Developing Humanitarian Engineering Perspectives Among Underrepresented Scholars Through Engagement with the Sustainable Development Goals in Global Contexts

Dr. Renetta G. Tull, University of Maryland, Baltimore County

Dr. Renetta Garrison Tull is Associate Vice Provost for Strategic Initiatives at the University of Maryland, Baltimore County (UMBC: An Honors University in Maryland). She serves Professor of the Practice for the College of Engineering and Information Technology, and is part of the Engagement Team. She is also on detail with the University System of Maryland (USM), where she is Special Assistant to the Senior Vice Chancellor for Academic Affairs, and Director of Pipeline Professional Programs for the system's 12 academic institutions. She is the Co-PI and Founding Director for the National Science Foundation's PROMISE: Maryland's Alliance for Graduate Education and the Professoriate (AGEP), and Co-PI for the Louis Stokes Alliance for Minority Participation (LSAMP) and Bridge to the Doctorate programs for the USM. Dr. Tull serves on a number of boards for women and diversity in STEM initiatives throughout the US and in Latin America. She is Vice President of Initiatives for the Latin and Caribbean Consortium of Engineering Institutions (LACCEI), and co-leads the "Women in STEM" initiatives for the organization. As a former professor at the University of Wisconsin-Madison, her engineering and speech science research covered topics of accessibility. Her current research in Maryland looks at intersections of social science theories, STEM equity, and physics. She was a "Cover Girl" for O'Reilly Media's "Women in Data" issue in 2015, a finalist for the 2015 Global Engineering Deans Council/Airbus Diversity Award, Sci Chic/Medium.com 35 "Women STEM on Social Media Stars" (July 1, 2016), and 2016 winner of the Claire Felbinger Award for Diversity from ABET. She is a Tau Beta Pi "Eminent Engineer," and can be found online @Renetta_Tull and https://renettatull.wordpress.com/.

Ms. Shawnisha Hester, University of Maryland, Baltimore County

Shawnisha S. Hester is an Evaluation and Assessment Coordinator. She earned both her BA in Psychology and MA in Applied Sociology from University of Maryland, Baltimore County. She went on to complete her MSW from University of Maryland School of Social Work. Her research interests focus on using qualitative research methods that measure various phenomena and making connections via an interdisciplinary approach; qualitative evaluation and assessment measurements; increasing the number of minorities in STEM fields, and program development at the graduate level. She has had the opportunity to present at a regional and national conference and she has conducted research internationally. In addition, Ms. Hester is a licensed graduate social worker (LGSW) in the state of Maryland and provides outpatient mental health treatment to members in underserved communities. Contact information: shawnisha@gmail.com

Mrs. Yarazeth Medina, University of Maryland, Baltimore County

Accountant with multidisciplinary research interests aimed to diversify and increment access to higher education. Research interests focus on bringing the disparity of availability of information that improves programs that enforce participation in science, technology, engineering, and math fields (STEM), especially of underrepresented students in higher education. Technical interest in work related with federal funding, auditing, and programs to improve quality of life. Experience with financial auditing for state Congress, government projects, and universities in the U.S. demonstrate diverse work and skills. Mission: Global diversity and inclusion in STEM fields. Presence: U.S., Latin America, Caribbean and Asia.

Ms. Denise Nicole Williams, University of Maryland, Baltimore County

Denise N. Williams is a third year Chemistry PhD candidate at the University of Maryland, Baltimore County (UMBC) as a member of Dr. Zeev Rosenzweig's nanomaterials research group. She is currently a National Science Foundation AGEP Fellow, a Meyerhoff Graduate Fellow, and a research associate of the Center for Sustainable Nanotechnology. Prior to her time at UMBC, Denise earned a Bachelor of Science in Chemistry and a Bachelor of Science in Forensic Science from the University of New Haven

in West Haven, Connecticut in May 2015. More information on her and her research can be found at denisenw.wordpress.com.

Hector Medina, University of Maryland, Baltimore County
Ms. Erika T. Aparaka, University of Maryland College Park

Erika Aparaka is a Ph.D. candidate at the University of Maryland College Park.

Developing Humanitarian Engineering Perspectives among Underrepresented Scholars through Engagement with the Sustainable Development Goals in Global Contexts

