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WIP: Exploring Concept Maps as an Innovative Assessment Tool in Teaching and Learning Outside the Classroom

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WiP: Exploring Concept Maps as an Innovative Assessment Tool in Teaching and Learning Outside the Classroom

Abstract:

This Work-in-Progress (WiP) paper explores concept mapping as an analytical instrument to assess the effects of a 10-week, mentor-guided summer research program for undergraduate engineering students. Specifically, it examines how this program fosters connections, a fundamental component of the Entrepreneurial Mindset (EM). Concept maps are visual representations of knowledge and connections between topics. EM encompasses a multitude of essential skills, including the inclination to discover, evaluate, and exploit opportunities, all of which are critical for developing students into well-rounded engineers.

Concept maps are tools used in both learning and assessment within broad K-20 academic contexts. They aid in student learning by developing non-linear connections of acquired ideas over time. In engineering education, leaders in EM scholarship have demonstrated the impact of concept maps on measuring the development of knowledge, skills, and attitudes (KSAs) of first-year engineering students. While the efficacy of concept mapping as an analytical approach has been established, this paper takes a novel approach by demonstrating the adaptability of this assessment tool to high-impact experiential learning beyond the conventional classroom setting. This tool can illustrate stages of the learning process, thorough understanding, development of conceptual relationships, knowledge gaps, and the ability to disseminate knowledge through scientific communication. Concept maps harness the development of complex, interconnected ideas and can be applied to learning, not dependent on the style of the educational process. The primary objective of a Grand Challenges Scholars Program Research Experience for Undergraduates (GCSP-REU) is to provide students with an opportunity to apply their classroom-acquired knowledge to the National Academy of Engineering (NAE) Grand Challenges. Scholars participating in this study completed a concept map, with the center topic being their chosen NAE Grand Challenge theme, and used ideas from their research as the branching topics from the theme. The participants then built upon their concept maps throughout the research experience. Concept maps give a unique opportunity to encourage, document, observe, and quantify the development of a student's EM during hands-on experiences in an REU.

This work-in-progress paper describes the successful implementation of concept mapping as an analytical tool to measure student learning outcomes in the non-traditional learning environment of an REU. Furthermore, this paper describes a work in a current study to explore the development of research self-efficacy and engineering identity development of early career engineering students who participate in a 10-week interdisciplinary research experience and community-building activities through the Engineering Grand Challenges Scholars REU

program. This paper illustrates the key role of the GCSP-REU in cultivating the development of key components of the EM throughout the 10-week experience through validated questions for research identity and engineering self-efficacy, as well as an evaluation of the development of an EM using concept mapping.

Introduction:

In the current technology-focused society prioritizing interdisciplinary collaboration, it is crucial to incorporate best practices in undergraduate education. Specifically, introducing engineering undergraduate students to research can elevate the development of future academic and industry leaders in engineering. Building off of previous work and keeping the EM at the forefront of this research, this paper is derivative of last year's work of initializing the Grand Challenges Scholars Program Research Experience for Undergraduates (GCSP-REU) by introducing a way to analyze the role in which self-curated concept maps could showcase an individual's growth throughout the research experience. This paper will analyze the process of that research, identify necessary growth areas, and expand upon the concepts previously explored to refine our research process.

Last year's work introduced the implementation of a summer REU for engineering students who were GCSP scholars. Applied research experiences for undergraduate students present a unique opportunity to foster learning and empower professional growth. The GCSP-REU program seeks to cultivate a nurturing environment and build a *community of practice* - a group of people who share a similar interest and learn how to develop their professional career identity as they interact regularly - to empower early-career undergraduate engineering students. By implementing innovative strategies, first- and second-year engineering students expressed increased interest in applying their technical knowledge in engineering. The GCSP-REU, combined with similar efforts, has generated over 250 engineering students who are involved in the Grand Challenges Scholars Program over the past decade.

