

Directorate for Engineering Advisory Committee Meeting

National Science Foundation

Alexandria, Virginia

April 6-7, 2022

Virtual

ENG AdCom Members Present:

Dr. Leah Jamieson (Chair)
Dr. Tilak Agerwala
Dr. Gretchen Baier
Dr. Charles Bott
Dr. Bika Carter (Day 1 only)
Dr. Robin Cogger
Dr. Karina Edmonds
Dr. Cynthia Furse
Dr. Kimberly Jones
Dr. Ann Kelleher
Dr. Gregory Keoleian
Dr. Tsu-Jae King Liu
Dr. James R. Martin II
Dr. Danielle Merfeld
Dr. Franklin (Lynn) Orr
Dr. Ismael Pagán-Trinidad
Dr. Lance Pérez
Dr. Sarah Rajala
Dr. James Thompson
Dr. Bruce Tromberg

ENG Senior Staff Present:

Dr. Susan Margulies (Assistant Director)
Dr. Don Millard (Acting Deputy Assistant Director)
Dr. Shekhar Bhansali
Dr. Sohi Rastegar
Dr. Mihail Roco
Dr. Robert Stone
Dr. Jeanne VanBriesen
Dr. José Zayas-Castro

Wednesday, April 6, 2022

The meeting convened at 11:00 a.m.

CALL TO ORDER

Dr. Leah Jamieson called the meeting to order. Advisory Committee Members and ENG leadership introduced themselves. The committee unanimously approved the minutes of the Fall 2021 meeting. **Dr. Susan Margulies** reviewed the agenda with the committee members.

DIRECTORATE FOR ENGINEERING REPORT

Dr. Susan Margulies, NSF Assistant Director for Engineering, described the organization of the directorate and introduced new staff and open positions. She described ENG activities and investments

in terms of the directorate's strategic goals and priorities. These include research and research infrastructure to address climate change, clean energy, and emerging technologies; opportunities for people, such as investments in engineering education and diversity, equity, and inclusion; and partnerships through ENG center awards and collaborations with federal agencies and other entities.

NSF BUDGET UPDATE

Ms. Caitlyn Fife, Division Director of NSF's Budget Division, described NSF's budget activities in the context of the U.S. federal budget process. NSF's FY 2022 appropriation is its highest ever, and the ENG allocation is being determined now as part of NSF's Current Plan. She described NSF's FY 2023 strategic pillars and crosscutting themes. The Directorate for Education and Human Resources will be renamed to the Directorate for STEM Education. The President's budget request for FY 2023 would further increase NSF's funding level.

Discussion

The committee discussed how funding allocations are made within NSF. The agency's funding priorities, such as supporting the new Directorate for Technology, Innovation, and Partnerships (TIP), clean energy, come from Congress, the Administration, and NSF itself. NSF has a lot of flexibility to distribute funding and negotiates on high-level numbers with the Office of Management and Budget.

NSF'S NEW STRATEGIC PLAN

Ms. Janis Coughlin-Piester, Deputy Office Head, NSF Office of Budget, Finance and Award Management, presented NSF's new strategic plan for FY 2022-2026, which was created with input from NSF advisory committees and reflects new opportunities and challenges. **Dr. Stephen Meacham**, Section Head for Integrative Activities, NSF Office of Integrative Activities, introduced the four strategic goals: Empower STEM talent, Create new knowledge, Benefit society, and Excel at operations. Each goal has associated indicators of progress.

Discussion

Committee members asked what NSF learned during the pandemic what it means for the agency. Overall, the community continued sending NSF new proposals and training students at about the same level. NSF provided supplementary assistance to ensure that some people, such as those early in their careers, could go on to academic careers. NSF is examining whether virtual panel reviews allow broader participation.

ENG STRATEGIC PLANNING

Dr. Margulies updated the committee on strategic planning in the Engineering Directorate, which has been developing in context of national challenges, the Vision 2030 report, the NSF Strategic Plan 2022-2026, Administration priorities, NSF pillars and themes for FY 2023. The ENG mission is to transform our world for a better tomorrow by driving discovery, inspiring innovation, enriching education, and accelerating access. The ENG vision is to be a global leader in identifying and catalyzing fundamental engineering research, innovation, and education. The ENG goals – Propel, Expand, and Catalyze – are align with those of NSF and the National Science Board. Dr. Margulies described new activities and ones

that will continue or expand, which will advance ENG goals. ENG is thinking about what needs to be done now with problems, people, and partnerships in order to achieve impacts in 5 to 10 years.

Discussion

In general, the committee supported ENG's goal-based approach. They encouraged the Directorate to remain flexible and nimble and continue to encourage topics that are out of the box. ENG needs to communicate its value and uniqueness both internally and externally.

