"All of the work students do as part of the National Academy of Engineering Grand Challenge Scholars Program (GCSP), which blends research, interdisciplinary curriculum, global experience, service learning, and entrepreneurship, helps them to develop an entrepreneurial mindset. In essence, the overall goal or intended outcome of the GCSP—a globally competent engineer—reflects, and even requires, an entrepreneurial mindset, so integration of EM was a natural fit."

- Amy Trowbridge, Senior Lecturer and Director of ASU’s GCSP

**Case at a glance**

**Integration goals:** Integrating EM into existing GCSP Summer Institute program curriculum and FSE150 course materials and project, helping students to understand what EM is, and recognizing how and where students are developing EM through GCSP

**Materials affected:** FSE150 syllabus and course slides, as well as activity and project materials; GCSP Summer Institute curriculum materials

**Lessons learned:** That, ultimately, beyond revising materials for the introductory course and summer program, other integration was based primarily on messaging, since many activities in GCSP naturally encourage EM development. Also, as students choose and complete experiences to achieve the GCSP competencies, they connect with many curricular and engagement-related EM integration activities at ASU
Context

The Grand Challenge Scholars Program (GCSP) is a program of the National Academy of Engineering (NAE). When it was established at ASU in 2011, GCSP was among the first student engagement programs within the Ira A. Fulton Schools of Engineering (FSE). Of the NAE’s 50-plus Grand Challenge Scholars programs, ASU’s GCSP is now its largest. Each year, approximately 150-200 freshmen engineering students join our GCSP.

Students in ASU’s GCSP focuses on the NAE’s 14 Grand Challenges for Engineering through the FSE research themes of health, energy, sustainability, security, and education. Students are initially recruited for this program once they are accepted into one of ASU’s Fulton Schools of Engineering, before they officially start their first year. A majority of the students begin the program as freshmen; however, current engineering students can also apply. Grand Challenge Scholars complete coursework and experiential learning opportunities within the program’s five competency areas: research experience, interdisciplinary, entrepreneurship, global/multicultural, and service learning. Students choose their own path through the program, selecting experiences and courses connected to a theme area they are passionate about (e.g. health, sustainability, security, etc.) to achieve those competencies. As they complete their experiences, students showcase their accomplishments and reflect on their experiences in a digital portfolio.

Students begin the program by completing a course specifically developed for GCSP students, FSE150: Perspectives on Grand Challenges for Engineering. The FSE150 course satisfies one of the interdisciplinary components of the program and is designed to increase students’ awareness of the social complexities of meeting the needs of local and global challenges through engineering and technology. Students also learn more about the GCSP in the course and start creating an individualized plan to complete the program components during their undergraduate studies. Each year approximately 50 students begin their journey in GCSP even before classes begin at a week-long residential GCSP Summer Institute (SI) program. The GCSP SI program is designed to help students to learn about GCSP opportunities at ASU, and to begin building community. This program is unique to ASU’s GCSP.

Like the GCSP SI program for incoming freshmen students, the FSE 150: Perspectives on Grand Challenges for Engineering course (which is only open to GCSP students) and the student-led Grand Challenge Scholars Alliance organization are unique to ASU’s GCSP. By facilitating connections between students and ensuring that students are oriented and growing within the program from their first day at ASU, these unique components have enabled ASU’s GCSP program to build a community of scholars.

GCSP has numerous touch points across ASU’s EM ecosystem. In addition to the required FSE 150 course, all Grand Challenge (GC) scholars take FSE 301: Entrepreneurship and Value Creation (FSE 301). Many of them also take FSE 104: Engineering Projects in Community Service (EPICS) and FSE 494: EPICS in Action,
most often to achieve the GCSP competency in social consciousness through service learning. Similarly, many GC scholars participate in the Fulton Undergraduate Research Initiative (FURI), one of the ways they can complete the program’s research component. GCSP students may apply for up to two semesters of FURI funding and are expected to present their research at the bi-annual FURI Symposium, which is open to the public, including students, faculty, staff, donors, family, K-12 students, and the wider college community.

