First Year Students Developing a Systems Perspective in the Grand Challenge Scholars Program

Amy Trowbridge, Haolin Zhu, James Collofello
Ira A. Fulton Schools of Engineering
Arizona State University

***Abstract*—This work investigates how participation in the National Academy of Engineering (NAE) Grand Challenge Scholars Program (GCSP) influences first year engineering students' development of a systems perspective. Students in the NAE GCSP participate in curricular and extracurricular activities to gain research/project experience, an interdisciplinary perspective, an entrepreneurial mindset, multicultural awareness, and social consciousness. At Arizona State University, most GCSP students begin program participation in their first year, primarily through a GCSP specific course designed to help them to develop an interdisciplinary perspective. Each year, approximately 20-25 percent of the incoming GCSP freshmen get involved in the program before classes start, during a weeklong summer program. To evaluate how these GCSP activities influence students' development of systems perspective, qualitative research methods were used to analyze students' end of semester course reflections. Results of a thematic analysis of the data indicate that first year students participating in these activities experience a change in how they think about engineering, recognizing the complexity of problems facing society and the need to consider societal factors (e.g. policy, culture) when developing engineering solutions.**

Keywords—Grand Challenge Scholars Program; Interdisciplinary; First-year experiences; Social Impact; Systems Perspective

I. Introduction

In response to the rapidly changing world, engineering experts have increasingly recognized a need for engineering graduates to develop a broader, more interdisciplinary skillset and mindset. In the *Engineer of 2020* report, the National Academy of Engineering (NAE) stated that engineering graduates not only need technical skills, but also knowledge of business principles, leadership skills, creativity, and the ability to adapt to changing demands and conditions to be successful engineers [1]. The NAE also recognized that it is important for graduates to consider social issues when developing engineering solutions, and recognized that societal challenges will influence engineers and engineering in the future. In a 2007 report on the future of engineering education, the National Science Board recognized the need for engineers to develop systems thinking skills, as well as the broad set of skills discussed by the NAE [2]. These reports have influenced engineering education in many ways through modifications to accreditation criteria, research, curriculum, and other systematic changes. Engineering educators have made changes to curricular and co-curricular activities to broaden students' skillset, and researchers have attempted to define and assess these interdisciplinary skills.

Across the various expert reports on important engineering skills, one concept that often appears is the ability of an engineer to understand the interdisciplinary nature of engineering, recognizing that engineering happens within the context of society. Lattuca et al. recognizes this as a need for interdisciplinary learning in preparing engineers, describing interdisciplinarity as "a process that requires synthesis of various disciplinary knowledge and methods to provide a more holistic understanding of a given problem" [3]. In developing a measure for interdisciplinary competence, Lattuca et al. recognized multiple dimensions to assessing interdisciplinary competence including possessing interdisciplinary skills or the ability to connect information from multiple fields to solve a problem, reflective behavior, and recognizing disciplinary perspectives [3,4]. Similarly, in the context of design, Palmer et al. defines contextual competence as "an engineer's ability to anticipate and understand the constraints and impacts of social, cultural, environmental, political, and other contexts on engineering solutions" [5]. An entrepreneurial mindset is another valued asset of an engineer, according to The Kern Family Foundation, as it allows engineers to "understand the bigger picture,…recognize opportunities, evaluate markets, and learn from mistakes to create value for themselves and others," [6]. Others have recognized a need to develop systems thinkers who have the interdisciplinary skill and ability to work across disciplinary boundaries to collaborate on solving complex societal problems. This need, according to Grohs et al., arises from the nature of the complex problems engineers face in society today, which are defined by interconnected technical and contextual (societal) elements [7]. The understanding of engineering as one part of a whole system (within the context of society), and recognition of the interconnections between the parts aligns with a basic level of understanding systems thinking [8,9]. Although the terminology used varies, each of these competencies or ways of thinking are related to one basic concept: engineers need to recognize that multiple disciplines, including engineering, are needed to solve societal problems, and that engineering solutions, in turn can impact society.