Introduction

Opportunities to participate in international engagement experiences broaden students' perspectives and perceptions of real world problems [1]. A strong sense of "global engineering identity" can emerge when students are part of international teams that consider solutions to humanitarian challenges [2], [3]. To encourage retention in engineering among undergraduate and graduate students from underrepresented groups, a multi-campus team of faculty and administrators developed a plan to expose students to humanitarian engineering perspectives within global contexts. Through the University System of Maryland's PROMISE: Maryland's Alliance for Graduate Education and the Professoriate (AGEP), Louis Stokes Alliance for Minority Participation (LSAMP), and LSAMP Bridge to the Doctorate (LSAMP BD) initiatives, federally-funded programs of the National Science Foundation, the leaders took students to international conferences that fostered global team-based approaches to the National Academy of Engineering's (NAE) 14 Grand Challenges, and the United Nations' 17 Sustainable Development Goals (SDGs). Students attended international conferences on three continents in 2016 and 2017. The conferences introduced students to the NAE's Grand Challenges in plenary sessions, and the SDGs in smaller group sessions, with a charge to transform the world. Students from across the globe developed action plans to potentially address problems within their communities. Students were encouraged to consider real-life scenarios of their choice that could be further refined and potentially implemented upon return to their home countries. The structure of the small group sessions allowed students to be members of international teams, agree upon a problem to tackle, conduct early research, and propose a concrete path towards addressing one of the SDGs. Semi-structured qualitative data collection was used for the project, to uncover trends that connect humanitarian engineering activities at international conferences to the GCs and the SDGs. Data collection through crowdsourcing, utilized pre-and post activity reflections that students posted online. Students blogged throughout a one-week period for each of the three conferences. There were 27 respondents across the three events. Content analysis was used to disaggregate data and group similarities.

This work seeks answers to questions such as, *"Does exposure to humanitarian issues within an engineering context increase interest in global social issues among underrepresented STEM scholars?"* and *"Can structured engagement in activities that include international concerns contribute to one's global competencies?"* Students were presented with questions throughout the excursions, each building upon the day's activities and the students' reactions to their experiences.

Data showed that the students from the University System of Maryland's PROMISE AGEP, LSAMP, and LSAMP-BD delegations demonstrated a clear need to assist the global community. They were particularly interested in working on problems related to industry innovation,

infrastructure, gender equality, sustainable cities, and communities. Students realized that approaches to solutions could not be centralized to their own country, and that their proposals had to be feasible and logical for other parts of the world. As an example, challenges with bringing clean water to remote regions and approaches to sanitation required a need to take time to learn from peers from other countries. Students were asked to provide ubiquitous solutions to the problems. They were asked to consider themselves as part of the respective communities as a means of assessing the practicality of potential approaches. Students' perspectives changed throughout the course of the conference, as they reflected on their ability to bring global contexts to their research. After participating in these conferences, students experienced a greater awareness of sustainability. They were also inspired to experience different cultures, cultivating greater appreciation for the need to engage with the international community when sharing research. The exposure to humanitarian engineering perspectives influenced global STEM identity, while appreciating disciplines outside of engineering, e.g., psychology, social behaviors. Further, students learned that strides can be made toward solving global problems when collaborations and relationships are formed and fostered.

Background

The National Academy of Engineering and the United Nations have each developed lists of challenges and concerns that have been designed to bring awareness to improving life on the planet. The 14 goals of the National Academy of Engineering's Grand Challenges (NAE GCs) are: "Advance Personalized Learning," "Make Solar Energy Economical," "Reverse Engineer the Brain," "Engineer Better Medicines," "Advance Health Informatics," "Restore and Improve Urban Infrastructure," "Secure Cyberspace," "Provide Access to Clean Water," "Provide Energy from Fusion," "Prevent Nuclear Terror," "Manage the Nitrogen Cycle," "Develop Carbon Sequestration Methods," and "Engineer the Tools of Scientific Discovery" [4].

Figure 1: United Nations Sustainable Development Goals [6].

These 14 goals fit into four cross-cutting themes: sustainability, health, security, and joy of living. The UN's *2030 Agenda for Sustainable Development* has ambitions that resulted in a list of 17 Sustainable Development Goals (SDGs), shown in Figure 1, which are based on the UN's former 8 Millennium Development Goals (MDGs). The MDGs focused on halting spread of HIV/AIDs, universal primary education, and reducing poverty rates by 2015. The SDGs replaced the MDGs in 2016, with a plan to bring attention to and eradicate a number of social issues by 2030. The SDGs represent world leaders' adoption of an agenda that will continue to address poverty, pay attention to health and the planet, and build inclusive societies [5].

Engineering educators have been increasingly concerned about students' global competencies and connection to global issues. Industry leaders want students to have global skill sets, an understanding of cultures, and awareness of attitudes connected to U.S. arrogance and disconnection from global concerns, in order to avoid cultural insensitivity. Further, there are concerns that educators are not acknowledging the need for global competencies, which leads to lack of student participation in global activities. In addition, limited international experience on the part of faculty and staff is an identified obstacle that reduces student participation in study abroad and international education activities, particularly when there is a lack of institutional support [1], [3]. Studies by international organizations recommend that "global competence become a key qualification of engineering graduates," and that global perspective should be part of engineering practice [7].

