Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025 ASEE
Paper ID #48873

Inspiring Early Engagement and Community Building Among First Year Students in a Multiyear Co-Curricular Program through A Summer Program: Successes Based on Ten Years of Implementation

Amy Trowbridge, Arizona State University

Amy Trowbridge is an Associate Teaching Professor in the Ira A. Fulton Schools of Engineering at Arizona State University and is co-Director of the Grand Challenges Scholars Program (GCSP) at ASU, recognized by National Academy of Engineering (NAE). 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 student learning, and the use of digital portfolios for students to showcase and reflect on their experiences. Amy has contributed to the development of an interdisciplinary grand challenges focused course and introduction to engineering course in both in-person and online (MOOC) formats at ASU. She is also actively involved in the ASU Kern project and Kern Entrepreneurial Engineering Network (KEEN), focused on students' development of entrepreneurial mindset. Amy received the national 2019 KEEN Rising Star award from KEEN for her efforts in encouraging students in developing an entrepreneurial mindset. She is also a member of the current interim Executive Committee for the international GCSP Network, and mentors schools to develop GCSPs as part of the GCSP New Programs committee.

Dr. Haolin Zhu, Arizona State University

Dr. Haolin Zhu earned her B.S.E. in Engineering Mechanics from Shanghai Jiao Tong University and her Ph.D. in Theoretical and Applied Mechanics from Cornell University, with a focus on computational solid mechanics. Dr. Zhu is an Associate Teaching Professor of the freshman engineering education team in the Ira A. Fulton Schools of Engineering at Arizona State University (ASU). In this role, she focuses on designing the curriculum and teaching in the freshman engineering program and the mechanical engineering program. She is also the Co-Director of the Grand Challenges Scholars Program (GCSP) at ASU. In this role, she focuses on student support and tracking, curriculum, program requirements, as well as programming for current students in GCSP. Dr. Zhu was also involved in the ASU ProMod project, the Engineering Projects in Community Service program, the Engineering Futures program, the Global Freshman Academy/Earned Admission/Universal Learner Courses Program, and the ASU Kern Project. She was a part of the team that designed a largely team and activity based online Introduction to Engineering course. She has also co-developed two unique MOOCs, Introduction to Engineering and Perspectives on Grand Challenges for Engineering for the Global Freshman Academy/ASU Earned Admission/Universal Learner Courses Program. Her Ph.D. research focused on multi-scale multiphase modeling and numerical analysis of coupled large viscoelastic deformation and fluid transport in swelling porous materials, but she is currently interested in various topics in the field of engineering education, such as innovative teaching pedagogies for increased retention and student motivation; innovations in non-traditional delivery methods, incorporation of the Entrepreneurial Mindset in the engineering curriculum and its impact. She has published over 30 papers and presented at various conferences about her work. She was recognized as an Engineering Unleashed Fellow and won the Fulton Outstanding Lecturer Award for her contributions in Engineering Education.

Jacob R Matti, Arizona State University

Inspiring Early Engagement and Community Building Among First Year Students in a Multiyear Co-Curricular Program through A Summer Program: Successes Based on Ten Years of Implementation

Abstract

This Complete Evidence-based Practice paper describes the design and implementation of a week-long summer program that aims to engage incoming first year students in the Grand Challenges Scholars Program (GCSP) in building a peer community on campus and learning about opportunities to engage in work addressing global challenges at Arizona State University (ASU). The GCSP Summer Institute (SI) is a program that has been hosted at ASU every summer since 2014 for 20-50 incoming first year students accepted into the GCSP, a multi-year co-curricular program, at ASU. The program aims to provide students with opportunities to become familiar with the GCSP at ASU and the National Academy of Engineering (NAE) Grand Challenges in Sustainability, Security, Health, and Joy of Living, and to develop a sense of community with other students in the GCSP. The program was originally designed and hosted in-person as a residential week-long experience, then later adapted to a virtual online experience during the COVID-19 pandemic and recently returned to an in-person residential week-long experience. Program activities include faculty talks, lab tours, hands-on activities designed to explore global challenges from an interdisciplinary perspective, a team-based design-build challenge, panels (of current students and faculty), and social activities.

Program evaluation surveys were given to student participants and student staff (program counselors) at the end of the program each year and at the end of each program day (for in-person program only) to evaluate the effectiveness of the program at meeting the intended outcomes. Results of program evaluation surveys across ten years of program implementation indicate that the program successfully helped students connect with their peers, understand the NAE's Grand Challenges for Engineering, gain awareness of research at ASU related to these Grand Challenges, and learn about GCSP opportunities. The results also show that the in-person programs consistently outperformed the virtual programs in meeting certain program objectives, specifically in building connections with other students and introducing students to ongoing research through interactions with faculty and lab tours. However, both virtual and in person participants felt the program was valuable for incoming students in the GCSP.

Introduction and Motivation

The Grand Challenges Scholars Program (GCSP) at Arizona State University (ASU), established in 2011, is one of more than 90 GCSPs in the international GCSP Network that aims to prepare engineering graduates with broader perspectives and skills to tackle the National Academy of Engineering (NAE)'s Grand Challenges for Engineering to realize the NAE's vision for Engineering in the 21st century: "Continuation of life on the planet, making our world more sustainable, secure, healthy, and joyful," [1]. Each student in the GCSP develops their own pathway in the program to gain experience in research, interdisciplinary, entrepreneurship, global, and service-learning activities and coursework, all focused on an overarching Grand Challenges theme (Sustainability, Security, Health, or Joy of Living). Though all the GCSPs in the GCSP Network are guided by the same framework and program outcomes, referred to as the

GCSP Competencies (Talent, Multidisciplinary, Viable Business/Entrepreneurship, Multicultural, and Social Consciousness) [2], each GCSP has its own specific program requirements and structure defined by its host institution. At ASU, the majority of the students join the GCSP as incoming first year students or during the first year and stay engaged in the program until graduation. Throughout their multi-year journey in the program, students each choose to focus on one of the Grand Challenges themes, based on the vision statement mentioned above (sustainability, security, health, or joy of living), and complete a customized set of courses and/or experiences to achieve the GCSP Competencies. To provide mentorship and support to students throughout their individualized journeys, GCSP students also complete three required courses, in their first year, second year, and third year in the program, respectively [3] [4]. These courses also help students to explore the theme areas, stay connected with their chosen theme, and provide opportunities for professional development, connecting their GCSP experiences with their interests, academic and career goals.