There are multiple engineering education efforts including curricular, co-curricular, and extra-curricular activities that focus on helping students to develop an interdisciplinary perspective and/or systems thinking. As mentioned previously, there have been many curricular efforts made at engineering institutions to incorporate more human-centered design or entrepreneurially minded learning to encourage students to focus on creating value for customers and society when developing engineering solutions [6,10,11,12]. There are also many co-curricular and extracurricular activities focused on service learning and global experiences, which serve to broaden students' perspectives of engineering. One particular co-curricular program with an explicit focus on developing interdisciplinary perspectives is the NAE Grand Challenge Scholars Program [13]. The NAE Grand Challenge Scholars Program (GCSP) is a curricular and co-curricular program focused on preparing students, through courses and experiences, to develop Talent, Multidisciplinary, Viable Business/Entrepreneurship, Multicultural, and Social Consciousness competencies needed to solve global challenges. There are currently more than 60 institutions with an established GCSP, each providing their own set of experiences and coursework students can participate in to achieve the five GCSP competencies to graduate as a NAE Grand Challenge Scholar [13]. Although the GCSP has existed at some institutions for several years, little research has been conducted on students' experiences in the GCSP [14,15]. This work aims to provide some initial insights into how participation in the GCSP influences first year students' perspectives about engineering.

II. Context

At Arizona State University (ASU), we have institutionalized many aspects of peace engineering including a transdisciplinary approach emphasizing innovation and creativity while stressing the importance of applying science and engineering to the solution of practical problems. Our ASU charter states:

ASU is a comprehensive public research university, measured not by whom it excludes, but by whom it includes and how they succeed; advancing research and discovery of public value; and assuming fundamental responsibility for the economic, social, cultural and overall health of the communities it serves.

Our engineering school also does not include traditional departments but instead is organized as six thematic multidisciplinary schools promoting cross collaboration across disciplines. We invest heavily in what we call the Fulton Difference, which consists of a variety of curricular and extracurricular programs designed to build complementary skillsets for our students and further develop their ability to impact society. One such program is our Grand Challenge Scholars Program.

At ASU, a majority of the Grand Challenge scholars start their program as freshmen. Throughout their participation in the GCSP, they choose curricular and co-curricular experiences to participate in within each of the five competency areas that are focused on one overarching theme that they choose as their focus in the program: one specific Grand Challenge or a Grand Challenge theme (energy, health, sustainability, education, security). Students also use digital portfolios throughout the program to document their accomplishments and reflect on their experiences in these five competency areas.

There is a variety of different ways in which first year students admitted into the GCSP start their participation in the program. Each year, approximately 20-25% of the incoming GCSP freshmen participate in an optional weeklong residential summer program before classes start. This program provides students the opportunity to meet other GCSP students, learn about the Grand Challenges related research through tours and faculty talks, and to explore the grand challenges together through hands-on activities. During their first year, students' involvement in the program is primarily through the FSE150 GCSP specific course that counts toward the interdisciplinary competency and is designed to help them develop an interdisciplinary understanding of the global Grand Challenges; become aware of societal issues (sociocultural, economic, political, environmental, etc.) that constrain and/or influence engineering solutions; understand how engineering solutions add value and impact society from multiple perspectives; identify their interest, locate ongoing research, and create a preliminary plan of study for completing the program. The majority of this course is organized around five theme areas: energy, health, sustainability, education, security. For each theme area, students interact with a faculty or researcher through a guest lecture to learn about their current research, engage in active learning activities or discussions focused on interdisciplinary aspects of the challenges, and listen to their peers presenting about current research they have found in that area. Students also work on a semester-long team project to identify an opportunity to create value, develop a futuristic solution, research technologies and identify the technological development milestones in order to prove the feasibility of their solution in the future, explore societal factors that influence the development and implementation of their solution, and identify societal impacts of their solution. Besides this course, several first year GCSP students also participate in a service-learning program called Engineering Projects in Community Service (EPICS) in which they work closely with a community partner to design and develop a solution that meets their needs in a multidisciplinary team environment. This counts toward the social consciousness competency in GCSP. Most GCSP students do not get involved in activities for other competency areas such as research until after their first year.

Outside of GCSP, many GCSP students also engage in other entrepreneurially minded learning opportunities before or during their first year, as part of the first year engineering experience at the institution. These activities include a three-day summer camp and a design-focused introduction to engineering course that incorporates human centered design principles. Although these opportunities are not directly related to the GCSP, they are part of the first year students' experience at the institution.

III. Research Aims

This research aims to understand how participation in the GCSP may influence first year engineering students' development of a systems perspective of engineering. This work specifically focuses on analyzing how students understand and describe the relationship between society and technology in their reflections on their experiences in an interdisciplinary GCSP course.