Previous research on REU programs for engineering students overwhelmingly emphasizes the importance of developing attributes of technical competence and a broader array of technical skills that come with increased participation of underrepresented populations in engineering disciplines [1]. By being conscious of those attributes through the development of the 10-week summer research program, the intentionality is to create a cohort of burgeoning engineers who are prepared both academically and experientially for a lifetime of innovation and commitment to their field. Combining this varied topics approach with experiential learning opportunities results in scholars producing electronic portfolios (e-portfolios) that are comprehensive and include all five completed competencies of Talent (Research), Interdisciplinary, Entrepreneurship & Viable Business Models, Multicultural, and Social Consciousness. This e-portfolio includes but is not limited to undergraduate research, projects, and high-impact experiences that can be leveraged to pursue future academic and professional careers.

Combining e-portfolios with an interdisciplinary approach to education scenarios allows us to perform the analysis of our cohort's growth in varied ways. Previous cohorts were tasked with the performance of a pre-and post-program survey as well as a traditional reflection essay [2]. Extrapolating on that idea and the engineers' inherent drive for innovation, in this 2023 cohort we elevated the research design by adding concept maps to assess student development throughout their 10-week summer REU experience. This WiP Paper discusses the efficacy of this choice, the results of the transition, and the plans for the future extrapolation of concept maps to observe educational growth in non-classroom settings.

Concept maps are a visual representation of a cognitive map, showing the interconnectedness of learned ideas [3], [4], [5], [6], [7]. They typically start with a central idea, and then branching ideas called nodes. Nodes that contain related ideas may be connected with cross-links to indicate a relationship. The line typically includes a short phrase to indicate the nature of the relationship, called a linking phrase. Each pair of nodes connected with one cross-link and linking phrase is called a proposition. A proposition must form a cohesive, meaningful idea independently of the map. Concept maps can grow in complexity, connectedness, and size over time with further learning and a deeper understanding of the central idea [8]. Concept maps are useful tools because they offer an opportunity to understand the pathway students take to developing expertise in a subject area [7].

Concept maps have proved useful in a variety of educational settings, levels, and purposes as teaching and assessment tools in various fields, including Science, Technology, Engineering, and Mathematics (STEM) [9], [10], [11], [12], [13], [14], [15], [16], [17]. The value of concept mapping is still evident in modern engineering education. Research on EM scholarship has thoroughly established concept mapping as a tool within engineering education [9], [10], [11], [12], [13]. Concept mapping allows students to explore ideas creatively, while still allowing instructors to understand thought processes and knowledge development [12]. This previous research lays the groundwork for concept mapping as a tool to analyze a student's EM. Through this research, this paper seeks to accomplish the mix of extrapolation of concept mapping to a new context which can assess the GCSP-REU program as a whole. The described proposed application of concept mapping is an application to an REU program with hands-on learning outside of the classroom within engineering education.

Description of Program:

The National Academy of Engineering (NAE) and engineering educators envision a better tomorrow by preparing undergraduate STEM students to define and build a sustainable, secure, healthy, and enjoyable future [14], [15], [16]. The NAE's fourteen grand challenges encompass the greatest challenges and opportunities that engineers face and will continue to face in the 21st

Century [14]. These tenets are implemented within the nationwide program of the Grand Challenge Scholars Program (GCSP), a 10-week summer Research Experience for Undergraduates (REU) program to provide hands-on experiences for participating scholars.

The e GCSP-REU program curriculum is continuously evolving and revised, based on prior year's feedback and reflections, to provide this year's scholars with impactful hands-on experiences over the 10-week summer program. Utilizing the ideas conceptualized through the "Future Work" section of the 2023 study, "*The Grand Challenges Scholars Program Research Experience: A Great Opportunity to Cultivate Belonging in a Community of Practice*," various changes were implemented in aid of the evolution of the program [2]. Firstly, the weekly meetings continued with a hybrid option for student researchers to allow for maximum participation of scholars. Polling of the 2023 cohort resulted in an agreed-upon time that is applicable for all scholars to meet for 90-minute weekly lab meetings. These meetings were improved by including team activities to engage all participants and asking scholars to reflect on their weekly research experience by responding to a few questions as they document their responses in their research lab notebooks.