Keeping students engaged and successful in a multi-year program like the GCSP, with individualized pathways, requires extra effort and support. According to literature, connecting students with peers and fostering positive relationships with faculty and staff to foster a welcoming environment for students can improve their success and retention in college [5], [6], [7], [8]. Several universities have implemented programming, either in person or online, to help students connect with their peers and university resources prior to their arrival on campus to set them up for success. Specifically, Summer Bridge programs which invite first year students to spend time on campus in the summer prior to their first year have been implemented at many institutions as an effort to help students gain access to academic and social resources needed to help them to succeed. These summer bridge programs often primarily focus on increasing engineering students preparedness at math, and have led to increased first year GPA and retention, both indicators of student academic success [9], [10], [11].

Motivated by the literature discussed above, many efforts have been made to engage students in the GCSP, the ASU GCSP community (students, faculty, and alumni), and related opportunities at ASU to support students' success and retention in this co-curricular program. The required first year course for the program, originally piloted in 2012, was the first effort made to help students get started in their program journey through engagement with the Grand Challenges, GCSP requirements and opportunities and GCSP peers and faculty [3]. In 2013, an optional weeklong residential GCSP Summer Institute program was introduced for the first time by the former program director with aims to engage students in the GCSP community and related ASU opportunities early, prior to the first-year course. The GCSP Summer Institute was redesigned by a new program director in 2014 to more intentionally focus on engaging students in exploring and learning about grand challenges related to all broad theme areas (Sustainability, Security, Health, and Joy of Living) through a variety of different activities and engagements with faculty and providing students with more opportunities to collaborate with their peers to build community. Since the implementation of this new version in 2014, the GCSP Summer Institute (or similar virtual summer programming) has been hosted at ASU for 20-50 students every year, aimed at introducing new incoming first year GCSP students to the GCSP community, the NAE Grand Challenges for Engineering, and opportunities available to them at ASU. This summer program provides opportunities for incoming first year GCSP students to learn about the Grand Challenges theme areas and related ongoing research at ASU, help them explore GCSP

opportunities and resources, and connect them with their peers, older GCSP students, program staff, and faculty.

This paper describes the design and implementation of the GCSP Summer Institute over the past ten years, and evaluates the effectiveness of the program over that time period. The following sections will provide details about the GCSP Summer Institute's program design and its implementation, both in person and virtually during the COVID-19 pandemic. Survey results that measure how well the program objectives are achieved across those years are shared and analyzed.

Program Details

The GCSP Summer Institute (SI) is an optional week-long residential pre-college summer program offered to new students accepted into the GCSP that encourages students' early engagement in the program. Incoming first year engineering students who are accepted into the GCSP during the spring prior to their first year at ASU are invited (but not required) to participate in this summer program. A small fee is charged at program registration to help ensure participants' commitment to participation. Program costs, including housing, meals, transportation, student counselor stipends, etc. are covered by the GCSP, which is funded by the college.

The objectives of the GCSP Summer Institute include: (1) developing a sense of community with other students in the GCSP; (2) observing and/or experiencing ongoing research at ASU in the Grand Challenges theme areas (Health, Security, Sustainability, Joy of Living); (3) becoming familiar with GCSP opportunities and requirements; (4) meeting program faculty and staff, and learning about resources available to them in GCSP; (5) becoming familiar with the National Academy of Engineering (NAE) Grand Challenges for engineering through the themes of Sustainability, Security, Health, and Joy of Living; and (6) completing hands-on activities related to the Grand Challenges.

The GCSP Summer Institute program was designed to engage students in a variety of different activities and experiences over the course of approximately 5 days to meet the outcomes above. As a residential program, the students arrived on Sunday evening, participated in day-time activities at various locations on campus during each weekday, connected with peers during organized evening activities and stayed in the dorms each night, and departed on Friday afternoon. Program activities were planned by faculty who lead the GCSP collaborating with 1-2 GCSP students serving as GCSP SI Lead counselors. Additional GCSP students were hired as SI counselors to help engage students in program activities throughout the week both during the day (day counselors) and night (night counselors), and a staff coordinator supported the program logistics. The types of day-time activities included in the program include faculty talks, lab tours, hands-on activities designed to explore global challenges from an interdisciplinary perspective, a team-based design-build challenge, and panels (of current students and faculty). Evening activities, led by SI night counselors, include various types of social activities such as board games, escape room, movies, and arts and crafts. The staff coordinator planned and arranged the social activities, while the faculty directors planned and led the daytime activities in collaboration with the SI Lead counselors.

The daytime activities for the GCSP Summer Institute were intentionally structured to ensure students had the opportunity to explore and learn about global challenges related to each of the theme areas (Sustainability, Security, Health, Joy of Living) in different formats while also connecting with their peers and faculty. Each day of the program was focused on exploring one of the theme areas. Notably, from 2014 to 2018, the GCSP at ASU focused on the college's five research theme areas which were Education, Energy, Sustainability, Health, and Security. Beginning in 2019, the program focused on the four NAE Grand Challenges theme areas instead, namely Sustainability, Security, Health, and Joy of Living, and used the fifth day of the program to help students to connect their experiences from the various themes together through a team design-build challenge activity and a showcase of students' past, present, and future inspirations from the week.