IV. METHODS

A. Data Collection

As part of coursework in the FSE150 course, students started their GCSP digital portfolios and used their portfolio throughout the semester to record and reflect on their experiences in the course related to the five GC theme areas. At the end of the semester, each student also summarized their overall experiences in this course in a final reflection. The prompt given to students for the final reflection asked them to provide examples of work they did in the course, and describe the value of this experience to them, and how it connects to other experiences, their interests, and goals. These final reflections were published in students' GCSP digital portfolio and links were collected on the last day of classes each semester.

B. Participants

Fifty-nine first year GCSP students enrolled in the FSE150 course provided consent to participate in this research study. Out of these 59 participants, 53 took the course in the Fall 2017 semester and six in the Spring 2018 semester.

C. Data Analysis

Each participant was assigned a random code for anonymous analysis. The final reflection written by each participant was copied from his or her GCSP digital portfolio and pasted to a Microsoft Word document. The document was then named based on the code assigned to that student, and any identifying information was removed.

Thematic analysis of the data was conducted following the process described by Braun and Clarke [16]. Analysis began with two researchers independently reading the participants' reflections to become familiar with the data. The researchers then identified four themes to use as a framework for the thematic analysis; three themes were based on the course outcomes and informed by the data, while the fourth theme emerged after a few reflections were coded:

1. Recognize impact of technology on society
2. Recognize societal influences on technology
3. Recognize the need for multiple disciplines in developing technology or engineering solutions
4. Recognize connections between themes (e.g. health, sustainability, security, energy, education)

Two researchers then independently coded the reflections, labeling portions of the data that aligned with each of the themes. The researchers compared analysis results and discussed any discrepancies until agreement was reached to ensure inter-rater reliability. The frequencies with which each theme appeared in each reflection were counted and tabulated.

V. FINDINGS

Concepts related to one or more of the four themes appeared in the reflections written by 52 of the 59 participants. Recognizing societal influences on technology and recognizing the impact of technology on society were the most prevalent, appearing in the reflections of 39 and 35 participants, respectively. Concepts related to the other two categories, recognizing the need for multiple disciplines and recognizing connections between themes or fields were less prevalent, but still appeared in 24 and 21 participants' reflections, respectively. The findings related to the four categories including excerpts from the data and initial interpretations are summarized below.

A. Impact of Technology on Society

This theme represents the desired course learning outcome that students start to recognize the ways in which technology and engineering impact society, both positively and negatively. The data collected indicates that many students do recognize in general that technology impacts society, with several participants making general statements about the impact of engineers and technology on society and its importance. The excerpt below illustrates a general statement about technology's impact on society and the importance of those impacts to engineering:

"I was initially attracted to the GCSP because I have always been interested in helping solve problems that people and the world face today however I did not understand the full importance of identifying all of the ways that a technology can change things. Through in class activities, group assignments, individual assignments and guest speakers, I began to develop a sense of how crucial societal impacts are in engineering."

Many students describe positive impacts on society, with some making statements about how technology improves lives or makes life easier. Although not as prevalent, several students recognized technology could have negative impacts on society as well. The excerpt below describes negative impacts:

"It certainly has affected my interest in the Health theme in the sense that it has made me want to learn more about the negative effects of technology on public health. It has made me want to reconsider all the current technology that it deemed as helpful and look at the negative aspects of it - because not all innovations are perfect, and they all affect society in ways that are hardly recognizable, yet still extremely significant"

Several students provided examples, from class activities or projects, of how a specific technology such as infrastructure, solar panels, fuel cells, or virtual reality can impact society. Others focused on describing how specific aspects of society were impacted by technology, for example, economy, environment, or ethics.

B. Societal Influences on Technology

Students described the societal influences on technology and/or engineering in their reflections in several different ways. Some students made general statements about the need to consider societal influences or factors when developing engineering solutions. Most commonly, students described specific societal factors that constrain or influence engineering solutions including economics, regulations, ethics, environment, resources, and culture. Interestingly, there was a wide variety of different specific societal factors mentioned in these reflections. In some cases, a specific class activity or guest speaker was mentioned as the cause for the new understanding or perspective. The excerpt below followed the mention of a specific guest lecture focused on renewable energy:

"What most surprised me about these case studies is that there existed complaints about every energy source that did not have to do with cost. It is amazing that I have believed that everyone is in favor of renewable energy and the only thing stopping the country from getting all energy from renewable sources is the cost of it."