Rationale

The University System of Maryland's PROMISE AGEP and LSAMP programs developed initiatives around international conferences for their underrepresented STEM students to provide professional development and global competence, and to increase STEM identity within a new place. Experiencing learning within a different country can be loosely described as education within a "third place," as it is uniquely different from home, and from the academic home base. Oldenburg [8] defines the third space as a neutral territory where individuals from all walks of life can convene as equals. In this space, a leveling occurs that dispenses with formal titles, hierarchies and status, and focuses rather on the gifts that those present bring to the space. Within contexts of underrepresented or marginalized communities, a "third space" has a special context. It is well-known that students from underrepresented minority backgrounds can experience microaggressions, or subtle insults that can be related to race or difference, within academic spaces. When an additional "space" is purposely invoked, it can be used to establish a positive climate. This alternative space or "counter-space," becomes a special place where participants escape microaggressions or subtle insults [9]. The leaders of the PROMISE AGEP, developed by NSF to provide professional development and training for underrepresented minority graduate students (URM), are keenly aware that social (racial and/or ethnic) isolation is a common experience for many graduate students in general [10]. Underrepresented minority students face additional challenges that can stem from a lack of diversity within the academic STEM department and/or entire institution. URM students face the additional burden of being a small part of the campus community where they may not encounter many, if any, students from their race [11], [12]. This can be compounded at the international level, where students may not have had previous travel experiences, or are present in spaces where a person from their background is in the minority.

To invoke a strong "third space" that would serve as a "counter-space," the PROMISE leadership decided that the international conference could established as one of those special places where underrepresented students at both the graduate and undergraduate levels could receive engage in professional development within a global, inclusive community. Choosing the type of conference was important, as it had to be a meeting that was welcoming, and inclusive. Conferences of the Latin and Caribbean Consortium for Engineering Institutions (LACCEI) and the World Engineering Education Forum (WEEF) were chosen because both meetings maintained inclusive climates, within a variety of countries. The PROMISE leadership examined these meetings and spaces, and experienced the climate in advance of bringing groups of URM students. The PROMISE leadership was assured by the leaders of LACCEI and WEEF that the conferences would provide positive experiences for the students. PROMISE also wanted to be sure that the students would be able to develop a positive STEM identity as part of the conference experience. Students with strong STEM identities can demonstrate competence in the discipline, possess the skills to perform scientific practices, and achieve recognition (from oneself and meaningful others). STEM identity encompasses three constructs that are inter-related: competence, performance and recognition [13]. The leaders of LACCEI and WEEF designed their conferences with inclusive activities that included strong traditions of recognizing diverse students as contributors to the global STEM community. Thus, each of these conferences had the potential to make a positive impact on students' educational experience.

With the goal of having students achieve a strong STEM identity, global competence, the excursions to international LACCEI and WEEF conferences were aimed toward improving retention, and providing a sense of greater investment in the global community. The conferences were designed to provide international exposure, improve contextual understanding of a global system, provide opportunities to work with diverse teams, and invoke social capital that students could use as 'experience' leverage when engaging in formal and informal networking on an international level. The plan for the experience in the international contexts included contributing to students' professional attributes such as appreciation of other cultures, proficiency on diverse teams, and communication across cultures [7].

As more attention is being paid to the need to build global competencies among engineers, the project described here takes on the task of making sure that access to international exposure is inclusive. Engineering professors around the world (e.g., Canada, Australia, London) are among those calling for engineers to be multidisciplinary, take into account socio-economic and cultural differences, and develop inclusive learning spaces. Further, there is a call for organizations to strategically include more diverse groups to participate in addressing the world's challenges [2], [3], [14], [15]. The LACCEI and WEEF conference organizers, along with the international Student Platform for Engineering Education Development (SPEED) includes within its program attention to the world's challenges via the Grand Challenges and the SDGs. Further, these groups call all conference participants to action, noting that their global diversity is a strength.

LACCEI, WEEF, and SPEED bring attention to ways to that engineers can address humanitarian efforts. To address challenges, there are a growing number of multidisciplinary researchers who are calling for coordinated approaches [16], [17]. SPEED has worked with LACCEI and WEEF conferences in different countries to develop SDG-based projects for students to undertake during their conference experience. The conferences as a whole make mention of the GCs. The

University System of Maryland's PROMISE AGEP and LSAMP programs seek to increase students' STEM identity by exposing them the overlap between SDGs and GCs within the counter-spaces of inclusive international engineering conferences. PROMISE and LSAMP elicited students' responses to experiences with people, discussions, and projects that promote use of engineering skills to address humanitarian action.

