NSF Engineering Education and Centers

# Grantees Conference

# MEETING REPORT

**SEPTEMBER 22 – 23, 2022**
**Sheraton Pentagon City Hotel**
**Arlington, VA**

ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

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- We support discovery and scholarship among education researchers by providing opportunities to share and build upon findings.
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2022 NSF Engineering Education and Centers Grantees Conference Meeting Report



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## ACKNOWLEDGMENTS

The Planning Committee for the 2022 NSF Engineering Education and Centers (EEC) Grantees Conference provided invaluable input and recommendations on conference theme, agenda, and activities. The committee was composed of four EEC Principal Investigators (PIs) representing a variety of EEC programs: Faisal Aqlan (Associate Professor, University of Louisville); Brooke Coley (Assistant Professor, Arizona State University); Trina Fletcher (Assistant Professor, Florida International University); and James Huff (Associate Professor, Harding University). ASEE staff members Alexandra Sharpe and Rachel Koroloff served as committee liaisons.

Jumoke Ladeji-Osias, NSF EEC Program Director for Engineering Education, provided guidance and feedback in the early planning stages of the conference and helped inform the conference structure and agenda. EEC Program Officers Christine Grant, Amelia Greer, and Patricia Simmons further assisted with conference planning and participant outreach and communications. The conference speakers and attendees, with their contributions over two days of sessions and discussions, provided the substance of this report.

This conference report was drafted by Mark Matthews and finalized by Alexandra Sharpe. Quality Evaluation Designs oversaw conference evaluation activities, developed the post-conference evaluation survey, conducted qualitative and quantitative analysis of the post-conference survey, and composed the conference evaluation report. The following ASEE staff members contributed to the report by taking notes during conference sessions: Heather Deale, Sarah DeLeeuw, Cathy Kouko, Rachel Levitin, and David Scott Mazzeo.


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# EXECUTIVE SUMMARY

The 2022 National Science Foundation (NSF) Engineering Education and Centers (EEC) Grantees Conference, held September 22–23, 2022, in Arlington, Virginia, provided a forum for more than 190 Principal Investigators (PIs) and team leaders to learn, explore, and share ideas promoting innovation in engineering education research and practice.

Organized around the theme of "reflecting to re-envision," conference sessions were designed for participants to learn about and discuss new, digital infrastructures of teaching and learning, ways to overcome disciplinary silos, strategies for redefining what it means to be an engineer, and methods to implement an anti-racist culture and place faculty and student mental health and well-being at the center of new systems of care.

Grantees from the following EEC programs were in attendance: Broadening Participation in Engineering (BPE); Engineering Education, including Research in the Formation of Engineers (RFE) and Research Initiation in Engineering Formation (RIEF); Faculty Early Career Development Program (CAREER); Research Experiences for Teachers (RET); Research Experiences for Undergraduates (REU); and Revolutionizing Engineering Departments (RED). The conference had three major objectives:

1. to foster knowledge sharing across the network of grantees in attendance;
2. to cultivate personal and professional relationships, collaborations, and partnerships; and
3. to prompt discussions about state-of-the-art and ongoing division-level research efforts.

Results from the post-conference evaluation survey indicated that all conference objectives were met. As expressed by survey respondents, the most valuable aspect of the conference was networking, with 90% of responders rating the frequency of networking opportunities as "excellent" and 94% rating the value of networking opportunities as "excellent." The highest rated conference session was the NSF-led breakout session by cluster. Despite high marks for the frequency and value of networking opportunities, survey responses indicated that attendees wished to have more frequent opportunities for structured networking and small group discussions earlier in the conference so they could have more time to identify potential collaborators and reconnect with them throughout the conference.

## BACKGROUND

Engineering Education and Centers (EEC) is a division within NSF's Directorate for Engineering (ENG) that is divided into four program clusters:

1. Broadening Participation in Engineering
2. Centers and Networks
3. Engineering Education
4. Engineering Workforce Development

The goal of the EEC Grantees Conference is 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, including Research in the Formation of Engineers (RFE) and Research Initiation in Engineering Formation (RIEF)
- Faculty Early Career Development Program (CAREER)
- Research Experiences for Teachers (RET)
- Research Experiences for Undergraduates (REU)
- Revolutionizing Engineering Departments (RED)

Beyond sharing ideas and best practices, there was a broader theme for the conference: "reflecting to re-envision." Multiple recent crises have brought educators to an inflection point in engineering education research and practice. While this moment should motivate educators to re-envision how to move forward, this can most powerfully be done through in-depth reflection on where engineering education is at this moment and focusing on what has previously been unseen in engineering education research and practice. The theme, "Reflecting to re-envision" may relate (but is not limited) to:

- Exploring new, digital infrastructures of teaching and learning
- Creating and leveraging synergies, overcoming disciplinary siloing, and/or achieving and innovating through interdisciplinarity
- Redefining what it means to be an engineer (e.g., systems thinking, design to incorporate care, sustainability, addressing potential harm in research, and faculty responsibility/accountability)
- Implementing an anti-racist culture, incorporating equity into training and practice, and taking accountability to move forward as engineers
- Placing faculty and student mental health and well-being at the center of new systems of care and acknowledging that student and faculty mental health are connected
- Reconstructing the systems faculty members are embedded in to contribute to their individual well-being, thinking about ways to create and sustain that well-being

## CONFERENCE FORMAT

The 2022 EEC Grantees Conference program included plenary sessions, concurrent sessions led by grantees and invited speakers, and breakout sessions facilitated by NSF Program Officers. The program also included poster sessions, a networking reception, and other opportunities for networking and knowledge-sharing.

Two plenary sessions featured addresses by prominent engineering educators. Lesia L. Crumpton-Young, President of Texas Southern University, gave a talk entitled, "Reflecting to Re-Envision: The Role of Institutional Innovation, Transformation, and Disruption." Crumpton-Young declared, "We are in an era of transformation in higher education," and engaged attendees in a running dialogue on the dramatic change required in STEM and how to make that change happen on their campuses. Karl W. Reid, Senior Vice Provost and Chief Inclusion Officer at Northeastern University and Director of the Engineering PLUS Alliance, gave the presentation, "A Systems Approach to DEI...and Why It Matters." By 2026, the Engineering PLUS Alliance hopes to increase training of women and underrepresented minorities in engineering by 100,000 bachelor's degrees—nearly double the current number—and 30,000 MS and PhD degrees, a 30 percent increase. The key thrust of Reid's talk was to explore and discuss ways to dismantle systemic obstacles that have kept the numbers of women and minorities in engineering frustratingly low for four decades.

Opening remarks on days one and two were offered by NSF EEC Division Director José Zayas-Castro, who described the full scope of the division's efforts and discussed ongoing division goals, and Assistant Director of the NSF Directorate for Engineering (ENG) Susan Margulies, who spoke of ways for engineers to broadcast the passion and hard work involved in what they do to a wider audience.

**"We are in an era of transformation in higher education."**

Three blocks of concurrent sessions took place on Thursday, September 22, each with five workshop-style, grantee-led presentations. These sessions revolved around the "reflecting to re-envision" conference theme, with specific topics including constructive peer reviewing, the illuminating potential and complications of secondary data analysis, experiences of Black women pursuing doctorates, mental health stigmas, and concept maps as an effective engineering design tool. Interactive breakouts led by NSF Program Officers took place on Friday, September 23, by EEC program cluster.

Two poster sessions showcased research from more than 100 PIs. Networking breaks and a formal networking reception provided opportunities for attendees to discuss their work, share ideas, and form collaborations.

## OPENING REMARKS

### Day 1 Opening Remarks

**José Zayas-Castro,** *Division Director, Engineering Education and Centers (EEC), National Science Foundation*

José Zayas-Castro began with thanks to ASEE, the Planning Committee, Program Directors, and colleagues in the room. Highlighting EEC's four main clusters (Centers and Networks, Engineering Education, Broadening Participation in Engineering, and Engineering Workforce Development), he went on to describe the full scope of the division's efforts. He reminded participants that their work is at the heart of NSF's mission of investing in discovery, innovation, and preparing the future science and engineering workforce. EEC funding supports the work of solo investigators, mid-size teams, multi-campus Engineering Research Centers (ERCs), and Industry–University Cooperative Research Centers. Sponsored research ranges from basic to translational research, and from single disciplines to the convergence of multiple disciplines. The division also backs engineering students and educators at multiple stages: undergraduate, graduate, post-doc, and early, middle, and late career faculty. Zayas-Castro's presentation also reflected two ongoing EEC goals: 1) to prepare a new generation of engineers that reflects the nation's diversity and responds to pressing social needs; and 2) to strengthen the community of engineering education researchers.

Transforming engineering education, an EEC priority, is the goal of division investments to further broaden participation, enhance the professional formation of engineers, revolutionize engineering departments, integrate DEI concepts into the curricula, and engage students, teachers, and veterans in research.

The flagship Revolutionizing Engineering Departments (RED) program has expanded to encourage collaboration across departments and welcomes proposals from two- and four-year engineering technology programs. Seeking a lasting and broad impact from RED investments, NSF instructs grantees to consider sustainability after funding ends. RED projects should also seek to influence other departments, both within the department's institution and at other institutions.

Zayas-Castro's presentation went on to explain two programs that seek a clearer understanding of the process of becoming an engineer: Research in the Formation of Engineers (RFE) and Research Initiation in Engineering Formation (RIEF). RFE aligns with other EEC programs in seeking both to broaden participation and influence how the engineering profession conducts and views itself. RIEF differs from RFE in that it targets instructors who are newcomers to engineering education research. Established researchers, including social scientists, can participate as mentors.