Several students described the importance of considering the needs and wants of the customer or user when developing solutions. The customer's needs and wants, of course, are influenced by many sociocultural factors. Some students discussed specific examples of this, such as making technology more intuitive and helpful when designing for people with limited relevant expertise and resources.

Another way in which this societal influences on technology theme appeared was when students described engineering problems in societal terms. Several students mentioned that engineers focus on solving societal problems, either in general statements or when describing specific examples of engineering projects. The excerpt below provides an example of recognizing problems as societal:

"..(this course) has truly given me a new perspective that is not just, 'Alright, if I can optimize this engine to run at 70% efficiency we can change the world'. It has given me the context that on skin-level is something that would aid an engineer, but in hindsight, the broader context is what defines a well-rounded engineer. The issue that the engineer may face might not be how to design some complex mechanism, but how to address society's needs and desires."

C. Need for Multiple Disciplines in Developing Solutions

In their reflections, students recognized that the process of developing and implementing technology requires the expertise and work of more than one discipline, including disciplines outside of engineering. Students described the need for multiple fields to be involved in a solution, both through general statements and by describing a situation that requires a specific discipline. The following excerpt provides an example of recognizing the need for a specific expertise to ensure the success of a health-related technology (bionics):

"Now, before enhancement bionics become popular, congress and other decision making bodies need to come together to create the oversight. Perhaps the oversight is just another number of laws or an international bionic oversight division."

Several students recognized the importance of viewing problems from a variety of perspectives and/or within a societal context rather than mentioning specific disciplines. When making these statements, some students credited the GCSP course with encouraging them to view engineering problems from multiple perspectives, enabling them to understand the societal context. Students' also described the importance of looking at the societal context when approaching any engineering design. Although this finding is similar to recognizing societal influences, it was different in that these statements described the need to consider the complete societal context surrounding a design rather than describing specific societal factors. In the following excerpt, a student describes how his or her approach to engineering has changed:

"The different activities we did throughout the semester also began to teach the mindset of an engineer. I've learned to take a broad approach to tackling problems, considering all aspects affecting them to create complete and efficient solutions. I now look deeper into not only the background information of problems, but also into how the solutions will affect other areas such as the economy, society, and the individuals."

Statements about the complex nature of engineering problems sometimes accompanied students' recognition that multiple disciplines or viewpoints need to be considered in engineering. Several students mentioned recognizing the complexity of the problems that engineers face, including aspects that go beyond engineering such as economics and politics.

For some students, the recognition that multiple disciplines and viewpoints are necessary to solve complex societal problems lead to a change in what they believed was the necessary skills and role of an engineer. This includes mentioning the need to think about the people, other societal factors that will influence a solution, and the potential impact of technology on society. In the following excerpt, a student recognizes engineering requires more than technical skills:

"I had a perception that a successful engineer as someone that creates something radical and world-changing on a technological level, and not someone that capitalizes on a specific social need… However, after the experience and comprehensive knowledge through the course, it is quite clear in hindsight that being an engineer, and a good one at that, requires a symbiosis of technological know-how and social know-how."

D. Recognize Connections Between Fields

This theme emerged from the data when the researchers began to notice several students discussing connections they saw between different themes or fields. As mentioned previously, the course is organized around five theme areas (Health, Energy, Security, Sustainability, Education), thus when students describe connections between themes, they are noticing connections between these particular fields or application areas. Some students made general statements about some or all of the themes being connected to one another, while others described specific examples of the connection between different themes. It is interesting to note that a few students specifically mentioned a connection between sustainability and all themes, indicating that engineers should always consider the sustainability of solutions. The following excerpt shows a general statement about connections between themes, followed by a specific example:

"Additionally, looking at all of the challenges in a single class gave me a chance to understand how each one relates to each other and to realize how much they have in common. There is

no use in making a device that improves one's health if it is not secure against hackers, or in creating a new source of energy if it is not sustainable and good for the planet."

Rather than describing connections between the overall theme areas themselves, some students described how societal issues, solutions, or individual engineering disciplines connected to the theme areas. Several students described how solutions or societal issues within one area related to solutions or societal issues in another area. Several students described a new or unexpected connection between their chosen engineering major discipline and one or more theme areas, recognizing that a single discipline can connect to multiple different theme areas.

