2017 NSF Engineering Education and Centers Grantees Conference

Meeting Report

October 29 – 31, 2017
Renaissance Capital View Hotel
Arlington, VA

ASEE

ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

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- We support engineering education across institutions by identifying opportunities to share proven and promising practices.
- We support education locally, regionally, and nationally by forging and reinforcing connection between academia, business, industry, and government.
- We support discovery and scholarship among education researchers by providing opportunities to share and build upon findings.
- We support innovation by fostering the translation of education research into improved teaching practices.
- We support disciplinary technical researchers by disseminating best research management practices.

2017 NSF Engineering Education and Centers Grantees Conference: Meeting Report.

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October 2018

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Washington, D.C.
www.asee.org

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Acknowledgments

ASEE would like to acknowledge the many contributors to this report:

The Planning Committee for the 2017 NSF EEC Grantees Conference provided invaluable input and recommendations on conference structure, agenda, and outcomes. The committee was composed of four EEC principal investigators representing a variety of EEC programs: Maura Borrego (Associate Professor, University of Texas at Austin), Jeremi London[1] (Assistant Professor, Arizona State University), Leidong Mao (Associate Professor, University of Georgia), and Idalis Villanueva (Assistant Professor, Utah State University). ASEE staff members Rocio Chavela and Alexandra Longo served as committee liaisons.

Elliot Douglas, NSF Program Director for Engineering Education[2], provided guidance and feedback in the early planning stages of the conference and helped inform the conference structure and agenda. EEC Program Officers Mary Poats, Paige Smith, and James Moore[3] further assisted with conference planning and participant outreach and communications.

The conference facilitators and participants, with their contributions over two and a half days of sessions and discussions, provided the substance of this report.

This conference report was drafted by Peter Meredith with input from Alexandra Longo and proofreading and editorial expertise provided by Mark Matthews and Mary Lord.Brian Yoder Rossen Tsanov developed the post-conference evaluation survey; Rossen Tsanov conducted qualitative and quantitative analysis of the post-conference survey and drafted the conference evaluation report.

The following ASEE staff members contributed significantly to the report by taking notes on all conference sessions: Kendall Moffett-Sklaroff, Austin Ryland, Rossen Tsanov, Daodao Wang and Brian Yoder.

1 Jeremi London is now Assistant Professor of Engineering Education at Virginia Tech.

2 As the conference was taking place, the program director position was transitioning from Elliot Douglas to Julie Martin, who was also present at this conference.

3 James Moore currently serves as Interim Vice Provost for Diversity and Inclusion and Chief Diversity Officer at The Ohio State University. His term at NSF ended prior to the implementation of this conference.

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Executive Summary

The 2017 National Science Foundation (NSF) Engineering and Education Centers (EEC) Grantees Conference was held on October 29 – 31, 2017 in Arlington, Virginia. The conference brought together principal investigators (PIs) and team leaders from seven EEC programs to share and explore ideas aimed at promoting innovation in engineering education research, with the overall goal of increasing the impact of EEC projects to benefit the engineering education community and society at large. More than 260 people participated, including representatives from NSF and the American Society for Engineering Education (ASEE).

The conference had three major intended outcomes: 1) foster knowledge sharing across the network of grantees in attendance; 2) cultivate personal and professional relationships, collaborations, and partnerships to further individual, organizational, and EEC-division-level goals; and 3) inform conference attendees about state-of-the-art and ongoing efforts that could help them increase the impact of their NSF awards. Results from the session ratings and post-conference surveys indicated that these outcomes were met. Networking and poster sessions proved to be most conducive to knowledge sharing and relationship building. The majority of attendees reported interacting with one to five grantees across programs; these interactions took many forms, from sharing ideas and data to discussing potential collaborations. Plenary and concurrent sessions proved most effective at informing attendees about efforts to help increase project impact. Numerous attendees noted that they were able to expand their vision of impact through these sessions, where they learned about work being done by others, how it relates to their own projects, and how impact can go beyond individual projects and have a larger scientific, cross-disciplinary, and societal footprint.

Grantee concerns emerged during NSF-led breakout sessions that grouped clusters of attendees around their EEC programs. These sessions were broadly structured around two main questions: How could your projects have impact or be scaled up if you were able to expand them, and how can NSF support impact and scalability, bearing in mind that funding itself is fixed? Each EEC program had its own concerns, but shared themes emerged—and not just around funding. Grantees expressed a desire for NSF to have more involvement in disseminating and communicating findings, defining impact, providing professional development opportunities, and facilitating collaboration amongst grantees. These sessions left grantees with a sense of regeneration and NSF program officers with new ideas and thoughtful recommendations.

About the Conference

Background

The 2017 National Science Foundation Engineering Education and Centers (EEC) Grantees Conference was held October 29-31, 2017 in Arlington, VA.

Engineering and Education Centers (EEC) is a division within NSF's Directorate for Engineering. It is responsible for inspiring, identifying, and supporting innovative projects and collaborations in four key areas for the advancement of engineering:

- Center-based transformational research
- Research and implementation programs to form 21st-century engineers
- Workforce development
- Inclusion of underrepresented groups in engineering

The purpose of the EEC Grantees Conference was to bring together principal investigators (PIs) and team leaders from institutions with EEC awards to learn, explore, and share ideas aimed at promoting innovation in engineering education research and practice. Attendees represented the following range of programs:

- Broadening Participation in Engineering (BPE)
- Engineering Education
  - Research in the Formation of Engineers (RFE)
  - Research Initiation in Engineering Formation (RIEF)
- Research Experiences for Teachers (RET)
- Research Experiences for Undergraduates (REU)
- REvolutionizing engineering and computer science Departments (RED)

Beyond simply sharing ideas and best practices, there was a broader theme for the conference: increasing the impact of EEC projects. To provide a frame of reference ahead of the conference, potential attendees were informed that impact may relate (but is not limited) to:

- Forming networks and stimulating discourse among researchers
- Contributing to the training of skilled students and professionals
- Improving two-way dialogue between researchers and the public
- Benefiting future research and the capacity for scientific and technical problem solving
- Enhancing the potential to benefit society and/or address larger societal challenges

Participants interact at the conference's Sunday evening networking session.

Conference Format

More than 260 people attended the EEC Grantees Conference. This figure includes representatives from NSF and the American Society for Engineering Education (ASEE), which hosted the event. The conference agenda and meeting artifacts can be found in Appendix A. The conference included plenary sessions, concurrent sessions led by grantees and invited speakers, and breakout sessions moderated by NSF program officers. The conference agenda also featured poster sessions, structured networking sessions to encourage relationship building among grantees, and a variety of other opportunities for knowledge sharing.

There were three plenary sessions. The first, on Monday, October 30, was led by NSF and provided the opening remarks for the conference. At lunch that day, Julia Williams, interim dean for Cross-Cutting Programs and Emerging Opportunities and professor of English at Rose-Hulman Institute of Technology, led the second plenary with a talk entitled "The Change-Maker's Toolkit: Preparing Faculty to Make Academic Change Happen," which tackled one of the perennial difficulties in advancing the cause of engineering innovation. On Tuesday, October 31, Jeremi London, assistant professor of engineering at Arizona State University's Polytechnic campus, led the final plenary, "We Can Do Better: Insights on Going from Research to Impact in Engineering Education," which drew from ongoing research on how to characterize what impact means in the context of publicly-funded engineering education research.

Three rounds of 75-minute concurrent sessions (15 sessions in total) took place on Monday. These sessions explored a variety of topics related to project design, development, dissemination, and evaluation, with an emphasis on impact. These were open to all attendees to encourage cross-fertilization of ideas and a sharing of strategies.

Tuesday's breakout sessions were organized by cluster to offer attendees an opportunity to further collaborate with other grantees and to interact with NSF program officers, who served as moderators for these sessions. While their format varied slightly, breakout sessions generally fostered the sharing of ideas and best practices, and in some cases offered a chance to ask questions about the future of EEC in an uncertain funding climate.

Two structured networking sessions took place during the conference. At the Sunday networking session, invited RET (Research Experiences for Teachers) and REU (Research Experiences for Undergraduates) site participants led a special poster session to present their work. More information on these site participants can be found in Appendix B. Both networking sessions had informal addresses, and as a bonus for those who participated in the networking bingo activity during Sunday's session, three grantees won the opportunity to offer three-minute presentations on their work to the full group of attendees during the Monday evening networking session.

The two 75-minute poster sessions for EEC grantees took place on Monday morning and Monday afternoon and filled two large spaces on the conference floor with approximately 60 posters per session. Posters reflected the full range of topics that EEC promotes, from summer immersion courses to pulling together diverse teams to preparing undergraduate students for degrees in nanotechnology. These sessions were very well-attended, with conference-goers lining up to ask questions, and the flow of the sessions—in two adjacent rooms at the heart of the conference area—kept people busy.

By the end of the conference, EEC grantees had been exposed to a variety of best practices of a large cross-section of their peers, with input from NSF program officers about program direction and recommendations from experts on how to increase project impact.

Intended Outcomes

In designing the conference, organizers were guided by an overarching theme: increasing the impact of EEC projects. To encourage this to happen, the organizers identified several intended outcomes for the conference that guided the choices of topics for sessions and the organization of the breakout groups. Three major goals are listed below, along with observations from the meeting on how these outcomes were achieved.

1. **Foster knowledge sharing across the network of grantees in attendance.** The design of the EEC Grantees Conference, with three rounds of sessions devoted to topics that were not specific to particular EEC programs, guaranteed that grantees would engage with people from other programs on topics of mutual interest. Both evenings (Sunday and Monday) featured informal networking sessions that were a little more structured than usual, facilitating face-to-face encounters. Additionally, grantees were able to engage in knowledge sharing with undergraduate students and teachers, who were recognized throughout the conference. In addition to the poster session dedicated to their participation in EEC grants, several students and teachers took an active role in concurrent sessions, and the breakout session devoted to REU grantees on Tuesday morning made time to hear directly from undergraduates about their experiences in the program. Outside of the network of grantees, conference participants also were able to share knowledge with NSF program officers. NSF program officers made themselves available during the Tuesday morning breakout sessions and were very visible at other sessions as well, jumping in if questions were raised that required an NSF answer. In addition, NSF program officers used the breakout sessions to clarify frequent misunderstandings about deadlines and the content of annual reports.

2. **Cultivate personal and professional relationships, collaborations, and partnerships to further individual, organizational, and EEC-division-level goals.** From the opening REU/RET site participant poster session on Sunday evening through the closing plenary session on Tuesday, the halls at the conference venue were buzzing. The two grantee poster sessions offered a unique opportunity for attendees to gain a better understanding of each other's work and how it related to their own. Session feedback, which was received through the conference app, indicated that these poster sessions were extremely conducive to relationship building and enabled participants to increase their professional networks[4]. Detailed evaluation results can be found in Appendix C.

3. **Inform conference attendees about state-of-the-art and ongoing efforts that could assist them in increasing the impact of their awards.** This all started with impact, the driving theme of the conference, and the search for ways to characterize and quantify this construct dominated many of the sessions and plenaries. Several sessions offered hands-on advice on specific methods for increasing impact. In particular, one session offered advice from editors on submitting papers to journals. Another served as a tutorial on effectively working with your project evaluator. Beyond that, issues such as use of social media kept emerging from many of the sessions, including the NSF-led program-specific breakout sessions as well as concurrent sessions.

Conference participants play networking bingo at the Sunday evening networking session.

4 The conference app was developed using Whova event app and event management software.

Conference Sessions

Plenary Sessions

Opening Remarks

How does the National Science Foundation's Engineering Education and Centers division make an impact, and how can its impact be measured? That was the question posed by Elliot Douglas, NSF Program Director for Engineering Education[5], in opening this conference.

Douglas introduced his fellow program officers and recognized the conference Planning Committee. He praised the work of the REU students and RET teachers whose posters had dominated the hallway in the poster session the previous evening. After a realistic nod to the difficulties of producing lasting impact with projects that are necessarily constrained by NSF's three-year funding cycle, he promised an opportunity at the conference to gather ideas about how to make projects more impactful and effective.

Don L. Millard, EEC's Acting Division Director and Deputy Division Director, then took the stage. "This is our carpe diem moment; this is the opportunity," said Millard. Referring to the Mann report[6]—the first evaluation of U.S. engineering education, now 100 years old—Millard said the emphasis on improving the education of engineers is as vital as ever. "This is our opportunity to actually change the nature of how we approach teaching of engineering," he said. "I encourage you, over the next day and a half, to be able to band together in ways where the force of many is going to be much greater than the force of one." Engineering has reached the point where it "has the opportunity to be able to be democratized," he said. "What the liberal arts degree was to the 60's, engineering can be the degree of the future."

Millard then introduced the session's main speaker, Dawn Tilbury, who began an appointment to head NSF's Engineering Directorate in June 2017. Tilbury prefaced her remarks by pointing out that although she now heads the engineering directorate, her first NSF grant was in education. In 2016, NSF announced its 10 Big Ideas. Tilbury emphasized two:

Elliot Douglas, former NSF Program Director for Engineering Education, offers introductory remarks in the conference's Monday morning session.

1. **Convergence.** In the context of the Big Ideas[7], this means cross-disciplinary efforts driven by a specific and compelling challenge, such as clean water, clean air, sustainable energy, or personalized medicine. Engineering is a discipline, but we need to educate students to be open to new ideas and different disciplines. Thus, we must look for frameworks and solutions. How can students be open to other disciplines to address big natural challenges?

2. **Inclusion.** NSF INCLUDES (Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science) is a comprehensive initiative to enhance U.S. leadership in science and engineering by seeking out and developing applied technology from all sectors and groups in our society. "So, this is really about very broadly widening the participation," Tilbury said. "The goals of NSF INCLUDES are to facilitate partnerships, communication, and cooperation, and to build on and scale what has been demonstrated to work in different programs in communities across the country." She mentioned an upcoming conference for NSF INCLUDES grantees scheduled for January 2018. "The change in educational practice has not kept up with the pace of technical challenges in our society."

Returning to the theme of the conference, Tilbury said that engineering education researchers need to do a better job of measuring the impact of projects

5 As the conference was taking place, the program director position was transitioning from Elliot Douglas to Julie Martin, who was also present at this conference.

6 https://www.asee.org/member-resources/reports/Mann.pdf

7 https://www.nsf.gov/about/congress/reports/nsf_big_ideas.pdf

designed to improve engineering education and of translating lessons learned into the broader community. She asked if it was possible to make the change systematic rather than relying on interested faculty. To close the session, Douglas returned to the stage and encouraged grantees to "talk across"—to go outside the group of people with whom they usually share discussions, draw ideas from REU and RET participants, and take what they've learned in their research and apply it in the future.

The Change-Maker's Toolkit: Preparing Faculty to Make Change Happen

Speaker:
Julia Williams, *Rose-Hulman Institute of Technology*

Williams possesses a strong background in studying change strategies within the engineering education ecosystem by focusing on the change agents themselves: engineering faculty members. Through the NSF-funded RED Participatory Action Research (REDPAR) project, she has studied potential change agents who are engaged on their campuses through NSF's REvolutionizing engineering and computer science Departments (RED) program. Responding to the lack of systemic change in STEM education, which speaks to a problem with the approach to change that this community has pursued thus far, Williams' plenary talk[8] sought to answer one important question: Can we overcome limits that prevent the diffusion of new ideas—and barriers to the adoption of effective practices—by focusing on the change agents themselves in terms of their skills and change expertise?

To begin her talk, Williams drew upon the message of a TED talk on change leaders and followers given by Derek Sivers called "How to Start a Movement."[9] The key takeaway was that no matter how dedicated and active the leader, the movement won't really get going until other people follow that leader—people who weren't necessarily instrumental in coming up with the idea but recognize how precious it is and are willing to commit to supporting it. Translated to engineering education, that suggests it takes more than a single strong personality to effect change on campus, so seeking out a core of committed followers is more likely to achieve success.