Other funding opportunities mentioned included Historically Black Colleges and Universities–Excellence in Research (HBCU–EiR), which aims to strengthen research capacity at HBCUs and establish stronger connections between HBCU researchers and NSF; Research on Emerging Technologies in Teaching and Learning (RETTL), which supports research on emerging technologies for teaching, such as artificial intelligence, robotics, and immersive or augmenting technologies, and enhancing the work of teachers, mentors, and educators in formal and informal settings; Ethical and Responsible Research (ER2), which funds research that identifies and explains effective ways to instill ethical conduct in

STEM researchers; Early-Concept Grants for Exploratory Research (EAGER), which supports early stage research on untested but potentially transformative ideas or approaches; and Ocean Workforce, aimed at preparing the specialized technical workforce required to run ocean observing systems, such as cabled and moored instruments and autonomous or remotely operated vehicles.

EEC grantees can also participate in NSF's Research Coordination Networks (RCN) program, set up to help groups of researchers communicate and coordinate research, training, and educational activities across disciplinary, organizational, geographic, and international boundaries.

## Day 2 Opening Remarks

**Susan Margulies,** *Assistant Director, Directorate for Engineering (ENG), National Science Foundation*

In her presentation titled, "AM/FM Solutions for Expanding Public Awareness and Understanding of Engineering: Turning Up the Volume and Increasing the Frequency," Susan Margulies spoke of how engineers can broadcast to a wider audience the passion and hard work involved in what they do by starting with a clearer understanding of what engineering is.It starts with a clearer understanding of what engineering is. Margulies elaborated on this with a quote from Nobel Laureate Frances Arnold, a Caltech chemical engineer, who noted "a wonderful feature of engineering by evolution is that solutions come first; an understanding of the solutions may or may not come later." She followed these words with a quote from Theodor von Kármán, founder of what became NASA's Jet Propulsion Laboratory: "Scientists study the world as it is, engineers create the world that never has been." Science and engineering are complementary, Margulies said: "We unleash scientific discoveries because we enable new technologies, new mindsets, new fields that allow scientists to discover new areas of knowledge."

People need to have an awareness of the importance of engineering so they will support using public funds for a growing research portfolio—what NSF calls the "discovery engine"—and the infrastructure it demands, along with continued organizational excellence. NSF has also devoted resources to bringing in the "missing millions"—Americans from every background, in each state, who have the potential to participate in STEM. Faster progress in diversity is needed to reduce a significant talent gap. As multiple reports over the years have documented, enhancing people's awareness of what engineering is and highlighting its importance, showing that it welcomes people like them, is essential to attracting and retaining engineers.

The recently enacted CHIPS and Science Act adds a new dimension to NSF's research portfolio. It has led to the creation of the new NSF Directorate for Technology, Innovation and Partnerships (TIP), and supports research

and workforce development related to biotechnology, climate change and clean energy, manufacturing, semiconductors and microelectronics, and emerging technologies. The new federal statute also puts NSF on a path to increasing investments in EPSCoR (Established Program to Stimulate Competitive Research) jurisdictions, which have historically received comparatively small amounts of federal research funding.

Seeking to develop a diverse, globally competitive STEM workforce, NSF has enhanced infrastructure for education, sponsored important research on learning and evaluation, and worked to improve public scientific and technological literacy. Recognizing that preparation for undergraduate engineering must begin in K–12, NSF has championed not only stronger STEM teaching but also efforts to institutionalize engineering at the pre-college level.

NSF has developed an array of channels to promote engineering research, education, and innovation with the public, students, and policymakers, including social media, public and media outreach, and videos. Recently, the foundation sponsored the National Academy of Engineering (NAE) Symposium on Extraordinary Engineering Impacts on Society: Over Seven Decades of Contributions from the National Science Foundation. In this symposium, distinguished engineering leaders contributed more than 20 presentations on topics ranging from nanotechnology to tissue engineering and public policy.

Faculty members can help raise public awareness and understanding of engineering by following a strategy that begins with what Margulies termed “the Five ‘I’s”: Inform—Where has engineering made a difference? Tell stories. Inspire—Why do we become engineers? Why are we proud to be engineers? Include—Feature engineers who are representative of our diverse nation. Speak with Intention—Engineering does not equal science. Institutionalize and democratize engineering in K–12.

## PLENARY SESSIONS

### Reflecting to Re-Envision: The Role of Institutional Innovation, Transformation, and Disruption

**Lesia L. Crumpton-Young,** *President, Texas Southern University*

An industrial engineer whose academic career has combined faculty and leadership roles at Historically Black Colleges and Universities (HBCUs) and Predominantly White Institutions (PWIs), Lesia L. Crumpton-Young conducts research in her own discipline while also studying what enables undergraduate and graduate students to succeed in STEM. She earned a 2007 Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring.

Crumpton-Young began her presentation with the declaration, "We are in an era of transformation in higher education," and engaged attendees in a running dialogue on what kind of dramatic change was required in STEM and how to make that change happen on their campuses. "If we aren't the individuals leading that charge, then it absolutely won't be done," she emphasized. She promised a short plenary: "My background is human factors engineering, and I know you will stop listening."

Playing off the conference theme of reflection, she said, "One of the things I used to always say in the classroom is that as engineers, we can be so busy doing the task and getting things done that we rarely take the time to reflect… Who wishes they [could] take time to reflect?" Without reflection, she went on, "we won't be able to reimagine what engineering education should be."

Invoking the terms "innovation," "transformation," and "disruption" throughout her talk, Crumpton-Young suggested innovation can infuse several university activities: classroom time, policies, admissions, operations, faculty meetings, collaborations, research, and student affairs. She recalled that when she was a graduate student at Texas A&M, she had a professor "who cared about [her] success." What would happen, she asked, "if we created an ethos of care and well-being?"

Transformation, she said, requires inspired leaders with the ability to inspire others. Her own institution invokes transformation in its mission statement: "We transform lives." By preparing students for the jobs of their dreams, she continued, "we know we contribute to generational blessings and eradicate generational curses." Crumpton-Young noted that the Carnegie Foundation plans to add a new classification reflecting the extent to which higher education institutions enable social and economic mobility while serving a diverse student population.

Within institutions, Crumpton-Young warned, "some people become gatekeepers," blocking transformation. A gatekeeper in the role of Chief Financial Officer, she pointed out, can "hold transformation hostage" by simply not signing off on funding, halting the implementation of faculty's new ideas. Transformation, Crumpton-Young emphasized, must come at all levels.

Texas Southern, for example, has initiated a process of disruption by holding a faculty retreat with the book author of *The Disruption Mindset: Why Some Organizations Transform While Others Fail*. One practice clearly in need of disruption, she said, was "academic hazing"—putting students in the position of having to prove they don't fit certain preconceptions. When students sit in the back of the classroom and fall asleep, for example, what assumptions do faculty make about them? "I honestly believed students in the back row were sleepy," she recalled. Another example she recalled was the diminishing response of a colleague to a certain project proposal: "Two little ladies are going to do the project. We'll see how that turns out." A transformation in mindset, she implied, is as important as transformations in policy and infrastructure.

Her request to the audience, "What's one thing we need to disrupt?" brought an immediate response— "Capitalism"—followed by a lively discussion of needed changes. Audience members suggested, for example, dispelling the notion that "only traditional forms of knowledge have value," adopting a collective model of research and teaching "where everyone's voice is heard," discouraging working in silos, recognizing the importance of DEI and its benefits, broadening the operational definition of excellence, and getting rid of a fear of confrontation.

More individual responses followed Crumpton-Young's question, "How will you innovate, transform, and disrupt?" "Make a decision to stand up," one attendee said. Another would convene a group and move from ideas to implementation. Other ideas expressed were: "Not hoard the data," "Focus on the student," "Publish only what's impactful," "Go for the moonshot," and "Ask a question that centers the response on things we care about."

Crumpton-Young ended her talk by stressing the importance of reflection and imagination in deciding "where we want to make the biggest impact, where we want to make sure transformation happens, and what we want to introduce as revolutionary." She concluded: "We have to respond. We have to get it done."

## A Systems Approach to DEI, and Why It Matters

**Karl W. Reid,** *Senior Vice Provost and Chief Inclusion, Northeastern University*

A materials scientist, Karl W. Reid has spent much of his career advancing diversity in higher education as an Associate Dean of Undergraduate Education at the Massachusetts Institute of Technology (MIT), his alma mater. Formerly a Senior Vice President at the United Negro College Fund and Executive Director of the National Society of Black Engineers (NSBE), Reid has most recently championed diversity in higher education as Senior Vice Provost and Chief Inclusion Officer at Northeastern University.

In 2021, Reid secured a $10 million cooperative agreement with NSF for an ambitious plan to generate, by 2026, a dramatic increase in engineering degrees earned by women and underrepresented minorities: 100,000 bachelor's degrees—nearly double the

current number—and 30,000 MS and PhD degrees, a 30 percent increase. Working with several well-established organizations active in diversifying STEM education, including co-PI ASEE, the Engineering PLUS Alliance hopes to reach its goal by recruiting more than 500 engineering institutions and community colleges into regional hubs. Within the hub institutions, fellows (PEERs) would be trained to employ practices proven to increase diversity in engineering education. The Alliance is part of NSF INCLUDES.

While Reid described the alliance, the focus of his presentation was to explore and discuss ways to dismantle the systemic obstacles that have kept the numbers of women and minorities in engineering frustratingly low for decades. "Why are we not seeing significant change, turn-the-curve change, tipping point change?" he asked. The problem is not lack of educational tools; "we don't have a shortage of best practices," Reid noted. "'Best practices' is a four-letter word for me now," he said. The challenge, he argued, is confronting the combination of historic and present-day structural inequities, biases, and human psychology.