Integration details

Formal integration of EM began by examining the ASU GCSP overall to evaluate where EM development already occurred in existing program components and where it could be further enhanced. We used the Fulton GCSP requirements/program manual to take a holistic look at the GCSP with the aim of identifying where EM fits and seeing how the program is related to EM beyond the obvious connection with the program’s entrepreneurship component. This assessment led to enhancing ASU’s curriculum for GCSP participants. Initial ideas of how to message and encourage EM/the 3C’s came from KEEN materials on defining the 3C’s and information received at a KEEN Integrating Curriculum with Entrepreneurial Mindset (ICE) Workshop, led by faculty from Lawrence Technological University. Since the FSE150: Perspectives on Grand Challenges for Engineering course is required for all students in the GCSP and already contained some assignments and outcomes that align with EM, it appeared to be a great place to start further integration of EM.

The introductory GCSP course (FSE 150) was developed for the program to introduce students to the GCSP, and to the interdisciplinary global nature of the NAE Grand Challenges. It was also developed to further encourage students to explore approaches to solving global challenges they are interested in from the very start of their academic career in GCSP. The “Future Solutions Project,” a creative open-ended team design project, was add to FSE 150 and first implemented in 2013, EM was not explicitly integrated into the Future Solutions project and piloted until Spring 2016.

The project modifications required students to focus more on identifying an opportunity to create value, designing a solution to meet the needs of a target customer, and describing the impacts their solution will have on society, including the value it will create. In Fall 2016, further modifications to the project were made explicitly requiring students to communicate the value created by their solutions when they presented their project work to other faculty, staff, and GCSP students through posters and models during a poster session at the end of the semester. Throughout the course, the 3C’s were used to describe the core activities of engineering, and creating value for society was emphasized as it relates to engineering solutions to the NAE Grand Challenges. EM was also integrated into the course syllabus for the Fall 2016 semester, when the following two course learning outcomes specific to EM were added:
• Identify opportunities to create added value in the Grand Challenge areas, and conceptualize a potential future solution.
• Interpret why (and in what ways) a technology/design solution adds value from multiple perspectives (technological, sociocultural, economic, environmental, global, etc.), and describe a design solution in terms of its societal value (as well as its technical features and function).

The changes to the project and addition of these learning objectives were inspired by the GCSP director’s involvement with KEEN and learning about the 3C’s. Working to find ways to further integrate EM into the course gave her an opportunity to look at the course objectives anew and revise them to more directly represent what students achieve in the course through the Future Solutions Project.

Also in 2016, the GCSP SI program’s curriculum was revised to incorporate more focus on the 3C’s. T. A sustainability-focused, hands-on design activity was revised to include more emphasis on customers and provide opportunities for interaction with customer representatives during the design phase. Students utilized a Value Proposition Canvas to create design features that satisfied specific customer needs and described the value created when presenting their prototypes.

In 2017, EM also served as a means of further strengthening the connection between GCSP and the Fulton Undergraduate Research Initiative (FURI). KEEN team staff members reviewed the list of FURI participants who were also in GCSP and identified projects with an EM element. One of these students received KEEN research funding in addition to her GCSP research stipend or FURI funding, and during the spring 2017 FURI Symposium, she presented in the same area with KEEN signage as other KEEN research funding recipients. Together these students’ presentations provided insight into how the 3C’s influenced their projects.

NOTE: Supporting resources for this case study can be found within its companion KEEN card (link below), which is also where the community can discuss the case and its broader topic.

**Integration outcomes**

Between spring 2016 and spring 2018, the changes made to further integrate EM into FSE 150 have been implemented in numerous sections of FSE 150, reaching more than 300 students (including about 50 students from University of New South Wales in Australia who were participating in a global version of the course), and represent our progress toward achieving our EM integration goals. Ultimately, however, there is still more we can do. Opportunities for broader and deeper EM integration consistently present themselves. At the same time, we recognize that we need to do more to formally assess how and where students are developing EM through GCSP.