Justification:

In a revision to the previous standard of practice, concept maps were implemented to analyze the growth both before and after the experience of students involved in the GCSP-REU program to build upon the findings of the previous study, relying on the experiential learning data collected from survey studies rather than the implementation of concept map analysis. In opposition to a standard reflection essay, the use of concept maps as an assessment tool allows for a thorough outline of relationships between ideas and concepts and how they individually connect those ideas and concepts organically [8], [10].

To score these maps, we used the traditional scoring method outlined in "*Concept Maps as an Assessment Tool for Evaluating Students' Perception of Entrepreneurial Mind-set"* [8]. The traditional scoring method uses three values, the Number of Concepts (NC), Highest Hierarchy (HH), and Number of Cross-links (NCL) to calculate a total concept map score. The NC represents the knowledge breadth subscore where concepts are the items contained within a boundary (excluding the central topic or starting node). The HH represents the knowledge depth sub-score where a hierarchy is defined by propositions that include the concept map topic (concepts stemming from the central topic). HH is the number of concepts in the longest path down a hierarchy. The NCL represents the knowledge connectedness sub-score where cross-links are links between concepts in different hierarchies. The total concept map score is the sum of the NC, five times the HH, and ten times the NCL [17].

Sample:

The 2023 summer GCSP-REU program supported 22 undergraduate engineering students from various majors at the prescribed institution (Figure 1). The 22 students were selected through an application process from a pool of GCSP scholars. The student application process included questions about research goals. Interested students were required to submit a one-page résumé, a current transcript, two potential research mentors' information, and a letter of interest indicating the anticipated impact of their summer research experience on the GCSP talent competency and future goals. Asking students to provide two research faculty mentors they were interested in working with for this research empowers the students to identify the research and mentor that aligns with the grand challenge topic of their interest. If a research mentor was not identified at the time of application, individualized mentoring was offered by the GCSP director to connect the student to potential mentors and facilitate the conversation to express interest and ask for mentorship. After a careful review of each application, students were notified of the decision. Of the accepted students, 50% (n=11) identified as female. 18.18% (n=4) of these students participated in the 2022 iteration of the GCSP-REU and returned to the program in 2023. A complete breakdown of information can be found in Figure 2. Of the 22 program-accepted REU participants, 21 participants chose to be included in the research study through IRB-approved informed consent. Of the 21 participants, 19 completed at least two concept map collection reviews and were included in the data presented.

Research participants choose a self-selected pseudonym that is used throughout the blinded study. Students signed an informed consent, indicating their willingness to participate in the study including their pseudonym on the first day of the GCSP-REU. These forms were collected and stored immediately, separate from all subsequently collected study data. Participant identity was protected to promote honest answers.

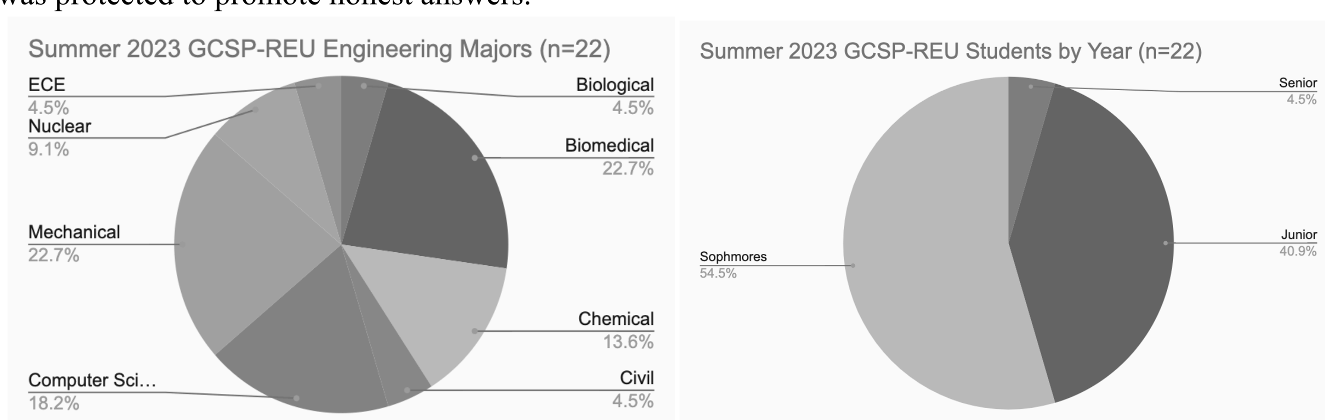

Fig. 1. Breakdown of 2023 GCSP-REU participants by engineering major (left) and by current undergraduate year (right).