The 5E Instructional model, commonly used in science education, was used as a basis to structure the activities within each day. The 5E model consists of five phases each with different functions that contribute to students' overall learning: engagement, exploration, explanation, elaboration, and evaluation [12]. This model was adapted and used as a framework for each day of the GCSP Summer Institute. Specifically, each day started with brief video(s) to Engage students to help increase their awareness of the Grand Challenges theme area. Students were asked to share their reactions and possible future actions in response to the videos. Next, students Explored the Grand Challenges further through an activity. For example, they created a multi-sided paper object to share different facets of sustainability, or guessed which medical technologies were shown in various pictures for Health. An additional hands-on activity was included later in the morning or afternoon each day for further Exploration. These hands-on activities varied in format and content over the years, but included activities such as design challenges, a Model UN activity, and a trade and bartering type activity focused on securing adequate energy for a village community. The Explanation phase included brief faculty talks (and question/answer period) about their research and challenges in the area and lab tours. The talks and tours sometimes included demonstrations and interactive activities such as participating in a virtual reality experience. At the end of each day, students were asked to think about what they experienced and write down what inspired them during the day. They were also encouraged to look at a list of faculty in the grand challenges theme area to identify how they might Expand upon what they learned in the future. An example schedule for one of the days is included below in Table 1.

Table 1: Example daily schedule for Sustainability theme day

	Wednesday
	Theme: Sustainability
7:00-8:15 AM	**Breakfast**
8:30-10:15 AM	**Engage & Explore Sustainability**
10:15-10:30 AM	**Break**
10:30-11:30 AM	**Faculty Presentations + Q&A: Sustainability**
11:30AM-12:00 PM	**Expand: ASU GC Work**
12:00-1:00 PM	**Lunch**
1:00-2:30 PM	**Sustainability Activity**
2:30-3:00 PM	**Break & Travel**
3:00-4:30 PM	**Sustainability Lab Tours**
4:30-4:45 PM	**Travel**
4:45-5:00 PM	**Daily Wrap-up & Exit Ticket**
5:00-5:15 PM	**Travel back to Dorm**
5:30-7:00 PM	**Dinner**
7:00-9:00 PM	**Evening Activity**
9:00-9:15PM	**Daily Chat**
9:15-11:00 PM	**Free Time**
11:00 PM	**Quiet Hours begin**

When hosting the program as an in-person residential program was not feasible after the COVID-19 pandemic started, a virtual version of the program with similar objectives was offered. In 2020, a four-day virtual program was designed drawing inspirations from the in-person program. Instead of structuring the program days by theme, the four days in the virtual program each focused on the following: ASU GCSP, NAE Grand Challenges, GCSP Competencies, and All About YOU (focusing on personal interests, goals, and next steps). Each day included live sessions conducted via Zoom (including faculty talks, panels, and other interactive sessions), asynchronous activities such as a virtual scavenger hunt, and optional live social activities (e.g., Mafia, trivia, drawful). A design-build challenge was also integrated throughout those four days with both live sessions and asynchronous work sessions. Students worked on the design challenge individually but had opportunities to see each other's work in a project showcase. Important program information was shared with participants through a Canvas LMS shell. Recorded videos of brief descriptions of research labs were also shared through the Canvas LMS shell, and used as virtual "lab tours". In addition to the Canvas shell, Slack was

used as a platform for participants to interact with each other. To promote engagement, Slack discussion prompts were posted by counselors throughout the program, encouraging students to engage with each other through sharing their interests, pictures of pets, etc. The combination of these tools enabled an interactive and engaging experience for participants in a virtual environment. Many valuable lessons learned from this initial virtual program implementation informed improvements in subsequent years. For example, in 2021, when the program remained virtual, the design-build challenge was changed to a team-based experience, offering more opportunities for participants to interact and collaborate with each other. A virtual live lab tour series was also introduced in 2021 to replace the recorded versions. These live-streamed lab tours hosted by faculty allowed the participants to virtually follow a staff person as they toured each research lab, and to interact with the faculty members by asking questions live. The virtual program experience also influenced the design of future in-person SI programs held in 2022 and 2024, specifically encouraging the inclusion of a week-long team design challenge, and the addition of student and faculty panels.

Following the COVID-19 pandemic, student engagement in summer activities including this program was lower which led to additional shifts in GCSP summer programming. In 2022, the in-person GCSP Summer Institute was hosted as a residential program following the same format as previous years, but the number of participants (18) was much lower than previous years (40-50). Due to other program challenges and constraints, the in person GCSP Summer Institute program could not be held in 2023, which led to the development of a new virtual engagement program, GCSP Connect. The GCSP Connect program was held virtually with live Zoom sessions and all materials housed in Canvas LMS as was done for the virtual Summer Institute, but the program structure and content differed. GCSP Connect took place over 6 days, with approximately 3-4 sessions each day lasting a total of 3-4 hours. Sessions in Connect included a faculty presentation (including Q & A) for each theme, a faculty panel, a student panel, sessions focused on Counselors sharing their experiences, an introduction to GCSP and two interactive activities aimed at helping students to explore opportunities available through GCSP. A team challenge was included on the final day of the program. Community activities, including online games and an escape room experience, were hosted virtually each day to encourage social interactions and connections between student participants. In 2024, when the Summer Institute program was again offered as a weeklong in-person residential program, the schedule was restructured. In order to allow for a day-long visit to another campus to engage with faculty and research labs there and an additional half-day visit to an off campus center that focuses on immersive media experiences, the individual days were no longer each focused on a theme. Instead, the different activities (faculty talks, lab tours, and hands-on activities) focused on exploring each theme were spread throughout the program and were arranged in such a way that all four themes were highlighted each day.