The RED program focuses strongly on effecting change in academic departments, and Williams stressed the need for "toolkits." A change-maker needs a toolkit with specialized technical skills, she said, and each profession teaches you to recognize these tools and use them appropriately. She mentioned three tools with particular relevance to the EEC Grantees Conference: strategic partnerships, communication, and shared vision. Williams introduced a tip sheet on strategic partnerships and asked the audience to brainstorm some of the issues from their own institutions. As for communicating change, Williams drew on her own experiences and stressed the need for constant communication and check-ins. She said she found she was more effective the better she understood how the people she was dealing with related to one other—including a better understanding of personal quirks.

Which tools work? Williams suggested drawing from two areas of research, higher education and organizational change, with reference to the work of Charles Henderson, Andrea Beach, and Noah Finkelstein[10]. She highlighted an often-made assumption that people and systems are predisposed to resist change. In fact, she said, resistance is a symptom that may indicate other problems: lack of alignment, for example, or inappropriate change strategy, or too much change.

Since 2012, Williams has organized a three-day workshop focused on the individual called *Making Academic Change Happen*. Initially held at Rose-Human, it also has been taken on the road. She talked about her involvement with the RED project, which commenced in 2014 - 2015 and started with 19 colleges and universities and works partly through the RED Participatory Action Research project (REDPAR). REDPAR targets RED teams whose disciplinary experts in engineering and computer science have not been equipped with the knowledge, skills, and abilities that research suggests are essential for effective change management. Much of the focus is on identifying and addressing cultural barriers within engineering departments to change and inclusion, and Williams said the dark cloud hanging over such efforts is the relatively low success rate of change projects on campuses. The skills needed to accomplish change, she concluded, are different from those needed to be a successful faculty member.

8 See https://docs.asee.org/public/EEC/Change%20Makers%20Toolkit%20Plenary%20-%20Slides.pdf

9 See https://www.ted.com/talks/derek_sivers_how_to_start_a_movement

10 Henderson, C., Beach, A., & Finkelstein, N. (2009, September 30). *Four Categories of Change Strategies for Transforming Undergraduate Instruction* (Publication). Retrieved May 1, 2018, from University of Michigan website: http://homepages.wmich.edu/~chenders/Publications/HendersonTransitions2011.pdf

Jeremi London, Assistant Professor at Arizona State University, shares practical insights on what can be done to improve the impact of research in engineering education during her Tuesday morning plenary session.

We Can Do Better: Insights on Going from Research to Impact in Engineering Education

Speaker:
Jeremi London, *Arizona State University*

London is a familiar figure to anyone connected with NSF who is concerned with increasing impact in engineering education. She made her mark as an NSF Summer Scholar in 2011, 2012, and 2013, where by her own account she raised questions again and again about what impact meant and how to measure it. Her presentation[11] at the EEC Grantees Conference highlighted her own research into figuring out what broader impact means, how to achieve it, and how to measure it.

She opened with an arresting visual image: a stack of dominoes. Dominoes are the first things that come into her mind, she said, when she thinks of impact. What images came to other people's minds when thinking of impact? From the comments on the floor, it was clear that people had a variety of images in mind. Her conclusion: We all think about different things when we think about impact.

London said she had been asking herself ever since her Summer Scholar days what it meant for her research to have an impact. She introduced her work as director of the RISE (Research and Impact in STEM Education) research group at Arizona State University (ASU), which uses mixed-methods research designs to investigate the impact of STEM education research and strives to make an impact itself. London stated that we have a back-and-forth relationship with the concept, and our understanding of the topic has shifted. There are three difficulties inherent in talking about impact, as described in London and Cox's 2015 paper on the subject[12].

1. Attribution issues—it is very difficult to connect an impact with a particular research project or researcher;
2. Assessment and evaluation issues—largely complicated by what counts as data, assessment methods, who should conduct the assessment, and when it should occur;
3. Interpretation issues—two people can often disagree on the findings of research, it can be positive or negative, and can be modest or transformative.

With these in mind, London offered a formulation of her own for describing impact: a time-sensitive interpretation of the extent to which a series of interactions have led to incremental and transformative change happens in and beyond the context in which the change originated.

Commonly expressed types of research impact include scientific—primarily academic—and societal. However, there's no direct link between the two. So, London asked: What if there's a third: a contextual impact on people, priorities, or processes? Broadening the disciplinary perspective to the whole range of academic endeavor, she pointed out that the arts and humanities have different ways of gauging impact than the sciences[13]. What if there were a framework everyone could agree on, she asked—a framework that was less dependent on the three difficulties identified earlier?

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11 See slides at https://docs.asee.org/public/EEC/We%20Can%20Do%20Better%20Plenary%20-%20Slides.pdf

12 London, J., Cox, M. (2015). *The Beginning of a Scholarly Conversation on Impact in Engineering Education: A Synthesis of the Three Major Difficulties Associated with Studying Research Impact.* Proceedings of the Australasian Association for Engineering Education Annual Conference, Victoria, Australia.

13 London also addressed the question of how to engage in activities that lead to greater impact in education, describing the use of project-based learning to help students grappling with statistics classes at ASU. She also mentioned a Kern Family Foundation grant with an unusual and innovative approach to mentoring: bringing back former students who are still at the undergraduate level to help second-year students as project mentors.

London asked how we can collectively characterize what it means for engineering education to have an impact and said that was the focus of her project: to develop an impact framework for engineering education. London started showing up at conferences around the world with a set of 125 colorful cards with simple impact descriptors on them, all of which used frameworks for measuring impact already developed in other fields. Participants in the activity were given 30 cards each, at random, and were asked to sort them into three piles. The first pile was for statements that were relevant to measuring impact in engineering education. The second pile was for irrelevant cards. The third was for cards that could easily be relevant if adapted to an engineering context.

London shared her preliminary results. Twenty percent of the impact descriptors were dismissed as not relevant. However, 47 percent were identified as relevant, and 33 percent as relevant if adapted. What these results suggest, she said, is that 80 percent of impact criteria already identified in other disciplines that characterize and measure research impact may be employed to measure impact in engineering education. The impact she hopes for, she says, is to not only advance the scholarship on impact and facilitate the use of a shared language around this topic, but to provide a framework that enables more realized impacts in engineering education.

Concurrent Sessions

The 2017 EEC Grantees Conference featured three concurrent session time slots on Monday, October 30, one before lunch and two after. Each time slot allowed attendees to select from five topics. None of these was repeated, but there was an opportunity during the networking session that evening for attendees to catch up on topics they'd missed. Concurrent sessions took several different formats, from presentations to panel discussions to hands-on exercises. All session materials (including slides and supplementary resources) are provided as clickable hyperlinks in Appendix A: Meeting Agenda and Artifacts.

Professional Societies as Partners in Impact: Panel Session

Speakers:

Karl Reid, *National Society of Black Engineers (NSBE)*
Raquel Tamez, *Society of Hispanic Professional Engineers (SHPE)*
Peter Finn, *Society of Women Engineers (SWE)*
Aisha Lawrey, *American Society of Mechanical Engineers (ASME)*

Moderator:

Ashok Agrawal, *American Society for Engineering Education (ASEE)*

In this interactive panel session, expert panelists representing professional societies fielded questions about partnerships from moderator Agrawal and the audience. Agrawal posed several questions to the panelists related to creating and sustaining partnerships.

Nicola Sochacka (University of Georgia), Nathaniel Hunsu (University of Georgia), and Joyce Main (Purdue University) discuss research quality frameworks in the concurrent session "Upstream from Impact: Frameworks for Improving Research Quality."

When asked how one can determine when a partnership is necessary, Tamez recommended having an agreement in place that spells out the rights and obligations of the parties. When identifying partners and thinking about sustainability, Reid noted that partners need to think about the collective impact and have a common agenda. Finn added that there should be a backbone group driving any partnership. What happens when the funding ends? Lawrey and Finn recommended strategic thinking, with Finn emphasizing the importance of a five-year strategic plan. Lawrey and Tamez suggested bringing in executive management and leveraging a grant management office to help manage deliverables.

How can professional societies engage the community to expand outreach? Several panelists saw a role for professional societies in encouraging culture change in academic departments. Tamez stressed the importance of having meaningful relationships with universities. Reid mentioned as an example the 50K Coalition, which has professional society support and was designed to answer the question: "Can we put together a national network of societies on college campuses to increase diversity in engineering?" Finn talked about SWE's experience with women in academic communities. Asked how people in universities should approach the societies, Reid suggested that the societies should translate research that is often theoretical or rarefied into practice. Lawrey added that the societies need to make sure faculty and students know the benefits of society membership.

When asked what they had learned from their success and failures, the panelists had several distinct takeaways. Reid learned that it's integral to have humble leaders. Tamez learned that not all partners are created equal and that societies are small organizations with limited time and resources. Lawrey learned the benefit of being part of the grant-writing process. As the closing question, panelists were asked for one big impact from a project. Lawrey cited educational awareness around diversity and inclusion. Finn mentioned getting critical mass around an initiative. Tamez said the 50K Coalition and ASSIST had brought together different CEOs in an impressive way. Reid added that you can be successful in outputs but still focused on outcomes.

Upstream from Impact: Frameworks for Improving Research Quality

Speakers:
Brent Jesiek, *Purdue University*
Allison Godwin, *Purdue University*
Joyce Main, *Purdue University*
Nicola Sochacka, *University of Georgia*
Joachim Walther, *University of Georgia*
Nathaniel Hunsu, *University of Georgia*

The objectives for this session on improving the quality and impact of research included introducing research-quality considerations across different methods and traditions, and helping grantees by identifying quality issues that had arisen in their own research.

In the first portion of this session, Sochacka and Walther (University of Georgia Engineering Education Transformations Institute) introduced what they called their Q3 Project, for Qualifying Qualitative Research Quality. The project had two goals: fostering discussion and building capacity around qualitative research quality; and developing a theoretical understanding of research quality that reflects common perceptions and practices within engineering education. They raised three questions about research quality across all validation constructs: Do we get to see what we think we see? Are our interpretations grounded in the participants' social realities? Are our findings relevant and meaningful beyond our study setting? The framework, they said, can be used as a planning and process tool and can provide multiple lenses through which to examine quality issues and challenges.

The second portion of this session dealt with quality in quantitative engineering education research and was led by Allison Godwin, Brent Jesiek, and Joyce Main (Purdue University). First, these facilitators focused on a definition of quantitative research methods, which emphasize objective measurements and data analysis from polls, questionnaires, or surveys, or computational manipulation of existing data. Quantitative data draws generalizations across groups of people or phenomena. Traditionally, this emphasizes the data analysis stage in research. The facilitators argued, however, that validity in quantitative research has moved from a checklist approach to making an argument for validity evidence, turning from "validated" studies, approaches, and instruments toward developing an argument for how each study builds a case for validity. Facilitators then turned to evaluating the quality of mixed-methods research designs—methods that combine

elements of qualitative and quantitative research. Three approaches were outlined: methods orientation (selection process, alignment quality); research process orientation; and timing of phases orientation, which emphasizes development.

Conference participants work on a hands-on activity in the concurrent session "3 Million Teachers Can't Be Wrong — Just Try It: Hands-on Engineering Design."

3 Million Teachers Can't Be Wrong— Just Try It: Hands-on Engineering Design

Speakers:
Jacquelyn Sullivan, *University of Colorado, Boulder*
Marissa Forbes, *University of Colorado, Boulder*
Dua Chaker, *University of Colorado, Boulder*

Sullivan began this interactive session by introducing her team members and their project: The TeachEngineering Digital Library, which offers more than 1,500 design instructional activities online at www.teachengineering.org. The introduction was an eye opener for many of the attendees, who were learning about it for the first time. Sullivan outlined the project's history, noting its focus on curriculum design, and then Forbes, her colleague, introduced a hands-on exercise, the "injured hiker challenge"—drawn from the project's own work.

For this exercise, participants split into teams to discuss how to rescue an injured hiker the fastest and cheapest way with the most lightweight stretcher they could come up with. The idea is to design the stretcher as a team, which provides an opportunity to use the engineering design process for problem solving in a way that highlights and overcomes the constraints. Using potatoes as hikers and sticks, paper, pencils, and sponges to build stretchers, the teams spent 10 minutes brainstorming and building before the first team rushed its injured "hiker" around a course marked with tape on the floor. The other teams followed. Everybody was ranked and put their scores on the board. Participants were given the opportunity to redesign, and another chance to post a score.

Sullivan prompted each team to present its design to the room and explain its process and constraints—and how it overcame them to improve its product. The result was a mix of original ideas, which Sullivan facilitated by interjecting thoughts and tips on using design as a pedagogical tool, and simple principles such as "fail often to succeed sooner."

Forbes concluded the session by fielding questions from the room and explaining what comes next for the TeachEngineering initiative, whose future includes collaborations and original projects. TeachEngineering is going to social media for outreach—YouTube, Instagram, Facebook, Pinterest—and Forbes streamed a promotional video from its YouTube channel. The videos are kept short—about two minutes—to appeal to students, and most experiments can be carried out with basic supplies from the grocery store, to keep activities accessible and affordable.

Building Strategic Partnerships

Speakers:
Cara Margherio, *University of Washington*
Julia Williams, *Rose-Hulman Institute of Technology*

As part of their work with the NSF RED program, Margherio and Williams train and support RED awardees, facilitate consortium-level activities, and conduct research on the process of academic change. During this session, they discussed their research findings and provided practical advice for identifying and approaching potential partners.

RED teams have voiced several reasons for building strategic partnerships, including finding allies, attracting resources, and supplementing skill sets. Margherio and Williams suggested reaching out not just to people you know, but to others on campus you might not naturally gravitate to—even if they aren't in engineering. The facilitators said they expected that everyone, somewhere, was concerned with a change project, and

asked participants to write down a brief description of their project and summarize its ultimate goal. At each table, participants shared what they wrote.

The facilitators then asked participants to list the resources needed to complete their projects, saying no resource was too silly or small. As soon as people had finished, however, Margherio pointed out that they'd listed what they needed themselves—and pointed out that one-sided relationships only go so far. To meet the needs of both sides in a strategic partnership, RED teams have sought to establish supportive frameworks aimed at aligning goals and activities, building on their partners' strengths, creating mutually beneficial relationships, and developing a shared vision.

Throughout the session, more opportunities for interactivity and discussion occurred. Williams reminded participants of the need for win-win situations when trying to bring partners on board. She recommended serious research into potential partners, including leadership style, communication style, demands from above, and institutional involvement, and suggested looking at social media as well as websites. Discussion then ranged over internal constraints as well as partner problems, including people in the middle of the pipeline who aren't excited about the project and "cave people"—colleagues against virtually everything.

Williams confessed that she'd learned from some failed projects and cautioned against railroading projects through. She advised asking the following questions: How do I know if I've met saturation? Have I really considered the wide range of partners? How do you know if you have too many partners, if you're losing focus, or are focusing on who is needed? She also recommended taking a conversational approach to authority over a confrontational style. To conclude the session, the facilitators broadened the range of potential partners to include the local community, businesses, career services, and even state and local government. Academic projects need partners—and academics need to look for them.

Thinking like an Entrepreneur: Designing your Educational Projects for Impact

Speakers:
Karl Smith, *University of Minnesota and Purdue University*
Russell Korte, *George Washington University*

For three years, Smith and Korte have been working on an NSF-funded project known as I-Corps™ for Learning (I-Corps™ L). The project pushes educators to think about sustainability and scalability by incorporating Lean Start-up principles intheir initiatives, using customer discovery to identify a need for a product or innovation and then aligning the project with that need so resources are available to sustain it.

