

## **Reviewing the Current State of Grand Challenge Scholars Programs Across the United States**

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# Reviewing the Current State of Grand Challenge Scholars Programs Across the United States

## Abstract

In 2008, the National Academy of Engineering (NAE) identified the Grand Challenges for Engineering in the 21<sup>st</sup> Century representing the fourteen most pressing issues facing modern society requiring engineering innovation. To equip the next generation of engineers with the tools to address these challenges and create global sustainable solutions, engineering education must expose students to these Grand Challenges during their undergraduate studies. More than 120 engineering schools across the country have committed to producing at least twenty students specifically equipped to tackle these challenges through the NAE's Grand Challenge Scholars Program (GCSP). The GCSP aims to progress undergraduate engineering around global issues rather than isolated disciplines and help students in the program develop skills in five components: Research Experience, Interdisciplinary Curriculum, Entrepreneurship, Global Dimension, and Service-Learning.

To date, there are no specified requirements for each of the program components; students attaining the NAE Grand Challenge Scholar designation can achieve this recognition in a variety of ways based on the institution's requirements. For example, at one institution students are required to have industry experience outside the United States for Global Dimension, while at other institutions students are required to study abroad or take cross-cultural courses. In an effort to understand the variation between the thirty-five active GCSPs and corresponding variant student capabilities, each institution's program and student requirements were analyzed via information provided on the NAE GCSP website and available from individual institutions' websites. In this paper, the authors highlight the range of experiences and immersion required for each program component and detail unique and innovative practices. Ultimately, the goal of this work is to track similarities and differences between Grand Challenge Scholars Programs and drive towards a more thorough understanding of student-learning outcomes and experiences.

## Introduction

### *History of the NAE Grand Challenges*

In 2008 the National Academy of Engineers (NAE) identified fourteen Grand Challenges as the most pressing issues requiring engineering innovation that face 21<sup>st</sup> century society. These challenges range from providing access to clean water to securing cyberspace to reverse-engineering the brain [1]. Grand Challenges are complex issues that require engineers and scientists from across disciplines as well as experts in the areas of economics, public policy, and others. Grand Challenges critically address quality of human life and sustainability but also serve as a challenge to engineers and society by bringing disciplines together to craft the solution. In 2015, over one hundred twenty schools had written letters of commitment to President Obama, pledging to produce engineers who were well equipped to tackle these Grand Challenges [2].

## Grand Challenge Scholars Program

The Grand Challenge Scholars Program (GCSP) formed to meet the needs of schools committed to educating engineers trained to tackle these challenges in their future careers. Since its inception, universities have been free to create their own versions of the program. The original GCSP included Duke's Pratt School of Engineering, The Franklin W. Olin College of Engineering, and the University of Southern California's Viterbi School of Engineering [3-5]. There are currently thirty-five active Grand Challenge Scholars Programs across the United States. Given the flexibility of the program, the composition can vary widely from university to university. At some institutions it is open to students in engineering and non-engineering majors, providing the opportunity for additional, non-engineering perspectives on the challenges and potential solutions.

The GCSP is comprised of five competencies: research, interdisciplinary curriculum, entrepreneurship, global dimension, and service learning (Figure 1). The first Grand Challenge competency, hands on project/research, involves completion of some experience in a research setting related to the scholar's challenge. This could include laboratory work, collection of data or surveys, investigations into potential solutions for their Grand Challenge, etc. The second competency is interdisciplinary curriculum, wherein the student is encouraged to take courses outside of their specific discipline. Entrepreneurship, the third competency, aims to develop student's skills in working with investors, business plans, and market analyses that are just as crucial as the engineering technical solution. The GCSP Global dimension, the fourth competency, aims to develop students' global perspectives and assist in their understanding of the global and complex nature of today's engineering systems. Finally, the fifth competency is service learning, which encourages a sense of civic responsibility in students, promoting the use of engineering knowledge for the greater good as well as inspiring the mentorship of less experienced engineers.