Methodology

This work is based upon three groups of participants who attended three different global, STEM-related conferences, one in the US and two hosted in foreign countries. These conferences were: LACCEI in Costa Rica (2016), WEEF in South Korea (2017), and LACCEI in Boca Raton, Florida (2017). The LACCEI conference in Florida was located in the United States, however it was an international conference that attracted an international audience. Further, all LACCEI conferences, regardless of location, are multilingual where plenary and keynote sessions are often given in Spanish, while breakout sessions are delivered in either Spanish or English. Select sessions are delivered in French, as Latin America and the Caribbean includes countries where the dominant languages are Spanish, French, or English. Translation services are provided for all participants, and participants may present research and content in their preferred language. WEEF conferences use English as the official language, regardless of the conference location. Each of the three conferences contained a student component that was led by SPEED. The SPEED-based student sessions at the WEEF conference was also called the "Global Student Forum (GSF.)" All students were required to participate in both the SPEED-sponsored student sessions, and the general attendee sessions, e.g., plenaries, keynotes, and select breakout sessions. Students also presented research at the conferences, and were required to support one another's research presentations. Although students were allowed to choose their breakout sessions, all students were required to attend sessions on gender equity, such as the "Women in STEM" forum at each LACCEI.

Data Collection

Using a grounded theory approach, students were asked to experience the international conference with minimal preconceptions. They were asked to remain observant and to report on their experiences via an online blog. A question was posted to the blog by the PROMISE leadership, asking the students to reflect upon their daily experiences, and to engage in online conversations with one another regarding their opinions on activities and interactions. Questions were also asked of the students in groups, following plenary sessions, and during group meals. Students were asked to reflect upon the questions that were asked orally, and respond as part of the group discussion. Variations of these "verbal group discussion" questions were posted to the blog so that students could respond in writing, following the oral conversation. This process can be viewed as a variation of crowdsourcing that combines reflections from oral responses, with written reflections captured by the blogging. The participants were required to blog about their experiences in every conference, in addition to answering targeted questions regarding improving global competence. Members of the faculty and staff did not blog, but they contributed to the oral conversations, and their responses were captured by the student bloggers.

Some of the questions were aimed toward engaging on a world-wide scale [19]. The variation of crowdsourcing here applies to the outsourcing method of gathering information from a selected group. Its scalability is aimed at improving continuous interactions outside of the United States. The amount of interactions should increase the quality of the preparation of the participants by having them self-evaluate their global competence and helping them create a plan to become a well-rounded professional in STEM [20]. The use of technology is receiving more attention in recent years, as the use of all kinds of technologies being harnessed for humanitarian action [21]. Three different delegations traveled across three different continents and blogged about their international experiences. These blog responses were prompted by several open-ended questions to facilitate the discussion. The open-ended questions were based on the activities for the day and caused the participants to reflect on their experiences. Data was collected in 2016 at the LACCEI conference in Florida and the WEEF conference in Seoul, South Korea; and in 2017 at the LACCEI conference in Florida.

The blogs, titled: the "International Engagement Pt. III: LACCEI & Costa Rica 2016", "International Engagement Part IV: Korea w/ the Global Student Forum & World Engineering Education Forum", and "LACCEI 2017 – Boca Raton, FL – Global Competencies & Broadening Participation in STEM" summoned graduate students and faculty from the LSAMP, LSAMP BD, and AGEP communities of Maryland, Ohio, and Massachusetts to contribute to online discussions about engineering grand challenges, international engagement, academic mobility and global engineering. Participants were informed that their responses would be used for research and that we were interested in challenges and strategies that either affect or facilitate global sustainability. All who visited the blog were invited to participate in the discussion and they were free to use any format for the blog name or avatar. Furthermore, we welcomed and encouraged participation from the general public and the international audience.

Participants

There were 27 total project participants, but only 21 participants contributed to writing the blogs. The other six participants did not contribute to the blog directly, but participated in oral conversations during the conferences. With the exception of one student, the student participants at each conference were different. These oral responses were captured and posted to the blog by other participants. The participants for conference participation were purposefully chosen from a variety of the backgrounds that included engineers (mechanical, computer, bio-), biologists, social scientists, education, human-centered computing, mathematicians, chemists, etc. These distribution of participants for this PROMISE and LSAMP project are summarized in Tables 1-3.

Table 1: Distribution of conference participants' positions, disciplines, and nature of the engagement for LACCEI - *Costa Rica, July 2016.*

10 Males, 10 females. Bloggers: 18*
Disciplines represented: Mechanical Engineering (7), Computer Science, Electrical Engineering, Computer Engineering, or Human-Centered Computing (6), Language/Literacy/Culture or Engineering Education (4), Biology or BioEngineering (2), Mathematics (1)

* The sentiments of the participants who did not blog were included by other bloggers.

These participants had different research areas, and all were from groups that are underrepresented in science. There was a unified intention to create an interdisciplinary environment with people from different ranks (undergraduate students, graduate students, postdocs, faculty, and staff) in order to stimulate conversation. There was also a purposeful plan to include a few participants outside of traditional engineering fields, so that they could be fully immersed into an engineering context. Similar distributions of student delegations were engaged at the Korea conference (Table 2) and Florida Conference (Table 3).

Table 2: Distribution of conference participants' positions, disciplines, and nature of the engagement for WEEF - *Korea, November 2016.*

4 Males, 3 females. Bloggers: 3*
Disciplines represented: Mechanical Engineering (3), Human-Centered Computing (1), Language/Literacy/Culture or Engineering Education (2), Business (1)

* The sentiments of the participants who did not blog were included by other bloggers.