A systems solution, he offered, would confront the series of structural and institutional policies and practices, developed in a historical and cultural context, that have long worked to the detriment of people of color. Like an iceberg, systems can remain largely invisible, hiding frameworks of racial inequity and misogyny in housing, land, healthcare, and employment.

Reform-minded educators can have their own blind spots as well, Reid allowed. A conventional response to the historic lack of opportunity is to admit more underrepresented students and hire more faculty of color. The idea of studying human psychology, sociology, motivation, and achievement doesn't come up. We need to "think through the elephant," Reid said, and that includes teaching. He praised Paul Gray of MIT, an electrical engineer who, as associate provost in 1968, spurred a transformation in the recruitment of minority students and faculty. Gray wanted to understand the Black experience but didn't draw a connection with how he taught engineering. Later, when Gray was asked, "Did any of that change your teaching?" he replied, "No—I taught controls."

The norm for organizational change is evolutionary adaptation. Northeastern pursued a faster route: quickly becoming a global university. Over a decade, the school added 13 campuses in the U.S., Canada, and the United Kingdom. After the George Floyd murder, Northeastern decided to incorporate DEI in everything it did. Every leader had to have a DEI action plan. The intent was to make DEI a default mindset and cultural norm.

Citing a range of sources, from business to social science, as well as his own experience, Reid presented a series of overall guides to organizations seeking to make a collective impact:

- Create a purpose that inspires
- Recognize the unintended impacts
- Leverage existing networks and funds of knowledge
- Let the data speak
- Integrate accountability
- Scale for wider impact - both direct impact and impact on shifting mindsets and relationships

From working at IBM early in his career, Reid learned to appeal to a customer's bottom line. He advised positioning work "so it aligns with the organization to address their pain point." Likewise, institutions can be persuaded that they would benefit from diversity. He drew a quote from *The Medici Effect,* a title inspired by the Renaissance and the kind of innovation generated in 15th century Florence: "The best chance of coming up with great new ideas is when we mix diverse perspectives, fields, cultures, and backgrounds."

## CONCURRENT SESSIONS

*The following concurrent sessions took place on Thursday, September 22, and are listed alphabetically by session title.*

### Bringing Personality, Psychology, and Narrative Identity to Advance a Holistic Understanding of Engineering Students and Professionals

**Jonathan M. Adler,** *Professor of Psychology, Olin College of Engineering, and Editor, Personality and Social Psychology Review*

In this session, Jonathan M. Adler showed how factors that figure prominently in psychology can provide important and relevant data and tools for engineering education researchers. Adler's research is focused on identity development (particularly in mid-life), how individuals constitute a sense of self in quantitative and qualitative ways, and how that relates to psychological well-being.

He opened with an overview of personality traits and their connection to academic performance. Personality consists of three overlapping types of traits: dispositional traits, narrative identity, and characteristic adaptations. Dispositional traits break down into those that are stable, heritable, dimensional, and universal.

The Big Five dispositional traits are: (1) openness to experience; (2) conscientiousness; (3) extroversion; (4) agreeableness; and (5) neuroticism. Conscientiousness, extroversion, and neuroticism have been shown to be as important to lifespan as IQ and social and economic status. There's also a correlation between academic performance and the traits of agreeableness and openness, according to a study Adler cited.

Adler noted that much of what he's seen in engineering education research literature relates to characteristic adaptation. For instance, studies of college students consider their lifespan stage. As emerging adults, traditional-aged students are concerned about identity development and relationship development. "A lot of what you're already measuring," Adler noted, has to do with characteristic adaptations, but, he continued, "Don't forget about developmental concerns."

For several reasons, one's narrative identity—reconstructed past, perceived present, imagined future—is important in predicting overall well-being. Narrative identity can be captured in the stories people tell about their significant life experiences. In adolescents, narrative identity is a product of cognitive maturation, social expectation, biological transformation, and autobiographical memory. Adler cited examples of studies drawing heavily on student narratives, including work by Kate McLean of Western Washington University, who has explored the connection between identity and the reasons unrepresented minority students choose to major in STEM—or not.

Adler's presentation concluded that research

on narrative identity offers engineering education researchers a "rich source of powerful data," and a "robust, thriving field of established tools you can adapt and apply," giving researchers new "qualitative and quantitative opportunities."

## Community College, High School, and Middle School Collaboration—Extending RET through Outreach and Summer Workshops

**Heather Broadhead,** *Associate Teaching Professor, University of Southern Mississippi School of Polymer Science and Engineering*

**Natasja Brown,** *Biology Teacher at Ocean Springs High School and Adjunct Instructor at Mississippi Gulf Coast Community College*

During this session, Heather Broadhead and Natasja Brown discussed the RET Site for Sustainable Polymer Engineering Research, a six-week program for high school and junior college teachers focused on team building, research experience, and curriculum development.

Brown, a site participant herself, described her two-year summer research experience. In 2021, she investigated antimicrobial agents for polymer surfaces and products, and hydrogels, including biomedical applications, antimicrobial additives, and drug delivery. In 2022, she studied biofilms—three-dimensional colonies of bacteria or fungi, such as dental plaques and pond scum, that adhere to surfaces—and bacteriophages, viruses that selectively target certain strains of bacteria. With local colleagues, she worked on two lesson plans, both based on the "5E approach" that aligned with state and next-gen science standards. One such plan, "Bye, Bye Bacteria," engages students in testing the effectiveness of various common products against the formation of bacterial growth; another plan, "Vanishing Viscosity," explores the dynamics of hand sanitizer use, such as why it changes from a gel to a liquid. These plans and the kinds of experiments they involve are ideal, Brown argued, for slower times of the academic year on days when some teachers would typically show a movie.

In general, the RET Site for Sustainable Polymer Engineering Research, Broadhead explained, incorporates outreach activities and summer workshops. In a one-week program for middle school teachers led by USM faculty and RET leads, RET site participant teachers shared their research experience with middle school teachers, who participated in team building and developing lessons based on the "5E" (Engage, Explore, Explain, Elaborate, and Evaluate) constructivist educational theory. The Upper Parent Academy, a science outreach project, invites parents to the school to gain knowledge about new strategies and concepts in the classroom. Through these efforts, Broadhead stated, the RET program expands its impact outside participating teachers and influences students, middle school teachers, students in

elementary grades through junior college, graduate student mentors, and employers of graduates.

## Concept Maps: An Effective Tool in Engineering Design Classrooms

**Nicole Pitterson,** *Assistant Professor of Engineering Education, Virginia Tech*

This session expanded on how concept maps can be employed as useful teaching and data collection tools "to promote learning and advance engineering education." In her research with Steven Hoffenson (Stevens Institute of Technology), Nicole Pitterson administered an in-class, 15-minute exercise at the beginning and end of a term to map key concepts related to product design.

As a regular part of the course, students wrote 300- to 500-word reflections about specific course-related topics. Partway through the term, the instructors introduced a market simulator to help make design decisions. At the end of the course, online surveys asked students Likert-scale and open-ended questions about the simulator and its value for their design projects. Multiple evaluators examined final project reports to assess the students' understanding of market concepts and how these concepts were implemented in their designs.

Originally intended for just engineering management and industrial systems engineering students, the project expanded to include mechanical engineering students in a comparative course. Overall project findings showed differences in how students from the various disciplines think about design. Mechanical engineering students showed a decrease in the relative presence of business-related topics, whereas engineering management students showed an increase in these topics, specifically in market-related content.

This session included an activity during which Pitterson asked participants to spend 10 minutes creating concept maps of their own, "using any research topic or interest of yours as the central node." In groups, they then shared their processes for creating the maps and discussed the differences and similarities in how they approached this task. If students created the maps, how would the participants grade them?

In closing the session, participants were asked: How can concept maps advance engineering education research? What are the advantages of digital versus hand-drawn maps? What else can be learned from using concept maps to document cognitive processes in the classroom?

## Defining Your STEM Identify through Self-Assessment and Cohort Building

**Hillary K. Fishler,** *Education Program Manager, Idaho National Laboratory (INL) Center for Advanced Energy Studies (CAES)*

Hillary Fishler led this session detailing the Advanced Manufacturing for a Sustainable Energy Future Research Experiences for Undergraduates (REU) Site. This site offers a 10-week summer research program for 10 undergraduate students each year for three years at the Center for Advanced Energy Studies (CAES) in Idaho Falls, Idaho. Through hands-on research experiences and networking opportunities, this project's goal is to help students develop their STEM identity and literacy to succeed in the classroom and in their career.

According to Fishler, this project was unusual in several ways. First, because it was hosted at a national lab as part of a state–federal

partnership, vetting and security clearances were key challenges, as were the isolated location at a desert nuclear site, housing, and lack of easy access to medical care. The project involved an expanded mentorship model, with faculty, lab mentors, and others working with students on projects. An effort was made to get the students to apply what they learned in classes to not only research projects but also how they might get a career at a national laboratory.

During this session, Fishler walked participants through a series of professional development activities employed during this summer research program. Activities included identifying circles of belonging, establishing personal and professional values and interests, developing a workplace cohort profile, building a personal statement as well as research statement, and developing a graduate school readiness plan.

Fishler concluded the session by articulating a few important lessons learned. When incorporating a mentorship model, the focus should be on the student experience. In pairing mentors with students, it's important to learn about each one's values and interests. If the student's goal is to get a job at a national lab, and they happen to be first-generation college students or experience setbacks, they should understand that's what the mentors are there to help with. Individual professional development needs should be gauged both in the application and throughout the program.