Description of Assessment Tool:

Concept maps have been broadly used and validated across educational contexts. They have been often used in course design and student assessment within a course, as described above. The assessment of students in a multidisciplinary summer research experience has not yet been documented. This novel application of concept mapping as an assessment tool broadens the usefulness and potential of concept maps for learning outside of the classroom, such as an REU.

Students within the GCSP-REU program who chose to participate in the research study were given instructions to construct their initial concept map on day one of the GCSP-REU experience (Appendix A). Participants chose if they would like to create a paper or digital concept map. Participants labeled each concept map with a self-selected pseudonym to protect privacy and encourage honest responses. Pseudonyms were written on the back of the concept map for paper submissions to allow participants to reidentify their maps face down, preventing peer or researcher observation. Pseudonyms remained the same throughout the experience, allowing individual growth to be compared at different times. Participants were not constrained on time and were allowed to turn in concept maps when completed. Students placed paper concept maps in a closed folder or submitted them anonymously online.

Halfway through the 10-week experience, participants received a photocopy of their first concept map on paper or were asked to reassess the digital version. Paper concept maps were laid out face down, with only the pseudonym visible. Participants were allowed to build upon the map if they had developed additional ideas for connections and nodes during the first half of the GCSP-REU. Participants returned the maps similarly to the first iteration. During the final week of the GCSP-REU, participants were given a photocopy or asked to reassess the concept map from the middle of the experience. Participants had the opportunity to build upon the concept map if they had developed new connections or ideas.

Additionally, students were also asked to answer pre- and post-survey questions. The questions were based on validated engineering self-efficacy questions adapted from Mamaril *et al.* [18]. The survey also included questions validated on research identity adapted from Branchaw, *et al.* [19]. The prompted responses to these questions were a combination of a five-point Likert scale, polar (Yes/No), and short answer. The complete survey and response type are provided in Table 1. Participants were instructed to circle a number from one to five, with one being least confident and five being most confident, indicating how they felt towards each question.

Table 1. Pre- and post-survey questions and associated response types. Students were asked to complete these questions during the first and last week of the GCSP-REU.

Question Number	Question	Response Type
1	I know how to identify a research lab and mentor.	Five-point Likert Scale
2	I know how to effectively communicate with my research lab team and mentor.	Five-point Likert Scale
3	I know the engineering design process.	Five-point Likert Scale
4	I know how to set research objectives, goals, and expectations with my mentor.	Five-point Likert Scale
5	If I have a research question, I know how to find the answer in the literature.	Five-point Likert Scale
6	I know how to identify a research question and form a hypothesis.	Five-point Likert Scale
7	I know how to write a research abstract.	Five-point Likert Scale
8	I feel confident conducting research independently.	Five-point Likert Scale
9	I feel confident analyzing data resulting from my research.	Five-point Likert Scale
10	I feel confident documenting and orally presenting my research findings.	Five-point Likert Scale
11	I feel confident communicating my result findings in a written form in a research poster.	Five-point Likert Scale
12	I feel confident in critical thinking and problem-solving	Five-point Likert Scale
13	What do you think is the role that undergraduate students play in research?	Short answer
14	Are you aware of opportunities for undergraduates to obtain funding for research?	Polar
15	Are you aware of opportunities for undergraduates to obtain funding for travel to present their research work?	Polar
16	How do you think your research experiences can contribute to your future career goals?	Short answer
17	What questions or concerns did you have before/after beginning your undergraduate research experience?	Short answer

Results:

Numerical pre- and post-survey results were collected and averaged (n=15) as shown in Figure 2. The average of participants' responses to each question between the beginning and end of the

GCSP-REU experience increased, with results for 10 out of 12 questions being statistically significant for this dataset (* $p < 0.05$). The average growth overall was 1.0 points across all numerical Likert scale questions indicating positive trends of growing confidence toward engineering self-efficacy and research identity.