Smith and Korte outlined three current initiatives with this goal: awareness sessions designed to introduce the core features of Lean Start-up, introduced at two summits in 2017; Smart Start, a one-week program focused on identifying customers and their needs scheduled for 2018; and a seven-week hybrid course with a national cohort aimed at using market research to identify real-world customers who are willing to adopt and pay for academic research. NSF is in discussion about the next steps in the process.

Evidence suggests that successful innovation involves finding research that advances science and technology, and finding a repeatable business model to use it. Current efforts, however, focus squarely on the research part. As a result, said Korte, "someone thinks they have done everything right, but they get out in the real world and they find out they were wrong." The presenters introduced examples of companies that seemed to have got things right, including Khan Academy and Can't Wait to Learn, an e-learning initiative for children in conflict zones.

Outlining a three-step process for finding a path to scalability and sustainability, the facilitators mentioned the need for framing a hypothesis with two competing canvases, business-focused and mission-focused, then testing it by searching for customers and building the company, and finally building the product or service.

The facilitators also outlined the top 10 start-up mistakes. The biggest: Developing a product no one wants. Who are your most important customers? What job do they need done? How should you consider your customer and their needs when designing the product?

The facilitators provided an example. General Electric had developed a medical imaging machine that was used in pediatric settings. They found that their product improved markedly after a designer realized that the product's customers were not limited to the decision-makers at the hospital—they also included the children who were sent through these imaging machines. The design team then worked to develop an imaging solution that sought to improve the children's experience, by developing Adventure Series room themes, where the machines were designed to

look like spaceships, ocean scenes, and more[14]. This examples illustrates that the decision maker may be very different from the end user, and different again from the beneficiary.

Value propositions answer two questions: What stakeholder problems are you trying to solve, and what stakeholder needs are you satisfying? The facilitators defined a value proposition as a promise of value to be delivered. A value proposition should:

- Explain how your innovation solves customers' problems or improves their situation (its relevance).
- Deliver specific benefits (descriptive and measurable).
- Tell the user or buyer why they should get the product from you and not from the competition (why it's unique).

Increase the Impact of Your Journal Publications

Speakers:

Lisa C. Benson, *Clemson University*
Maura Borrego, *University of Texas at Austin*
Cynthia J. Finelli, *University of Michigan*

All three session facilitators represented the *Journal of Engineering Education*, published on behalf of the American Society for Engineering Education by Wiley. Benson is editor-in-chief and Borrego and Finelli are deputy editors. The session covered four topics: optimizing aspects of your publication; controlling your story via social media; knowing your options on open access; and understanding impact factors and indices. Benson began the session by asking participants a question: Your paper may be published, but is it really having an impact?

With regard to academic search engine optimization, Finelli recommended the following:

1. Don't try to be cute with keywords—they won't optimize for search engines.
2. Use a good short title (about seven words). Include one or two keywords in the first 65 characters.
3. Optimize the abstract. Use keywords between three and six times in the first two sentences. The essential finding must also be in those first two sentences.
4. Use keywords in the main text and headings. When selecting keywords, use the Engineering Education Research taxonomy[15]. Choose one or two keywords from each category. Check the guidelines of the journal for which you're writing. *JEE*, for example, requires using the taxonomy.

Turning to social media, some questions emerged from participants. Why would the engineering education research community want to use social media? The answers included dissemination, recruitment, fast feedback, a desire to speak the language of a younger generation, its instantaneous nature, and shared interests. Different social media platforms have different characteristics. Twitter's word count, for example, has the useful effect of helping you refine your topic. LinkedIn promotes networking in a like-minded community, whereas YouTube engages the general public. ResearchGate, Academia.edu, and Google Scholar are all narrowly targeted. Which ones meet the needs of the community? It depends on what you're looking for.

To increase your visibility and impact on social media, the facilitators had five recommendations:

1. Build a targeted profile.
2. Use hashtags (#NSF, for example) to get the attention of specific audiences.
3. Engage your audience in meaningful conversation.
4. Make it a habit.
5. Think before you post!

The facilitators also noted that blogs have less impact than they used to. If you are going to blog, pick the right platform: WordPress is easy, while Medium.com is content-specific and organized by topic.

Tackling the knotty question of which version of an article an author can post online, the facilitators offered a quick quiz on various aspects of this topic, then discussed guidelines for sharing Wiley articles. They also tackled common truths and myths about open-access publishing, and came up with the following guidelines:

1. Publishing open access means anyone can access your article online, which can lead to greater readership and impact.

14 More information on the GE Adventure Series can be found here: https://www3.gehealthcare.com/~/media/documents/us-global/products/accesories-supplies/brochures/adventure%20series/gehealthcare-brochure_adventure-series.pdf?Parent=%7BAFE522E5-B54D-4BFA-8343-F41B8A2F69D9%7D

15 See http://taxonomy.engin.umich.edu/

2. Open access journals can be high quality or low quality; check whether they require peer review, ask about the publisher's reputation, consider any impact factors.
3. Fees may be associated with open-access publishing; journals may need to recoup costs through subscriptions or access fees. (Your institution or library may make small grants available to cover these fees.)
4. You may be able to retain copyright.
5. *JEE* offers an open access publishing option.

The facilitators then shed light on recent developments on impact factors and citation counts. Impact factors such as Web of Science's are typically the property of a journal, can be ranked in relation to journals in the same field, are updated every year, and can increase or decrease over time. By contrast, citation count is usually the property of a single publication, journal, or author, is updated continuously, and does not decrease over time. It is based on the simplest possible formula—number of times cited—and is accessible on Google Scholar or Web of Science. What makes the field interesting, however, is a plethora of newer, alternative measures of impact: h-index, I-10 index, Eigenfactor, and Altmetrics. Some have characteristics that the others don't.

New Directions for Broader Impacts at the National Science Foundation

Speaker:
Sheldon Jacobson, *University of Illinois*

In this session, Jacobson shared his findings from a 2016 NSF-funded workshop that he organized.[16] The 2016 workshop was entitled *Setting a Broader Impact Innovation Roadmap* and had the goal of defining a roadmap for Broader Impact inovations.[17] This workshop brought together mechanical, industrial, and civil engineering researchers and administrators who had previously demonstrated innovation in broader impact activities through their research.

Two major criteria are employed by NSF when reviewing proposals: What is the intellectual merit of the proposed activity? What are the broader impacts of the proposed activity? NSF's Broader Impacts Review Criterion advanced the argument for Intellectual Merit based on wider societal effects and offered examples of the kinds of activity that can be qualified as Broader Impact. Examples include: a) advancing discovery and understanding while simultaneously promoting teaching, training and learning; b) broadening the participation of under-represented groups; and c) benefitting society on a larger scale.[18]

One of the major findings from the *Setting a Broader Impact Innovation Roadmap* workshop was that participants did not have a singular notion of Broader Impact; instead they saw broader impacts from varying perspectives. Participants expressed the view that some members of the research community have only a vague understanding of the Broader Impact Criterion. Thus, one of the workshop's main outcomes was identifying a clear classification of the diverse set of goals and outcomes encompassing broader impacts.

Workshop participants suggested that NSF enact a framework for Broader Impacts, providing structure that enables PIs to better define and identify the broader impacts of their projects. A classification with three dimensions was suggested, focused on immediacy, type of societal benefit, and time horizon for the outcome. Immediacy could range from high to low. Societal benefit could be classified in terms of information and communication, global leadership, people and human capital, economic, health, and national Interests—and perhaps more. As for the time horizon, the immediacy of research can sometimes be blunted by the limitations of dissemination mechanisms, such as journal publication and conferences; these projects have significant societal impact but are sometimes not effectively disseminated to the research community and public.

One major question pondered during the 2016 workshop was "Is there a tradeoff between intellectual merit and broader impact or are they inextricably linked?" Workshop participants felt that Broader Impacts should be more than an add-on to Intellectual Merit; they should be viewed synergistically, as complementary contributions to a research proposal. Better understanding of the Broader Impact Criterion may help limit tension between Intellectual Merit and Broader Impacts.

16 Session co-organizers were Jerome F. Hajjar (Northeastern University), Dawn Tilbury (University of Michigan), and Andrew Johnson (Texas A&M University).

17 This workshop was held in April 2016 in Arlington, VA and was funded through the Division of Civil, Mechanical, & Manufacturing Innovation (CMMI), which is part of the NSF ENG Directorate for Engineering (ENG).

18 See https://www.nsf.gov/pubs/2007/nsf07046/nsf07046.jsp

Jacobson shared several suggestions offered by *Setting a Broader Impact Innovation Roadmap* workshop participants that could serve as possible approaches to enhancing broader impacts: Funded proposals that see extrinsic or far-reaching impact could have the ability to request an additional funding supplement; evaluation of Broader Impacts criteria should be homogenous across NSF programs—with all programs viewing Intellectual Merit and Broader Impact as complementary contributions to proposals; and communications should be enhanced and improved across all stakeholder groups, including NSF Program Officers, PIs, panelists and reviewers, universities, and the general public.

Love your Evaluator

Speaker:
Gary Lichtenstein, *Quality Evaluation Designs*

This session, led by experienced project evaluator Lichtenstein, explored how EEC PIs and their staff can build positive working relationships and increase the value of the external evaluator to a project.

Lichtenstein offered several suggestions for getting the most benefit from an evaluator. These suggestions included bringing the evaluator in early, preferably at the proposal stage, and familiarizing them with the project team. Evaluators are experts in linking goals to strategies, objectives, and outcomes. Their contribution can be helpful for the proposal and for defining project parameters. They can also help create a data management plan.

Lichtenstein then provided an overview of what it is that evaluators actually do. Evaluators make sure the grant is being implemented as proposed, on schedule and with expected deliverables, looking at strategic planning, leadership, and communication. Evaluators also ask how effective the grant strategies are in achieving the proposed outcomes. Were the strategies implemented with fidelity? Was the implementation effective? To this point, developing a logic model (or a theory of change) is crucial for an evaluator, covering Problems → Goals → Strategies and Objectives → Outcomes. The role of the evaluator on the front end is to help the PI answer those questions raised by the logic model, and then devise metrics and a data collection plan. If a logic model is not already a requirement for projects and PIs (it often is), then it should be the first thing they request from their evaluator.

Evaluators ask "why?" They want the "why" for both the implementation strategy and effectiveness. The link between the findings and the data to answer the "why" should be very solid; this is the cause-and-effect link. Evaluators need to do a data check with the client to clarify fuzzy points and entertain interpretations. And they need to highlight patterns, not isolated data points. They need to articulate and accentuate what's working and what the challenges are, and why.

To recap, Lichtenstein asked participants to tell him the only three questions an evaluator should ask. His three questions are:

1. Is the grant being implemented as proposed, or was it implemented as proposed—on schedule, with expected deliverables?
2. How effective are or were the strategies in achieving the proposed outcomes?
3. Why?

When asked about cost and budgeting for an evaluator, Lichtenstein said NSF guidelines suggest 5 to 15 percent from the budget go towards evaluation but added that the magic isn't in the price but in the value and scope. He said that as an evaluator, he could work with any budget and design the optimal evaluation to produce value. Elliot Douglas (then NSF Program Director for Engineering Education), who participated in this session, emphasized that evaluation findings about challenges and what didn't work are valuable and are not to be sugar coated, feared, or swept under the rug. Evaluators often can articulate the findings better because they're removed and unbiased, and because they have the logic model's line of connections and cause and effect on their side. In that sense, evaluation reports could be more valuable than progress or annual project reports, both for the PIs and for the client.

Making an Impact with Policymakers: Lessons from the Field

Speaker:
Gabriella Gonzalez, *RAND Corporation*

How do you produce work that reaches policymakers? Gonzalez began this session by offering three pieces of advice for making project findings policy-relevant: crafting your policy story, determining your audience, and matching story and audience to outlet; you can't assume all audiences will have the same response.

When crafting the policy story, Gonzalez suggested imagining being on an airplane next to a stranger. You need to come up with two sentences on policy to

appeal to this stranger. Define the problem. Identify the findings that will solve the problem and explain the research questions. Pinpoint the main messages and sub-points—and figure out how to condense and organize them.

As a case study in making an impact with policymakers, Gonzalez spoke about a partnership between the RAND Corporation and Baltimore City Public Schools that was designed to improve Latino and African-American representation in STEM careers. The summer learning/school-year program included math instruction, hands-on project-based work, virtual learning, and exposure to STEM careers. The key question at the heart of this partnership was whether providing high-achieving minority students from under-resourced urban schools the opportunity to take Algebra I in middle school would put them on a trajectory to enter STEM fields in college. The project was a success, but Gonzalez suggested that the way the results are presented makes a difference when you're relaying them to other people. In crafting your policy story, being precise with language matters. Does this program really work? Will the findings really help policy making at the school level? The state level? What would Education Secretary Betsy DeVos do with this information at a federal level? How you present the results will affect the answers to all these questions. Opening the floor to the audience, Gonzalez had several participants recount policy stories of their own. These ranged over topics such as the underrepresentation of black women in STEM, zero-tolerance disciplinary policies and their effect on student access, and state standards and tests as a barrier to advancement. As these stories were told, Gonzalez and members of the audience discussed ways to refine the messages.

Gonzalez then discussed the need to determine one's audience. Who can benefit from your research outside academia? Corporations, lawmakers, HR personnel? Lawmakers, K-12 teachers, school superintendents, curriculum developers? Community organizations? Figuring out who you're talking to and why will help you harness your work. You need to get policymakers' attention for two minutes; in those two minutes, you need to show them the importance of the policy. Make sure you have data and findings to back it up. Gonzalez asked participants to list the various audiences that might find their findings valuable. She encouraged participants to look for audiences in all sorts of places: deans and CEOs of STEM-based organizations, department heads, undergraduate faculty advisors, academic support specialists and others at both two- and four-year institutions; companies that write state tests, teacher associations, community stakeholders, and anyone who can benefit from a more qualified workforce. Gonzalez encouraged session participants to be proactive and tell the people who need to know—they won't reach out to you. Use social media, use op-eds, use conferences, call decision-makers and ask to meet them.

The second case study Gonzalez introduced explored personalized learning. The problem she presented: Personalized learning is an approach to education in which how a student learns every day is less constrained by the needs of other students or by external grade-level requirements than traditional forms of learning. It is increasingly popular and is helped by technological advances, but does it work? The main message that emerged: Personalized learning can produce modest achievement gains, but it poses implementation challenges. Gonzalez saw several audiences for this message: teachers and school administrators, parents,

Conference participants work on an individual exercise during a concurrent session.

leaders in state and local education, the federal government, Congress (if you reach out to staffers on a relevant committee, you often get a 10-minute appointment and they'll start to get to know you), and foundations that fund personalized learning in classrooms. There are many outlets, too, and you should make an effort to match your outlet to your audience. Outlets include RAND reports, journal articles, op-eds, and faculty websites.

As parting advice, Gonzalez suggested mapping a plan at the start of a project, even before securing funding. Define the problem, figure out audiences, and ask how and where to disseminate the findings. Follow legislative sessions and new bills as they get underway. Stay current with recent news, use plain language, nail the hook, and focus on one creative idea or interesting finding.

Creative Approaches to Promote Interdisciplinary Research: Experiences from REU and RET Sites

Speakers:
Vinod Lohani, *Virginia Tech*
Jeremy Smith, *Virginia Tech*
Debarati Basu, *Virginia Tech*
Eileen Cahill, *Georgetown University (REU site participant)*

Lohani, PI of both a REU and a RET program at Virginia Tech, first introduced the REU site on Interdisciplinary Water Science and Engineering at Virginia Tech, which started in 2007 and is currently implementing its fourth cycle. The mentorship team is composed of 22 faculty members and more than 80 graduate students drawn from five colleges at Virginia Tech. They have worked with 95 REU undergraduate students—62 women and 33 men, 18 percent of them from underrepresented minorities. The REU site has four goals:

1. To expand undergraduate students' participation in interdisciplinary water research projects.
2. To encourage undergraduate students to pursue graduate education.
3. To develop a diverse, internationally competitive and globally engaged scientific and engineering workforce.
4. To develop undergraduates into independent researchers rather than dependent learners.