## Don't Be Reviewer #2! Learn to Write a Truly Constructive Peer Review

**Julie P. Martin,** *Associate Professor of Engineering Education and Assistant Vice President for Talent & Team Development, The Ohio State University, and Editor-in-Chief, Journal of Women and Minorities in Science and Engineering (JWM)*

The goal of Julie P. Martin's session was to learn about being a peer reviewer who provides constructive criticism and is empathetic to the author of an article. T*he Journal of Women and Minorities in Science and Engineering (JWM)* seeks to influence the culture of academic publishing in STEM education by setting "a higher standard in how we treat each other and our life's work." The "Reviewer #2" of the session title is the kind of reviewer who exacts revenge on peers with overly critical anonymous reviews.

One of the first activities for the group was to go to menti.com and submit three words that describe writing a review. Martin, a materials scientist by training, made a strong point that the opposite of constructive reviews is destructive reviews. And "destructive peer review is academic bullying at its worst." A Facebook group called Reviewer #2 Must be Stopped has over 97,000 followers, emphasizing how many

victims there are to destructive reviewers. Because reviews are anonymous, destructive reviews are rampant. Martin suggested that "constructive peer review is a form of mentoring."

Martin asked the audience what the purpose of a review is. After hearing a variety of ideas, she explained a few guidelines. Revisions should focus on prioritized recommendations, not copy-editing changes. Reviewers need to make sure they include what is "good" about the manuscript too; this ensures that when the author makes revisions, they also know what to keep. Additionally, reviews should help the editor determine if the manuscript should be accepted.

Martin then asked participants to share in small groups an example of what defined some of the best reviews they had received. Attendees in one group noted that they could more easily cite examples of the bad reviews they'd received, an experience many shared. Many also noted that feedback on conference papers tended to be more constructive than feedback on peer-reviewed journal articles.

Next, attendees were asked to brainstorm strategies and tips for writing a constructive review. One suggestion was to be explicit about communicating the "why" behind their criticism. Several attendees agreed that it was good practice to read through the paper and then step away from it for some time before writing the review, so that the most "memorable" points would become more obvious. Attendees suggested opting to focus on the positive by reframing weaknesses as opportunities for strengthening. They also agreed it was better to focus on the content rather than address the author directly.

Follow-up activities in the session helped turn these insights into general approaches to offering constructive criticism in article reviews. These approaches include being specific (using examples directly from the manuscript), addressing one's own positionality (acknowledging biases and existing power structures), being direct (especially if one is reviewing a second or third revision), and remembering that ultimately the review should be useful to both the author and the editor.

## Engineering and Empathy Pre-K/K: Approaches and Findings of a Design and Development Project

**Michelle Cerrone,** *Senior Research Associate, Education Development Center, Center for Children and Technology*

**Melissia Higgins,** *Vice President of Programs and Exhibits, Boston Children's Museum*

This session opened with the questions: What will the future look like if we give young children more opportunities to practice being empathic innovators and problem-solvers? What if we introduce engineering and empathy, in parallel, at this very young age?

Michelle Cerrone and Melissia Higgins's research project seeks answers to the following research questions: 1) What contextual factors mediate how Pre-K/K educators can incorporate integrated engineering and empathy into teaching and learning? 2) What do Pre-K/K educators view as important design considerations for developing high-quality integrated engineering and empathy resources for their classrooms? 3) What tools and supports can enhance teachers' existing knowledge and practices to help them successfully deliver integrated engineering and empathy activities in early childhood settings?

The project incorporates design-based research to come up with an intervention that responds to several factors, including stakeholder contexts, strengths, and needs. The project includes formative research with both teacher curriculum review and classroom testing, and a summative evaluation that includes classroom testing, pre-and-post teacher surveys, and classroom observations.

Cerrone and Higgins explained that teachers may be skeptical about the value of pairing engineering and empathy and may lack confidence in their understanding of engineering concepts or how to engage children in engineering activities. Teachers tend to support empathy development situationally (versus following a curriculum). In addition, empathy development may be mediated by cultural differences in how families talk about and express emotions. The professional development component of this project served to effectively dispel some of the teachers' misgivings and "w[as] instrumental in building teacher understanding of the link between engineering and empathy."

The classroom activities were built on the skills that pre-K/K educators already prioritize and fit into the regular routines of pre-K/K classrooms. Perceptions of children's engineering and empathy skills increased between the start and end of the project.

The session included a small group activity that demonstrated how to integrate empathy and engineering and was inspired by Robert McCloskey's classic children's story *Make Way for Ducklings*. Cerrone and Higgins posed the following question to the attendees: How can a safe path be created for a mother duck and its brood to cross a busy street? Participants were given a variety of materials and asked to work on a design for 20 minutes. Each table or pair were challenged to only use their non-dominant hand when designing their solution. They were given a piece of paper with a picture of a road and other various materials (including rubber ducks, toilet paper rolls, yarn, popsicle sticks, and cups) to create a diorama/3D representation. When the activity concluded, Cerrone and Higgins challenged attendees to consider how different their experience of the activity and how different their design

solutions would have been if the story (the context, and therefore the opportunity for empathy) had not been included.

## Instructor Adaptability and the Course Complexity Typology as Tools for Faculty Development

**Heidi Diefes-Dux,** *Professor of Biological Systems Engineering, University of Nebraska–Lincoln*

**Grace Panther,** *Assistant Professor of Civil and Environmental Engineering, University of Nebraska–Lincoln*

The COVID-19 pandemic has tested faculty members' ability to adapt to a new remote teaching environment while maintaining rapport with students and keeping them engaged with course material. Session leaders, Heidi Diefes-Dux and Grace Panther, found in this stressful period "a unique, one-time opportunity to study instructors' teaching experiences." Their research is intended, in part, to reveal lasting changes in faculty members' approaches and the support that faculty need in implementing the best teaching practices.

This session aimed to introduce "adaptability theory" and "course complexity typology" as ways to inform faculty development and research. Participants in this session were introduced to adaptability theory and how it applies to faculty development. They were led to describe course elements that typify course complexity and were encouraged to apply the course complexity typology to an example course. Attendees also discussed and joined in responding to the research questions.

The two researchers began the session by breaking down the sudden new demands on faculty and their responses to those demands into different cognitive and emotional components. One method the researchers used to gauge how instructors coped with new and uncertain situations in teaching undergraduates was to use a survey asking respondents to rate a series of statements on a "strongly disagree" to "strongly agree" scale. The survey included such statements as "I take action to improve work performance deficiencies," "I usually overreact to stressful news," and "I become frustrated when things are unpredictable."

The idea of "course complexity" deals with the extent to which instructors incorporated proven teaching techniques in the newly required remote learning environment. Successful engineering instruction requires a "wide array of teaching practices and strategies." In gauging course complexity, Diefes-Dux and Panther hope to better understand the ways faculty members were able to revise how they taught their courses in order to maintain that array of teaching practices and strategies during a pandemic.

Attendees were handed two course syllabi and asked to identify whether each addressed a series of dimensions, including "significant" domain learning and professional skills development, integration of domain and professional skills learning, opportunities for active learning, assessment, rapport with students, and transparency and fairness. In groups, attendees compared their answers. Questions arose about several dimensions. Regarding assessment, the question arose if the norm of the exams included was excessively stressful for students in a remote setting. Were students able to work in teams, as required by the example syllabus? Were office hours arranged to be convenient for students? It was noted that the pandemic gave rise to a lot of academic integrity issues. Attendees were asked to consider how scores on adaptability and course complexity could be combined in a way that would be useful to institutions in understanding and encouraging work-based

learning on the part of faculty.

## Project ENGAGES: Lessons Learned and Successful Strategies to Implement an Authentic STEM Research Experience for African American High School Students at a Tier One Research University

**Manu O. Platt,** *Professor of Biomedical Engineering, Georgia Institute of Technology*

This session, led by Manu O. Platt, focused on "Project ENGAGES" (Engaging New Generations at Georgia Tech through Engineering and Science), a program that began in 2012 in response to the realization that few Atlanta high school students were entering Georgia Tech. Of the high school graduates who did enter college, many were returning without degrees. Project ENGAGES was formed to inspire these students to pursue higher education in biology, biotechnology, chemistry, and engineering and to pursue careers in those fields.

Launched by Platt and Robert M. Nerem, a leading biomedical engineering professor until his death in 2020, this project was developed as part of Georgia Tech's NSF-funded Emergent Behaviors of Integrated Cellular Systems (EBICS) Science and Technology Center. Besides biomedical engineering, it draws Georgia Tech talent from several other scientific and engineering fields.

Platt described the competitive year-long work-study program as beginning with a four-week summer boot camp, followed by part-time work during the academic year assisting graduate researchers and post-docs. Students come from seven predominantly African American and Hispanic public Atlanta high schools. From the beginning, the high schoolers were paid. They now receive $15 an hour.

The multi-stage recruitment and application process starts with several events to interest students at the partner high schools. Out of some 30 applicants—who must be strong academically, and are required to submit a personal statement, resume, and solicit two letters of recommendation—20 are invited to an in-person interview with a five-member panel: "one of the most important days of my job," Platt says. Mentors, who earn a $750 travel stipend, are paired with students after a series of brief meetings. Platt stressed that it's important for mentors to self-select and "not be 'volun-told.'" Mentors are empowered to be "the boss" and regard students as employees.

A combination of features aims to ground students in various aspects of research as a profession. Besides hands-on lab skills training, students are mentored in presentation skills, time

management, financial management, library databases, conflict resolution, professional communication, and diversity and inherent bias awareness. They also get field trips to industrial laboratories and educational support to improve standardized test scores.