Results and Discussion

To evaluate the effectiveness of the program, a survey was administered to all participants and program counselors at the end of the program each year. Participants were all incoming first year undergraduate students from a variety of different majors within the college of engineering at ASU. For the in-person programs, daily surveys were also distributed to all participants during the evenings to collect feedback about the day's sessions and activities. This study focused only on program participants' responses to questions in the end-of-program survey from the past ten

years (2014-2024) that were related to the program objectives. Data from the 2021 virtual GCSP Summer Institute was not included due to insufficient responses (only one valid response was collected that year). The total number of survey respondents for each year is included in Table 2 below.

Table 2. Number of survey respondents by year

Year	2014	2015	2016	2017	2018	2019	2020	2022	2023	2024
Number of Survey Respondents	38	37	43	40	28	40	27	17	26	28

Quantitative analysis was performed on responses to the Likert scale questions that directly or indirectly measured the effectiveness of the program at meeting each of its desired outcomes. The results were compared across the past ten years and are presented and discussed below.

To assess the first program objective, developing a sense of community with students in the GCSP, responses from the survey question, "Do you feel you have created a sense of community with other GCSP scholars?" were analyzed. Participants rated their experience on a Likert scale of 1 to 5 (1=not at all; 5=completely) and the mean scores across the last ten years are shown in Figure 1 below. The results are consistently high for the years when the program was in person (2014-2019, 2022, and 2024). The mean score for 2020, when the program was offered in a fully virtual format during the COVID-19 pandemic, was the lowest in the past ten years. That year, the design challenge was implemented individually for participants and the opportunities for them to interact with others were limited to the live sessions, which was much less compared to the in-person programs where the students were with each other for a full week.

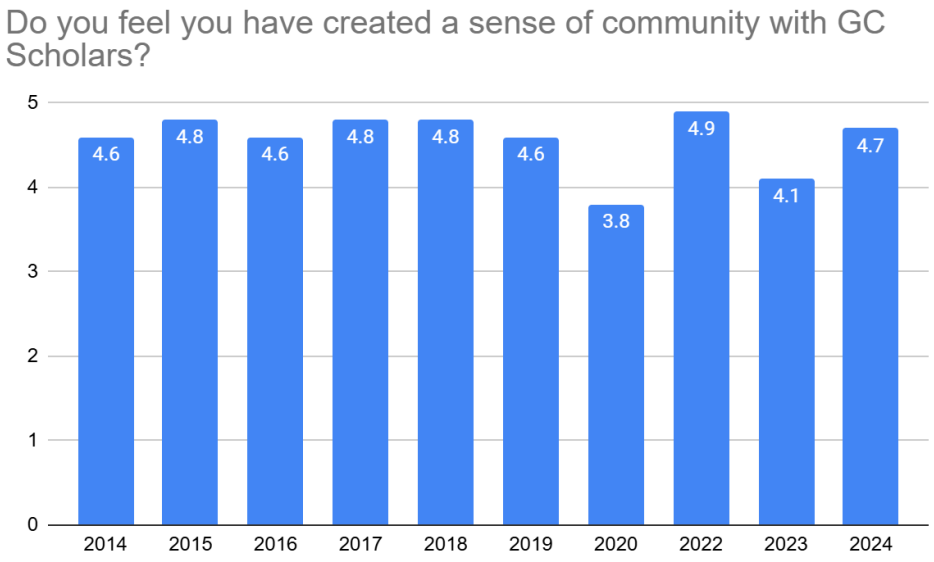

Figure 1. Developing a sense of community with students in the GCSP

Responses from three survey questions were analyzed to evaluate the program's effectiveness at achieving its second objective: observing and/or experiencing ongoing research at ASU in the Grand Challenges theme areas (sustainability, security, health, joy of living). The first question asked participants to rate how knowledgeable they felt about research being done at ASU in the Grand Challenges theme areas on a Likert scale of 1 (not at all) to 5 (completely). The results, presented in Figure 2, show consistently high scores for the years when the program was implemented in person. The two years with virtual program implementation, 2020 and 2023, showed slightly lower mean scores for this question, likely due to less opportunities to directly interact with faculty and visit research labs. For example, videos shared through Canvas that were used as "lab tours" in the year 2020's program were likely less impactful compared to in person lab tours. And the year 2023's virtual program did not offer any lab tours so participants interacted with fewer faculty and only learned about ongoing research through their faculty talks. The second and third questions asked them to rate how beneficial the faculty talks and lab tours were, respectively, using a Likert scale of 1 to 5 (1=least beneficial; 5=extremely beneficial) and the results to those questions are shown in Figures 3 and 4. These two questions were not included in the survey for the year 2023 that had different program sessions, so that year is excluded in the results presented. It is not surprising that 2020's pre-recorded virtual lab tours received the lowest score compared to all the other years' in-person lab tours.

