will have its own section in the ePortfolio. The ePortfolio will be monitored by their respective GC Mentor as well as the Program Director and the steering committee respectively throughout the student's time during the program to ensure the student stays on track. As well, the ePortfolio may be expanded and used to prepare an Honors thesis.

3.3 Steering Committee & Leadership Roles

Within the TTU GCSP there will be a leadership group that will ensure high standards are maintained. Faculty, Administrators, and staff will form the Grand Challenges Scholars Program steering committee. The committee will consist of the GCSP Director and committee representatives appointed by the department head of each engineering major at Texas Tech. There will be a representative from Chemical Engineering, Civil Engineering, Computer Science, Electrical Engineering, Industrial Engineering, Mechanical Engineering, Petroleum Engineering, and one representative appointed by the Dean of the Honors College. Faculty will have direct oversight of the curriculum and advising. The role of the committee will be to;

- Make admission decisions on applications and monitor the GC Scholar's progress (along with GC Mentor)
- Maintain the integrity of the program
- Identify learning opportunities that support the structure of the GCSP
- Review changes in structure due to new course development or new opportunities as they present themselves
- Approve ePortfolio's that successfully integrate the GC Components

Overall, the Steering Committee will advise the GCSP Director on strategy and operation issues to facilitate continuous improvement to the GCSP at Texas Tech University.

3.4 Funding & Support

The sustainability and quality of the programs manifested at Texas Tech to support the GCSP requires interdisciplinary work, project work, global initiatives, and the integration of engineering and science across the college. TTU currently provides a variety of opportunities for the students with training and networking opportunities.

Students can also compete for the opportunity to pursue financial aid through scholarships, fellowships, and grants through the College of Engineering and the Honors College.

To maintain connections with the program TTU will ensure the Program Director, or other faculty representative and/or a student will attend the GCSP annual meeting in Washington D.C. to share best practices and facilitate group discussions.

4. Conclusion

Through the opportunity forged together by the National Academy of Engineers and the leadership role B.L. Ramakrishna has played, Texas Tech University aims to provide a competitive program to help students be the leaders of tomorrow. Through fundamental knowledge taught in the classroom, to becoming world citizens, and understanding the communicative powers needed to take ideas and implement them into the world our school motto rings loudly, "From here, it's possible".

5. Appendix

Appendix A: *Introduction to the Grand Challenges Course Description*

Introduction to the Grand Challenges for Engineering

New 1-hour credit course combining lecture and discussion (2 contact hours per week)

This course satisfies multidisciplinary studies requirements in the GCSP curriculum. The content of the course is designed to adequately address the Social & Behavior Sciences core area.

This course, centered around the Grand Challenges for Engineering in the 21st century, will offer the opportunity for students to develop a truly cross disciplinary appreciation for the grand challenges from a social, global and historical perspective. It will help build a foundation to understand the present challenges facing humanity by discussing the challenges faced by societies across the globe throughout our history over millions of years and particularly over the past 12,000 years. The course will explore how earlier societies addressed (or in some cases, failed to address) the challenges. While history of technology can claim to be basically secular, there are a multitude of forces that guide what technologies are adopted by given society to address the specific challenges they face. The structure of the course is designed such that the undergraduates will develop an in-depth understanding of the intersection of technology and the grand challenges facing society through the lens of the social and behavioral sciences. This approach will illustrate to the students that how societies react to the challenges they face and what technologies are developed and deployed to address them is a product of a complex interaction between history, social systems, global pressures and political vision.

The students will learn about a selected number of the Grand Challenges for Engineering the 21st century through a problem-based learning pedagogical approach. Teams of students will understand analysis of several case studies that have been specially chosen for this class. Faculty from the Edward E. Whitacre College of Engineering who actively engaged in cutting edge research aligned with the Grand Challenges will illuminate students about the state of the art and the enormous opportunities that are presented for future engineers and technologists. Each Challenge presented to the students will emphasize the global and societal important of solving them in addition to the need for technological advances. The students will learn to appreciate how the present priorities of people and governments from different parts of the world depend on their respective historical and cultural aspects. The course will illustrate the necessity to create a global network of engineers and technologists developing synergistic working relationships with

not only each other but also with social scientists and policy makers to adequately solve the world's problems. Issues such as health care, technology transfer, security, education, environmental pollution and water scarcity will take on global and social dimensions. The students will be expected to work in groups to debate and create reports assessing the social consequences of the grand challenges on economic, technological, political, and cultural fabric of society.