The program has several unique features. In a new twist, participants will soon be conducting some research in India. In addition, the REU faculty includes Marc Edwards, who has studied lead contamination of drinking water supplies in both Washington, D.C. and Flint, Michigan. Eileen Cahill, the REU undergraduate student who was part of the team of presenters, described her research over the summer into water contamination and the REU program's field trips, guest speakers, and graduate student panel.

Lohani asked the audience for their feedback on potential impacts of an REU site that already had 10 years' experience. Responses included:

- Participation in research, with the potential for increasing retention.
- Creating enthusiasm among junior faculty.
- Helping diversification efforts, including a specific suggestion for working with Native American students.
- The ability to improve programs in areas such as robotics.

Lohani said he could see an impact from the program at three levels: at the department and college level (the development of an interdisciplinary laboratory, the Learning-Enhanced Watershed Assessment System, or LEWAS, and the use of LEWAS-based instruction in various engineering courses, such as hydrology); at the university level (the use of LEWAS by other colleges, and the inspiration for an interdisciplinary undergraduate research program that became the Institute for Critical Technology and Applied Science, or ICTAS); and at the regional and global level, with influences on water issues as far afield as India and Australia. The program has also reached out to high schools and held a summit for Historically Black Colleges and Universities (HBCUs).

Lohani briefly introduced the NSF Research Experience for Teachers (RET) Site on Interdisciplinary Water E3G (Engineering, Ecology, Environment, Geosciences), whose funding cycle is 2016-19. Its goal is to provide teachers of grades 9 through 12 and at community colleges with an interdisciplinary water research experience that integrates water research perspectives from engineering, ecology, environmental science, and geosciences. The project team is developing and implementing a six-week research experience program for RET site participants with hands-on learning in E3G areas, and it is also creating a professional development program for teachers.

What questions might you ask REU or RET participants if you wanted to assess these programs? Lohani encouraged the audience to discuss this, then outlined how the Virginia Tech assessment process works. Two Ph.D. students who work on REU programs also assist the program's external evaluator with assessments,

using focus groups and questionnaires. Assessment is defined broadly and includes mass-media mentions, awards and fellowships, and research papers. Lohani offered 11 suggestions and lessons learned from the Virginia Tech experience:

1. Research projects for REU fellows and their roles should be clearly defined.
2. Prior communication with REU fellows helps.
3. Structured schedules for professional development activities are recommended for a good cohort experience.
4. Professional activities should include a variety of experiences—seminars by research faculty members as well as industry professionals to help REU fellows think about their career options.
5. Multiple opportunities for oral presentations are helpful.
6. Graduate students should challenge REU fellows to develop independent research skills.
7. Activities that promote social interaction and professional bonding among scholars are as critical as the research activities.
8. Coordination with the university-level undergraduate research office is always helpful.
9. External assessment experts play an important role in site evaluation.
10. Documentation of research papers in the form of a research proceeding provides a source for ownership and pride to REU fellows.
11. Cohort presentations in the form of YouTube videos may assist in program recruitment.

RET Site Best Practices: Design, Implementation, and Sustainability

Speakers:

Vikram Kapila, *New York University (NYU)*
Bradley Bowen, *Virginia Tech*
Kevin Cavicchi, *University of Akron*
Margaret Pinnell, *University of Dayton*

This interactive panel session began with each panelist describing his or her own RET program. At NYU, Kapila's program involves mechatronics and robotics (a promising topic area as both specializations are in heavy demand by businesses and the tech industry). The program tailored its STEM curriculum to student interests and to address workforce demands for graduates. It also immersed teachers in research to help them cultivate enduring habits: design, collaboration, entrepreneurism, and being solution-oriented. It's a summer program with some follow-up—in classrooms, in colleges, and with contests. Kapila offered a tip: Stick with authentic tools and activities. Teachers will see through the non-authentic.

Virginia Tech's Bowen described an RET program centered on precision engineering for agriculture that was conducted at North Dakota State University. Math and science teachers in rural North Dakota are often the only subject teachers at their schools. The program paired five in-service teachers with five pre-service teachers, who worked on ongoing faculty projects run by a professor of mechanical engineering and a professor of electrical engineering. It used locally grown materials, mostly flax and hemp, and the specific challenge was to establish a way to embed sensors in biodegradable platforms. The RET program's focus was on sustaining a shift in teaching practices and establishing a collaborative network.

At the University of Akron, Cavicchi has had two rounds of RET funding, 2012-16 and 2016-19. Introducing his subject, he asked: We know about polymers, but do we know how to talk to teachers and students about polymers? His program involved the Akron Global Polymer Academy, an outreach arm of the University of Akron. Teachers attended an eight-week summer program, four days a week, with three of the days for research and one for lesson-plan development. There were a couple of tweaks to the program; Akron didn't start out holding workshops in the summer, but it turned out that's when teachers wanted them. The second time around, they included more quantitative assessment of lesson plans. The program has led to a graduate student boot camp in the College of Education, and it runs teacher night programs to connect the university with industry and K-12 educators.

Pinnell, of the University of Dayton, said her school has hosted two RET sites, one on innovation and a second on materials and manufacturing. The second was in partnership with Central State University and Wright State University. Pinnell pointed out that together, those cater to three very different student bodies; Dayton is a private, Catholic institution with 7,000 undergraduates, Central State is an HBCU, and Wright State is a large public university with 14,000 students. Pinnell listed several key elements to the program design: leveraging regional strength in innovation, manufacturing, schools, and industry; encouraging professional development beyond the research experience by including elements such as curriculum design, a hand-picked faculty, the involvement of undergraduate engineering students, and the fostering of community. Big wins: STEM for all,

including K-8 and special education; STEM for literacy, creative confidence and risk taking, the creation of a community of STEM advocates, a changing of the conversation, and innovative pedagogical techniques. Passion, she said, drives success.

The panel then turned to the audience for questions. One participant asked what it was that attracts teachers to these programs. Answers included money and the opportunity for professional growth. Bowen noted that North Dakota State paid for all travel and housing plus stipends. With regard to teachers' performance on site, one participant asked how to deal with teachers who don't perform at the level expected. Kapila suggested using someone already on staff to hold them accountable. Always have a letter of commitment from the school principal. In a case where a teacher makes an unreasonable demand—regarding days off, for example—you may have to say no. Pinnell said Dayton has a written agreement that spells out lab hours. Cavicchi recommended holding back the final payment until they turn in their lesson plans. From the floor came a recommendation to schedule a 10-minute check-in with teachers after two weeks, just to touch base and troubleshoot any issues.

A concern about the difficulty of finding teachers compared with the ease of attracting undergraduates was clearly not a problem at some institutions, but for those where it is, participants recommended showing up at science competitions, spreading the word at tech groups, and asking principals to suggest teachers—schools superintendents may be too remote. In other observations, it was noted that in Houston, ExxonMobil has an Introduce a Teacher to Engineering Day. That's much easier than having someone working alone at a worksite to gain industrial experience. A recommendation for working with community college faculty was to give them more independence—and lots of tips they can pass on to high school teachers. As a final piece of advice, Bowen strongly suggested that for every RET PI in a school of engineering, you have a co-PI in the college of education.

Strategies for NSF-funded Workshop Development and Implementation

Speakers:
Karen High, *Clemson University*
Cindy Lee, *Clemson University*
Shannon Stefl, *Clemson University*

To begin this session, Lee responded to initial logistical questions from the audience on award timelines and award amounts (typically, with NSF, up to $50,000 or up to $100,000). Lee then talked about how to develop a workshop as a vehicle for increasing and broadening project and research impacts.

Stefl addressed major considerations around developing a workshop: defining the goals, recruiting participants, building a support structure, and evaluating the results. One of Clemson's recent workshops was entitled *Who's Not at The Table? Building Research Capacity for Underserved Communities in Engineering.* Its goal was to develop a national research agenda for broadening participation in engineering, particularly among LGBTQ+ and first-generation or low-income students, among veterans, and among people with disabilities. Three PIs collaborated on the project, from Clemson, Drexel University, and the University of Washington; each PI had a different focus. The goals of the workshop were to engage members of the research and practice communities in dialogues about challenges to participation, and to leverage their expertise to generate the data from which the research agenda emerged. The workshop practiced what it preached, incorporating inclusive and accessible practices. It cast a wide net for participant recruitment, advertising with professional societies, inviting individuals to apply, and requesting colleague recommendations. The workshop engaged faculty, university staff and administrators, and graduate students. The workshop was supported by an advisory board and an external evaluator. The third facilitator of this session, Karen High, described how the project was conceptualized, offering details on timeline, budget, and implementation.

The description of the Clemson workshop spurred many questions about logistics, lessons learned, building collaborations, and cost. The session ended with a table-by-table activity for generating workshop ideas. High and Lee answered questions and then facilitated a report out. Ideas included a multi-institution network of connections, and lessons from PEER Collaborative engineering workshops.

Topics also included burnout and sustaining faculty interest. The contingent from Clemson offered help in the future to any grantees who were considering organizing a workshop.

Her Story is Our Story: The Value of the Personal Narrative in Participant Engagement

Speaker:
Sharon Torres, *Arizona State University (ASU)*

At the time of the EEC meeting, ASU had hosted two annual Women of Color STEM Entrepreneurship Conferences, and a third was planned. The conferences are a collaborative effort to advocate for increased participation of women of color in entrepreneurship and small businesses; to advance entrepreneurship education and student engagement; and to transform the ways that entrepreneurship is viewed, taught, and experienced in higher education. During this session, Torres drew on the experience of those conferences to highlight the value of personal narratives in participant engagement. Session participants were asked to introduce themselves and include a personal vignette in which they were to give advice to their younger selves, a request that yielded some fun interactions.

Torres introduced two tools for telling a story, digital narratives and strategy sessions. The Center for Digital Storytelling, a California-based nonprofit, has a seven-element key to storytelling.[19] The elements are:

1. Point of View: What is the main point of the story and what is the perspective of the author?
2. A Dramatic Question: A key question that keeps the viewer's attention and will be answered by the end of the story.
3. Emotional Content: Serious issues that come alive in a personal and powerful way and connect the audience to the story.
4. The Gift of Your Voice: A way to personalize the story to help the audience understand the context.
5. The Power of the Soundtrack: Music or other sounds that support and embellish the story.
6. Economy: Using just enough content to tell the story without overloading the viewer.
7. Pacing: The rhythm of the story and how slowly or quickly it progresses.

Digital storytelling, said Torres, is an effective instructional tool for teachers and students alike, and it's also an effective tool for advocacy that can be used to empower marginalized populations and engage them in community-based initiatives. How we share the story is just as important as the story itself; no matter what the topic is, it can be engaging.

Torres invited participants to define their own stories. Her prompts were:

1. What single experience most shaped who you are? Describe it in a single, vivid scene.
2. How has your identity changed over the course of your life? Write a scene from your teenage years that epitomizes the type of person you were, and then write a scene from recent life that shows how you've changed.
3. Tell the story of a location—one very close to your heart that you already know well, or a new one that inspires your curiosity. Pay particular attention to your own connection to the location, however small or large that connection may be.
4. Tell the story of an important long-term goal you have accomplished.

As people started sharing, the room became animated. Most participants were smiling and opening up readily to their neighbors, some even laughing at themselves and their narratives. Torres asked people to pair up, choose a story prompt, and assign a storyteller and a listener. The storyteller would develop and tell his or her story. The listener would provide brief feedback. Two participants shared descriptive stories from their childhoods. Torres's observation: Reflecting on these stories helps to understand others and empathize. To round out the activity, Torres shared details of her own story and its relevance to intersectionality and inclusivity.

Turning to digital narratives, Torres discussed issues of content and intended use, which can range from assembling an institutional memory to advocacy and marketing. Pre-production is important and involves assembling a team, researching the subjects, developing questions, and planning logistics. Post-production includes transcription, coding, and storyline. To illustrate the finished product, Torres played the conference videos from ASU from both 2016 and 2017, demonstrating the range of experience that can be captured in this way and highlighting process improvement. The first video, produced on an iPad at

19 http://digitalstorytelling.coe.uh.edu/page.cfm?id=27&cid=27&sublinkid=31

the conference, is full of short, candid interviews that look amateur but still come across as passionate and raw, whereas the second was created by professional team using prompts given to them in advance.

Inspiring Change Agents to Transform Engineering Education: Challenges and Strategies for Engineering Education Pioneers

Speakers:
Cynthia J. Atman, *University of Washington*
Jennifer Turns, *University of Washington*

In this session, Atman and Turns drew on the NSF-funded project Engineering Education Pioneers and Trajectories of Impact, in which graduate students and junior faculty interviewed individuals identified as pioneers in engineering education. Looking back on the history of engineering education, it is an exploration of many personal journeys by pioneers who came by different pathways with a variety of motivations to build a new, welcoming community. What is the history of these pioneers—people like Charlie Yakomoto, who retired in 2006 from Indiana University—Purdue University Indianapolis? What is their backstory?

The main project activities are interviews with 47 early contributors to engineering education. These are conducted by graduate students ("prospective pioneers," as the facilitators referred to them). Their findings will be analyzed to investigate their impact, and profiles will be posted online at http://bit.ly/engredupioneers as the Pioneers Project. The goal of the project is to make connections across different generations of the engineering education community and to catalyze a new generation of engineering education scholars, in the belief that the pioneers hold insights for the broader community.

Pierre Bourdieu, the French sociologist, theorized that power and hierarchy in any system of social relations (including an academic field or institution) could be understood in terms of possession and exchange of four types of capital: economic, symbolic, social, and cultural. Using this lens, the Pioneer Project aims to understand the pioneers' career narratives as sequences of lacking, gaining, and leveraging various types of capital.

Fleshing out Bourdieu's types of capital (economic: assets that have direct monetary value; symbolic: reputation, recognition, prestige; social: social connections, networks, group memberships; and cultural: shared knowledge, skills and activities), participants undertook a succession of activities to explore their own "capital" in terms of engineering education. The facilitators pointed out that the very subject of engineering education was non-normative for the Pioneers, who had to have an engineering foundation first before going into such an "aberrant" field. By the end of the exercise, participants had traveled their own journeys from understanding where they lacked capital to figuring out where they could gain capital and be able to leverage it.

The facilitators concluded by asking participants to think about two questions: how to use this framework to help further individual careers, and how to employ it to help advance the community.

Designing Propagation Plans to Promote Sustained Adoption of Educational Innovations

Speaker:
Jeffrey E. Froyd, *Ohio State University*

Attempts to achieve change are often ineffective because they fail to use strategies that will make adoption more likely. Froyd and his team have developed a rubric to assess whether a project will sustain adoption, and the framework has been used to assess NSF proposals. Proposals are rated in six areas, and the rubric is designed to make sure that a project team is aware of who needs to buy in to its project to assure adoption. Participants in this session reviewed a proposal using the rubric, rated the proposal, and discussed the ratings.

Froyd introduced his team's framework assessment instrument, known as DSAAI (Designing for Sustained Adoption Assessment Instrument) and outlined six aspects of a propagation plan that influence the likelihood of propagation:

1. Intended audience is identified (who makes adoption decisions).
2. Propagation strategies engage intended adopters.
3. Project begins to address issues of propagation from the very beginning of the project.
4. Propagation strategies consider the different aspects of the instructional system.
5. Level of thoroughness in propagation strategy.
6. Propagation strategies depend on the type of project.