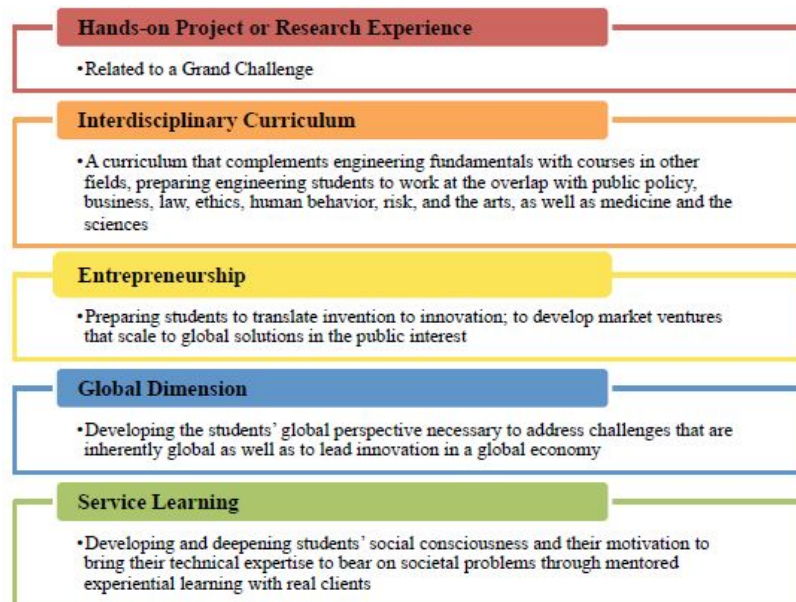


Figure 1. Grand Challenge Scholars Program Competency Summary [6]

## *Current State of the Grand Challenge Scholars Program*

It is common for GCSP students to select one of the fourteen Grand Challenges as their focus and tailor their academic and extracurricular activities around developing the skills needed to work on engineering projects involving this challenge. The GCSP was set up by the NAE such that each school is allowed to develop its own student and program expectations. Therefore, each program has developed primarily according to its own desires and objectives, resulting in lack of uniformity among programs. Since the GCSP has many variations across institutions (and the program can even vary among students within an institution, depending on the requirements of the school), it is important to review the state of the GCSP among institutions across the nation in order to assess the success of the program and predict future progress. This paper summarizes variations among programs, highlights some of the more unique features in particular programs, and outlines potential areas for future research.

## Methods

The authors utilized two sources of information to compile data from the Grand Challenge Scholars Program across the United States: National Academy of Engineering website and academic institutions' websites [7]. We performed an initial search on the NAE website to collect letters of commitment detailing specific program and student requirements. This led us to direct links to each institution's GCSP webpage. When information was not accessible on NAE website or there where no direct links provided, we utilized Google search engine by typing in 'School Name' Grand Challenge Scholars Program' and documenting GCSP information from this way. We organized data in a spreadsheet divided into the five GCSP competencies and analyzed similarities and differences between programs.

## Results

The NAE has not yet specified requirements for GCS programs or scholars, which allows for a large amount of variation among approved programs in the United States. The rigor of the program, strictness of the requirements, manner of the deliverables, and number of scholars varies widely between programs. We discuss similarities and differences between programs in the sections that follow and present these results in Table 1.

### *Commonalities Among GCS Programs*

There are some commonalities among all programs. Scholars at all programs are exposed to a slew of unique and worthwhile benefits. The program provides a chance to network with professors, professionals, and peers. It allows scholars to pursue their own engineering interests while working towards a healthier, more sustainable, happier society. It exposes scholars to research, business, and nonprofit communities. This enables scholars to begin to consider where they would like to work after their graduation. It also provides scholars with leadership opportunities within the program, through their service-learning projects, in the laboratory, and among their peers. As discussed previously, there are often funding sources and opportunities for students to find research experiences, cooperative education programs, or internships through the

GCSP. The program also awards students with the prestigious title of Grand Challenge Scholar, which they will be able to carry with them throughout their professional career.

### *Levels of Engagement*

Seven programs include built-in levels of engagement, which allow the participating scholars to select the amount of time and effort they will input into the program. For these programs, scholars must complete the highest level of engagement for at least one competency; other competencies may be completed at lower levels of engagement. Duke University's program requires students to complete "In Depth Experiences" for the Research and Interdisciplinary curriculum components, logging at least four hundred hours in each category [3]. The University of Maryland- Baltimore County's (UMBC) system consists of tiers: Gold experience (six or more credit hours of an activity), Silver experience (three credit hours), and Bronze experience (one credit hour). This program requires students to have at least one Gold and no more than two Bronze experiences [8].

The University of Utah's program requires that scholars complete predetermined activities that will account for "depth" for one and "breadth" for two of the competencies [9]. The University of Iowa has two engagement systems built into the program. First, any undergraduate may apply to be either a Fellow or a Scholar [10]. A Fellow agrees to pursue three of the five competencies while scholars must pursue all five. Within the competencies, scholars may achieve low, medium, or high engagement as defined by the program. Lafayette College allows students to take a "shallow dive" into the Grand Challenge curriculum or become a full scholar [11]. The Ohio State University's program requires students to have in-depth, immersive experiences for two of the five competencies and medium engagement for two of the five [12]. The final component may be completed at minimum depth. Similarly, the University of Tennessee's program requires one competency at an extensive level, two at an intermediate, and two at an introductory [13].