The students will engage in debates and discussions on structured controversies regarding topics that have been specifically chosen for this class. The students will learn about Nanoscience and engineering and apply their knowledge to explore the potential of Nanotechnologies as an enabling technology to address many of the grand challenges. The students will also take a critical look at science fiction writing from the 19th and 20th centuries and connect with some of the imagined technologies that have been already realized. Then they will propose their own "science fiction-like" technologies and solutions to the grand challenges.

The course outcomes are;

1.   Gain an appreciation for the challenges faced by humanity throughout history

2.   Get a glimpse of the various grand challenges for engineering as identified by the National Academy of Engineers

3.   Exposure to the cutting-edge research being carried out at Texas Tech University to address these challenges

4.   Appreciate the cultural and societal differences around the world and especially how it influences the use of technology to solve global problems

5.   Use theoretical framework of the social theories of technology to understand how social values play a crucial role in shaping technologies, deploying technologies and how those societal values are influenced by technologies

6.   Understand the economic, political, cultural and societal implications for solving the problems that are global in scope

7.   Learn how to apply their knowledge and experience to a more global and societal setting and to develop their role in addressing future global endeavors

8.   Acquire the skills and knowledge needed to solve complex global problems and compete in the increasingly technological global economy

9.   Develop an individual learning plan based on their own interested and the many opportunities available at TTU

10. Learn how to manage technology to solve global problems in a sustainable way

Appendix B: *List of Sample Multidisciplinary Courses*

Related to the Four Themes

Sample Sustainability Courses:

BIOL 1305 and 1113: Ecological and Environmental Problems

BIOL 3309 and 3109: Principles of Ecology

BIOL 3301: Field Ecology

ECO 3336: Environmental Economics

ENGR 1301: Engineering Design for Sustainability

ATMO 2301: Weather, Climate, and Human Activities

ATMO 2316: Severe and Hazardous Weather

GEOG 3301: Remote Sensing of the Environment

GEOG 3310: Environmental Change

GEOG 3353: Man, Resources, and Environment

GEOL 3328: Geology of Energy Resources

PUAD 3300: Environmental Politics and Policy

PUAD 3300: Sustainability: Energy, Environment, and Society

PUAD 3300: Energy Politics and Law

AAEC 4309: Sustaining Global Ecology, Natural Resources, and Economy

AAEC 4313: Natural Resource Economics

NRM 4320: Natural Resource Policy ENCO

3301: Energy Industry Fundamentals

Sample Health Courses:

COMS 3365: Communication in Healthcare

HDFS 2303: Life Span Human Development

HLTH 3301: Epidemiology

HLTH 3311: Communicable and Chronic Diseases

KIN 4301: Introduction to Biomechanics

ANTH 2300: Physical Anthropology

NS 1410: Science of Nutrition

ADRS 2310: Understanding Alcohol, Drugs, and Addictive Behaviors

Sample Security Courses:

AAEC 4309: Sustaining Global Ecology, Natural Resources and Economy

AGED 2304: Agriculture and Society

ARAB 3305: Introduction to Arab-Muslim Civilization

IE 4381: Introduction to Critical Infrastructure

CS 3375: Computer Architecture

ECE 4325: Telecommunication Networks

IE 4382: Cybersecurity for Information Systems

IE 4383: Industrial and Networked Control Systems

IE 4384: Security for Systems and Software

IE 4385: Cyber Attacks

Sample Joy of Living Courses:

PHIL 2330: Science and Society

PFI 1305: Life, Love, and Money

ANTH 2302: Introduction to World Cultures and Ethnology

ARCH 1311: Design, Environment, and Society

COMS 1301: Interpersonal Communication

EDCI 2301: The Education Effect: Why American K-12 Education Really Matters

EPSY 2301: iGeneration: Living and Learning on the Internet

HRDV 2303: Diversity and Cultural Competence in the Workplace

KIN 2300: Science of a Healthy Lifestyle

HLTH 1300: Patterns of Healthful Living

PHYS 1402: Physics of Living Matter

Appendix C: *List of Sample Entrepreneurial Courses*

Sample Entrepreneurial Courses:

BECO 4376: Austrian Economics

CHE 4392: Entrepreneurship for Chemical Engineers

EDHE 5305: Leadership, Entrepreneurship, and Change

HIST 4324: History of Capitalism

MCOM 4325: Media Entrepreneurship

MGT 3375: Entrepreneurship: New Value Creation

MGT 3390: Perspectives on Entrepreneurship

MGT 4374: International Entrepreneurship

MGT 4376: Entrepreneurship: Discovering Entrepreneurial Opportunities

MGT 4386: Entrepreneurship: New Venture Creation

RHIM 4320: Hospitality Entrepreneurship

RTL 4340: Entrepreneurship: Retail Business Planning