Table 3: Distribution of participants' positions, disciplines, and nature of the engagement for LACCEI - *Florida, July 2017.*

5 Males, 1 female. Bloggers: 6
Disciplines represented: Mechanical Engineering (3), Computer Science (1), Chemical or Biomolecular Engineering (2)

Data Analysis

This project used a content analysis approach to examine qualitative blog response data. The data were disaggregated and grouped, based on relevance to 17 SDGs and 14 GCs. Content analysis was used for these responses because the method "yields unobtrusive measures, in which the sender nor the receiver of the message is aware that it is being analyzed" [18]. The analysis describes the experiences that each participant had and how the international experience has impacted them. Several of the questions had multiple parts. Table 4 includes the questions asked of the bloggers within the various conference settings.

Results

The observations and experiences at the three globals conferences resulted in a total of 20 questions, with sub-questions based on the conferences' content, and the participants' comprehensive learning experiences during the length of the trip. The resulting questions included topics related to GCs and SDGs in general, and with particular emphasis on SDG 4: Quality Education, and SDG 5: Gender Equality. The questions that resulted from conference sessions and observations are displayed in Tables 4-6. In the aggregate, participants provided 167 qualitative responses. The responses provide a snapshot of the ways that the diverse students

who participated in this project interacted with one another, as they participated in delegations for projects within international contexts that drew upon their engineering knowledge.

Table 4: Questions on Grand Challenges for Engineering and Sustainable Development Goals to Stimulate Online Blogging within the International Engineering Contexts

Questions	*Conference*
Write a few sentences about the most important aspect of each of the sessions, e.g., Global Engineering Projects	Costa Rica 2016
How did the ecological excursion at La Paz ("Catarata de La Paz," a waterfall garden, ecological nature park, and environmental sanctuary) influence your views on global sustainability?	Costa Rica 2016
What are you learning at GSF (the Global Student Forum) related to engineering and tech?	Korea 2016
a) Please discuss your GSF projects. b) What made the winning project(s) worthy of accolade?	Korea 2016
Please discuss your impressions from today's plenary sessions: The Platinum Society (Japan), Smart Societies (Korea), and The Grand Challenges (National Academy of Engineering).	Korea 2016
You are a U.S. citizen, on foreign soil, learning about the results of an election back in your country. • How are you processing results? • Explain your feelings about your experience at the DMZ [Korea - Demilitarized Zone]? • How do these two events shape the way that you see your role as an engineer/technologist?	Korea 2016
What were your thoughts about the "Ethical Hacking" exercise? What did you learn that you didn't know before?	Florida 2017
Discuss the session that you attended following the morning plenary, e.g., sustainability, teaching engineering. What did you learn that was new?	Florida 2016

The questions in Table 4 are covered generally by the SDGs and GCs, including references in specific activities such as "La Paz" and the connection of *SDG 15: Life on Land*, and the "Ethical Hacking" activity which connected to *GC 8: Secure Cyberspace*.

While the Florida LACCEI 2017 conference yielded the least amount of data, we learned that networking was a major part of the students' experience. In particular, Florida participants discussed having "male champions for women (inclusion)." They had conversations about gendered social and cultural expectations, and contexts that should consider policy change to increase the global inclusion of women. These two specific examples align with the *SDG 4: Quality Education*, and *SDG 5: Gender Equality,* as students grappled with ways to reduce social inequities.

The LACCEI 2016 delegation in Costa Rica was the largest of the three conferences. Many of the findings were in alignment with the other two conferences, but this particular delegation emphasized "outside of the box thinking" and the necessity for, and utilization of, the intersectionality of working with various disciplines. Similarly, issues regarding sustainability and advancing STEM were mentioned. What follows are examples corresponding to a specific NAE GC or an SDG goal.

Results related to SDG 5: Gender Equality

Students were required to attend the "Women in STEM" forum at the LACCEI conference in Costa Rica. Most of our female participants found the experience of talking about gender equality "empowering," while the male participants mentioned the need to to transform themselves into "male champions," and increase awareness amongst their peers. Table 5 showcases questions that arose as a result of conversations related to SDG 5, which speaks directly to gender.

Table 5: Questions on "Gender Equality" (SDG 5) to Stimulate Online Blogging within the International Engineering Contexts

Questions	*Conference*
Please discuss your thoughts on the Career-Life Balance session. Please be detailed and complete in your comments. What did you learn? ● How did it affect you? ● How do you see your role in supporting women in STEM? Please be specific and detailed.	Costa Rica 2016
Discuss the "Women in STEM and Diversity Panel." What resonated most for you? How will you become a champion for women and people from diverse backgrounds in STEM?	Florida 2017

The topic of gender inequality in academic contexts regularly entered the students' conversations, as it was noted that recruitment and retention of tenured female faculty from underrepresented backgrounds in STEM fields have been constant struggles. For this reason, it was not unexpected to see "Gender Equality" (SDG 5) as one of the principal goals mentioned in the data. Similarly, we saw responses that embraced having women at the table in order to make decisions. One respondent wrote:

> "... to include men in the [women inclusion] conversation will give women more allies. We live in a male-dominated world, so to get the ones in "power" (so-to-speak) on our side, they can help facilitate change."