We can confidently say that student projects in FSE150 are much more customer-focused, with students making good attempts to describe the value their proposed
solutions would create for customers and society. Students’ portfolio reflections on their GCSP experiences also show evidence that the program provides opportunities that naturally help students to work with and develop the EM. However, the director would still like to make that more evident in students’ own minds—that is, to make students more aware of what EM is and why it is valuable. She would also like to help them to consciously recognize their use of EM and how their GCSP experiences help them to develop the EM, so that they can encourage themselves to consistently apply the mindset with their engineering skill set, doing what they do as students and working engineers. Regardless, we will continue using and improving the Future Solutions Project to help GCSP students to begin to develop the EM from the start.

Finally, after looking at graduates’ GCSP portfolios and reflecting on the program with EM integrated into it to the degree it is now, the director’s initial thinking about the natural fit between GCSP and EM was confirmed: The GCSP’s core purpose of having students complete research, think and work interdisciplinarily, globally, and entrepreneurially, as well as complete service learning work focused on a theme area they are passionate about helps develop the entrepreneurial mindset, which in turn helps engineers meet the needs of local and global challenges.

**Future plans**

ASU’s GCSP plans for the future include

- Identifying additional EML opportunities for students to achieve their entrepreneurship competency for GCSP through experiences beyond starting a business
- Developing opportunities to help ASU GC scholars to identify experiences in GCSP they have already completed in which they’ve started to develop EM, and to help them think about how they could approach the rest of their GCSP (and other) experiences to continue developing the EM
- Remaining active in KEEN’s GCSP subnet
- Hosting EM challenge or workshop opportunities for GCSP students from multiple institutions

**Considerations**

This integration effort did require finding ways to purposefully integrate EM messaging and activities into a program that, by design, helps students develop the entrepreneurial mindset. We had to look beyond the obvious “entrepreneurship” component of GCSP to see how students’ experiences in other areas of the program can also contribute to development of EM. In essence, it has been somewhat difficult to implement EM integration where EM already exists, into, that is, a program for students who all complete FSE 301, and many who complete EPICS as well as FURI, all of which are activities or courses that have integrated EM. That is why the integration efforts focused specifically on the GCSP-specific opportunities for students (the FSE150 course and Summer Institute program).
The success we have had integrating EM into its GCSP is due in part to the great support the program receives from across the University and the fact that the program was already well established here. Contributing to the University’s support for ASU’s GCSP is the fact that its director and participants have been very active within the NAE GCSP community. For example, a student and several faculty members represented ASU at the 2016 NAE Grand Challenges Scholars Program Annual Meeting in Washington, D.C. At the event, Amy Trowbridge, senior lecturer and director of ASU’s GCSP program, shared best practices from ASU’s program on a small panel, and Kaleigh Johnson, a chemical engineering senior, represented ASU on a student and alumni panel, where she shared how the program shaped her career goals and undergraduate experiences. ASU GCSP students have also traveled to the Global Grand Challenges Summit in Washington, D.C. in 2017, and in Beijing, China in 2015 to learn from experts and to represent ASU GCSP.

Ultimately, this effort has also required the involvement of numerous individuals and groups, most notably FSE150 instructors, who have collaborated to implement EM efforts, and staff who provide support for the program and its events. ASU’s engineering students themselves, a large and diverse group with varied experiences, also play an important role in helping to encourage the spread of EM recognition and enhancement among their peers.

**KEEN Card**

This case study has a companion card on the KEEN Engineering Unleashed website.

**Related Cases**

**Curriculum**
- Immediate Contributions: EPICS (FSE 104)

**Engagement**
- Starting Strong: E2 Camp
- The Energy of Inquiry: Fulton Undergraduate Research Initiative (FURI)
- Change Makers: KEEN Professorships
- Golden Opportunities: KEEN Student Mini-Grants

**Workshops**
- Onboarding 1: EM Workshop for Faculty
- Onboarding 2: EM Workshop for Staff

**Life Cycle**
- The Impact Meter: Assessing Student Mindset