

## **WIP: A Qualitative Analysis of Students' Emerging Understanding of Becoming a Grand Challenge Scholar-Engineer**

**Amy Trowbridge, Arizona State University**

Amy Trowbridge is a Lecturer and Director of the Grand Challenge Scholars Program in the Ira A. Fulton Schools of Engineering at Arizona State University. Her teaching focuses primarily on first year engineering students, and she is interested in curricular and co-curricular experiences that broaden students' perspectives and enhance learning.

**Dr. Tirupalavanam G. Ganesh, Arizona State University**

Tirupalavanam G. Ganesh is Assistant Dean of Engineering Education at Arizona State University's Ira A. Fulton Schools of Engineering. He is Associate Research Professor in the School for Engineering of Matter, Transport, & Energy. He has bachelors and masters degrees in Computer Science and Engineering and a Ph.D. in Curriculum and Instruction. His research interests include educational research methods, communication of research, and k-16+ engineering education. Ganesh's research is largely focused on studying the impact of k-12 and undergraduate curricula, and teaching-learning processes in both the formal and informal settings.

**Diana Karen Chen, Arizona State University**

Diana is a current undergraduate Computer Science student attending Arizona State University with special interests and focus on advancing education through the advancement and innovation of technology.

**Jorge Luis Roldan**

# **Work in Progress: A qualitative analysis of students' emerging understanding of becoming a Grand Challenge Scholar-Engineer**

## **Context**

The National Academy of Engineering (NAE) Grand Challenge Scholars Program (GCSP) has been implemented at Arizona State University (ASU) and over 30 other engineering schools as an effort to prepare future engineering leaders who can collaborate and succeed in a global, transdisciplinary environment<sup>[1,2]</sup>. The GCSP aims to prepare future engineers through a combination of curricular and co-curricular experiences in five component areas: research, interdisciplinary curricula, entrepreneurship, global experience, and application of engineering to meet social needs. Each student chooses her own unique set of experiences, to achieve the distinction of Grand Challenge Scholar, endorsed by both the university and the NAE. A majority of the experiences must also be aligned with the Grand Challenge(s) they have chosen to dedicate their efforts toward solving. At ASU, students choose one of five grand challenge theme areas (Education, Energy, Health, Security, Sustainability) or one of the 14 NAE Grand Challenges<sup>[2]</sup>. Students are admitted to the GCSP as freshmen, and most start work on the program requirements in their first semester. Prior to starting their first semester classes, 25% of students attend a week long residential summer institute aimed at introducing the GCSP at the university. Students enroll in a semester long multidisciplinary course in their first semester to explore the grand challenges and to develop a plan to meet program requirements. The summer institute and introductory course provide students an opportunity to connect with their peers and near peers who have made progress in the GCSP and begin building a community of scholars. Subsequently, students choose their own path through the program completing courses and experiences relevant to their Grand Challenge theme. Requirements include at least two semesters of research, 80 hours of service learning, and coursework combined with experience(s) in global, interdisciplinary, and entrepreneurship subject areas. Students are expected to document and reflect on their work in their portfolios as they complete the experiences. Upon completion of GCSP, students must submit their completed portfolio before they graduate.

Although several universities have active programs with GCSP graduates, there is no published work focused on understanding the impact that the GCSP experience has on student development as engineers. Dancz et al. published a first attempt at developing a rubric to assess the outcomes for the five GCSP components, but it was not applied to GCSP; its use was limited to the assessment of student outcomes in a specific sustainability course<sup>[3]</sup>. Our work aims to understand how participation influences development as a Grand Challenge Scholar-Engineer.

## **Research Aims/Question**

This exploratory research effort aims to understand how participation in the NAE GCSP impacts student development as engineers. Specifically, this study will focus on the following research question: *How do students understand and describe their experiences in the GCSP?*

## **Conceptual Framework**

The development process that students' experience to become engineers is a complicated one, which can be influenced by many different internal and external factors. Stevens et al. described becoming an engineer as a three-dimensional process which includes developing accountable disciplinary knowledge, forming a professional identity as an engineer, and navigating through

engineering education<sup>[4]</sup>. This model developed by Stevens et al is applied in this work as a useful framework for beginning to understand how participation in GCSP contributes to students' development as engineers. We agree with Stevens et al and Turns et al that these three dimensions (disciplinary knowledge, identity, and navigation) are a good model for the main components of becoming an engineer <sup>[4,5]</sup>. Furthermore, these ideas are interconnected thereby offering us the means to describe student development as a Grand Challenge Scholar-Engineer. This framework provides a useful means of making sense of students' curricular and co-curricular experiences. We think that the GCSP, which can be viewed as a distinct set of experiences that a student completes during her education, fits well with the components and ideas of this framework. Applying ideas from Stevens et al, students' experience in the GCSP could be described as a combination of both official and unofficial routes they take through their education in the process of becoming engineers<sup>[4]</sup>. Disciplinary knowledge, identity formation, and navigation will be applied in this work as an initial framework to use to make sense of students' understanding of their experiences in the GCSP as described in their portfolios. As we make progress, we aim to identify additional dimensions and describe how they are characterized in the data corpus in the context of becoming a Grand Challenge Scholar-Engineer.

## **Methods**

Data Collection: Data were collected using document analysis and semi-structured interviews. Participants' portfolios were reviewed in their original form, either as a written document or as a digital portfolio containing written content. Each portfolio analyzed in this study contained a description of all or most of the GCSP experiences. For each component of the program, the portfolio asks students to describe what they did, what they learned, how it relates to their Grand Challenge theme, and the value of the experience to them in terms of their career. The semi-structured interviews were 60-90 minutes long, and focused on the participants' experiences in the GCSP. In the interviews, students were asked to discuss how and why they joined the program, describe their experiences, and what they have learned from those experiences.