Concept maps were scored numerically using the traditional method. Score comparisons between concept maps one, two, and three are presented in Figure 3. The average growth in concept map score across all participants between concept map collection one, at the beginning of the 10-week GCSP-REU, and collection three, at the end of the program, was 40.3 points. The growth in concept map collection scores was statistically significant ($p = 0.00332$).

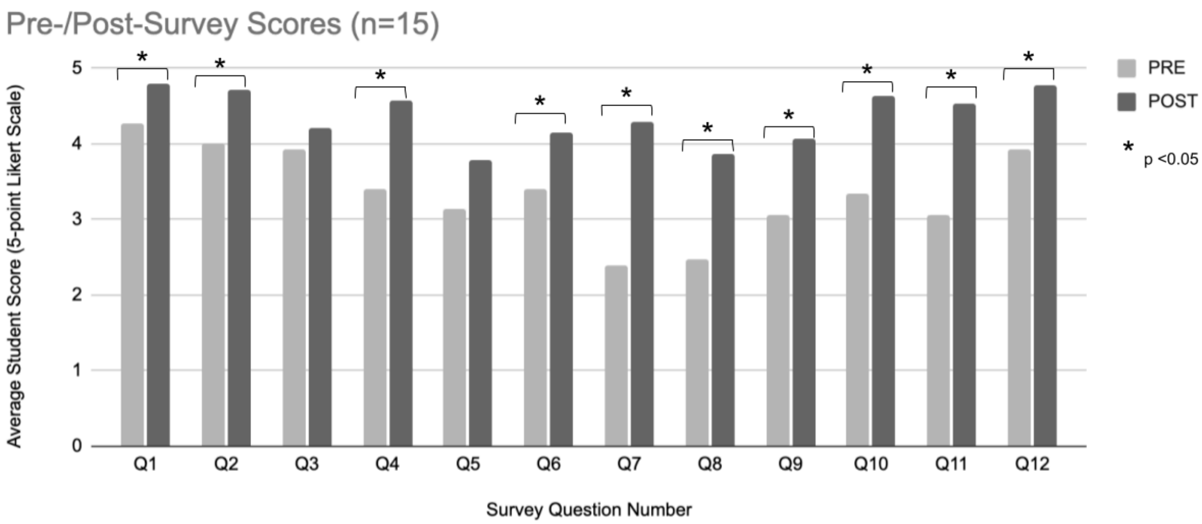

Figure 2. Pre- and post- survey response averages for engineering self-efficacy and skills for entering research based on a five-point Likert Scale from one being least confident and five being most confident.