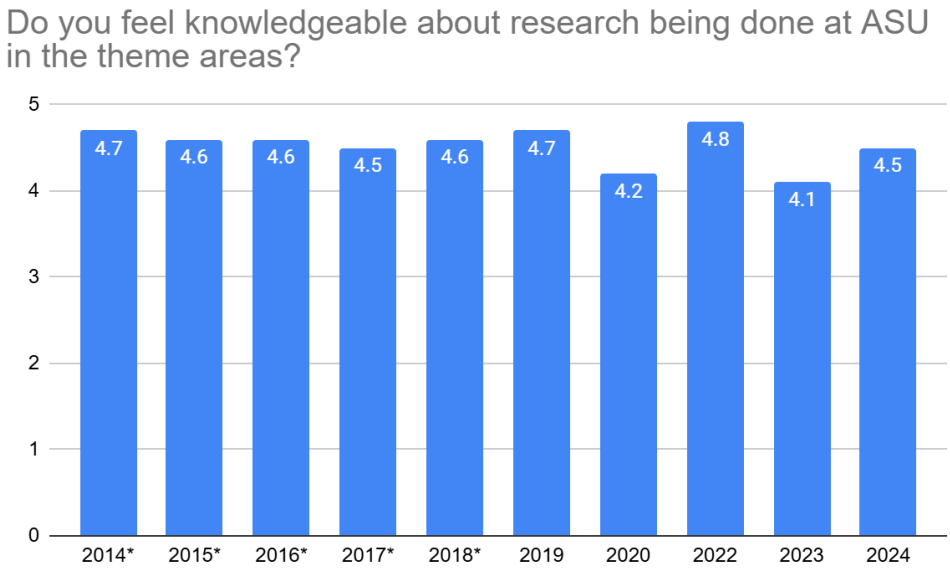

Figure 2. Participants' perceptions of feeling knowledgeable about research being done at ASU in the GC theme areas (sustainability, security, health, joy of living) (*the survey question asked about research opportunities rather than research in the theme areas)

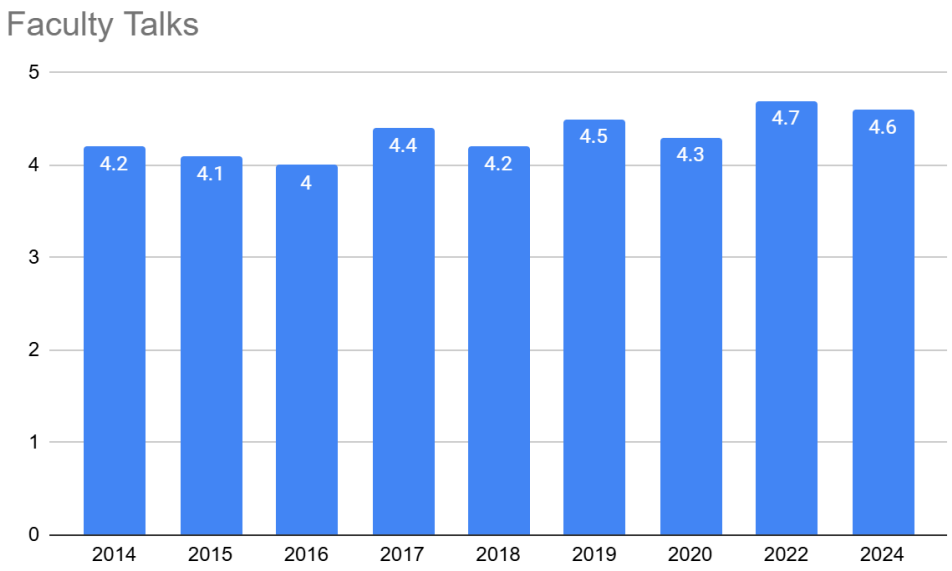

Figure 3. Participants' perception of how beneficial the faculty talks were

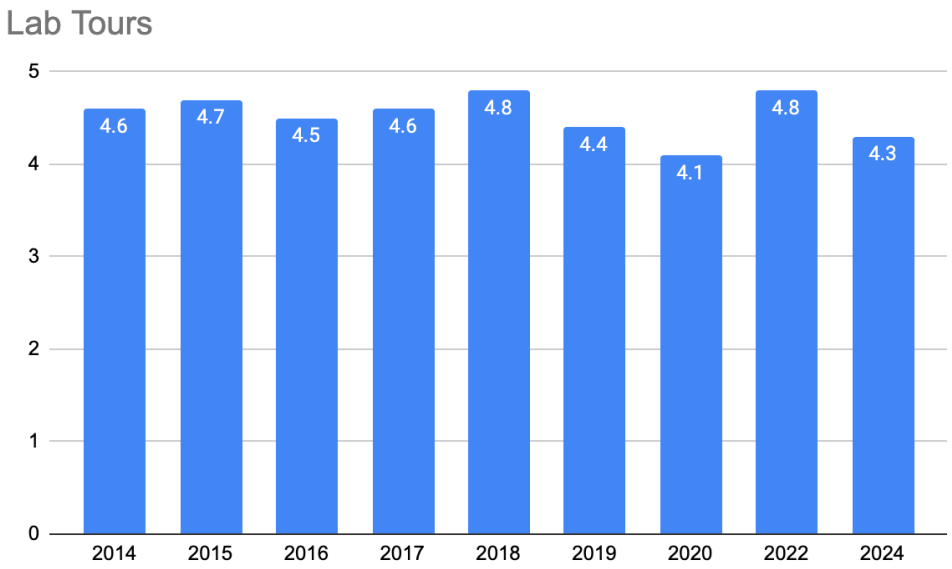

Figure 4. Participants' perception of how beneficial the lab tours were

To evaluate the third program objective, becoming familiar with GCSP opportunities and requirements, responses to these two survey questions were analyzed: "Do you understand the GCSP requirements/competencies?" and "Do you feel knowledgeable about opportunities at ASU to achieve GCSP competencies?" Participants rated each question on a Likert scale of 1 to 5 (1=not at all, 5=completely). The results are displayed in Figures 5 and 6, respectively. The second question was added to the overall program survey in 2019, so only data from 2019 to 2024 (excluding 2021) is presented in Figure 6. Overall, the program successfully introduced new students to the program requirements, competencies, and opportunities to achieve the competencies.