E. Other Findings: Broadened Perspectives of Engineering

During the coding process, another interesting finding appeared that did not fit neatly into one of the previously defined theme areas. Several students described how their experiences in the GCSP course had broadened or changed their perspectives in some way about engineering. Some described having a broader perspective of the problems engineers face, while others now recognized the wide range of impacts that engineers can have on society. The following excerpt provides one example of a general statement about having a broader perspective after completing the course:

"Through FSE 150, my classmates and I were able to develop a broader and deeper perspective on engineering, and the potential impact of our role in this field. I was personally inspired by the amazing potential for change, and desire to be an innovator in my future as an engineer."

VI. Discussion

This study aimed to understand how first year students participating in the ASU GCSP understand and describe the relationship between society and technology, in an effort to see the influence of GCSP on the development of an interdisciplinary systems perspective. The findings indicate that the students recognize several ways in which society influences technology, and that technology has significant impacts on society. Students recognized the need for multiple disciplines, including but not limited to engineering, to be involved in developing successful solutions to problems which all exist within a societal context, and described the importance of viewing problems from multiple perspectives. Several students also recognized connections between themes or areas of application, such as health, sustainability, and security, and described several examples of challenges and solutions overlapping between themes. Building on the connections and need for multidisciplinary approaches, several students also described having a broader perspective of engineering, including the diversity in what engineers do and the wide range of impacts they can have on society.

The findings of this study indicate that the course outcomes on which the themes were based were met, and students did begin to develop an interdisciplinary perspective of engineering in their first year GCSP course. A majority of students described one or more relationships, either general or specific, between society and technology in their reflections on the course. The fact that a majority of students described these relationships provides some evidence that the interdisciplinary aims of the course have been met. Students' mention of course activities, talks, and projects when discussing relationship between society and technology provides further evidence that the course may have influenced their views. Furthermore, although we recognize that we cannot prove that the students' perspectives were changed or developed because of this course alone, several students did mention in their reflections that a change in perspective occurred as a result of the class. This study shows how course activities and a project can influence students thinking, encouraging them to think with a broader perspective, viewing engineering and society on a more systemic level.

The nature of the different sociotechnical relationships described by the students in this study, as indicated by the themes, align well with related competencies defined by others in the field including contextual competence [5], an entrepreneurial mindset [6], and interdisciplinary competence [4]. Students' recognition and description of a variety of different ways in which society constraints and influences technology aligns directly with Palmer et al.'s definition of contextual competence [5]. A focus on creating value for customers within the context of society, which characterizes an entrepreneurial mindset, can also be seen in the findings of this study, when participants described the need to consider the customer or user when developing solutions, and recognized the positive impacts of technology on society [11,6]. The findings of this study also relate to interdisciplinary competence, as students recognized the need for a broad multidisciplinary approach to understanding and solving complex societal problems [3]. Students' statements about the need to include multiple disciplines and apply multiple viewpoints to solve problems in their reflections may also indicate some level of interdisciplinary competence as they are recognizing the limitations of a single discipline and the value of connecting information from multiple fields to solve a problem.

The findings of this study also include some evidence of the students beginning to develop a systems perspective, at a basic level, during their first year in the GCSP. By describing a variety of different connections between society and technology, students are recognizing interconnections between parts of a system, which is related to the base level of systems engineering according to Hopper and Grohs [8,7]. Although the students in this study are not using the word 'system' in their reflections, they are recognizing that engineering is not the only 'part' to consider when developing and implementing technology. This base level of systems thinking is especially apparent in the students' recognition that multiple disciplines are needed to help understand and approach these complex global problems, which are embedded within a societal context. The recognition that engineering happens within a societal context, and that, as engineers, they need to be aware of these other disciplines, and consider external non-technical factors indicates some level of understanding of society and technology as parts of a system. These findings also relate to peace engineering, in that the students are developing understanding of engineering within a societal context at a systemic level, and awareness of the impact of technologies on society, which will enable them to solve complex, global problems including, but not limited to peace [17].

VII. Conclusions and Future Work

This study provides insights into how first year students describe the relationship between society and technology, and how participation in the GCSP may influence students' development of a systems perspective. Results indicate that, after completing an interdisciplinary GCSP course during their first year, students recognize several different relationships between society and technology. Specifically, students recognize the impacts of technology on society, several societal factors that influence engineering solutions, and the need for applying multiple disciplines and perspectives when developing solutions for complex societal problems. Some students also recognized that solutions and problems perceived to be a part of different themes or application areas, such as health and security, actually may be interconnected in several different ways. In addition, after participating in the interdisciplinary GCSP course, some first year students described having a broader perspective of engineering, what engineers do, and the impact engineers can have on society.