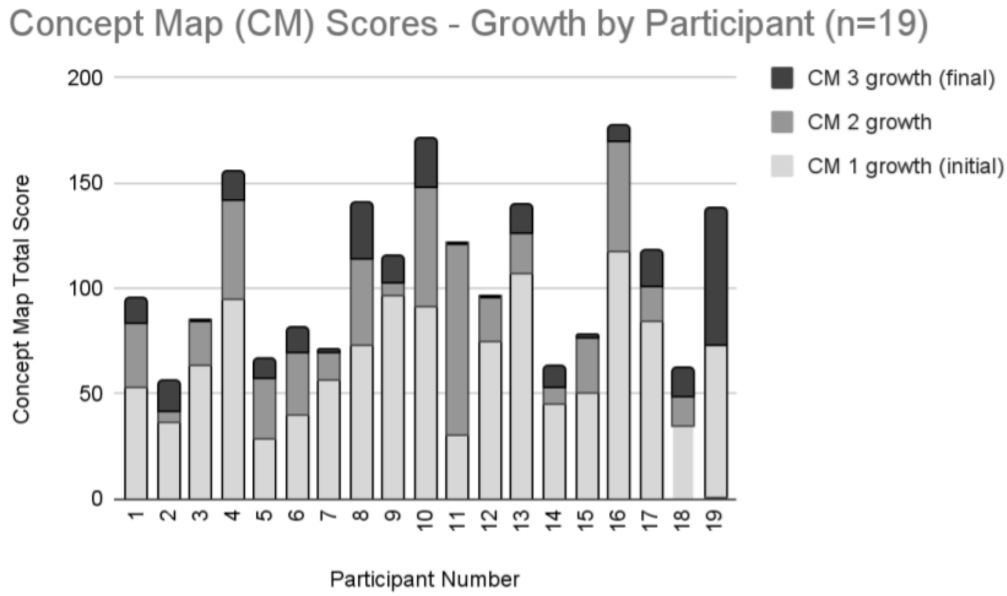

Figure 3. Individual growth by participant per iteration. Each bar section indicates growth at concept map collection one (CM 1), two (CM 2), and three (CM 3), respectively. Full bar length indicates total concept map score using the traditional concept map method at final collection (CM 3).

Due to the length of the 10-week study, protecting student identity, and adhering to IRB guidelines, some data sets were not complete. Some participants failed to answer the questions on the back of the pre- and/or post-survey. Some participants did not complete each of the three concept map collection iterations during the duration of the program. Participant data sets with no data past the pre-survey and one concept map collection were not included in the data analysis due to a lack of longitudinal data.

The results present supportive evidence that the GCSP-REU program aids in the development of undergraduate engineering students' research identity, engineering self-efficacy, and EM. The development of EM is displayed through the aspect of connectedness shown in concept maps, and the positive trend in students' ability to create a concept map on their grand challenge topic and related research. This study evaluates the effectiveness of concept maps in assessing outside the classroom in non-traditional, non-uniform learning environments, as well as evaluates the success and progress of the GCSP-REU in developing the engineers of the future.

Teaching and Learning:

Possessing an accurate measurement tool to adjudicate the efficacy of the GSCP-REU 10-week program is essential to keeping stock of the burgeoning engineer's competencies and skill sets as they transition to the workforce. Various studies point to the essential nature of undergraduate research experiences in relation to future STEM careers, with as high as 68% of undergraduate respondents to a 2008 study showcasing who had gone through a similar research experience declaring they "have an interest in a STEM career," with just under one in three respondents in the same study sharing they "developed a new expectation of obtaining a PhD," [20]. While still pursuing their undergraduate education, we have seen engineering studies who have committed to an undergraduate research project are more likely to commit to engineering, thus higher retention rates, increases in course grades, and greater persistence in the major, all of which combine to result in higher graduation rates when compared to their counterparts who did not engage in an undergraduate research program [21].

Specific to the GCSP-REU 10-week program, we have cultivated an interdisciplinary approach to our weekly meeting topics to educate on the foundational ideas of research and facilitate interesting discussions (Appendix B). This is built with the Grand Challenge Scholars Program competencies at the forefront, specifically Talent (Research), Multidisciplinary, Entrepreneurship & Viable Business Models, Global Awareness, and Social Consciousness. The intentionality behind this varied coursework is to create a cohort of burgeoning engineers who are prepared both academically and experientially for a lifetime of innovation and commitment to their field. From the first introductory meeting, there begins a curated lesson plan consisting of the integration of current concepts like AI into traditionally accepted tenets of engineering education like Applications of Research in Industry which allows for the development of engineering students with an interdisciplinary focus. There are workforce personality tests built in, in our case the Clifton Strengths Assessment, which measures the weight of the varying degree of 34 talents and delivers a personalized rank-ordered description of the individual's high-performance traits, giving these students a leg up by discreetly showcasing their competencies. Utilizing their strengths throughout the research process and gaining confidence throughout the research process, students are guided through the following weeks of essential topics for personal growth, like resume building and poster presentation. The end of the 10-week REU results in a showcase of individual accomplishments for each student in the form of a poster presentation.