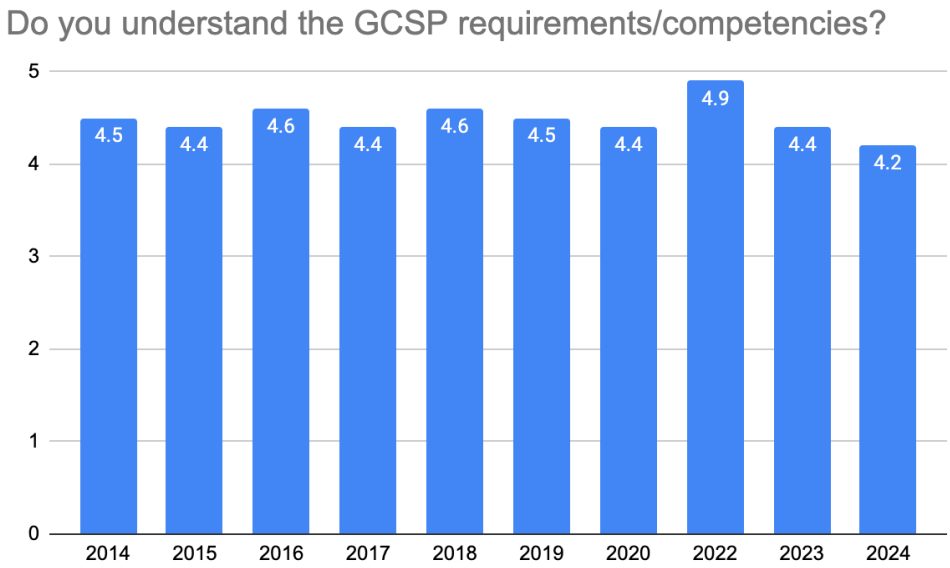

Figure 5. Participants' perceived understanding of GCSP requirements/competencies

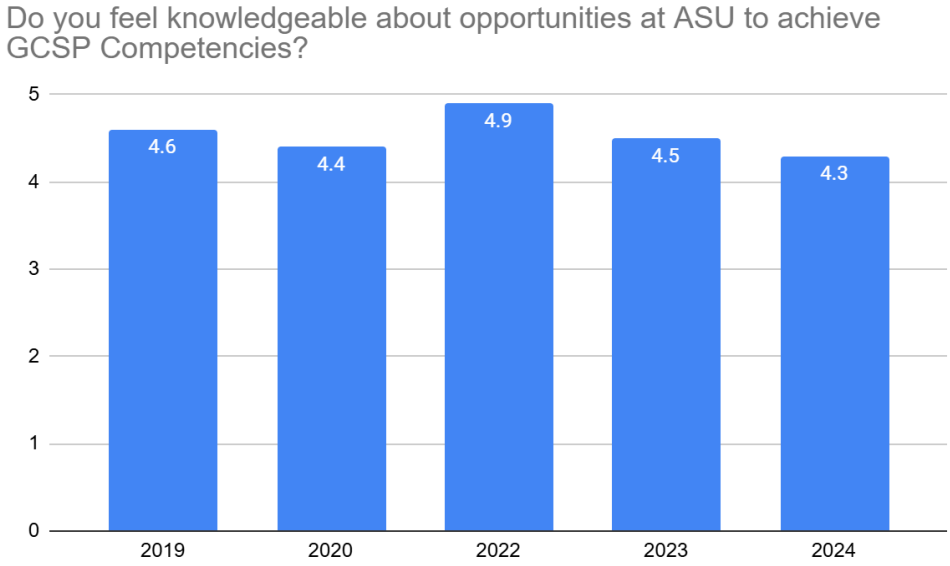

Figure 6. Knowledge of opportunities at ASU to achieve GCSP competencies

The fourth program objective, meeting program faculty and staff and learning about resources available to them in GCSP, was not directly measured through the survey. The survey questions about research and opportunities at ASU to achieve program competencies indirectly measured this program objective. Additionally, the participants met program faculty and staff and interacted with them closely through daily activities and/or evening activities. They also met at least eight other ASU faculty through faculty talks and lab tours throughout the in-person summer program (at least four other faculty for virtual programs), contributing to their knowledge of resources.

To evaluate the program objective related to becoming familiar with the NAE Grand Challenges for engineering through the themes of sustainability, security, health, and joy of living, responses to the question, "Do you understand what the Grand Challenges for Engineering are and the vision they represent?", on a Likert scale of 1 (not at all) to 5 (completely) were analyzed and the results are presented in Figure 7. The results show the program's great success at introducing participants to the Grand Challenges for Engineering and the vision they represent.

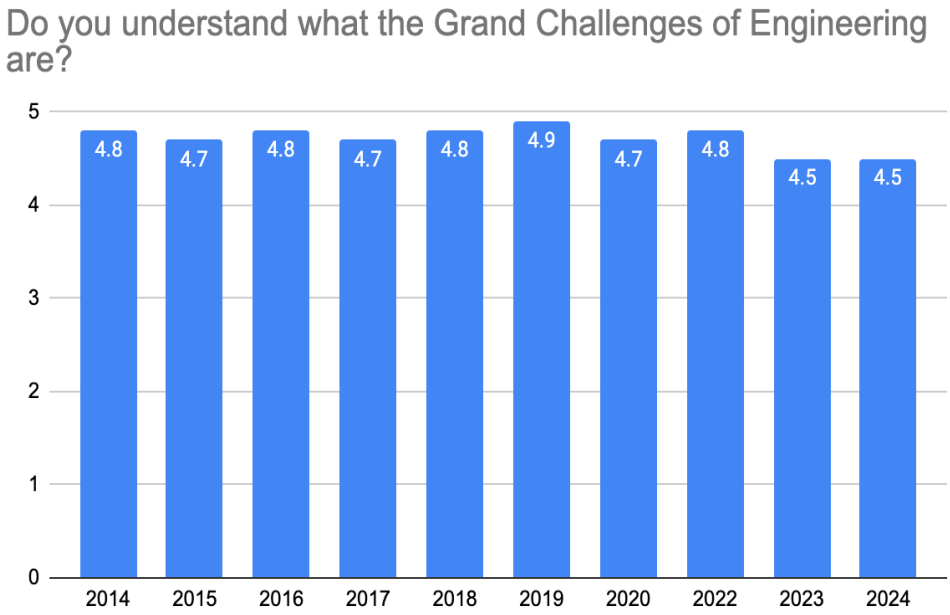

Figure 7. Participants' perceived understanding of what the Grand Challenges for Engineering are and the vision they represent

The last program objective, completing hands-on activities related to the Grand Challenges, was achieved when hands-on activities were implemented throughout the program when it was in person. But participants also rated how interesting they found the hands-on activities on a Likert scale of 1 to 5 (1=least interesting; 5=extremely interesting) and the results are displayed in Figure 8. Continuous program improvements, especially those focused on the hands-on activities, led to higher scores in more recent years, as shown in the results.