### *Grand Challenge Course*

Six of the institutions with approved programs provide a Grand Challenge-specific course that students must complete in order to earn the designation of scholar. Arizona State University requires a Perspective on Grand Challenges for Engineering course to begin fulfilling the Interdisciplinary Curriculum component [14]. UMBC requires three one-credit hour seminars while North Dakota State University requires a single seminar [8, 15]. Georgia Institute of Technology requires student to complete a three hour course during each of their first two semesters [16]. In addition, Miami University has a zero-credit hour course entitled Grand Challenge Scholars Experience, which has requirements such as attending seminars, presentations of other Scholar's research, and completion of reflections and progress reports [17]. Lafayette College has scholars enroll in a quarter hour credit class during each semester they are working on their research competency [11]. The University of Toronto, while outside of the United States, is part of NAE GCSP and requires a Grand Challenge specific course for the Interdisciplinary Curriculum component called the Interdisciplinary Approach to Addressing the Grand Challenges [18].

### *Required Courses*

While all programs require some coursework in order to complete the program, partially due to curriculum component, some schools require scholars take specific courses. Beyond Grand Challenge-specific courses, some programs require non-Grand Challenge coursework for all scholars. Arizona State University requires FSE 301: Entrepreneurship and Value Creation for a scholar's entrepreneurship component [14]. Clemson University requires one credit hour of coursework in research principles, which is administered by the scholars' department (depending on their engineering discipline) [19]. James Madison University requires a four-semester capstone design course to complete the research competency[20]. Louisiana Tech University has a select list of classes which may be taken in order to complete the Interdisciplinary Curriculum [21]. The University of Tennessee requires EF 357 Introduction to Entrepreneurship for entrepreneurship and UH 267 Service Learning for the service-learning component [13].

### *Portfolios*

Many schools require the completion of a portfolio or a reflection for either a single competency or summarizing their entire GCSP experience in order to complete their curriculum. For example, while most programs allow publications based on their research to fulfill the scholar's research competency, Clemson University, Florida Gulf Coast University, North Carolina State University, Lafayette College, and UMBC have specific requirements for the form a scholar's paper must take or a specific symposium a Scholar must present at [8, 11, 19, 22, 23]. Scholars at the Franklin W. Olin College of Engineering must complete an in-depth reflection examining their interdisciplinary curriculum courses and how they have furthered their ability to solve their chosen Grand Challenge [4]. Programs such as Arizona State University, Duke University, and the University of Tennessee (among others) require a comprehensive Grand Challenge portfolio [3, 13, 14]. Several other schools have similar requirements, as seen in Table 1.

### *Required Number of Service Hours*

Most programs allow scholars to complete their service-learning competency by taking lead on a service project, working with a service organization, or serving alongside other scholars. However, some schools have a specific number of required hours. Arizona State University sets the minimum number of hours at eighty while Clemson University requires scholars to have thirty hours of documented service-learning [14, 19]. Georgia Institute of Technology does not set a specific number of hours but requires all scholars to work together on a mandatory service project each semester [16].

### *Incoming Freshman Eligibility*

A select number of schools allow first-semester students to participate in the program. These schools include Arizona State University, Georgia Institute of Technology, and the University of Utah [9, 14, 16].

### *Sources of Funding*

Some programs offer scholars the opportunity to apply for funding for educational or professional opportunities. Arizona State University scholars may apply for a GCSP Research Stipend, which includes one semester of funding at \$1,600 [14]. ASU scholars may also apply for the Experiential Learning Grant, which awards up to \$800 for domestic experiences and \$1,500 for International Experiences [14]. Bucknell University makes an effort to reduce the costs of service-learning and global dimension experiences for students who are on financial aid [24]. Scholars at Duke University can apply for up to \$5,000 to fund the completion of their GCSP e-portfolio and the experiences required to complete the program [3]. At Lafayette College, scholars may be paid through the GCSP as long as they are not registered for the GC research course at the same time [11].

Scholars at North Carolina State University must complete a budget (up to \$2,500 in expenses) before joining the program [23]. The students can apply for funding for their research or travel to Grand Challenge-related conferences or summits. Scholars at the University of Iowa are eligible for financial support from the James R. Whiteley Grand Challenges Scholars Fund [10]. Scholars may apply for help to cover the costs of experiences used to fulfill the competencies as well as renewable scholarships supported by the fund. The University of North Dakota awards each Scholar \$500 per semester as well as research grants, business development grants, work and study abroad fellowships, and service learning grants. The University of Southern California does not select scholars until they have completed all five competencies and are nearing graduation [5]. Therefore the designation of scholar from this institution is very competitive and students who are selected are given a cash award.