This inherent multidisciplinary approach, with varied topics and formats suited to appeal specifically to this next generation of engineering students, requires a measurement metric that can encompass the full breadth of this program. By utilizing an adaptive qualitative measuring system like concept maps, students are given the freedom to express their perceptions of growth in varied topic areas, and practitioners are allowed to validate their varied growth experiences through a multitude of adjudication and scoring methodologies.

Building Relationships:

Previous work shows the benefit of cultivating a *community of practice*, returning GCSP-REU members were paired with new students entering the program [2], [22]. The returning participants (six out of the 27 new summer REUs who plan to participate this summer) served as a resource to peer-mentor the new participants as they develop an *engineering identity* and learn research skills. The scholars participating in the program were requested to fill out a poll and choose a day in the week they would like to meet, as well as the meeting location that would be most convenient for them. In-person attendance of these meetings this past summer was incentivized with provided refreshments and engaging team-building activities. Secondly, we informed the scholars about helpful resources before the beginning of the program that would greatly assist them. Through hosting an informational networking event before beginning research where we will introduce the program leadership, the introduction of a universally accessible Moodle site, and concise and clear program expectations, while foundationally allowing students to meet their peers. Through discussion with previous cohorts and using tools like Moodle and GroupMe, useful information has been distributed early and regularly. For example, it is important to encourage scholars to get the parking pass early as they will be commuting to their research labs or in-person meetings. The scholars are also encouraged to apply for the Office of Undergraduate Research Award to earn financial support that pays for non-educational fees. Thirdly, a focus on weekly goal-setting and reflection will be implemented to add individual structure and guidance to the experience, contributing to the development of engineering *self-efficacy*.

Inside and outside of this 10-week GCSP-REU program, opportunities to facilitate connection and engagement have been tailored for students to leave this experience with a cohort of fellow researchers in their field. The success of the GCSP-REU program is found in empowering students throughout the rest of their academic careers and beyond. The inclusion of the necessity of picking a research mentor is a core tenet of the program, broadening a staff member's impact to an undergraduate student whom they may not have connected with prior, resulting in another resource for the student to have as they move into their career. By educating students on the functions of research in a classroom setting, the GCSP-REU relieves the responsibilities of a student's chosen mentor so their relationship can be built through the proficiency of undergraduate research. The peer-mentoring aspect also allows for a relationship between those who have been in the program to aid the journey of those just starting and can inspire previously new cohort members to join the peer mentor aspect as well for next year. Relationships are essential to the GCSP-REU program.

Discussion:

Overall, this study shows continued success in the GCSP-REU program, as well as introduces concept mapping as a tool to assess this unique learning experience. There were positive preliminary results in the concept mapping assessment technique for the GCSP-REU program. In addition, the pilot study provided valuable insight into student perceptions of concept map instructions when used as an assessment tool. Students participating in this program are at various educational levels, in different engineering fields, have different experiences in research, and have different past experiences constructing concept maps. These differences are compounded into a variety of concept mapping methods. Ultimately, many student-to-student stylistic differences in map construction presented a crucial issue to using the concept maps as an assessment tool for the GCSP-REU. In addition, question three and question five of the pre-/post- survey did not result in statistically significant growth throughout the 10-week experience. Question three states “I know the engineering design process.” This is likely due to the prescribed institution’s requirement for first-year students to take an engineering course with a focus on the engineering design cycle during their first year. Question five states “If I have a research question, I know how to find the answer in the literature.” This result better informs decisions for future workshop topics and activities. The average score on the pre-survey was 3.9 and rose slightly to 4.2 on the post-survey. This limited growth could be attributed to the expertise already possessed by students after this course. Otherwise, broad, positive, and statistically significant growth in the pre- and post-survey Likert-scale questions and concept map scores was observed, indicating a positive impact on the participants’ engineering self-efficacy and research identity.