Although this study provides some insight into how first year students describe the relationship between society and technology and develop a systems perspective, we do recognize that there are some limitations to this work which can be improved upon in future work. The data used in this study was collected from students' final reflections in a GCSP course, however, we recognize that other factors outside the course may also have influenced students' thinking. In future studies, this work could be expanded to study the specific impact of this course, other GCSP-related activities such as EPICS, or other elements of the first year engineering experience at ASU through longitudinal and/or comparison studies. This work could also be used in combination with other past and future studies to better understand how participation in GCSP impacts students' perspectives and development as engineers.

References

[1] National Academy of Engineering, The engineer of 2020: Visions of engineering in the new century, Washington Press, 2004.

[2] National Science Board, Moving Forward to Improve Engineering Education, National Science Foundation, November 19, 2007

[3] L.R. Lattuca, D.B. Knight, H.K. Rho, and B.J. Novoselich, "Supporting the Developent of Engineers' Interdisciplinary Competence," Jounral of Engineering Education, vol.106 issue 1, pp.71-97, 2017.

[4] L.R. Lattuca, D.B.Knight, and I. Bergrom, "Developing a Measure of Interdisicplinary Competence," The International Journal of Engineering Education, Vol. 29, no.3, pp.726-739, 2013.

[5] B. Palmer, P.T. Terenzini, A.F.McKenna, B.J.Harper, and D.Merson, "Design in Context: Where do the Engineers of 2020 Learn this Skill,", ASEE Annual Conference, 2011.

[6] The Kern Family Foundation, "The KEEN Framework", 2017-2018, Available: https://www.engineeringunleashed.com/

[7] T.J. Kriewall, and K. Mekemson, "Instilling the entrepreneurial mindset into engineering undergraduates," The Journal of Engineering Entrepreneurship Vol 1.1, 2010, pp.5-19.

[8] J.R.Grohs, G.R.Kirk, M.M.Soledad, D.B.Knight, "Assessing Systems Thinking: A Tool to Measure Complex Reasoning through Ill-structured Problems," Thinking Skills and Creativity, Vol.28, pp.110-130, 2018.

[9] M.A.Hopper, "Proposing Measures for Assessing Systems Thinking Interventions," UNLV Theses, Dissertations, Professional Papers, and Capstones, no. 282, 2007.

[10] R.D.Arnold, and J.P.Wade, "A Definition of Systems Thinking: A Systems Approach", Procedia Computer Science, Vol. 44, pp.669-678, 2015.

[11] A. Gerhart and D. Melton, "Entrepreneurially Minded Learning: Incorporating Stakeholders, Discovery, Opportunity Identification, and Value Creation in Problem-based Learning Modules with Examples and Assessment Speciifc to Fluid Mechanics, American Society for Engineering Education Annual Conference, 2016.

[12] M. Huerta, J. London, M. Arevalo Avalos, A.McKenna, A. Trowbridge, W. Huang, "Cultivating the Entreprenreurial Mindset thorugh Design: Insights from Thematic Analysis of First year Engineering Students' Reflections, American Society for Engineering Education Annual Conference, 2017.

[13] National Academy of Engineering, "NAE Grand Challenge Scholars Program," 2017. Available: http://www.grandchallengescholars.org

[14] A.Trowbridge. D.Chen, J.Roldan, and T.Ganesh, "Work in Progress: A Qualitative Analysis of Students' Emerging Understanding of Becoming a Grand Challenges Scholar-Engineer, American Society for Engineering Education Annual Conference, 2017.

[15] S. Donaher, C. Dancz, J.M. Plumblee, A.S.Gordon, K.Patel, "Reviewing the Current State of Grand Challenge Scholars Programs Across the United States," ASEE American Society for Engineering Education Annual Conference, 2017.

[16] V. Braun and V. Clarke, "Using Thematic Analysis in Psychology", Qualitative Research in Psychology, Vol. 3 no.2, pp.77-101, 2006.

[17] R.Jordan, K.Agi, E.Maio, I.Nair, D.Koechner, D. Ballard, "Invitation to Shape Peace Engineering From November 12-16, 2018," WEEF-GEDC 2018, Available: https://weef-gedc2018.org/wp-content/uploads/2018/06/Peace-Engineering_2018-1.pdf