According to Platt, 17 ENGAGES scholars have advanced from the state science fair to compete at the Intel International Science Fair, 12 have presented their research at national conferences while contributing to cutting-edge university research, and as part of the ENGAGES program, Georgia Tech graduate students have established science clubs for 7th to 10th graders in selected Atlanta public schools.

## Re-Envisioning Research with Secondary Data Analysis: Broadening the Conversation

**Jennifer M. Case,** *Professor and Head of the Department of Engineering Education, Virginia Tech*

This session considered the problems and challenges associated with sharing and re-analyzing data gathered in engineering education studies. Funding agencies encourage researchers to share their data, yet the body of engineering education research contains considerable amounts of data used only once by the original researchers.

This session included a panel comprised of Lisa Benson (Clemson University), Shane Brown (Oregon State University), Brian Burt (University of Wisconsin–Madison), Shawn Jordan (Arizona State University) and Nicole Pitterson (Virginia Tech). Much of the discussion during this session, among panelists and in an open forum, focused on trust: between researchers, and between researchers and the subjects of a particular study. Researchers, of course, will want to know the intentions of someone who asks to use their original data. Will the original study's methods be critiqued? Who will be the author? A second researcher might look at the original data "from a deficit perspective." Additionally, the subjects of a study should be told that their data may be shared and asked to sign a consent form. Depending on the research, the level of detail in the data can reveal participants' identities. "People have been burned," an attendee said.

One panelist was wary of sharing information that might jeopardize hard-won trust between a researcher and a community: "I'm an insider, part of the community. They trusted me. You get invested with this community." It's important for the person collecting data to be able to anonymize it. Another panelist spoke of anonymizing certain clues to identity: "If a participant is outed, it's my responsibility." But not every human subject wants anonymity. One wanted to be named so his grandchildren could know about it.

One attendee wondered how data sharing would square with an Institutional Review Board (IRB) demand that raw data about individuals be destroyed after initial use. It's suggested that there's no problem provided the subjects agree to data sharing. However, IRB approval may be insufficient in dealing with certain sensitive topics, such as matters considered sacred by Native Americans.

Other questions included: Can a study be designed with future data-sharing in mind, is NSF aligned with data-sharing, and how can researchers be rewarded for data-sharing? The assertion of "data sovereignty" by the researcher who collects it can come into conflict with the fact that the government is paying for the work. "It's not their data," one participant said.

Discussing education research more broadly, attendees talked about sample size. One suggested 30 to 40 people were necessary to

get good data, while another said a smaller population allowed for more depth. How a pool of subjects is chosen can be biased. So can the context of questions, which can convey ugly stereotypes.

## Re-Envisioning Robotics in Engineering Education: A Partnership Between e4USA and FIRST

**David Rogers,** *ARMI Chief Development Officer, DEKA Research and Development*

The partnership between Engineering for US All (e4USA) and For Inspiration and Recognition of Science and Technology (FIRST), presented by David Rogers, constitutes a collaborative effort between Morgan State University and Arizona State University to design and test blended e4USA and FIRST models to provide engineering education experiences to underserved populations.

Rogers began with a question: What exactly is meant by blending e4USA and FIRST models? The concept of blending is applied in various ways—blending content in a single classroom, blending between multiple teachers and offerings, and blending classroom and extracurricular activities.

The components of this project include a 30-week, high-school level course that focuses on four big ideas: 1) connect with engineering; 2) engineering professional skills; 3) engineering in society; and 4) engineering design and a Community of Practice (CoP) that involves a university/industry liaison, coach, engineering educator, and community partners.

FIRST was established in 1989 as a robotics community that sought to prepare youth for the future. FIRST offers multiple team-based robotics programs for Pre-K–12 students, facilitated both during school hours and after school. The FIRST Tech Challenge engages youth from grades 7–12 in a head-to-head robotic competition, utilizing reusable robot kits and guided by adult coaches.

## Reflecting on Positionality to Re-Envision Our Impact in Equity Research and Practice

**Stephen Secules,** *Assistant Professor and Co-Graduate Program Director of the School of Universal Computing, Construction, and Engineering Education (SUCCEED), Florida International University*

Stephen Secules began this session by asking participants to share with a person seated next to them how familiar each of them was with the concept of "positionality." A discussion then followed on the importance of positionality in equity and education research. Describing work he performed with six other scholars, Secules said he and his colleagues collaborated on a contextualized approach, pinpointing ways in which positionality impacts research. These ways include what research you choose to do, how you know what you know, what you observe as a researcher, how you make methodological choices, how you relate to participants, and how you represent yourself in writing and other communication.

Participants were grouped in pairs and asked to reflect on positionality regarding a certain research topic. They were asked to think about why they do the research or work that they do, how they got involved in engineering education, and how they would describe the interaction between their identity and their involvement with engineering education. Finally, they were asked, "What are the significant moments in the story?" In pairs, one person would be the researcher, taking notes, listening empathetically, and treating the story with respect and confidentiality. The other person would share a story of intersecting identity

and STEM research, alerting the "researcher" to anything confidential. In the second round of the activity, the positions were reversed.

A discussion then followed on the question, "How can we model our own role in creating change?" Participants were asked to think both pragmatically and theoretically about parts of research projects and how one's positionality could impact them. The point was made that as individuals think more critically about their social conditions, they also become more aware of the complexities and nuances of the structures that lead to oppressive systems.

The activities in this session generated a great deal of discussion and participants acknowledged the difficulty of achieving transparency, both as researchers and as research subjects. They discussed the ways positionality will vary depending on the research topic and question. Additionally, positionally changes over time, especially with experience.

Overall, session participants discussed the need to encourage researchers from dominant racial, ethnic, and gendered groups to engage with and conduct positionality-informed research.

## Reflecting to Re-Envision an Anti-Racist and Inclusive Doctoral Experience: Learning from Black Women in Computing and Engineering Before and During the Pandemic

**Sharnnia Artis,** *Vice President for Diversity, Equity, and Inclusion, George Mason University*

In 2017, Sharnnia Artis and several research colleagues began the Niela Project, a multi-year study of Black women's experiences as doctoral students and post-docs in engineering and computer science.

In this session, Artis referred to her scholarly orientation as "Black feminist thought" and provided an overview of the Niela Project. The study's primary research question: What are the perceptions of the experiences of Black women pursuing doctoral degrees in engineering or computer science? Two sub-questions were: How do Black women pursuing doctoral degrees in engineering and computer science perceive and characterize their experiences while enrolled in their programs? How do Black women shape their academic persistence and overall well-being?

While the outbreak of the COVID-19 pandemic, followed by unrest surrounding the killings of Black people by police, added a new dimension to the research, it did not fundamentally change their conclusions: a lack of communication, support, and mentorship means graduate students must navigate their own pathway. Strategies for persistence could be captured by the advice to turn productivity into therapy and prioritize self-care.

Several specific and ambitious recommendations have emerged from the Niela Project. Fostering a culture of care for Black women in general that prioritizes personal wellness, while providing meaningful and intentional advising and mentorship, will be crucial to the advancement of Black women engineers. While cultivating strong and healthy relationships and providing career development opportunities are important, so too is bringing awareness of the racism the Black community faces. Creating safe spaces for people to share their experiences openly will include providing cultural competency training, creating spaces for Black women graduate students to build community, and setting aside time and space for faculty,

staff, and students to advocate for causes supporting the Black community. Ultimately, these interventions will hinge on enhancing faculty, department, and overall student accountability.

Artis stressed that engaging in "anti-racism" work isn't only good for those affected by racism, it is good for all people and all programs. An anti-racist approach to higher education acknowledges the ways racism contributes to inequality and injustice in classrooms, on campuses, and in communities. It requires focused, intentional, and sustained action to change the system, policy, practice, or procedure responsible. Artis's presentation concluded, "When we address the concerns of students from minoritized communities, all students benefit from the outcome."

## Sociomaterial Contexts of Concepts in Academic and Workplace Settings: How and Why Can Aspects of the Workplace be Replicated in Courses

**Shane Brown,** *Professor of Engineering Education, Oregon State University*

**Matt Barner,** *Assistant Professor of Civil Engineering, University of Portland*

Shane Brown and Matt Barner share backgrounds that include both industry experience and engineering education research. Most of Barner's research focuses on similarities and differences between structural engineering practice and education. The pair's stated goal is to "understand and compare how civil engineering concepts are represented within academic and workplace contexts," and to "collaboratively develop engineering problems with faculty and practicing engineers that are adoptable and authentic to practice."

During this session, participants were asked to work in small groups to investigate, research, and discuss: 1) how knowledge is situated and distributed; 2) how we can understand knowledge as social and contextual; 3) how the context of higher education is different than the engineering workplace; and 4) how, given those differences, we can't fully replicate the engineering workplace in the classroom.

## Stigma of Mental Health Conditions as a Barrier to Addressing the Mental Health Crisis in Engineering

**Matilde Sanchez-Pena,** *Assistant Professor of Engineering Education, University at Buffalo*

**Nichole Ramirez,** *Assistant Director of Vertically Integrated Projects, Purdue University*

Matilde Sanchez-Pena and Nichole Ramirez opened their session by posing the question: What type of characteristics does the engineering mind have? Responses from session participants included being "creative," "curious," "focusing on problem-solving," being "rational," and "hardworking." Noting that these were all positive characteristics, Sanchez-Pena and Ramirez then asked how they can co-exist with a stigmatized identity, such as a mental health condition. An exploratory study in partnership with the National Alliance for Mental Illness (NAMI) worked with several individuals with mental health conditions who have been successful in engineering to find ways to intervene and support students with mental health conditions to have more success in the field. The session included a multi-phase activity where participants were moved into small groups and asked to read three case studies related to the experiences of individuals with a mental health condition in engineering: Jane, an undergraduate engineering student; John, an early career

engineering professional; and Jack, a late-career engineering professional.