In addition, the pre- and post-survey included short answer response questions. Question 13 states “What do you think is the role that undergraduate students play in research?.” There was notable growth in how students perceived their role as undergraduate researchers before and after the GCSP-REU. For example, one student answered this question “To carry out tasks that do not require much complexity to ease the burden of graduate research.” before the experience, and after responding with “Undergrads play a critical role in experimentation and data collection. They can also provide perspectives that professionals in the subject may overlook.” This response highlights how the experience can build students' research self-efficacy and engineering identity toward becoming an independent researcher. There were consistent themes in post-survey responses indicating the importance of undergraduate researcher contributions. Statements such as “[taking] initiative,” “provid[ing] a new perspective,” and “bring[ing] new ideas to the table,” from the post-survey reiterate how students view their role after the GCSP-REU. Overall, this insight provided positive feedback on the GCSP-REU and an opportunity to improve the concept map tool and group instruction for use in future iterations and associated assessment of the program, as detailed in the Future Works section below.

Future Works:

Taking the lessons learned year after year, we continuously improve our planning and execution process for the next year. Continued analysis of the 2022 and 2023 iteration of the GCSP-REU provides beneficial insight into program improvements and future revisions to the study and program design. Moving forward, we are using this experience to guide planning for future iterations in 2025 and beyond.

In addition to program improvements, the assessment tool will be modified to aid in consistency and evaluation. As previously mentioned, scholars were given open-ended prompts and were able to construct their concept maps on paper or digitally. These platforms led to increased variability in the concept maps and scoring that was not necessarily indicative of the student's knowledge. A distinct example was that digital concept maps prompted students to include linking words between ideas. Students creating their concept maps on paper did not always use linking words, which led to a distinct difference that presented itself in the scoring method. Students in this particular iteration of this study were compared to their previous maps and not amongst each other, therefore it did not affect this study. Future analysis may require comparison between maps, which motivates the need to minimize score differences based on personal preference. In future iterations, students will be instructed to create their maps solely online, using consistent software. Using online resources will also allow students to add to their concept maps without the physical boundaries of the paper.

Additionally, some concept maps were difficult to score due to the lack of a hierarchical structure. This made it difficult to understand the primary pathways between ideas and subsequent crosslinks. Future concept map instructions will include guidance to construct the concept maps sequentially, with the main concepts at the top, moving to the smaller, more specific concepts near the bottom. Providing instruction to use a gridded background may help students align their ideas.

A concern in moving forward is the illusion of positive results through the repetition of the study. In repeatedly giving the same set of students the same concept map throughout various parts of the 10-week research process, there is an understood implication of building upon writing what you had written before, therefore resulting in false positive trends. In addition, students who participated in this GCSP-REU may have taken courses or other professional development opportunities during the 10-week experience. We realize that the GCSP-REU is one aspect of the student's experience that may have contributed to this growth. Positive indications in both validated Likert-scale questions and concept map assessments strengthen the indications that concept maps are appropriate for assessing student growth in the EM framework through connectedness throughout their research experience.

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Appendix A

Concept map instructions as given to students during each iteration of concept map collection.

> *"A concept map is used to visualize the relationships between different topics and concepts. It includes concepts connected with lines. The lines of a concept map include words to describe the relationship of the 2 connected items. (Concept map example included).*
>
> *You are to create a concept map for your research experience as outlined in the instructions below. This can be created on the computer or hand-drawn. You can use the internet to look up additional examples of concept maps and concept map creation software.*
>
> *Instructions:*
> 1. *Create a concept map for this research experience electronically or by hand that fits on one page. An optional instructions page for C-Map software is included.*
> 2. *Use the name of your grand challenge theme (sustainability, security, health, or joy of living) as the central topic that all other topics and concepts branch from.*
> 3. *Your concept map should contain concepts from and that relate to your research experience."*

Appendix B

The weekly professional development meeting schedule for summer 2023.

Weekly Professional Development Meeting Scheduling	
Week 1	Introduction to Research
Week 2	AI & Applications of Research in Industry
Week 3	Institutional Library Resources - locating literature, using a citation manager, writing resources
Week 4	Career Develop Center - using CliftonStrengths in research
Week 5	Community Building
Week 6	Career Development Center Resume Workshop
Week 7	Poster Content Evaluations & Feedback
Week 8	Poster Presentation Help Session
Week 9	Final Poster Presentations at Summer Symposium
Week 10	Showcase & celebration with advisors