To address these, the team has put together a three-page structured project summary that asks for input about any project proposal in several areas: a project overview, potential adopters, activities to be undertaken to develop a strong product, a broader impact plan, an evaluation plan, a timeline, and a list of personnel who will work on the project and what they will do.

Froyd then argued that dissemination alone is not sufficient to bridge the gap between desired and current teaching practices when trying to foster change. For propagation to work, it needs three stages: interactive development, interactive dissemination, and interactive support. Interactive development allows more time to gather feedback and is more likely to develop something that is adoptable; you are engaging your potential adopters early. You learn what problems they face, how they currently solve them, and what types of alternative solution are acceptable. For these purposes, a minimally viable prototype is sufficient.

When it comes to dissemination, you're looking for interactive dissemination activities that are best suited to your product. The focus of dissemination is to get the word out to potential adopters and to motivate them to try an innovation; it is one step before actual propagation. Dissemination approaches range from less interactive (LISTSERVs, promotional materials) through moderately interactive (journals, a conference booth, a workshop) to very interactive (personal approaches). An examination of a tranche of NSF proposals from 2009 suggested there had been a preponderance of passive strategies over active. A mix of both seems more rewarding.

Froyd recommended supporting your adopters by identifying ways to collect information during development. Evidence suggests more than a third of faculty members who try a new instructional strategy end up dropping it. With good support that might not happen. A good support plan will ask four questions:

1. What are the characteristics of your product?
2. What stage of adoption are your users in?
3. What resources do you have available?
4. What stage is your project at?

Of course, the answers to these questions, and the support strategies you use, may change over time.

Breakout Sessions by Cluster

These breakout sessions offered an opportunity to collaborate with other grantees and NSF Program Officers and were separated by program: Engineering Education programs (RFE, RIEF and RED—combined, the largest group), REU programs, RET programs, and BPE programs. Grantees were not required to participate in their program's cluster and were encouraged to visit other breakout sessions if they were interested in learning more about other EEC programs.

Engineering Education (EE) Grantees

NSF Moderators:
Elliot Douglas and Julie Martin

Douglas and Martin, the session's moderators, were the outgoing and incoming NSF program officers, respectively. At their tables, participants were asked to discuss two prompts:

1. How could your projects have impact or be scaled up if you were able to expand them?
2. How can NSF support impact and scalability, bearing in mind that funding itself is fixed?

Discussions about scaling up varied widely at different tables. Some participants asked whether engineering faculty should bring in other faculty members from beyond STEM—humanities, for example. Presenting current disciplines in a different light was mooted: Can you change the appeal of aerospace engineering to make it more than "planes and rockets?" And there was discussion of scaling up a small program in engineering education at a single university, such as New Mexico State, by taking it to other colleges with similar demographics (in this case, a large Hispanic community).

As different tables reported out, it was clear that scaling up involved partnerships with all sorts of stakeholders, not just other institutions—policymakers, high schools and community colleges, schools of education, industry. One concern expressed was the lack of speed in communicating findings, which one speaker equated with a loss of impact. One suggestion was to induce speed by sharing preliminary reports with key stakeholders without waiting for journal publication. This would follow the example of the medical community, which disseminates breaking news very fast. Another was to establish a free repository, because you're often still disseminating information well after the grant has ended, when you no longer have funding to do so.

Several participants sought action from NSF, one asking the foundation to act as a matchmaker by connecting educators with policymakers—for example, by getting people in front of legislative hearings. Another observed that I-Corps™ L was valuable for making connections with stakeholders and asked if anything would replace it. One table observed that it's hard to build meaningful dissemination into an NSF budget.

When tables started discussing the second prompt, how NSF can support impact and sustainability, the discussions also ranged broadly. One table dissected the current state of play on impact statements, following the suggestion that NSF needs to be more careful in weeding out "fluffy" broader impact statements. Does NSF distinguish between a distinctive impact and an effective impact? Why can't broader impact statements clarify which audience they're intended to influence? What if we switched the order of the application form and put the broader impact statement before the statement of intellectual merit? Is "novel" and "unique" enough? Would it be better if a broader impact trumped a proposal's uniqueness?

The two NSF program officers tackled some of the questions raised immediately. When asked whether NSF can retweet work, for example, Douglas answered that it already does. Some of the suggestions were for better links between different projects—broader impact affinity groups, for example—for streamlined contacts between related projects, and whether, if NSF decides not to fund a grant, it can let the applicants know of any grantees who are working in a similar area. One table asked if it was clear what resources new PIs needed, and if there was a way to make more information available. There were two practical suggestions for connecting the dots across projects: fostering a community of broader impacts within the community itself, and creating a broader impact clearinghouse, with success stories—and making it easily accessible. One table suggested leveraging other parts of NSF and encouraging them to interact more with students and faculty.

Once again, the question arose of whether NSF can help educators reach lawmakers on a bill proposal, for example. The answer was no, but Douglas said NSF might be able to offer media training. Douglas also offered to think about another request, that NSF help with publishing after the grant period ends.

There were several requests for training, such as a webinar on PI best practices and pitfalls. One table suggested half-day sessions for grantees that piggyback on existing conferences; another wanted a virtual mechanism for matching researchers with outside collaborators— "a Tinder for researchers." There was a suggestion that NSF work with other federal agencies, such as the Departments of Defense and Education, to promote professional development.

The unveiling of NSF's 10 Big Ideas in 2016 spurred one table to ask if it was possible to come up with five within EEC itself. It had three initial suggestions: student retention, mentoring internships, and expanding access in K-12.

The closing minutes of the session for EE grantees turned to housekeeping. Some PIs are finding deadlines confusing; Douglas clarified them. Annual reports are due 90 days before the anniversary of the project. After those 90 days, they become overdue. Final reports become due the day after the project finishes. Douglas offered two tips for writing an annual report: Think of it like a short conference paper; impacts are critical. Common problems include: not enough detail; reports written in a way that assumes existing knowledge of the proposal and prior reports; and the absence of impacts or limited descriptions of them.

Douglas clarified the status of RED, which has lasted three years, with 19 awards. The idea was to develop a set of models for other schools to use. Now it's time for a pause to discuss whether it's time to move on to something different. There will be no solicitation for 2019. Questions were raised about the limitations of the RED PI role; one PI can't be on more than one RED grant. One questioner asked what happens if you submit an article that is not open access. The answer was that NSF has a repository (run by the Department of Energy), and grantees need to submit their work there. A comment was made about forthcoming open-access journals for engineering education that will be available soon.

Martin then offered to answer questions as the incoming program officer. Asked what she was most excited about in her new role, she said "the opportunity to help create a community and networks even broader than we have now. Also, there is language that talks about smaller, exploratory projects. There's an opportunity there. Not everyone has to submit something that takes three years and costs $300k. I'm going to be very open to that." Martin suggested making it clear to the program officer if you apply for one of these.

REU Grantees

NSF Moderator:
Patricia Simmons

Because this session was a way for NSF to get feedback from REU PIs and REU participants, NSF took notes and the main points were captured on a note pad that NSF collected at the end. The scheduled NSF moderator, Mary Poats, was needed in the adjacent RET session, and NSF AAAS Fellow Patricia Simmons led the REU session.

The session began with an open question-and-answer period with participants. A question about the level of funding was met with the reply that at the time of the conference, all funding was subject to a Continuing Resolution. There was speculation about $12 million versus $10 million. Some funding also comes from the Department of Defense. There was a reminder that supplemental requests can be requested for up to $20,000, and that there's another pot of money for veteran support. There's a special label for veterans: DCL 14-124. One participant asked if people will be required to use a common application. Mathematica Policy Research is looking into this question (response to the suggestion has been 80 percent positive), but meanwhile, it's business as usual.

At their tables, participants were asked to discuss and then report out on the two prompts designed for the breakout sessions:

1. How could your projects have impact or be scaled up if you were able to expand them?
2. How can NSF support impact and scalability, bearing in mind that funding itself is fixed?

For one table, scalability raised the question of finding mentors. We know who our good core mentors are, the table's participants said; if we expand we would need to find more. The National Research Mentoring Network (NMRN) teaches post-doc mentors and is generous with materials and training.

Another table discussed their projects' impact on students and student careers, while also mentioning their struggles with constraints for finding both mentors and funding. Participants recommended making local industry more aware of what REU does, and also suggested having a community of year-two students interact with year one, so no one's left out.

As it happens, some groups collaborate; if they don't have enough space at their school, they send an REU student to another school. But community is a big thing for REU students. How do you scale and not lose community? For some participants, scaling went hand in hand with recruiting and tracking, and it was observed that a common application might make it easier to track students. One table suggested that NSF could help with tracking students. One program uses Facebook, another LinkedIn; some universities and colleges follow up with texts or calls, although some students don't like to respond unless they have progress to report. Another participant reaches out to parents, calling them after the student graduates. However, it was observed that use of social media by students is going down.

Funding and program costs were clearly on many people's minds, one table asking gloomily what REU programs can do if there's a 10 percent cut to awards. One table expressed the view that some universities value grants more for their resume-building aspects than for their merits. One table talked about trying to recruit local students, to reduce travel and housing costs; another said good infrastructure can reduce some costs in housing and food. No one wanted to reduce stipends. One table said field trips can be expensive and suggested local alternatives that are free. Other suggestions included soliciting industry partners for financing and reducing costs by recruiting online instead of going to conferences.

An observation that it was not easy to find information about REU on the website produced several suggestions, including direct emails from NSF to faculty members. In general, there was some feeling that REU was hiding its light under a bushel: One student wanted a job from a company, but the company didn't know what REU was. There was a call for NSF to spread the word.

As in the other breakout sessions, clarification was offered over annual reports and when to submit them. The timing is important; if an annual report is overdue, it blocks other actions for the institution.

Students then shared their experiences in the REU program. On the application process, they said they need timelines for when students will know they are accepted. Some applied to multiple REU programs, others just to one.

NSF made clear that it's looking for impact from REU and wants PIs to include information on whether students have published. Some faculty members will include a student on a paper or let a student participate in a conference.

RET Grantees

NSF Moderator:
Mary Poats

This session for RET grantees followed an unscripted format and did not use the NSF prompts that the other clusters used. The first topic concerned RET housekeeping updates. NSF put the total number of active sites at 40 for RET and 120 for REU. For FY 2018 proposals, applicants were asked to consider submitting REU supplements with RET proposals. These can be up to $7,000 per student, an increase from $5,000. There are also veterans' research supplements, coded as DCL-14124.

The NSF moderator noted that NSF is strongly behind the teaching of engineering at the pre-college level. They seek lots of follow-up with RET program participants. In the future, a partnership with the RET programs and Amazon is possible; no one wants Amazon to monetize the curriculum, but its involvement may help certain teachers, such as those in rural schools.

There was discussion about developing two classes in AP Engineering: Engineering for All and Engineering Design. The Engineering Directorate supports an AP Engineering pilot program. Workshops will bring together teachers, academics, deans of engineering, the College Board, and federal agencies. There is already a draft AP engineering curriculum. There are big questions about who will teach the courses, who will train the teachers, and how they will be funded. However, next-generation K-12 science standards already include engineering, and engineering design is far and away the biggest theme for the K-12 curriculum. Engineering can learn from AP Computer Science for All, which can be taught by teachers with varied backgrounds including French or English. The College Board has yet to commit, and it still needs a pilot and outreach to teachers, regionally placed for testing, but interest remains high.

What can junior faculty do without administrative support at RET sites? Many graduate students have a passion for K-12 education, which serves as a good leadership opportunity, but budget ceilings can stand in the way. There is a trend to bring on graduate students in support roles. There was discussion of the importance of getting people to conferences for training or related professional development. There were also suggestions for integrating STEM into other areas, since K-12 teachers are all going through the STEM model of teaching. Building sets for theater productions ("Jack and the Beanstalk" was used as an example, with growing beans and a beanstalk design component). For engineers who can write, fundamental reading and writing skills are synergistic with STEM.

As for improving RET, there were major revisions to guidelines a year ago, but suggestions were solicited about what else can be done. These included having teachers serve active sites and allowing sites access to other sites' application materials, safety training, and quick-start materials; we should encourage people to do this instead of reinventing the wheel. Some sought a common application for RET, and REU is working on one. NSF said it wants to hear from teachers: What do they do for professional development—weaknesses, issues, strengths, concerns? Whom do they reach, what impact have they had? Some of those in the session wanted mentoring programs and social networking programs like those at other directorates. There was a call for the big picture, with the vision and common goals for all programs—a list of grantees and types of grants with short descriptions. It was suggested this type of grantee information could be included in the EEC conference app. One participant noted that having current secondary students in RET has worked well, and there was a call for webinars for new PIs and an open forum for sharing up-front to help one another within the RET community.

BPE Grantees

NSF Moderator:
Paige Smith

BPE grantees numbered about 20 and sat at four tables, which allowed space for proper introductions. Smith structured these to include keywords related to the projects people were working on; the ones that came up the most were "diversity", "equity," and "collaboration." Smith then asked everyone to sit by someone whose keywords fascinated them.

At their tables, participants were asked to discuss and then report out on the two NSF prompts:

1. How could your projects have impact or be scaled up if you were able to expand them?
2. How can NSF support impact and scalability, bearing in mind that funding itself is fixed?

Addressing scalability, the first table observed that there's a notion that longitudinal data is just more believable, but the problem is that you can't drill down enough to see true diversity. There's still a lot of data that they cared about but was never kept. There was some

discussion of the notion that even in longitudinal space, interventional studies can be more revealing and add the voices of students whose stories may be compelling.

The second table tackled staffing, recommending getting support from the department head and leadership to get more support. It observed that the ability to mentor and communicate with those who receive grants can be hard; there's a lot of information about successful BPE projects, but getting access is difficult. Table participants suggested finding a way to index projects, and asked NSF to share a list of PIs in similar programs for collaboration and discussion, and share best practices. A participant at another table asked whether the people who do the research in engineering education get the same respect as other people within the discipline and suggested looking at the biases. Someone else said people in engineering education researchers work with deans and administrators, but it is often said that they aren't listening.

The third table's concern about awareness of what's in the data and what info is out there struck a chord with participants in the room. One wondered whether self-reporting of LGBTQ+, Latino, or disability status differs from place to place, even over basic data such as who is being counted. Another participant observed that we have to focus on both visible and invisible disabilities. The language of disability is something some can take pride in, so when you start allowing other phrases it can be difficult to understand. Someone at a different table said they allow students to self-report and ask what word they would use to describe themselves—"respecting people's privacy versus putting it out there."

When the session turned to NSF support, participants were asked to consider matters beyond just funding. They were told to assume funding levels are fixed, so if they wanted more funding they needed to say what aspects of a program they'd cut. They were asked to record their suggestions on sticky notes, so NSF could collect them. As discussion began, Abiodun Ilumoka, NSF's program director for DUE, introduced herself and talked about S-STEM and Improving Undergraduate STEM Education. She pointed out that H1-B visa money funds S-STEM so it never really dries up.

During the report-out, the first table said they had discussed creating platforms to engage PIs, virtually or face to face. They were interested in whether it was possible to differentiate between funded and unfunded PIs, and wondered if there was a way to speak to unfunded PIs and see why they weren't funded, with the idea of encouraging reformulation into something that might get funded.

The second table raised questions around matching the evaluation to the work, particularly diversity work. This group asked whether and how success is defined, and if there's a review process to look at the final report. They asked NSF to put out a statement to encourage collaboration with other institutions, with guidelines on how to do that, including sharing data and data plans, as well as policy and public communication.

The third table wanted to require PIs to collaborate on their activities to broaden their impact. They wanted NSF to require those who have had prior funding to talk about their impact and successes. They said NSF needs to require evidence of broader impact in proposals and include this as a supplemental document.