Having a diverse engineering faculty also contributes to GC 1: Advance Personalized Learning. Data was collected in 2016 at the LACCEI conference in Costa Rica, and in 2017 at the LACCEI conference in Florida.

Results Related to GC 14: Engineering Tools of Scientific Discovery

The NAE's *GC 14: Engineering Tools of Scientific Discovery* was commonly mentioned throughout the blog posts. This GC was considered to be indicative of ways that engineers and scientists collaborate and brainstorm to develop the best techniques to resolve the obstacles related to environmental problems, such as global warming, pollution, waste disposal, climate changes, etc. Students saw that this GC related to ways that science helps us to be a better society, develop more effective and affordable medicines, improve food quality and production, and solve traffic patterns in high condensed urban areas. Students were put on global, multidisciplinary teams to consider such problems.

After attending a "Sustainable Engineering" session, many bloggers discussed what they had learned, and recounted how exposure to the topic impacted their mission to make the products of the world more useful. One particular blogger stated,

> *"I learned about using yuca and rice as material for biodegradable plastics. It's funny because during the Pre-Conference sessions, my team tried to come up with a way to make biodegradable plastics to help reduce wastes/landfills! I learned that when coming up with solutions like this, it is important to consider all aspects of error, so collaboration is key."*

Similarly, another blogger mentioned that,

> *"During the Sustainable Engineering session, there was a presentation about using compostable biomass materials as fuel for gas stoves in rural communities. This presentation was intriguing because it addresses the needs of localized areas and presents a globally-applicable solution. I learned about a way to go sustainable without the high cost of buying sustainable products! In my personal activities of reading about environmental sustainability, it was both entertaining and exhilarating to see the active work being done by scientists with similar interests."*

Results Related to SDG 4: Quality Education

The questions in Table 6 are covered by SDG 4 which discusses ensuring inclusive, quality education and the GC of "Advance Personalized Learning."

Table 6: Questions on "Quality Education" (SDG 4) to Stimulate Online Blogging Within the International Engineering Contexts.

Questions	*Conference*
Please discuss the session that you attended during this morning's parallel sessions, after our meeting. Include what you learned, and how you will use the information. (education, technology in class)	Costa Rica 2016
Think about the experience of traveling with a group. Did the "group travel for STEM" concept assist with your decision to participate in the conference, or assist with your process of traveling to another country? Please explain.	Costa Rica 2016
Write a few sentences about the most important aspect of each of the sessions below. ● Academic Mobility and Internationalization ● Thinking Outside the Box	Costa Rica 2016
● What did you learn from others outside of our delegation, e.g., other conference attendees? ● How will the experience in Costa Rica this week affect your immediate future? Provide at least three detailed examples about things that may affect your actions within the next two weeks, as a result of this trip.	Costa Rica 2016
What are you learning at GSF related to: ● Collaboration ● Culture	Korea 2016
Based on the activities of Tuesday 8 November: ● Please discuss your experiences with mentoring during this conference. ● Please discuss how having a research presentation here will advance your degree progress and affect your trajectory toward the PhD.	Korea 2016

Data was collected in 2016, at the LACCEI conference in Costa Rica, and the WEEF conference in Seoul, South Korea. *SDG 4: Quality of Education* was mentioned in the context of all learners

having access to a good education that would place them in a position to serve others as a whole, on local and international levels.

Our participants viewed education as a gateway for international change, and noted that without collaborative connections, meaningful policy and substantial implementation creating access to quality education for all would not be possible. Education was identified as a creative means to develop various solutions to the problems that were based on the SDGs. As an example, one student stated,

> *I attended the "Technology for Teaching and Learning" session today. I was most impressed with the technology used to design and build a remote laboratory for engineering students to test their circuitry knowledge in a virtual environment to them, yet their designs are carried out in real time on a remote server connected to actual hardware systems in Norway.*

One of the topics that was regularly mentioned was that participating in international experiences help the students to see that there are issues that need attention, which might be unrelated to those from their own country. This revelation was one of the highlights of participation in student forums, in both LACCEI and WEEF conferences that utilized the SDG framework for projects hosted by SPEED.