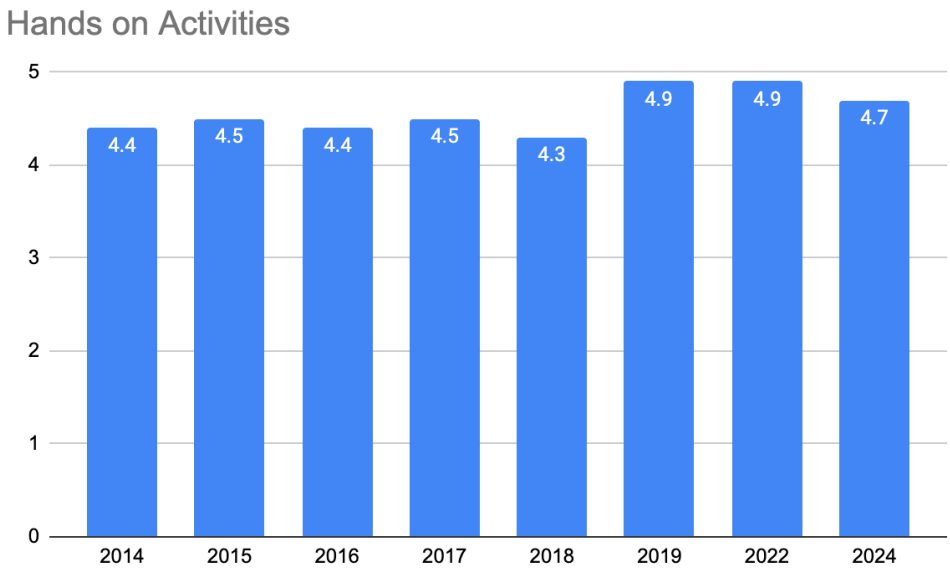

Figure 8. Ratings of Hands-on activities (1= least interesting; 5=extremely interesting)

In addition to measuring the achievement of program objectives, the survey also included questions that evaluated the overall effectiveness of the program. More specifically, the survey asked the participants to rate on a Likert scale of 1 to 5 (with 1 being not at all and 5 being completely): "How likely would you refer the Summer Institute program to an incoming student?" and "Did the Summer Institute meet your expectations?" These results are shown in the figures below. The results from Figure 9 indicate that participants found great value in the program and considered it a worthwhile experience for incoming students, even during the years of virtual implementation. Results shown in Figure 10 also demonstrate the program's overall success. The comparatively lower scores for virtual program years (2020 and 2023) indicate that in-person engagement probably provided a better experience resulting in greater participant satisfaction.

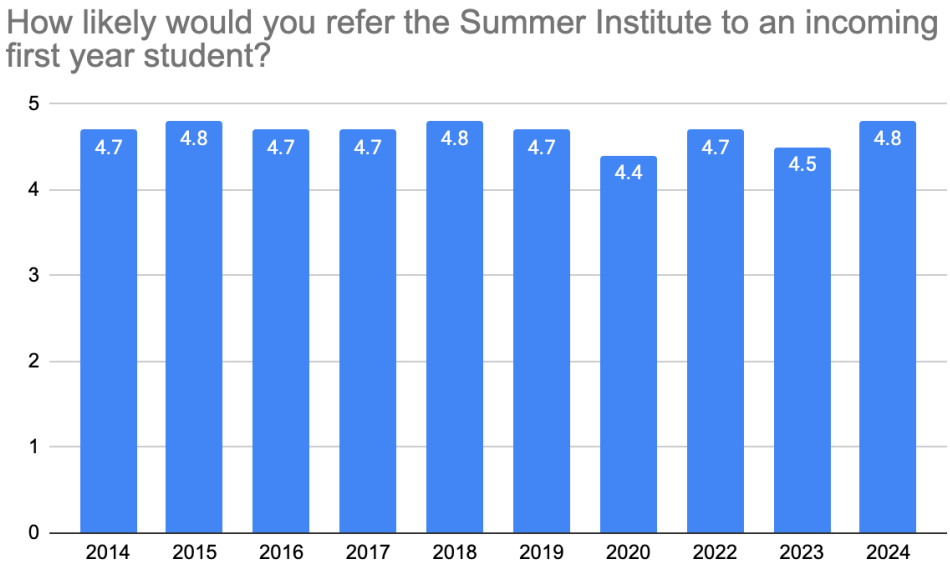

Figure 9. How likely participants would refer the Summer Institute program to an incoming student