The final suggestion from the report-out was for an advisory council on resource management. Participants sought an NSF guide on how best to manage resources, including recommendations for data collection so new

REU site participant and Suffolk County Community College student Joyce Chae discusses her work at the REU Site for Nanotechnology in Health, Energy and the Environment during the Sunday evening REU and RET site participant poster session.

grantees don't have to scramble for information. They called for a catalyst to put people in contact with one another—perhaps with NSF as a research matchmaker.

Before discussion ended there was a suggestion for committees to focus on continuing projects that can be brought together to ensure scalability and continuity. And there was discussion across the room about collaborating more and forming alliances, and a call for a Facebook-like platform that would let you participate and ask questions. Maybe there should be a jobs board and place to post about it.

As in the other breakout sessions, NSF program officers clarified deadlines for reports and extension requests and went over what should be included in an annual report. They included a plea not to assume prior knowledge on the part of the reviewer and an appeal for impact. NSF staff also asked grantees to share their work with NSF, including publications, pictures, websites and news stories.

From the floor, there were questions about getting started. How do you learn common or best practices getting started on a project? How do you find basic things like budget and get involved in the collaborations? Several suggestions were offered: one was good mentorship, another was putting together a one-pager of yourself and your projects (one participant recommended sending the one-pager to program officers in your field and telling them you're interested both in their work and in getting yours out). One participant mentioned the benefit of having a proposal development office, citing the University of Kentucky as an example.

NSF also made clear that it is strongly interested in funding research aimed at broadening participation, mentioning NSF INCLUDES. Taking an NSF INCLUDES approach means bringing new people into the project space and taking a collaborative approach to a challenge. NSF is looking not just for social innovation, but also for the research that goes on to support this. There is $250,000 in funding for two conferences over two years. The key for those interested is to create connections to NSF INCLUDES networks and share what they're doing in broadening participation and diversifying. It's fine to generate massive data sets; the question is how to make sure you're moving in the right direction.

Participant Andrea Ogilvie (Virginia Tech) shares her research during one of the conference's grantee-led poster sessions.

Poster Sessions

REU and RET Site Participant Poster Session

The face of engineering education today was reflected in the opening session of the EEC Grantees Conference with a strong showing of posters by REU and RET site participants. Selection was competitive; from a pool of more than 60 applicants, 20 were chosen to participate in the conference.[20]

Among the REU participants was Julia Canty, an undergraduate senior studying mechanical engineering at the University of Notre Dame who hopes to pursue a career in biotechnology. In front of her poster, she talked other participants through a bioengineering project she explored in an REU program studying rehabilitation engineering at Cleveland State University. For a community garden in Cleveland, Canty designed a fall-arresting harness that allows people with balance impairment to move from sitting to standing and could allow them to garden independently. The project was run primarily by physical therapists, which meant Canty had to collaborate and communicate across the disciplines of medicine and engineering.

20 Information on all REU and RET site participants who contributed to the poster session can be found at https://eecconference.asee.org/reuret-nominations/

RET participants included Kelsey Mongeon, who teaches junior high and high school science in rural Fessenden, North Dakota, where she is the only science teacher in her school district. Mongeon was in the first cohort of RET teachers at North Dakota State University in Fargo, N.D., where her research experience took her into engineering in precision agriculture with a strongly local focus. She listed two primary takeaways: learning and exploring the engineering design process and how to integrate it into the classroom at a K-12 school, and learning from other teachers in her position in similar rural districts.

Grantee Poster Sessions

Two poster sessions, one on Monday morning and the second that afternoon, filled a central hallway in the conference space and spilled over into an adjacent room. Attendance was strong at both sessions, and with close to 120 projects represented, the presenters fielded a constant stream of questions from grantees, NSF program officers and representatives, and the REU and RET site participants who presented their posters during the Sunday evening networking session. It is noteworthy that in the evaluation survey conducted after the conference (Appendix B), the poster sessions were singled out as influential in providing comprehensive understanding across programs, showcasing value and scope of projects, and demonstrating the collective reach and impact of EEC projects.

Memorable images of research in unexpected places cropped up frequently during these two poster sessions. Shawn Grimes, Executive Director of the Digital Harbor Foundation in Baltimore, demonstrated a project sponsored by University of Maryland—Baltimore County in which children from Baltimore City Public Schools are running a commercial 3D printing shop in Baltimore's Inner Harbor, while Terri Norton of the University of Nebraska—Lincoln, who teaches and researches the effects of natural hazards on civil structures, disaster debris management and sustainability, answered questions about a student trip to Japan in the wake of the 2011 earthquake and tsunami.

From Lamar University in Beaumont, Texas, Weihang Zhu, an RET grantee, discussed incorporating engineering design and manufacturing into the high school curriculum, while New Mexico Tech was represented as one of the partners in a multi-institution study to examine whether capstone design projects in engineering really work.

One of the strengths of the poster sessions was that they allowed conference participants to follow up informally with plenary speakers and concurrent session facilitators. Jeremi London of Arizona State University, who delivered the plenary talk on Tuesday, presented a poster with preliminary results from her research into establishing a framework for measuring impact in engineering education research.

Participants interact at one of the conference's grantee-led poster sessions.

Conference Outcomes and Future Directions

Evaluation Highlights

The 2017 NSF EEC Grantees Conference had three intended outcomes, all related to the goal of increasing the impact of EEC projects to benefit the engineering education community and society at large: 1) Foster knowledge-sharing across the network of grantees in attendance; 2) Cultivate personal and professional relationships, collaborations, and partnerships to further individual, organizational and division-level goals; and 3) Inform conference attendees about the state of the art and ongoing efforts that could assist them to increase the impact of their awards.

Results from the session rating and post-conference surveys indicated that these outcomes were achieved. Networking and poster sessions proved to be most conducive to knowledge-sharing and relationship-building. The majority of attendees reported interacting with one to five grantees across programs; these interactions took many forms, from sharing ideas and data to discussing potential collaborations. Poster sessions were also influential in providing comprehensive understanding across programs, showcasing value and scope of projects, and demonstrating the collective reach and impact of EEC projects.

Plenary and concurrent sessions proved most effective at informing attendees about efforts to help increase project impact. Numerous attendees noted that they were able to expand their vision of impact through these sessions, where they learned about work being done by others, how it relates to their own projects, and how impact can go beyond individual projects and have a larger footprint. In the words of one conference attendee, "The last session [the plenary talk led by Jeremi London] broaden[ed] my perspective on what kind of impact my previous research experiences have had, where I only viewed them in the realm of academic impact. They still have societal and contextual impact as the work that is done sparks other types of research."

On the whole, concurrent sessions ranked generally high with regard to topic choice and facilitator knowledge and engagement level. The sessions that allowed for networking interactivity among participants received the highest praise in respondents' open-ended comments. Topics that proved most valuable to attendees (based on session-rating survey results) included best practices in engineering education research, publication and dissemination advice, engineering education career pathways, partnership building, and developing and implementing NSF-funded workshops. The sessions on increasing the impact of publications and communicating with policymakers were reported as very instrumental in furthering respondents' understanding of impact.

The NSF-led breakout sessions afforded grantees the opportunity to communicate directly with EEC program officers. Session-rating survey results showed that these sessions were highly valued by attendees. They were viewed as being a worthwhile use of time and very effective at increasing attendees' professional networks and furthering their understanding of impact. In these sessions, grantees urged NSF to become more involved in disseminating and communicating findings, defining impact, providing professional development opportunities, and facilitating collaboration among grantees. Program officers were encouraging of and highly responsive to all grantee questions and comments, whether positive or negative, often offering on-the-spot feedback. These sessions left grantees with a sense of regeneration and NSF program officers with new ideas and thoughtful recommendations. Detailed evaluation results can be found in Appendix C.

Future Directions

Recommendations for Future EEC Conferences

An open-ended question at the end of the post-conference evaluation survey asked for suggestions and recommendations for future EEC Grantees Conferences. From the responses received, several themes emerged.

Concurrent Sessions

As noted earlier in this report, the conference sessions were highly praised by attendees overall. However, the survey generated several suggestions for improving them. Ten respondents reported that they were unable to attend multiple sessions of interest because the sessions were concurrent. Providing short abstracts for the sessions and posters, as well as duplicate sessions, would have helped participants get a sense of content

and prioritize their time and attendance options. Sessions could be recorded and presentations posted to benefit those who were unable to attend.

Respondents also suggested that more sessions be led by practitioners from fields outside engineering education (e.g. policymakers) to broaden the conversation and provide more examples of impact and how it can be increased. Attendees highly valued sessions that allowed for interactivity among participants, and sought more of these. Grantees also asked for opportunities to lead their own interactive sessions, where they would be able to present their work, interact with other grantees, and create more opportunities for potential collaboration. Attendees valued the sessions that provided practical advice for researchers. Rather than theoretical discussions of impact, several suggested that discussions look beyond academic papers and conference publications and address real-world examples, practices, and actionable recommendations for making a difference and increasing impact. Finally, respondents suggested that separate sessions be offered for new versus experienced researchers and for teachers versus students, since it is hard to provide the same value for each group in one inclusive session. REU site participants, in particular, desired student-targeted sessions focusing on, for example, resume-building and interviewing skills.

Logistics

Noting the three-year gap between the last conference and the 2017 NSF EEC Grantees Conference, respondents suggested that the conferences be held more frequently. A cost-effective way of doing this, some grantees suggested, would be to integrate this conference into or offer it in conjunction with other events attended by a similar audience (for example, ASEE's Annual Conference and the IEEE Frontiers in Education Conference). Integration with another event would save money on the conference venue and avoid depleting attendees' NSF grants on travel.

Recommendations for Increasing Project Impact

The 2017 NSF Engineering and Education Centers (EEC) Grantees Conference brought together EEC PIs and team leaders with the overarching goal of increasing the impact of EEC projects to benefit the engineering education community, other related disciplines, and society at large. Attendees gained a wealth of practical insights and offered recommendations for increasing the impact of their projects at all stages, from design and development to implementation, dissemination, and evaluation. Broken down by project stage, recommendations included:

Design and Development:

- Projects should be convergent (cross-disciplinary), inclusive (involving and engaging all sectors and groups in our society) and driven by a specific and compelling challenge.
- Use a framework assessment instrument, like the DSAAI (Designing for Sustained Adoption Assessment Instrument), when you are crafting your proposal to assess whether or not your project will sustain adoption.
- Professional societies should be approached as potential partners, as they often have the ability engage the community and expand project outreach.
- Team leaders should consider taking an entrepreneurial approach to designing projects, employing customer discovery tactics to ensure they are building a desirable and sustainable product.
- To get the most out of external evaluators, they should be brought in early, preferably at the proposal stage, and become familiar with project teams.

Implementation:

- With REU and RET projects, site participant roles and responsibilities should be clearly defined at the outset. Accountability measures should be established and agreed upon by the project team.
- When implementing a workshop, you must think about content (e.g. workshop goals and activities), logistics (participant recruitment, cost, and building a support structure) and evaluation (e.g. instruments and evaluation process).
- PIs, team leaders, and other project change-makers must be able to build and sustain strategic partnerships, communicate change, and establish and nurture a shared vision amongst project stakeholders.

Dissemination:

- Being published is not necessarily the same as having impact. When publishing your research, you should know how to optimize aspects of your publication, control your story via social media, and understand impact factors and indices.
- Impacts of projects and lessons learned should be better translated for the broader community.
- When disseminating your research to policymakers, you must first prepare by crafting

your policy story, determining your audience, and matching story and audience to your dissemination outlet.
- Storytelling and narratives are important when disseminating project information to different audiences. How the story is shared is often just as important as the story itself. The story of your project should be tailored to specific audiences and should always be engaging.

Evaluation:

- An impact framework for engineering education should be developed and formalized.
- Research quality must be considered across different methods (quantitative, qualitative, and mixed-method) and engineering education researchers should continue to discuss research quality to develop a theoretical understanding that reflects common perceptions and practices
- External evaluators can often articulate project findings better than PIs (due to their unbiased nature and other factors). External evaluator reports can be used for progress or annual reports to highlight or accentuate results, successes, and challenges.

Recommendations for the National Science Foundation

Breakout sessions arranged according to specific programs offered a unique opportunity for grantees to communicate directly with NSF program officers (who moderated these sessions). It was during these sessions that current concerns of EEC grantees came out most clearly, along with suggestions and recommendations for NSF—particularly related to how NSF can support impact and scalability (bearing in mind that funding itself is fixed). Naturally, each program has its own concerns, but shared themes emerged as well,

Regarding **dissemination and communicating findings**, grantees suggested that NSF acts as a matchmaker to connect researchers with policymakers. They also expressed concern over the lack of speed in communicating findings and difficulty disseminating information after funding has ended. It should be noted that NSF has a repository (run by the Department of Energy) and grantees can submit their work there. Not all attending grantees were aware of this repository.

On the subject of **defining and communicating impact**, grantees called for a clearer distinction between a distinctive impact and an effective impact. They recommended that NSF help foster a community of broader impacts within the engineering education research community itself as well as creation of a broader impact clearinghouse, with success stories. Grantees expressed a desire for NSF to require evidence of broader impact in proposals and include this as a supplemental document.

Grantees called for NSF to offer more opportunities for **professional development**, including webinars on best practices and pitfalls, educational sessions offered in conjunction with existing conferences, and collaboration with other federal agencies, such as the Departments of Defense and Education, to promote professional development on a larger scale. NSF was also urged to take a larger role in **facilitating collaboration among grantees**. REU and RET grantees and site participants expressed concern about finding and sustaining mentors; RET site participants in particular called for more mentoring and social networking programs like those at other NSF directorates. To further encourage grantee collaboration, attendees suggested that NSF: share a list of PIs in similar programs; create platforms that engage PIs (either virtually or face to face)—engaging both funded and non-funded PIs; require PIs to collaborate on activities that will broaden their impact; and require those who have had prior funding to talk about their impact and successes.