In Phase 1, participants were asked what elements they found surprising after reading the backgrounds of the three individuals. One group mentioned the common misconception that if someone is getting good grades, it is assumed that they are fine, even though they may be going through a crisis. Another group noted that, while people often talk about being stressed, we do not talk about the long-term effects of stress.

In Phase 2, participants considered what happened to the three individuals during their engineering experience. Groups were asked to consider what the interplay was between stigma, mental illness, and engineering culture. Groups mentioned lack of personal connection with others, the lack of support for students from faculty and peers, and the misalignment of education and career as being potential triggers for a mental health crisis.

Phase 3 led groups to identify different sources of support and coping mechanisms. Participants suggested student-led clubs, supportive families, and insurance policies that cover mental health services as important support mechanisms for students in mental health crisis.

In closing, participants were encouraged, as faculty, to seek out resources available on campus so they're able to direct and support students. Faculty may not be mental health professionals, but just showing that they care is impactful.

## Transformative Research Experiences for Undergraduates as Paradigm Shifters in Engineering Education: Learning from the ENGagED REU Model

**Debalina Maitra,** *Associate Research Scientist, Arizona State University*

In this session Debalina Matria discussed the Establishing New Generations of Scholars to Amplify and Grow Engineering Education (ENGagED) REU Site, which aims to provide research experience in engineering education to students from underrepresented groups.

The session began with several polling prompts. The first asked participants if they have ever participated in an REU—40% said yes and 60% said no. The follow-up polls posed the questions: What do you believe is the most important objective of an REU program? How common is it for people in your discipline to participate in REUs outside of your discipline? What to you makes an REU successful?

These prompts were followed by an activity where participants moved into small groups by discipline to describe and discuss traditional research experiences for undergraduates in that discipline.

Maitra then moved on to discuss "An REU of the Future–Vision 2030," an ideal for the future, in which every institution would have an undergraduate research program funded by the institution. One challenge in achieving this vision is how to convince institutions to channel money into undergraduate research. Faculty, Maitra emphasized, can play an important role in convincing institutions to support undergraduate research. They can start by tracking the students involved in undergraduate research. Tracking can then be used to show an institution that the program is successful by noting how many students go on to grad school, postdoctoral programs, or industry.

The session culminated by articulating the best practices for designing REUs for students from marginalized backgrounds. These included having a constellation of mentors, getting to know student working styles (e.g., DISC behavior-assessment tool), practicing intentional mentorship, providing autonomy, breaking projects into small deliverables, and considering students' identities.

## NSF-LED BREAKOUT SESSIONS BY CLUSTER

*The following section of this report includes material from the National Science Foundation (NSF) website when appropriate.*

### Broadening Participation in Engineering (BPE)

**Christine Grant,** *Program Director for Broadening Participation in Engineering (BPE) and Historically Black Colleges and Universities–Excellence in Research (HBCU–EiR), National Science Foundation*

During this session, Christine Grant spelled out the four BPE funding tracks, all aimed at strengthening pathways for faculty and students who have been traditionally underrepresented and underserved in engineering.

Track 1 (Planning and Conference Grants) are typically $50,000–100,000 and last for 12 months. Beyond Recruitment: Engaging Allies to Foster Black Junior Environmental Engineering Faculty Success (Award No. EEC- 2232538, PI: William Tarpeh, Stanford University), a recent award in this track, funds development of a workshop to identify strategies to promote retention and increase success of Black junior faculty in environmental engineering.

Track 2 (Research in Broadening Participation in Engineering) funds research on the systemic barriers that prevent traditionally underserved communities from pursuing and succeeding in engineering; support systems and social networks that increase access; innovative methods and projects to improve recruitment and retention of students, faculty, and employees from underserved communities; and making diversity, equity, and inclusion a priority in engineering. Awards are typically around $400,000 and last up to 36 months. A recent example of this research is the CAREER Award Disrupting the Status Quo Regarding Who Gets to be an Engineer and Assessing Student Satisfaction and Engagement in Teams (ASSET) (Award No. EEC- 2042377, PI: Jeremi London, Virginia Tech).

Track 3 (Inclusive Mentoring Hubs [IMHubs]) aims to connect and build networks for racial and ethnic groups not sufficiently represented in STEM, particularly engineering. Communities may include students (K–12, undergraduate, and graduate); university and college faculty and leaders; postdoctoral and career transitioning researchers; small businesses and industry professionals; K–12

educators and practitioners; and researchers from national labs. An example of a recently funded IMHub award is Raices Institute for Transformative Advocacy (RITA) (Award No. EEC-2217477, PI: Idalis Villanueva, University of Florida) which aims to equip Black, Indigenous, and People of Color of all intersecting identities (BIPOCx) engineering contingent faculty to form their own grassroots advocacy strategies for attaining equity in promotion pathways and working conditions at their academic institutions.

Track 4 (Centers for Equity in Engineering [CEE]) aims to catalyze an enduring culture change in engineering education, creating equitable and inclusive practices to recruit and retain a diverse community of students. This track requires that deans of engineering (or an equivalent top administrator) serve as PIs. CEE awards have two phases. In the 24-month first phase, colleges put in place organizational, structural, pedagogical, and training changes needed to meet project goals. In the 36-month or more second phase, the PI institution is encouraged to partner with at least two other institutions, one of which should be a Minority-Serving Institution (MSI), community college, or in an EPSCoR jurisdiction. One example of a CEE is Learning to Serve: A Center for Equity in Engineering at an Emerging MSI (Award No. EEC- 2217741, PI: Roger Bonnecaze, University of Texas at Austin). Designated a Hispanic-Serving Institution (HSI) in 2020, UT–Austin aims to closely align the representation of Hispanic/Latino and Black/African American engineering undergraduate and graduate students with that of the state's population of 18–22-year-olds. It plans new and expanded student, staff, and faculty learning opportunities around integrating equity and inclusion into engineering professional practice, teaching, and an individual's role in the institution; intentionally designed support structures (including support for new initiatives) and outreach and recruiting events; and improved and expanded expectations and accountability for all members of the engineering community.

Grant also spoke about the HBCU–EiR program and NSF INCLUDES. HBCU–EiR aims to strengthen connections between HBCU researchers and NSF programs. This program supports researchers at public and private HBCUs in domains aligned with NSF's research program areas, helps to further a PI's research, and improves both research opportunities for students and research capacity at the institution.

NSF INCLUDES is a foundation-wide program that facilitates the activities needed to build and maintain a strong NSF INCLUDES National Network. This network comprises Alliances, Design and Development Launch Pilots, Coordination Hubs, other NSF-funded projects, Federal Coordination in STEM (FC-STEM) agencies, scholars engaged in broadening participation research, and organizations that support the development of talent from all sectors of society to build an inclusive STEM workforce.

Grant explained how EEC grantees could participate in long-established NSF programs: Industry–University Cooperative Research Centers (IUCRCs) and Engineering Research Centers (ERCs). Additionally, the BPE goals are shared by the Directorate for STEM Education (EDU) (formerly the Education and Human Resources Directorate) and the Computer and Information Science and Engineering Directorate (CISE).

Breakout groups (K–12, undergraduate, graduate, faculty) brainstormed about what

the big issues are in BPE; how PIs can work together to coalesce along related themes; how you can leverage "progress" for future work; reaching a broader set of publication venues; and various program-specific issues, including: What are my options if my research project is larger than $350,000? My project is ending, what next? How do I balance fundamental versus programmatic research? What has changed due to the pandemic and how can NSF help?

## Engineering Education (RFE, RIEF, CAREER, and RED)

**Jumoke Ladeji-Osias,** *Program Director, Engineering Education and Centers (EEC), National Science Foundation*

**Dorian Davis,** *Senior Analyst, National Science Foundation*

Jumoke Ladeji-Osias and Dorian Davis led a discussion on the many opportunities that the EEC Division offers for educators and researchers to work across different clusters. The Engineering Education (EE) cluster consists of Research in the Formation of Engineers (RFE), Research Initiation in Engineering Formation (RIEF), Revolutionizing Engineering Departments (RED), and the Faculty Early Career Development Program (CAREER). During this session, Ladeji-Osias and Davis explored various research opportunities in the EEC cluster.

RED, considered the cluster's flagship program, is formally aligned with RFE and Improving Undergraduate STEM Education (IUSE), an opportunity offered by the Directorate for STEM Education (EDU). RED supports three tracks: RED Innovation—revolutionary approaches and change strategies to transform undergraduate engineering education; RED Adaptation and Implementation, intended to adapt evidence-based organizational change strategies and actions to the local context; and a new track introduced in 2022, RED Two-Year—development of new approaches to expand pathways to engineering and engineering technology education at two-year institutions.

RFE focuses on the processes and value systems by which people become engineers and includes introductions to engineering; development of technical and professional skills and knowledge; ways of thinking, knowing, and doing; engineering identity; and acculturation to the profession's standards and norms. RIEF includes PIs with little or no experience conducting social science or educational research.

The EE cluster's research priorities include personalized learning—how technology can impact engineering education; national priorities, such as engineering related to climate change and semiconductors; projects that characterize and enhance the impact of engineering research; projects that change research into practice; approaches for scaling evidence-based improvements; and networks and communities as facilitators of change.