### *Eligibility*

At The Franklin W. Olin College of Engineering, all students are eligible for the program [4]. There is no rejection from the program and all students are encouraged to take part in all five competencies. However, at the University of Utah and the University of Southern California, students cannot apply for the GCSP until they have completed the requirements for all five competencies [5, 9]. At University of Southern California, in particular, this is a highly competitive process, with some students not achieving the rank of scholar despite achieving all five competencies. There is also a wide variation in the required class standing of students applying for the program. Some programs accept incoming freshmen while others specify that a student must be a sophomore or junior. At Clemson University, for example, juniors cannot apply unless they have demonstrated significant progress towards the competencies [19].

### *Living in Residence and other Exceptional Requirements*

Georgia Institute of Technology's GCSP program requires that scholars live their freshman year in the Howell Residence Hall with over a hundred other scholars [16]. Additionally, they must attend mandatory retreats, pay a \$400 semester fee, and participate in a required service project. The Colorado School of Mines program also requires that students live in the Grand Challenge Scholars living-learning community on campus [25]. Some programs do not require scholars to live in a particular residence hall but allow scholars to use living-learning communities as

methods of fulfilling specific competencies. UMBC scholars who live in the Shriver Center Living Learning community can fulfill their service learning requirements in this fashion [8]. Duke University and University of Tennessee scholars are required to spend time working or studying abroad to fill their global dimension component [3, 13].

### *Benefits of Diversity versus Creation of a More Unified Program*

There are benefits to allowing programs to develop without additional structure. Each institution can design the program around the school's strengths and scholars can pursue their Grand Challenge Scholar distinction according to what they are most interested in. This diversity of program creates a wide range of potential experiences for scholars, which may aid engineering innovation post-graduation. Additionally, keeping a minimum amount of strict requirements may enable more schools to adopt the program which will in turn create more engineers who are uniquely suited to address the Grand Challenges.

However, there are drawbacks in having a program with minimal foundational requirements. The prestige of the Grand Challenge Scholar distinction varies between institutions and it is possible that some programs are not creating engineers who are prepared to address these major societal issues. Additionally, it is hard to gauge the overall success or productivity of the national program without a means of assessment. Development of any assessment tool would enable analysis of professional skills or attributes of a Grand Challenge Scholar and would allow for comparison of programs.

### Summary

While more than one hundred and twenty schools pledged to participate there are thirty-five active Grand Challenge Scholars Programs (GCSP) across the country. Of those programs, to be admitted, one requires an entry fee, three allow incoming freshman, and one allows all students. Within the program six institutions require a Grand Challenge-specific course with five institutions require a course, thirteen require portfolio, four require service hours, and two have a required study. Seven GCSPs distinguish themselves by levels of engagement, eight support students with some funding, two provide residence hall for scholars, one requires scholars attend a retreat and two institutions do not award title of scholar until completion of project. This large variation warrants further research into scholars produced from each program.

### Future Work & Recommendations

It is important that scholars are receiving adequate preparation to tackle modern global issues while simultaneously understanding the social, economic, environmental, ethical, and technical issues underlying these challenges. Future research will examine factors that encourage or dissuade undergraduate students from joining the program. For example, specific Grand Challenge Scholars Programs may deter students as a result of entry fees, money required to complete global dimension or service learning components, or requirements to attend retreats or live in certain residence halls. Additionally, some programs engage non-engineering majors and first year students while others do not, which may impact the program outcomes.



Engineers are entering industry, consulting, academia, government, law, business, and other diverse fields. Studying the extent to which the Grand Challenge Scholars Program can prepare students for each of these fields, each of which has an important role in solving the Grand Challenges, could help inform programs for adequate preparation of scholars for their future roles. This can be achieved by surveying past scholars, following the progress of graduated scholars post-baccalaureate, and interviewing faculty and employers involved with each scholar. Studying the program variations themselves and their effects on scholar's success is vital to provide recommendations for further program requirements.

Non-GCSP programs may be useful for developing a framework to evaluate scholar experiences and preparedness. For example, many universities require students to create exit portfolios to showcase what they have learned in their years at school. Since there are many more graduating seniors than graduating scholars per year, this would provide a larger sample size to work with when determining if an exit portfolio is beneficial. The same technique can be applied to undergraduate clubs or organizations with dues or fees, to determine if this dissuades high-achieving students from participating or ensures that students remain engaged in the program over time.



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