Appendix A:
Meeting Agenda and Artifacts

Monday, October 30

8:30 AM - 8:45 AM	**Opening Remarks** *Don Millard*, Acting Division Director, EEC Division *Dawn Tilbury*, Assistant Director, Engineering Directorate National Science Foundation
9:00 AM – 10:15 AM	**Concurrent Sessions I** • **Studio B:** Professional Societies as Partners in Impact (Panel) • **Studio C:** Upstream from Impact: Frameworks for Improving Research Quality ° Handout: Typology Questions ° Handout: Resource Guide • **Studio D:** 3 Million Teachers Can't Be Wrong—Just Try It: Hands on Engineering Design • **Studio E:** Building Strategic Partnerships • **Studio F:** Thinking Like an Entrepreneur: Designing your Educational Projects for Impact ° Handout: Session Booklet
10:30 AM – 11:45 AM	**Poster Session A**
11:45 AM – 1:15 PM	**Plenary I*** *Norman Fortenberry,* American Society for Engineering Education The Change-maker's Toolkit: Preparing Faculty to Make Academic Change Happen (*Julia Williams*, Rose-Hulman Institute of Technology)

1:30 PM – 2:45 PM **Concurrent Sessions II**

- **Studio B:** Increase the Impact of your Journal Publications
  - Handout: Sharing Guidelines for Wiley Journal Articles
  - Handout: Control your Story through Social Media and Online Format
- **Studio C:** New Directions for Broader Impacts at the National Science Foundation
- **Studio D:** Love Your Evaluator
- **Studio E:** Making an Impact with Policymakers: Lessons from the Field
- **Studio F:** Creative Approaches to Promote Interdisciplinary Research: Experiences from REU and RET Sites

3:00 PM – 4:15 PM **Concurrent Sessions III**

- **Studio B:** RET Site Best Practices: Design, Implementation and Sustainability
- **Studio C:** Strategies for NSF-Funded Workshop Development and Implementation
- **Studio D:** Her Story is Our Story: The Value of the Personal Narrative in Participant Engagement
  - Handout: Women of Color STEM Entrepreneurship Conference
- **Studio E:** Engineering Education Career Pathways: Looking Back to Look Forward
- **Studio F:** Designing Propagation Plans to Promote Sustained Adoption of Educational Innovations

4:15 PM – 5:30 PM **Poster Session B**

5:30 PM – 7:30 PM **Networking Session II**

Tuesday, October 31

8:00 AM – 10:15 AM **NSF Breakout Sessions by Cluster**

- **Salons 1 — 3:** Engineering Education programs (RFE, RIEF, and RED)
- **Studio B:** REU program
- **Studio E:** RET program
- **Studio F:** BPE program

10:30 AM – 12:00 PM **Plenary II****

We Can Do Better: Insights on Going from Research to Impact in Engineering Education (*Jeremi London*, Arizona State University)

Closing Remarks

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* Full concurrent session descriptions and facilitator information may be found online at https://eecconference.asee.org/program/concurrent-sessions/

** Full plenary session descriptions and speaker information may be found online at https://eecconference.asee.org/program/plenaries/

Appendix B: REU and RET Site Participants

In summer 2017, principal investigators for REU and RET sites were invited to nominate one site participant to attend the 2017 NSF EEC Grantees Conference. From a large pool of qualified applicants, 20 individuals were selected to attend the conference, 10 from REU sites and 10 from RET sites. These undergraduate students and educators presented their work and achievements during a special poster session during the Sunday evening networking session. More information on these individuals can be found on the conference website at https://eecconference.asee.org.

REU Participants

- **Emmeline Adu-Beng**
  California State Polytechnic University, Pomona
- **Chad Stuart Beardall**
  Brigham Young University
- **Julia Canty**
  University of Notre Dame
- **Joyce Chae**
  Suffolk County Community College
- **Refreeno Harvey**
  University of Arizona
- **Isaac Lello-Smith**
  Cornell University
- **Jenette Phillips**
  University of Maryland-Baltimore County
- **Lilia Sanchez**
  University of Texas, El Paso
- **Merhawit Temesgen**
  Laney Community College
- **Sophia Waxenberg**
  Pennsylvania State University

RET Participants

- **Terry Koker**
  Mahomet-Seymour High School
- **Angela Johnson**
  Pinole Valley High School
- **Marjorie Langston**
  Hamilton Township High School
- **Julie McGeary**
  Central High School
- **Kelsey Mongeon**
  Fessenden-Bowdon High School
- **Courtney Mountain**
  YES Prep
- **Chris Powley**
  Ogemaw Heights High School
- **Angela Puccia**
  Coventry Grammar School
- **Ron Ratkos**
  Mid Michigan Community College
- **Ashley Whitehead**
  Littlewood Elementary School

Appendix C: Evaluation Results Report

An online survey was distributed the 269 registered attendees for the 2017 Grantee Conference immediately after the event. The survey was open for a period of two weeks. The purpose of the survey was to understand if the conference goals and outcomes were achieved, as well as to obtain general feedback on overall satisfaction with the event and to make recommendations for future conferences. Ninety people (90) completed the survey (33% response rate). Two-thirds of all respondents identified as PIs or Co-PIs.

Summary of Findings from Post-Conference Survey

Conference Goals and Outcomes

According to survey data and analysis, the 2017 EEC Grantees Conference achieved the three major goals, which were to: 1) foster knowledge-sharing across the network of grantees in attendance; 2) cultivate personal and professional relationships, collaborations, and partnerships to further individual, organizational and division-level goals, and 3) inform conference attendees about state-of-the-art and ongoing efforts that could assist them to increase the impact of their awards.

Respondents reported that the conference provided a wealth of opportunities that promoted knowledge sharing across the networks of grantees in attendance. A majority of respondents indicated that they highly valued the opportunities that enabled them to engage, interact, network, and share knowledge with other grantees. Regarding the cultivation of relationships, every survey respondent reported that they interacted with at least one other grantee during this conference. The most common range of interaction was connecting with one to five grantees, although many reported interacting with more than ten grantees. Sharing ideas, discussing potential future collaborations, and sharing data and research were the most common topics discussed during these interactions.

Numerous participants noted that they were able to expand their vision of impact through interactions with grantees and participating in sessions, where they learned about important work being done by others and how it related to their own projects. Through these opportunities, participants were able to expand their vision of impact and began to think of it as a broader concept that goes beyond individual projects and has a larger scientific, cross-disciplinary, and societal footprint. In particular, poster sessions were influential in providing comprehensive understanding across programs, showcasing value and scope of projects, and demonstrating the collective reach and impact of EEC projects. Furthermore, survey respondents noted that personal interactions and conversations, networking, brainstorming and sharing ideas, and discussing potential collaborations helped them learn about leveraging resources and funding to increase impact.

Overall Conference Experience

Overall satisfaction with the 2017 NSF EEC Grantees Conference and its separate components was high (3.5 on a 1 to 4 scale). The individual sessions also ranked generally high on topics and knowledge, effectiveness, networking opportunities, facilitators, and furthering the understanding of impact. In open-ended comments, respondents provided a range of recommendation for future improvements. Recommendations included:

- Add more time for additional or duplicate sessions, or provide video recordings and slides from sessions in order to avoid schedule conflicts with the multiple concurrent sessions of interest.
- Bring more practitioners from a variety of different fields to provide first-hand perspective, user-content and actionable recommendations.
- Have separate targeted sessions and content for new versus experienced researchers on one hand, and for students versus faculty on the other.
- Host the meeting more frequently and more efficiently as part of professional societies' annual conferences.

Survey Data Report

Respondents' Profiles

The majority of survey respondents (77%) identified as PIs or Co-PIs while few (14%) reported being REU or RET site participants[21] . Among those who selected "Other" as a category, there were two program managers, two researchers, one external evaluator, one speaker, and one program director.

The breakdown by program showed that more respondents were affiliated with REU and RFE than other programs (Table 1). Those who selected "Other" reported affiliation with programs such as ERC (Engineering Research Centers); REE (Research in Engineering Education); RIGEE (Research Initiation Grants in Engineering Education), and the NUE (Nanotechnology Undergraduate Education). Among the respondents were six (out of ten attendees) REU students, and nine (out of ten attendees) RET teachers.

Table 1. Respondent representation by program

Program	Percentage	Count
Research Experiences for Undergraduates (REU)	25.2%	29
Research in the Formation of Engineers (RFE)	23.5%	27
Research in the Formation of Engineers (RFE)	15.7%	18
Research Experiences for Teachers (RET)	13.9%	16
REvolutionizing engineering and computer science Departments (RED)	8.7%	10
Research Initiation in Engineering Formation (RIEF)	7.8%	9
Other	5.2%	6

*The total number is higher than the total survey respondents (n=90), because they could select more than one program.

21 REU or RET Site Participant signifies an invited undergraduate student or K-12 teacher attendee, of which there were 20 in total.

Conference Satisfaction

Survey respondents ranked their overall satisfaction with the conference as high—an average of 3.5 on a 1 to 4 scale. High satisfaction was reported across all listed conference components (Figure 1).

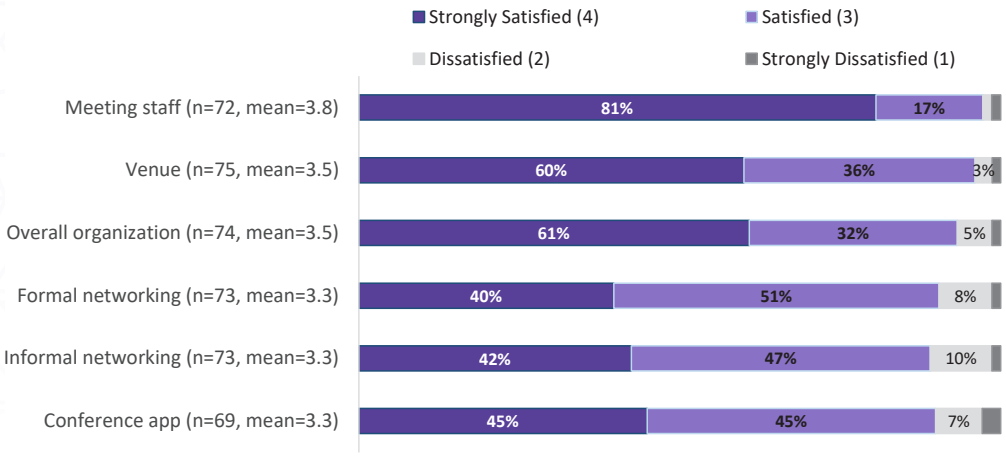

Figure 1. Participant satisfaction with meeting components

Qualitative analysis of open-ended survey data showed that attendees valued the opportunities presented for networking, knowledge-sharing and relationship-building (as reported by more than half of survey respondents). These engagement opportunities are addressed further under the *Conference Outcomes* section.

The conference sessions also received high praise in respondents' open-ended comments, especially sessions that allowed for networking and included audience participation and interaction (for example, poster sessions and interactive concurrent sessions). Sessions that showcased best practices in engineering education research, research methods, propagation plans, and publishing and dissemination advice were also particularly useful to participants, some of whom reported incorporating that new information into their work already.

Individual Sessions Rating

The conference organizers utilized an event planning and management app (Whova) to post the conference program, logistics information, attendees list, and presentation slides, as well as to allow for networking, communication, and notifications. The Whova app has a built-in five-star session feedback form (1 to 5 stars) which enabled attendees to rate each session separately. We asked attendees to rate five attributes of each session according to the following statements:

- I found this session to be a good use of my time.
- This session enabled me to increase my professional network.
- I found the facilitator(s) to be knowledgeable on the topic(s) presented.
- I found the facilitator(s) to be engaging.
- This session furthered my understanding of "impact".

A total of 286 responses were generated across all sessions with an aggregate average score of 4.1 (out of 5). Table 2, Table 3, Table 4 and Table 5 show the number of attendees, number of responses to the feedback form on the app, average ratings for session attributes, as well as the average score for each session.

The conference sessions that addressed the topics of publication and dissemination plans, policymaking, engineering education career pathways, building strategic partnerships, and strategies for developing and implementing NSF-funded workshops scored consistently high scores across the five categories, indicating high interest in and satisfaction with the topics and delivery in those sessions. The same top-ranked sessions scored particularly high on facilitators' knowledge and engagement, which suggests a connection between a good facilitator and overall satisfaction with other session components.

The two poster sessions scored consistently high across these categories and reportedly provided some of the most valuable content for participants. The poster sessions were ranked the highest of all sessions in the networking category. The two plenary sessions were also ranked very favorably, especially relative to the high number of attendees that they drew. The plenaries scored particularly high on the measures of knowledgeable and engaging facilitators.

The sessions on increasing the impact of publications and communicating with policymakers were reported as very instrumental in furthering respondents' understanding of impact. Three of the NSF clusters breakout sessions—BPE, REU, and Engineering Education—were also popular among attendees and received high scores across all five categories.

Conference Outcomes

According to participants' survey responses, the 2017 EEC Grantees Conference achieved its three major intended outcomes:

- Fostering knowledge-sharing across the network of grantees in attendance;
- Cultivating personal and professional relationships, collaborations, and partnerships to further individual, organizational and division-level goals; and
- Informing conference attendees about state-of-the-art and ongoing efforts that could assist them to increase the impact of their awards.

The reported data and analysis showed that there were many instances where the conference's intended outcomes were interwoven with each other. Therefore, they are not reported separately, but rather fluidly under the three cross-cutting outcomes:

- High level of engagement, networking, knowledge sharing and collaboration amongst attendees
- Enhanced understanding the broader collective impact of EEC programs and projects
- Increasing project impact

High Levels of Engagement, Networking, Knowledge Sharing and Collaboration

More than half of respondents (n=50) noted in open-ended comments that the most valuable aspects of the 2017 NSF EEC Grantees Conference were the opportunities for networking and knowledge sharing. Both formal and informal opportunities were valued for renewing old or forging new connections, sharing knowledge, planning collaboration and receiving critical project feedback. Furthermore, the conference's networking sessions, breakout sessions, and poster sessions also allowed grantees to showcase their work and to interact with both grantees and NSF program officers and representatives. Respondents noted that the poster sessions in particular were conducive to networking and showcasing and sharing their work.

Table 2. Average ratings for concurrent sessions (five-star scale)

Session	Attendees	Responses	Session attributes' average ratings					
			Time Worth	Increased Network	Expert Facilitators	Engaging Facilitators	Impact Grasp	Average Score
Increase the Impact of Your Journal Publications	49	10	4.8	3.6	4.8	5.0	4.8	4.6
3 Million Teachers Can't Be Wrong	28	9	4.8	3.9	4.9	4.8	4.7	4.6
Engineering Education Career Pathways	35	6	4.5	4.0	5.0	4.8	4.5	4.6
Making an Impact with Policymakers	11	1	5.0	3.0	5.0	5.0	5.0	4.6
Strategies for NSF-funded Workshops	30	4	4.3	4.3	5.0	4.8	4.0	4.5
Building Strategic Partnerships	29	8	4.5	3.5	4.9	4.8	4.1	4.4
HerStory is Our Story	27	5	4.4	4.2	4.4	4.6	3.8	4.3
Frameworks for Improving Research Quality	63	18	4.1	3.4	4.8	4.5	3.9	4.1
New Directions for Broader Impacts	67	11	4.1	3.1	4.1	4.3	4.4	4.0
RET Sites: Best Practices	39	5	4.2	3.4	4.2	4.2	3.4	3.9
Love Your Evaluator	18	2	4.5	3.5	4.0	4.5	3.0	3.9
Professional Societies as Partners in Impact	50	14	3.6	3.1	4.2	3.8	3.6	3.6
Thinking like an Entrepreneur	37	9	3.2	3.3	4.7	3.3	3.0	3.5
Experiences from REU and RET Sites	35	5	3.6	3.2	4.2	3.0	3.4	3.5
Designing Propagation Plans	22	5	3.6	2.2	4.4	3.4	4.0	3.5

Table 3. Average ratings for networking sessions (five-star scale)

Session	Attendees	Responses	Session attributes' average ratings					
			Time Worth	Increased Network	Expert Facilitators	Engaging Facilitators	Impact Grasp	Average Score
Poster Session B	NA	8	5.0	4.5	4.8	4.6	4.4	4.7
Poster Session A	NA	14	4.7	4.6	4.6	4.7	4.3	4.6
Networking Session II	NA	3	4.3	4.3	3.5	5.0	5.0	4.4
Networking Session I & REU/RET Site Participant Poster Session	NA	2	3.5	4.5	4.5	4.0	3.5	4.0

Table 4. Average ratings for breakout sessions (five-star scale)

Session	Attendees	Responses	Session attributes' average ratings					
			Time Worth	Increased Network	Expert Facilitators	Engaging Facilitators	Impact Grasp	Average Score
BPE cluster	23	3	5.0	5.0	4.7	5.0	5.0	4.9
REU cluster	36	3	4.7	4.3	4.3	5.0	4.0	4.5
Engineering Education cluster (RFE, RIEF, and RED)	67	9	4.7	4.0	4.6	4.4	4.2	4.4
RET cluster	30	3	4.0	3.7	4.0	4.0	3.7	3.9

Table 5. Average ratings for breakout sessions (five-star scale)

Session	Attendees	Responses	Session attributes' average ratings					
			Time Worth	Increased Network	Expert Facilitators	Engaging Facilitators	Impact Grasp	Average Score
We Can Do Better — Insights on Going from Research to Impact in Engineering Education	153	46	4.4	3.0	4.8	4.6	4.6	4.3
The Change-maker's Toolkit — Preparing Faculty to Make Academic Change Happen	190	75	3.8	3.1	4.6	4.4	3.6	3.9

One survey question asked participants to report the number of grantees with whom they interacted at the conference, selecting from four clusters: *Broadening Participation, Workforce Development, Engineering Education,* and *Other*. Figure 2 provides additional insights into the breadth of interactions at the conference by looking into the number of grantees with whom participants reported interacting in each cluster.