## Research Experiences for Undergraduates (REU)

**Amelia Greer,** *Associate Program Director, Engineering Education and Centers (EEC), National Science Foundation*

This session, led by Amelia Greer, consisted of discussions among small groups of REU PIs. In the first discussion, each group created a poster with a question and asked others in the group to respond with Post-it notes.

"How does your project impact the

engineering community, and others outside the engineering community?" resulted in the following selected responses and insights: engaging students from underrepresented communities; exposing students to alternate engineering career paths; increasing the supply pipeline by reaching out to students from institutions that do not have a regular outreach or research program; helping establish the connection between social science research and engineering; and engaging with populations that are unrepresented in engineering education, including veterans and people with disabilities.

In response to, "How do we share EEC findings with all of the communities that might benefit?" participants shared: a central online hub for all REU participants to submit work/posters accessible to other REUs, students; REU student conference to present research and network; and interactive virtual workshops.

"How could you scale up your project/increase impact (beyond more NSF funding)?" resulted in the following suggestions: coordinate with other faculty who have funding from other sources and work with their students; connect RETs with REUs to develop and deliver lesson plans; convene students from different REU sites with similar themes; facilitating industry conducting partnerships beyond visits and talks; and efficient mentor training and having the mentors execute and be available for the students during the summer.

When asked, "What would you need to support increased impact/scalability?" suggestions included: partnerships; synergistic collaboration with other institutions, including K–12; broad advertisement, dissemination tools, databases for tracking, and administrative personnel to handle logistics; and industry buy-in and support of a co-op model.

"How can you sustain your project beyond the life of your grant?" resulted in responses and ideas including: combining efforts with other faculty so the students have an umbrella cohort experience as opposed to being siloed; using REUs to train and mentor other cohorts; donor support; getting partners to fund students; building partnerships with state departments of education; publishing publications; and tracking student outcomes.

When asked, "What are your pain points/challenges in running your site?" participants responded with: getting funding late into the year; having quality mentors for the program; having a uniform start and end date for student participants; targeting applicants who meet our demographics; and funding for staff.

In terms of pressing topics participants wanted to discuss, specific topics included: funding mechanisms to organize an REU conference; additional hardship funding for nontraditional students (working, parents, caretakers); a central repository for lessons learned; and respectful pathways to research for students whose high schools didn't have elite STEM content.

After these Q&A sessions, participants were encouraged to think outside the box for ways to sustain their programs beyond NSF funding. They were also urged to help NSF work out ways for participants to touch base with colleagues among the 150 REU engineering sites each year. Volunteers were invited to form a leadership group and hold more regular discussions, maybe with monthly virtual meetings.

Participants were reminded that NSF's Education and Training Application (ETAP) is a great resource to help with recruitment and connecting with students. NSF strongly encourages the use of RET supplements to enable STEM educators to participate in REU programs.

## Research Experiences for Teachers (RET)

**Patricia Simmons,** *Associate Program Director, Engineering Education and Centers (EEC), National Science Foundation*

Patricia Simmons led a session detailing the role NSF's RET program and individual RET sites play in preparing and encouraging K–12 students and students at community colleges to pursue advanced degrees in engineering, engineering technology, and computer science.

The summer research opportunities for K–12 and community college STEM educators offered through RET sites and supplements help fill a crucial training gap for this subset of educators, while engaging them in experiments using state-of-the-art lab equipment alongside skilled researchers.

These experiences also convey the excitement of engineering, which teachers can take back to the classroom along with the modules and curricular materials they are expected to develop over the course of the summer. Besides filling gaps in teachers' experience and training, RETs must keep up with quickly advancing fields like data science and engage underserved communities.

Over the years, RET grantees at more than 20 institutions of higher education have contributed teaching and learning materials to teachengineering.org, the compilation of K–12 lesson plans and materials, aligned with state science standards, launched at the University of Colorado–Boulder and available through the National Science Digital Library.

During this session, participants were encouraged to break into small groups to share ideas and generate new ones. Ideas and insights included: the challenge of translating science research for middle school students; research topics that veered away from engineering to include investigating the presence of heavy metals in lobster tissue; teachers getting comfortable talking about their research; development of educational materials in renewable energy; teaching English learners; industry engagement; and the global component of RET.

Participants were invited to place Post-it notes on a series of posters responding to a question or prompt at the top.

Responses to, "What do you need to support and impact/scale?" included: it would be great to have a listserv of those currently with NSF RET grants to share ideas, solve challenges, etc.; translation to practice—meaningful connections between research, practice; and materials for teachers.

Responses to, "How to sustain a project beyond the life of the grant?" included: challenge sustainable by private industry; supplements; RETs from other NSF grants; partnering with industries, making university leadership understand impact and importance; and offer graduate credit—but who pays?

Additional "pearls of wisdom" included: advertise classroom implementation broadly build community support; get the school board on board; know the challenges faced by teachers; and pair teachers from different fields to develop materials for different subjects.

# APPENDIX A

## MEETING AGENDA

### THURSDAY, SEPTEMBER 22, 2022

| | |
|---|---|
| **8:00 AM – 8:45 AM** | **Opening Remarks**<br>• José Zayas-Castro, Division Director, Engineering Education And Centers (EEC), National Science Foundation |
| **9:00 AM – 10:15 AM** | **Concurrent Sessions I**<br>• Defining Your STEM Identity through Self-Assessment & Cohort-Building<br>• Don't Be Reviewer #2! Learn to Write a Truly Constructive Peer Review<br>• Re-Envisioning Research with Secondary Data Analysis: Broadening the Conversation<br>• Re-Envisioning Robotics in Engineering Education: A Partnership between e4USA & FIRST<br>• Transformative Research Experiences for Undergraduates as Paradigm Shifters in Engineering Education: Learning from the ENGAGED REU Model |
| **10:30 AM – 11:30 AM** | **Poster Session A** |
| **12:15 PM – 1:15 PM** | **Plenary Session I: Reflecting To Re-Envision: The Role Of Institutional Innovation, Transformation, And Disruption**<br>• Lesia L. Crumpton-Young, Texas Southern University |
| **1:30 PM – 2:45 PM** | **Concurrent Sessions II**<br>• Instructor Adaptability and the Course Complexity Typology as Tools for Faculty Development<br>• Reflecting to Re-Envision an Anti-Racist and Inclusive Doctoral Experience: Learning from Black Women in Computing and Engineering Before and During the Pandemic<br>• Sociomaterial Contexts of Concepts in Academic and Workplace Settings: How and Why Can Aspects of the Workplace Be Replicated in Courses<br>• Stigma of Mental Health Conditions as a Barrier to Addressing the Mental Health Crisis in Engineering<br>• Bringing Personality Psychology and Narrative Identity to Advance a Holistic Understanding of Engineering Students and Professionals |

## THURSDAY, SEPTEMBER 22, 2022

| | |
|---|---|
| **3:15 PM – 4:30 PM** | **Concurrent Sessions III**<br>• Community College, High School, and Middle School Collaboration—Extending RET through Outreach and Summer Workshops<br>• Concept Maps: An Effective Tool in Engineering Design Classrooms<br>• Engineering and Empathy Pre-K/K: Approaches and Findings of a Design and Development Project<br>• Project ENGAGES: Lessons Learned and Successful Strategies to Implement an Authentic STEM Research Experience for African American High School Students at a Tier One Research University<br>• Reflecting on Positionality to Re-Envision Our Impact in Equity Research and Practice |
| **4:30 PM – 5:30 PM** | **Poster Session B** |
| **5:30 PM – 7:00 PM** | **Networking Reception** |

## FRIDAY, SEPTEMBER 23, 2022

| | |
|---|---|
| **8:00 AM – 8:30 AM** | **Opening Remarks**<br>• Susan Margulies, Assistant Director, Directorate For Engineering, National Science Foundation |
| **8:45 AM – 10:00 AM** | **NSF Breakout Sessions by Cluster**<br>• Broadening Participation in Engineering (BPE)<br>• Engineering Education (RFE, RIEF, CAREER, and RED)<br>• Research Experiences for Teachers (RET)<br>• Research Experiences for Undergraduates (REU) |
| **10:30 AM – 11:30 AM** | **Plenary Session II: A Systems Approach to DEI, and Why It Matters**<br>• Karl W. Reid, Senior Vice Provost and Chief Inclusion Officer, Northeastern University |
| **11:30 AM – 12:00 PM** | **Closing Remarks** |
| **12:00 PM – 1:30 PM** | **Working Lunch: Reflecting to Re-Envision** |

# APPENDIX B

## INVITED REU/RET SITE PARTICIPANTS

REU and RET PIs were invited to nominate an exceptional site participant to join this conference. These students and educators presented their work and achievements with posters highlighted during the conference's poster sessions.

### REU Participants

**Efrem Dana**
Milwaukee School of Engineering

**Mikayla Friday**
University of South Florida

**Natalia Garcia**
Texas A&M University

**Madison Green**
California State Polytechnic University–San Luis Obispo

**Vaishnavi Kanduri**
Clemson University

**Caroline Lubbe**
University of Notre Dame

**Lily H. Parker**
Georgia Southern University

**Fiona Powers**
Montana State University

**Hannah Skye Smith**
University of Utah

### RET Participants

**Samantha Kaj Blair**
Dalton State College (Georgia)

**Natasja Brown**
Ocean Springs High School and Mississippi Gulf Coast Community College (Mississippi)

**John Gerzik**
Bryan Career & Technical Education Center (Texas)

**Apolinar Guevarra**
Foster High School (Texas)

**Jimmy Houseal**
Georgia Chaffee TAPP Big Picture High School (Kentucky)

**Daniel Regan Jalkut**
Northwestern University (Illinois)

**Ariel Delos Reyes**
Pasadena ISD (Texas)

**James Stallings**
Lakeside Junior High School (Arkansas)

## CONFERENCE EVALUATION REPORT

In consultation with the American Society for Engineering Education (ASEE), Quality Evaluation Designs (QED) created a post-conference evaluation survey, which was administered on the last day of the conference. The purpose of the survey was to understand if the conference objectives were achieved, as well as to obtain general feedback on overall satisfaction with the event and to make recommendations for future conferences. QED added demographic items and additional questions to explore customer segments. Of the 190 attendees, 152 survey responses were collected (80% response rate). The following report summarizes evaluation results. All data were collected in accordance with Ethical and Independent IRB ID #22196.