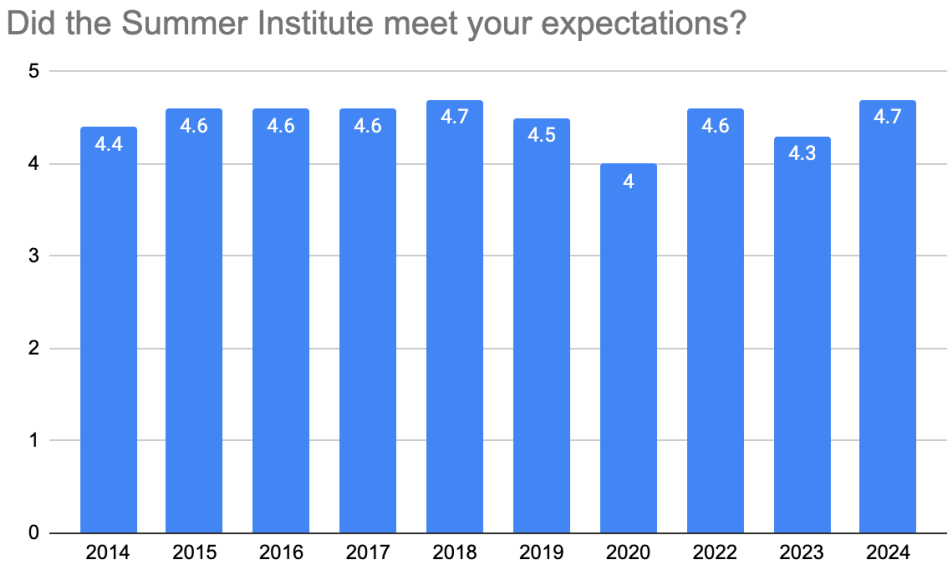

Figure 10. Summer institute meeting participants' expectations

Conclusion and Future work

A weeklong summer program, the Grand Challenges Scholars Program (GCSP) Summer Institute (SI) was designed and implemented for the past ten years for incoming first year students in the GCSP at Arizona State University (ASU) to encourage students' early engagement in the GCSP. The program aimed to provide opportunities for students to build a GCSP peer community and to learn about the Grand Challenges, the GCSP and related opportunities at ASU. The GCSP SI was implemented as an in-person weeklong residential

program with day activities focused on exploring Grand Challenges related to Sustainability, Security, Health, and Joy of Living and evening social activities. It was adapted to virtual formats for three years due to the COVID-19 pandemic and other constraints. Results from the program surveys over the last ten years indicate that the program was successful at meeting its objectives in both in-person and virtual formats. As a result of the program, students built a sense of community with their peers, gained an understanding of the NAE's Grand Challenges for Engineering, gained awareness of research at ASU related to these Grand Challenges, and learned about GCSP opportunities. Though the program was slightly less successful at helping students to build community when offered in an online format when compared with in person, students' response was still positive and the virtual program still met all other objectives. Feedback and data from these ten years will be used to continue to improve the design and implementation of this and/or other summer programming for the GCSP for future years. Future research may include comparing the virtual and in person implementations of the program in more detail and investigating the impact that participation in this summer program has on students' engagement and retention in the GCSP throughout their undergraduate education.

References

[1] C.D. Mote Jr., "Realizing the vision of the Grand Challenges for Engineering depends on the Grand Challenges Scholars Program", presented at 53rd National Academy of Engineering Annual Meeting, October 8, 2017. Available at: https://www.nae.edu/175289/Realizing-the-Vision-of-the-Grand-Challenges-for-Engineering-Depends-on-the-Grand-Challenges-Scholars-Program (accessed on January 15, 2025)

[2] GCSP Network, "About", https://gcspnetwork.org/about/ (accessed on January 15, 2025).

[3] A. Trowbridge and H. Zhu, "Work in progress: an interdisciplinary course designed to assist first-year students in planning and preparing for success in the NAE Grand Challenge Scholars Program,*"* in *2017 ASEE Annual Conf. & Expo.*, Columbus, Ohio, USA, June 2017.

[4] H. Zhu and A. Trowbridge, "Courses designed to support students' professional development and progress through a multi-year co-curricular program, the Grand Challenges Scholars Program," in 2024 ASEE Annual Conf. & Expo., Portland, Oregon, USA, June 2024.

[5] K. Schubert, X. Delgado Solorzano, L.Massey, C. Gattis, J. Popp, C. Cao, T. Carter, and D. Muralidhara, "A Successful 2-week Innovation- and Student Success-Focused Bridge Program for First-Year Students Paper" in *2022 ASEE Annual Conf. & Expo.*, Minneapolis, Minnesota, USA, June 2022.

[6] D. Ghazzawi, D.L. Pattison, C. Horn, J.Hardy, and B. Brown, "Impact of an intensive multi-disciplinary STEM enrichment program on underrepresented minority student success." in *J. Appl. Res. High. Educ* Vol 14.2, pp. 660-678, 2021.

[7] B. Bradford, M. Beier and F. Oswald, "A meta-analysis of university STEM summer bridge program effectiveness," CBE Life Science Education, vol. 20, no. 2, April 2021.

[8] K. Kendricks, A. Arment, K. Nudunuri, C. Lowell, “Aligning best practices in student success and career preparedness: an exploratory study to establish pathways to stem careers for undergraduate minority students,” in J. Res. Technol. Careers., vol. 3, no. 1, January 2019.

[9] L. Cancado, J. R. Reisel, and C. M. Walker, “Impacts of a Summer Bridge Program in Engineering on Student Retention and Graduation”, in Journal of STEM Education: Innovations and Research, vol. 19, no. 2, Jun. 2018.

[10] J. R. Reisel, M. Jablonski, H. Hosseini, and E. Munson, “Assessment of factors impacting success for incoming college engineering students in a summer bridge program” in Int. J. Math. Educ. Sci. Technol., Vol.43, issue 12, 2012

[11] B.Grace-Odeleye, J. Santiago, “A review of some diverse models of summer bridge programs for first-generation and at-risk college students” in Administrative Issues Journal: Connecting Education, Practice, and Research, vol. 9, no.1, pp. 35-47, 2019.

[12] I. Ergin, “Constructivist approach based 5E model and usability instructional physics,” *L. Am. J. Phys. Educ.*, vol. 6, no. 1, pp. 14-20, 2012.