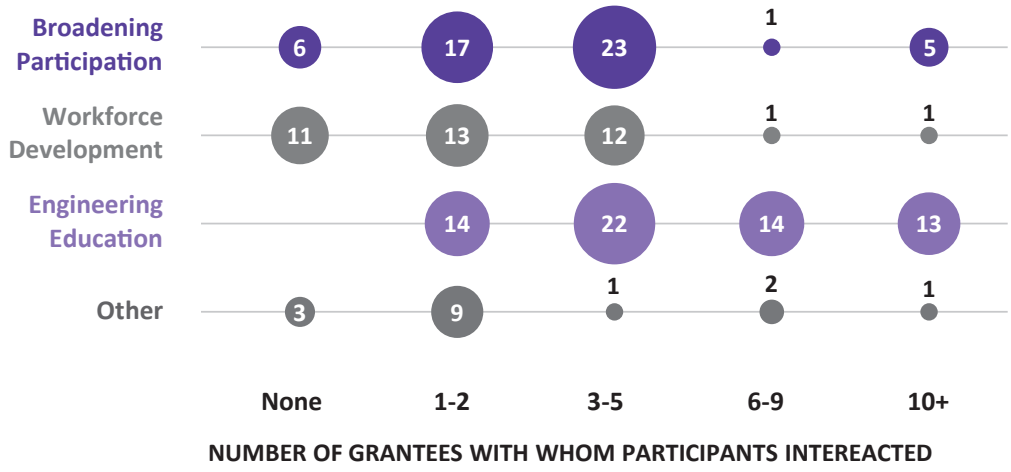

Figure 2. Response frequencies by cluster on the number of grantees with whom participants interacted.

The majority of survey respondents reported interacting with either one or two people, or with three to five people. Most importantly, everybody interacted with somebody: no respondents reported zero conference interactions. Only 12 out of the 90 respondents reported they interacted with no participants from a certain area, but they connected with a number of people from other area/s instead. *Workforce Development* was the one area that respondents most frequently reported no interactions with at all (one person shared a wish to identify peers from *Workforce Development* to connect with). *Engineering Education* was the cluster with most interactions consistently across all "number of grantees" categories. Engineering Education was also the cluster in which the highest number of participants interacted with 10 or more grantees.

When describing the type of interaction participants had with other grantees, the prevalent responses were sharing knowledge and ideas, collaborating, data and research. The themed responses are summarized by cluster:

- **Broadening participation (n=27)**
  - Sharing ideas (13)
  - Future collaboration (10)
  - Knowledge sharing (3)
  - Research (2)
  - Comparing experiences
  - Informal conversations
- **Workforce development (n=15)**
  - Sharing ideas (9)
  - Future collaboration (4)
  - Sharing data
  - Informal conversations
  - Following project updates
- **Engineering education (n=39)**
  - Sharing ideas (21)
  - Future collaboration (19)
  - Research and data (4)
  - Knowledge sharing and best practices (3)
  - Planning a workshop
  - Proposal development
  - Networking and community building
  - Receiving feedback on project
  - Emailing
  - Reading lists
  - Attending other conferences
- **Other (n=10)**
  - Sharing ideas (5)
  - Future collaboration (3)
  - Networking
  - Mentoring
  - Receiving feedback on projects
  - Advisory Board candidate

Enhanced Understanding the Broader Collective Impact of EEC Programs and Projects

Several questions in the survey dealt with the notion of impact: from understanding and defining impact, to leveraging projects to maximize impact. More than three-quarters of respondents (68 out of 88) "strongly agreed" or "somewhat agreed" that the information shared during the conference caused them to redefine what impact means for their projects. Figure 3 compares the five-point average agreement ratings by program.

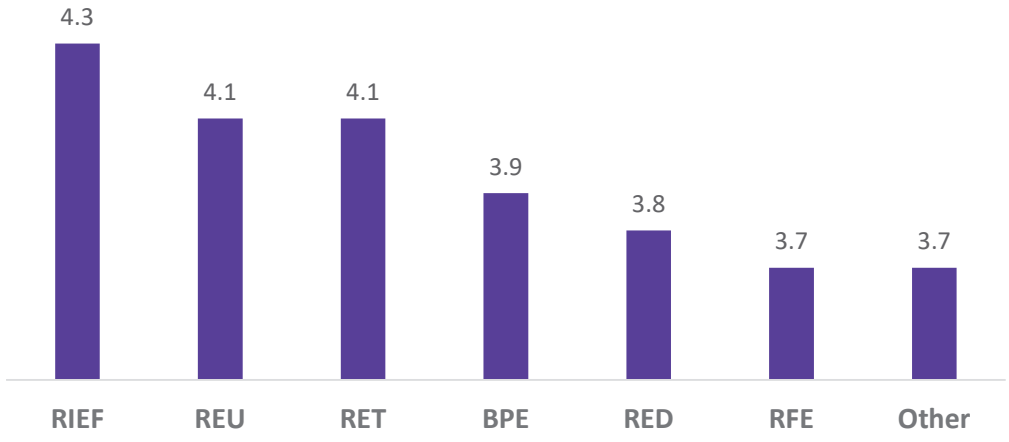

Figure 3. Average agreement ratings by program on whether information shared during the conference caused participants to rethink their definition of impact (1=Strong disagreement; 5=Strong agreement).

Several participants noted that they liked the conference's strong emphasis on impact, and the excellent articulation of impact in sessions and discussions (especially during Jeremi London's plenary and the concurrent sessions facilitated by Jeffrey Froyd and Julia Williams/ Cara Margherio). The conference provided the time and environment for participants to reflect on the notion of impact collectively, and to define it for their projects in broader, more creative, and alternative ways. Many respondents reported that they expanded their vision and understanding of impact, and began to think of it as a broader concept that goes beyond project targets and data metrics, and instead as something that cuts across different scientific, disciplinary and societal layers, oftentimes sparking new research (n=14):

> *"The last session broaden[ed] my perspective on what kind of impact my previous research experiences have had, where I only viewed them in the realm of academic impact, they still have societal and contextual impact as the work that is done sparks other types of research."*

In addition to the information presented during conference sessions, some participants reported arriving at a broader vision of impact through networking and conversations with peers at the conference (n=9). These interactions allowed for an exchange of resources and new ideas and presented opportunities to learn about important work done by others and how others' work relates to their own projects:

> *"The sessions I attended helped me network and learn about other important work that was being done and how it connects to my work. That was pretty exciting. Indirectly, this experience will stimulate me to think about the impact of my work and how it informs what we know about engineering education."*

Through conference sessions and networking opportunities, participants were able to better understand the work of others; learn more about different program areas and how EEC programs are interrelated; and better understand how these efforts can have a large collective impact. About three-quarters of respondents (62 out of 87) "strongly agreed" or "somewhat agreed" that the information shared during the conference expanded their view of the collective societal impact of EEC programs. Figure 4 compares the five-point average agreement ratings by program.

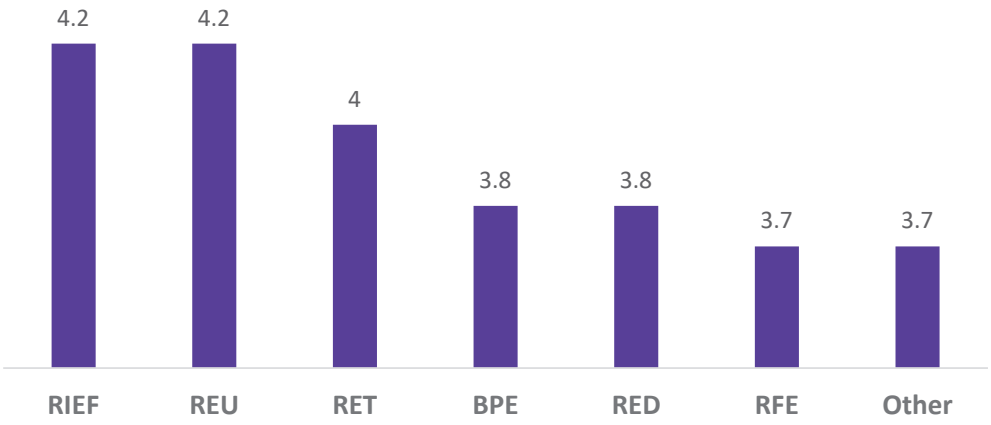

Figure 4. Average agreement ratings by program on whether information shared during the conference expanded participants view of the collective impact of the EEC programs on society (1=Strong disagreement; 5=Strong agreement).

Respondents shared that informal discussions and poster sessions were extremely influencial in providing comprehensive understanding across programs, showcasing projects' value and scope, and demonstrating the collective reach and impact of EEC grantees and projects (n=10). One shared recommendation was to have a closing activity that draws connections among EEC projects and seeks to identify collective impact opportunities, perhaps centered on projects presented in the poster sessions. Alternatively, ten respondents stated that they did not expand their view of impact as a collective concept and that they did not see enough evidence of that at the conference.

Increasing Project Impact

About 80 percent of respondents (37 out of 85) "strongly agreed" or "somewhat agreed" that the conference was instrumental in helping them learn how to leverage resources to increase project impact. Figure 5 compares the five-point average agreement ratings by program.

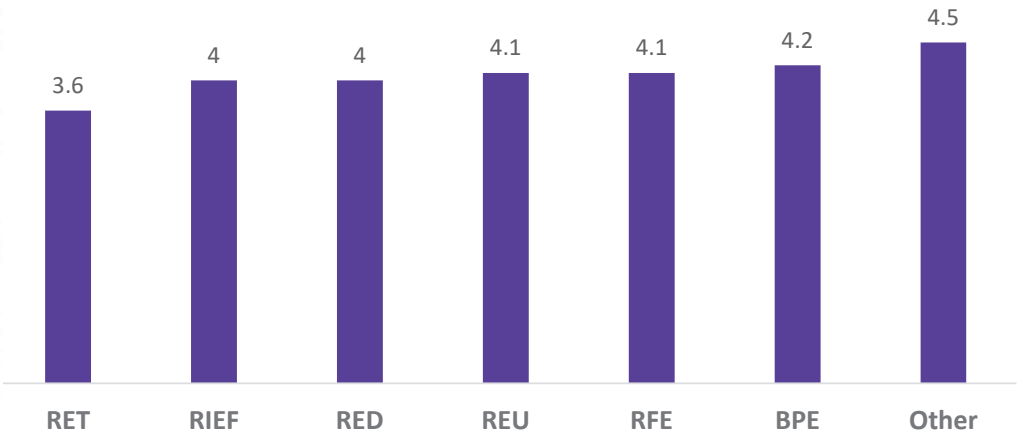

Figure 5. Average agreement ratings by program on whether participants learned something during the conference that will help them to leverage their projects to increase their impact (1=Strong disagreement; 5=Strong agreement).

In terms of learning about leveraging resources and funding to increase impact, the largest number of respondents pointed to engagement, networking, knowledge or idea sharing and collaboration as the most helpful components of the conference (n=11). Some even reported that they are already incorporating what they learned at the conference into their next proposal.

Two respondents shared that ideas presented at sessions also contributed to their enhanced understanding of leveraging resources to increase impact (e.g. best practices at RET or entrepreneurial pedagogy). Another two respondents reported that discussions on alternative forms of dissemination and publishing (e.g., self-publishing, white papers, online publishing) were useful in that they demonstrated new venues for getting research findings out to new audiences. For one REU PI, the conference helped provide ideas for new ways to optimize impact with limited funding. One undergraduate REU site participant shared that they learned how to better leverage their academic credentials and accomplishments in a job-seeking setting.

> *"I was inspired to increase my impact a number of ways. I am now thinking of ways I can research the effectiveness of various efforts I undergo in my classroom and ways I can leverage that research. The plenary speech also gave me an idea I can use in my classroom that I believe will expand my impact. Further, I engaged in discussions with other PIs and thus am excited to engage in further research and curriculum writing, and evaluating that impact. Finally, I have had my desire for a Ph.D. in relevant educational research rejuvenated after the conference, so I will be heading down that path, looking to make a broad impact."*

Suggestions and Recommendations

An open-ended question at the end of the survey asked for suggestions and recommendations for improvement of future EEC Grantees Conferences. More than half of respondents (n=51) provided feedback in response to the question. The emerging themes from their responses are summarized below.

Overall organization (n=18)
Several people made the case for not having the conference on Halloween, or any other "holiday," as they put it. For some coming from the West Coast and a different time zone, the early starting time in the morning was challenging. Limited space was an issue for highly-populated poster session and the concurrent sessions that drew the most interest among attendees. Ten respondents reported that they missed sessions they would have wanted to attend because the sessions were concurrent (n=10). Having short abstracts for the sessions and posters, as well as additional or duplicate sessions, would have helped participants get a sense of content and prioritize their time and attendance options. Alternatively, if having more sessions was not an option, then participants could have really benefited from access to information and content, such as recordings and posting of slides, from the concurrent sessions they were unable to attend.

Because dinner was not provided, most people did not stay until the end of the day and missed the late networking session. Those who did stay to network were hungry and exhausted from a very long day. Keeping attendees together for a "birds of a feather" dinner and evening networking could make a real difference (n=4).

Sessions and content (n=12)
Several people expressed the view that sessions and discussions around impact tended to be theoretical. They would have preferred looking beyond academic papers and conference publications to address real world examples, practices, and actionable recommendations in order to really make a difference and increase impact. Particular suggestions in that direction were to bring external stakeholders and presenters from outside fields to broaden the conversation and examples of impact, or to have more interactive sessions that are run by grantees, where participants get to present and discuss user-content and their own work, while interacting with other participants and creating opportunities for collaboration (n=9).

Several respondents suggested having separate sessions for new versus experienced researchers, and/or for teachers versus students, because it's hard to provide the same value for each group in one session for all (n=5). Students felt they needed a better sense of what is expected of them during the conference. They also had suggestions for session topics (for example, resume and interview skills, grad student information).

Several stand-alone suggestions regarding sessions and additional content that did not fall within the themes but were worth noting include:

- Providing guidance on NSF reporting
- Providing coaching on vocalizing impact
- Offering more inspirational keynotes, similar to the Ted talks

Additional time (n=9)
Additional time was requested by nine survey respondents both in terms of more sessions and having the ability to attend more of the concurrent and poster sessions, and in terms of having more time set aside for formal and informal networking, interaction, idea exchange and collaboration. Allowing a bigger time cushion in the form of a break between sessions is also preferable to having to rush from one session to another.

Efficiency (n=5)
Five respondents suggested that this conference be integrated into other events that are attended by a similar audience (e.g. ASEE's Annual Conference, FIE Annual Conference), given the presumed cost of a separate EEC conference and the cost that attendees incur on their NSF grants to travel to Washington, D.C. Integration with another event may also allow for more frequent conferences. Being cost-effective was noted by two out of the five respondents.

Conference app (n=4)
Some respondents indicated that there was too much information on the app, which made the app distracting, hard to sync, and difficult to use. Respondents noted that listing program information was useful.

Two stand-alone suggestions that can be applied to post-conference activities or in future conferences were also provided:

- Create an email listserv for grantees, so they can share ideas and results and request collaborators.
- Encourage PIs to bring co-PIs and student researchers to future meetings.