Discussion and Recommendations

Feedback from undergraduate and graduate students at both LACCEI and WEEF conferences revealed that it was important to have a central message revolving around the NAE's Grand Challenges and the UN's Sustainable Development Goals, as it created a sense of importance within the students, and elicited a desire to contribute to a greater cause. The implementation of crowdsourcing allowed us to obtain feedback from the participants' activities, and to have some insight with regard to their "sense of belonging" (within an engineering context) and their "STEM identity". This method enabled us to contribute to a platform that recorded outcomes from activities that are based on the GCs and SDGs, allowing for future guidance within these kinds of education forums.

Recommendation 1: Students should be able to work on action plans that can be easily implemented.

The WEEF conference includes the Global Student Forum (GSF), sponsored by SPEED, where students are placed into teams based on preference or appeal to a certain NAE challenge or UN goal. The main construct is that students are able to work, with some guidance from facilitators, on certain tracks focused on a challenge or goal. One noticeable problem is that the proposed solutions (action plans) can be scaled out of proportion, and are not feasible for certain parts of the world. (An example would be a mechanical solution that cannot be implemented, due to extreme weather conditions.) Conversations with participants and facilitators revealed that it would be more appealing to engage participants in the development of action plans that are applicable within a smaller time frames, and within a budget. The ability to participate in the WEEF and LACCEI conferences gives participants a chance to visit a different country, at the very least a different city, and by doing so learn more about the local culture. The participants

have opportunities to learn about the challenges within the region, as well as areas of pride. The unique opportunity also gave students at least one issue that locals to the area wanted to explore and potentially solve. This was an interesting activity for participants because they are able to understand how they can contribute to a greater cause.

Recommendation 2: Emphasize the importance of becoming an engineer.

Our students were concerned that engineering education may fail to continually address the importance of becoming an engineer or scientist. Participants mentioned that after a few years within their engineering academic programs, the motivation that led them into engineering is tested, and the feeling of "just graduating and getting a job" is what follows. Some students suggested that engineering curricula should teach more about feeding the passion that they have to make something great for society. Classes should help them to build on what drives them to work as part of teams and solve problems that are applicable to their hometowns.

Recommendation 3: Include graduate students on teams.

The creation of teams within the tracks to address the SDGs or GCs should include more graduate students. Graduate students involved in this project noted that it can be easy to lose the desire to continue to help others outside of their area of expertise or research. The time constraints and drive required to finish a graduate degree can negatively affect the desire to work on topics outside of their comfort zone. This recommendation is related to Recommendation 2 (revisiting the passion to contribute to society throughout students' entire undergraduate education.) It was suggested that mentors and advisors should promote that their graduate students engage in forums related to humanitarian efforts, such as those experienced at LACCEI, WEEF and GSF, and this action could potentially increase satisfactory outcomes of action plans that are proposed within a couple of days.

Recommendation 4. Utilize a cross-section of industry sponsors to guide selection of the goals.

The challenges and goals that were addressed during these conferences were also guided (facilitated) by local industry. As an example, one of the sponsors of the GSF and WEEF had primary interest revolving around clean energy. Many of the action plans developed that have gained traction as part of the GSF experience have worked on generation of energy using alternative methods (solar panels). It was noted that if more sponsors from different sectors in industry would participate, they would enable the contribution to different focused solutions around more challenges or goals.

Conclusions and Future Work

After learning about topics connected to the SDGs, and GCs, and hearing about solutions that were previously attempted, the students from the US were able to realize that there may be differences in the ways that solutions may work in the United States versus how solutions might work in other countries. Such a revelation contributes to students' STEM identity, as it enables participants to learn as much as they can from other cultures, based on the countries of origin of each team member. The large diversity of students who participated in the GSF sponsored by

SPEED allowed the facilitators to mix students from different countries and cultures in an effort to find as many different points of view within teams. This action promoted the need to learn and understand a little bit of every team member's culture in order to pursue an action plan that will potentially have a global impact. Participants are given a main track, and then they are able to pick a potential solution that falls within that larger scheme. The STEM identity is tested because of the diverse background of teammates, and the different levels of education that they have achieved or are pursuing (undergraduate, Masters and Ph.D. students). There is a slight pressure to engage in conversation, and participants may not be entirely comfortable, however, they work together and figure out how to move forward. In the end, this process tries to demonstrate that one solution is not applicable to all, and that the work accomplished could be modified and redirected to fit needs of people from different regions of the world. In this way, participants gain a global competency by learning that they fit into a bigger equation.

The international conferences that students attended in 2016 and 2017 performed as counter-spaces. The third space of the conferences subsequently introduced students to the NAE's Grand Challenges in plenary sessions, and the SDGs in smaller group sessions, creating alternative spaces that engaged participants in transformative thinking. Students from around the world convened together to develop their action plans for their communities. While the activity was structured, the space provided opportunities to address problems within their communities through conversations which are a hallmark feature of third and alternative spaces, thus melding first space (home) and second space (work) in a way that was egalitarian and could be conversed about in formal and informal ways. Additional data can be gathered to further support the goals of this project. We are taking two delegations to international LACCEI and WEEF conferences in 2018, and our social scientist will be working on questions that address this topic and open conversations about the importance of participating from the SDGs and the NAE's GCs.