Data Sources: There were 9 participants in this study—2 alumni, 6 seniors, and 1 junior. All participants have completed the GCSP requirements and have described most of their experiences in their final portfolios. The primary data source was the portfolios which described their GCSP experiences. Semi-structured interviews were conducted with 3 of the current students who will be graduating this semester. In the future, we will conduct additional interviews using the portfolios for artifact elicitation to gain further insights into the meanings their chosen GCSP experiences hold for them as they navigated the process of becoming a Grand Challenge Scholar-Engineer.

Data Analysis: Open and axial coding methods were applied to analyze the data collected to explore how students describe and understand their experiences in the GCSP<sup>[6]</sup>. Open coding began with three broad categories drawn from the framework developed by Stevens et al: 1) disciplinary knowledge; 2) identity formation; 3) navigation<sup>[4]</sup>. We labeled portions of the data record with likely concepts suggested by these three categories, and prepared notes/memos describing our thoughts about key elements identified in the data record. Once this process was completed, we compared the data record, labels, and memos and discussed our findings to search for crosscutting concepts to complete axial coding. At this point in this work in progress, we are continuing with the process of axial coding, identifying common themes across the dataset.

## **Data and Interpretation**

Excerpts from data and our initial interpretations are summarized below, and are organized based on our conceptual framework.

***Disciplinary Knowledge:*** Participants' experiences, particularly in research, allowed them to gain additional disciplinary knowledge beyond what they learned in the classroom.

Excerpt 1: "One of the most challenging aspects of joining this [research] lab is that I initially did not have a strong background in biology. However, I was able to educate myself in this discipline primarily due to my high interest in the subject. ... Working with him I learned how to use Solidworks, which we used to design the bioreactor... [S]hadowing graduate students in the lab [I] learned about microfluidics and biomaterials."

Excerpt 2: "Research is taking knowledge you learn in the classroom and creating new techniques that may or may not work in practice. It is the type of iterative and critical-thinking work that put my technical skills into a higher level. I began to realize that the answers aren't in the books or formulas, but how I was able to develop possible ideas to explain why something occurred."

Students mentioned a variety of additional skills they gained which they felt were valuable to engineers, thus possibly adding to the realm of disciplinary knowledge. For instance, participants mentioned the value of specific skills they learned such as the abilities to communicate to different types of people, and to recognize societal needs and impact.

***Navigation:*** Across all participants, it was clear that GCSP has a large impact on students' navigation of becoming an engineer. Participants described how the GCSP encouraged them to go beyond the typical engineering path, pursuing other 'unofficial' paths to become more well-rounded engineers.

Excerpt 3: "The GCSP has broadened my education in ways a traditional engineering degree could never do." This student was inspired by his initial GCSP course to begin doing research on DNA nanotechnology in his freshman year. An entrepreneurship course he took inspired him to participate in an entrepreneurship focused study abroad experience in the "Startup Nation" (Israel). He also took courses on global health and medical anthropology, and mentored students through an AmeriCorps education program.

There were also several instances in which it could be seen that navigation may lead to identity formation. When a participant pursues certain opportunities, it leads them to find their interests and become more aware of what they can be and do as engineers.

Excerpt 4: "The GCSP has allowed me to branch out beyond the normal engineering curriculum. Through the program, I am given the opportunity to build a unique path to becoming an engineer I, one day, hope to become." The unique path that this student referred to includes doing research to develop a mapping system to minimize pressure ulcers, completing courses on global health and business concepts applied to engineering, and worked on a variety of projects in social entrepreneurship including designing a solar energy system to support refrigerated enzyme storage in Nigeria, educational outreach to encourage interest in STEM fields, and designing a prosthetic terminal to enable amputees to play lacrosse.

**Identity formation:** Students described experiences that helped them to identify their interests, or confirm a future career goal. Examples below illustrate how these experiences contribute to forming identity as an engineer. Students referred to themselves as engineers, described their experiences as something that engineers do, and noted that the skills they gained were necessary skills for engineers. For many, GCSP helped them to grow; in their words, ‘become an engineer.’

Excerpt 5: “Overall this program... has helped me to go beyond my engineering degree and become an extremely well-rounded, and well-qualified engineer.” This student stated that an early course helped her to identify her interests and future career path. She confirmed her career path when she conducted her own research project focused on applying bioengineering to create a more sustainable manufacturing process for chemical products, and traveled to the UK to attend a Fulbright Summer Institute with students from around the world to learn about climate change. She subsequently completed courses in global energy trends and business concepts for engineers, and started her own social entrepreneurship project to create a green air compressor.

Next, we will comb through the data corpus to search for patterns that either confirm or disconfirm evidence regarding the three dimensions of becoming an engineer. This process will help us develop evidentiary warrant for assertions we will create and further confirm our interpretations through follow-up interviews where the portfolio will serve as a prompt to seek students’ meanings for their specific actions in the GCSP experience.

### **Initial Results and Next Steps**

Through the initial analysis we found that students’ reflections of their experiences were largely confined to how the GCSP increased their awareness, enjoyment, and interest in specific aspects of engineering. Some students also described the ways in which the GCSP increased their own opinions about the role of engineering in society and deepened their understanding of the role of engineers as professionals. To move beyond these initial descriptions, we will use portfolios as artifacts in interviews to elicit students’ meanings in actions through their GCSP. That is, what are the meanings the GCSP participants hold for the actions they select for their experiences in the five requirements embedded in the program: 1) multidisciplinary nature of engineering 2) research experience. 3) Global perspective. 4) Entrepreneurship experience. 5) Social relevance? We anticipate that upon completion of the study, we will be able to successfully document the ways in which the GCSP enables student development as a Grand Challenge Scholar-Engineer.

### **References**

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