## Summary of Findings

### Participant Demographics

In the survey, attendees were asked to provide demographic information about their gender, race/ethnicity, and academic status. More than half (55%) of respondents identified as female, with 39% identifying as male and 6% preferring not to say. More than half (57%) of respondents identified as White, with approximately one-fourth identifying as members of underrepresented ethnic/racial groups (refer to Figure 1: Race/Ethnicity of Respondents).

In terms of academic status, the most common responses were tenured faculty (40%) and pre-tenured faculty (23%). To a lesser extent, respondents identified as other (14%), non-tenure-track faculty (12%), or undergraduate, graduate student, or K–12 educator (11% combined) (refer to Figure 2: Academic Status of Respondents).

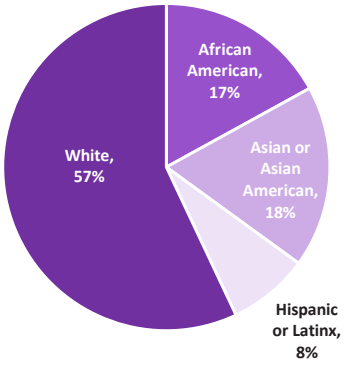


*Figure 1: Race/Ethnicity of Respondents*

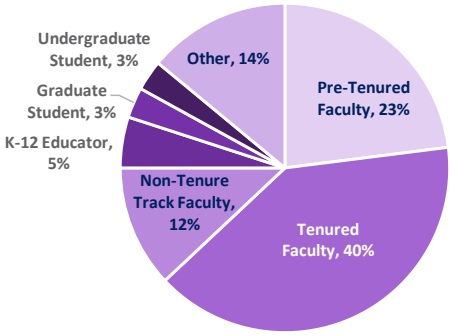


*Figure 2: Academic Status of Respondents*

# APPENDIX C

## Conference Objectives

The conference had three major objectives: 1) foster knowledge sharing across the network of grantees in attendance; 2) cultivate personal and professional relationships, collaborations, and partnerships; and 3) prompt discussions about state-of-the-art and ongoing division-level research efforts.

For the purposes of this evaluation, the first two objectives were merged under the single heading of "networking."

### Networking

Attendees highly valued their networking opportunities. When asked to rate their networking experiences, 91% of participants rated the frequency of their interaction opportunities as good–excellent, and 94% of attendees rated the value of their interactions as good–excellent, indicating that an overwhelming majority felt that the conference provided them with frequent and high-quality networking opportunities. Attendees especially appreciated the networking breaks built into the conference schedule; in survey comments and impromptu interviews, participants said they would like them to be even longer. Eighty-four percent of attendees reported that they would follow up on 3–4 or 5+ new connections they had made. Specific insights included:

> *"I think this conference was extremely useful and I got some great ideas [about] networking with others."*
>
> *"The breaks BETWEEN sessions helped a lot. Often [at other conferences], I meet people within a session that I want to speak with, but then I am rushing to the next one. This conference allowed that time for us to talk more and exchange contact info."*
>
> *"I think that slightly longer coffee/networking breaks would be good. Some of the talks bled into that time and I would have benefited from more opportunities to connect and think about collaborating on future grants."*

Nearly 40% of attendees have gone to a previous year's EEC Grantees Conference. Of these previous attendees, 87.9% of them made connections that they followed up with after the event, many of which led to research collaborations. Specific insights included:

> *"I've used networking time both to catch up with colleagues I've known for a long time and to discuss opportunities with people I've met at the conference. One of the colleagues I met at a grantees conference went on to do postdoc work with me, funded by a proposal we co-wrote."*
>
> *"Connections from a previous meeting (2019) resulted in collaborative grants and writing projects."*
>
> *"I met the RIEF network and submitted a successful RIEF after my first [grantees conference]."*

For many respondents (61.2%), this was their first EEC Grantees Conference. These participants would have liked more structured networking events earlier on in the conference to facilitate meeting new people. Twenty-one comments requested more structured networking events earlier in the conference. Respondents asked specifically for more small group breakouts earlier in the conference focused on career stage and/or interests, a session to help REU students get to know each other, and moving the NSF-led breakout sessions by program cluster to the first day of the conference to be able to connect with potential collaborators earlier

and know who to reconnect with during networking sessions.

### Prompting Discussions About Division-Level Research

The overall objective was addressed through a variety of sessions, including plenary sessions, grantee-led concurrent sessions, poster sessions, and NSF-led breakout sessions by program cluster. Attendees' ratings of plenary, concurrent, and poster sessions ranged from 3.0–3.5 out of 4.0.

The highest rated session was the NSF-led breakout session by program cluster, with an overall rating of 3.6 out of 4.0, indicating high value. In fact, if attendees did not attend this session, on average their Overall Value ratings were 15 points lower than those who did. Of the 119 survey respondents who did attend this session, their average Overall Value rating was 85.7, while the 20 survey respondents who did not attend this session had an average Overall Value rating of only 70.5. In survey comments, even those who did attend this session expressed they would have liked it to be earlier in the conference and longer so that they would have had more time to network with the connections they made at the session. Respondents also suggested that this session be made longer.

## Overall Conference Value

### Top Takeaways

Attendees rated Overall Value of the EEC Grantees Conference 83.5 out of 100.0 (Figure 6). Sixty percent of survey respondents rated the conference as high value. In their short answer responses (n=167) to a question asking for their "top takeaways," networking was the most-cited benefit of the conference, with inspiration being a close second (refer to Figure 3: Attendees Top Takeaways).

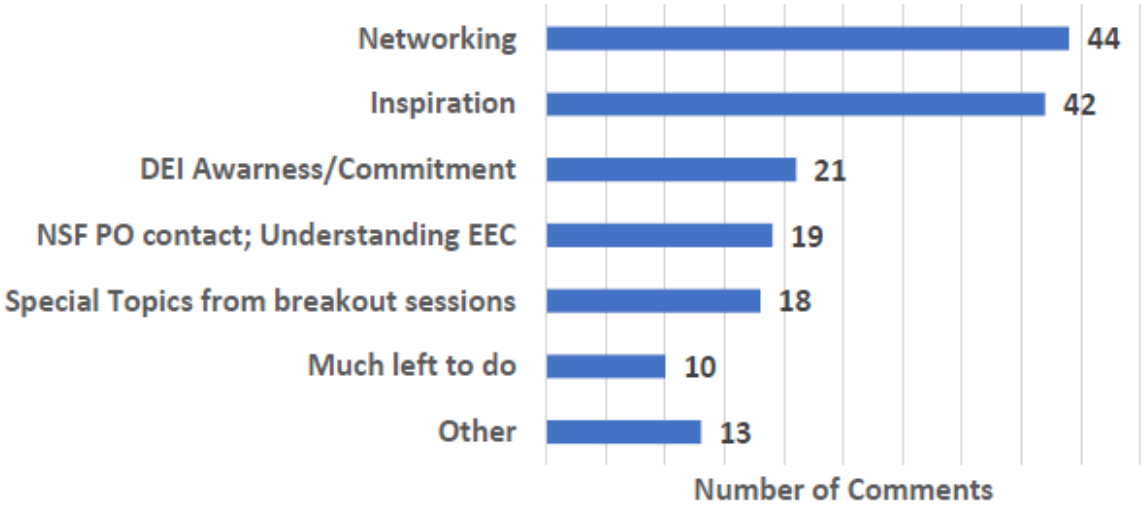


*Figure 3: Attendees Top Takeaways*

## Organization and Logistics

In terms of conference organization and logistics, ASEE Staff and Conference Organization received the highest ratings (3.6 and 3.5 out of 4.0, respectively). The lowest ratings were for Conference Venue and Food Options (3.0 and 2.5 out of 4.0, respectively), with specific comments emphasizing the isolated location of the venue and a lack of satisfactory options for those with dietary restrictions.

## Interpretations and Recommendations

### Building on 2019 Recommendations

The top three recommendations from the 2019 EEC Grantees Conference, as indicated by attendees in the 2019 post-conference evaluation survey, were to: 1) invite high-impact, inspirational plenary speakers; 2) provide more structured networking opportunities; and 3) provide more food options throughout the conference.

Attendees of the 2022 EEC Grantees Conference found both plenary speakers' presentations to be valuable and indicated one of their top takeaways as "being inspired." As such, we consider the 2019 recommendation to invite high-impact, inspirational plenary speakers well addressed.

In terms of the second 2019 recommendation to provide more structured networking opportunities, the 2022 conference attendees highly valued their networking interactions, but still requested to have more structured networking events earlier in the conference. The conference team should plan to continue to address this recommendation in future conferences, taking heed of and incorporating specific attendee suggestions and recommendations.

One consistent complaint in the survey comments across both 2019 and 2022 was that there were not enough food options, especially for those with dietary restations, so the 2019 recommendation to "provide more food options throughout the meeting" either was not addressed or was not addressed effectively. The conference team will take this recommendation into consideration when selecting venues and menu options for future conferences.



https://eecconference.asee.org