URM scholars' engagement with SDGs and GCs led to the development of global humanitarian perspectives relevant to engineering concepts. Participation in these global, STEM-related delegations, which was supplemented by comprehensive discussion blogs, illustrated students' particular awareness of the need for gender equality, globally-applicable technology, and globally-accessible quality education in the engineering community. For these expectations to be realized, students addressed the necessity for networking and collaboration, increased awareness, sustainability, and a sense of global STEM identity. Their participation in this international engagement project indicated URM student emersion in such experiences can increase interests in and the understanding of global engineering issues which could supplement their student experience and success.

Acknowledgements

References

[1] J. M. Grandin and E. D. Hirleman, "Educating Engineers as Global Citizens: A Call for Action/A Report of the National Summit Meeting on the Globalization of Engineering Education," *Online J. Glob. Eng. Educ.*, vol. 4, no. 1, pp. 1–28, 2009.

[2] A. Chan and J. Fishbein, "A global engineer for the global community," *J. Policy Engagem.*, vol. 1, pp. 4–9, 2009.

[3] F. Patel, "Deconstructing internationalization: Advocating glocalization in international higher education," *J. Int. Glob. Stud.*, vol. 8, no. 2, pp. 64–82, 2017.

[4] N. G. C. for E. COMMITTEE, *NAE Grand Challenges for Engineering*. 2008.

[5] UN, "The Sustainable Development Goals Report," *United Nations*, pp. 1–56, 2017.

[6] UN, "Sustainable Development Goals," *United Nations*, 2015. [Online]. Available: https://sustainabledevelopment.un.org/?menu=1300.

[7] A. Parkinson, "The Rationale for Developing Global Competence," *Online J. Glob. Eng. Educ.*, vol. 4, no. 2, p. 2, 2009.

[8] R. Oldenburg, "The Great Good Place," *Gt. Good Place*, p. 368, 1999.

[9] D. Solorzano, M. Ceja, and T. Yosso, "Critical Race Theory, Racial Microaggressions, and Campus Racial Climate: The Experiences of African American College Students," *J. Negro Educ.*, vol. 69, no. 1/2, pp. 60–73, 2000.

[10] B. E. Lovitts, *Leaving the Ivory Tower: The Causes and Consequences of Departure from Doctoral Study*, vol. 32. 2001.

[11] T. O'Meara, K., Griffin, K. A., Kuvaeva, A., Nyunt, G., & Robinson, "Sense of belonging and its contributing factors in graduate education.," *Int. J. Dr. Stud.*, vol. 12, no. 12, pp. 251–279, 2017.

[12] C. Lewis, R. Ginsberg, T. Davies, and K. Smith, "The Experiences of African American Ph.D. Students at a Predominately White Carnegie I-Research Institution," *Coll. Stud. J.*, no. 2, pp. 231–245, 2004.

[13] H. Carlone and A. Johnson, "Understanding the Science Experiences of Successful Women of Color: Science Identity as an Analytical Lens," *J. Res. Sci. Teach.*, vol. 44, no. 8, pp. 1187–1218, 2007.

[14] D. A. Delaine, R. Tull, R. Sigamoney, and D. N. Williams, "Global Diversity and Inclusion in Engineering Education: Developing Platforms toward Global Alignment," *Int. J. Eng. Pedagog.*, vol. 6, no. 1, p. 56, 2016.

[15] K. Willis, "Viewpoint: International development planning and the Sustainable Development Goals (SDGs)," *Int. Dev. Plan. Rev.*, vol. 38, no. 2, pp. 105–111, 2016.

[16] B. Balcik, B. M. Beamon, C. C. Krejci, K. M. Muramatsu, and M. Ramirez, "Coordination in humanitarian relief chains: Practices, challenges and opportunities," *Int. J. Prod. Econ.*, vol. 126, no. 1, pp. 22–34, 2010.

[17]   W. Reid, D. Chen, and L. Goldfarb, "Earth System Science for Global Sustainability: Grand Challenges," *Science (80-.).*, vol. 330, no. November, pp. 916–917, 2010.

[18]   R. P. Weber, "Basic Content Analysis. 2nd," *Newbury Park. CA Sag*, vol. 82, no. 397, p. 354, 1990.

[19]   J. C. Gellers, "Crowdsourcing global governance: sustainable development goals, civil society, and the pursuit of democratic legitimacy," *Int. Environ. Agreements Polit. Law Econ.*, vol. 16, no. 3, pp. 415–432, 2016.

[20]   T. Kohler, "How to Scale Crowdsourcing Platforms," *Calif. Manage. Rev.*, vol. 60, no. 2, pp. 98–121, 2018.

[21]   J. Belliveau, "Humanitarian access and technology: Opportunities and applications," in *Procedia Engineering*, 2016, vol. 159, pp. 300–306.