ENG should increase support for Historically Black Colleges and Universities (HBCUs), other Minority-Serving Institutions, and institutions that do not have very high research activity, which are heterogeneous. Planning grants and team-building grants are useful.

On partnerships, committee members suggested working with the Department of Energy on research infrastructure, workforce development, and creating an innovation ecosystem. At the National Institutes of Health, many other Institutes besides the National Institute of Biomedical Imaging and Bioengineering are supporting bioengineering research, so ENG could have an opportunity to partner with them. NSF may need to engage with new kinds of partners (such as for community engagement) in different ways and provide training on mentoring, communication, and proposal preparation. Proposal structure and format may need to be updated to work for new forms of partnerships.

ENGINEERING RESEARCH AND EDUCATION PRIORITIES FOR TACKLING THE CLIMATE CRISIS

Dr. Benjamin Preston, Assistant Director for Climate Services, Adaptation, and Workforce, White House Office of Science and Technology Policy, could not attend. The committee continued with the agenda.

CROWDSOURCING TO CATALYZE FUTURE RESEARCH DIRECTIONS: THE ENGINEERING RESEARCH VISIONING ALLIANCE (ERVA)

Ms. Jennifer Carinci, ERVA Executive Director, introduced ERVA, now one year old, with a short video. **Dr. Dorota Grejner-Brzezinska**, ERVA Principal Investigator from The Ohio State University, described how ERVA crowdsources ideas for future research directions. The first visioning event, held in December 2021, was on the role of engineering in addressing climate change, and it explored topics in 10 cross-disciplinary domains. ERVA also analyzed climate change topics in research publications. Two examples of areas with high growth potential for engineering are carbon capture research and research at the intersection of health and climate change. The second visioning event, held in March 2022, was on leveraging biology to power engineering impact, and it was framed around eight impossible things. In addition to the events, ERVA focused on developing its community and networks.

Discussion

Committee members noted that a justice theme could be part of engineering research challenges beyond climate change, and ERVA responded that human aspects have continuously shown up.

The committee discussed engaging diverse people and ensuring inclusivity, which ERVA has done by working with affiliate partners and their networks and by considering many dimensions of diversity

when selecting participants for the task force and the events. Having partners with diverse communities is important for the ERVA network.

Committee members discussed stakeholders, such as local and state government, who could be involved in later research and implementation phases of ERVA ideas.

CLIMATE AND CLEAN ENERGY OPPORTUNITIES FOR NSF ENG: DISCUSSION

Committee members said that, in climate change and clean energy research, the engineering community's strengths are in translating discoveries into applications and using a systems approach. With NSF's emphasis on sustainability and ethical design, social scientists should be involved in research from the design stage to ensure it advances the desired impacts.

Beyond its opportunities for research funding, NSF's biggest lever is the community that NSF has created. Societal and policy issues should be included to broaden the engineering community's perspective. Engineering researchers can also assist decision-makers at the state and local levels on projects to address clean energy and climate change. Sectors that connect with climate change and clean energy, such as the water sector, should be at the table.

Industry input on research gaps would also be helpful. Solutions have many components that need to be mapped and integrated to help align industry. The map should include on-ramps to enable people to contribute their expertise. It needs to be widely available and include good visuals to enhance communication.

NSF could motivate and align industry, which has many operators in this space. Other areas of industry have worked together successfully, such as semiconductor industry organizations collaborating on environmental strategy. NSF centers with industry partners may also have role.

EXTRAORDINARY ENGINEERING IMPACTS ON SOCIETY: AN UPDATE ON A NATIONAL ACADEMIES STUDY FOR THE NSF

Dr. David Butler, J. Herbert Hollomon Scholar, National Academy of Engineering, provided an update on an NSF-funded National Academies study to identify extraordinary engineering impacts on society. He reviewed the statement of task and described plans for a symposium and narratives for the public about the impacts. He introduced the study committee, their resources so far, and the considerations they will use in selecting impacts. Their dissemination activities will cross media platforms and be tailored to diverse audiences in order to increase understanding and appreciation of engineering, engineering careers, and the role of engineering research.

Discussion

Committee members suggested dissemination partners and connecting to current issues of public interest, such as the climate and energy crises, to increase interest among students and other groups. To expand their audience, they can go beyond places where people are already engaged in science and engineering.

The committee noted that engineering is also changing established disciplines, such as health research and medical school curricula. A report appendix could highlight impacts that don't make it into the body.

REPORTS FROM ADVISORY COMMITTEE LIAISONS

Dr. Tilak Agerwala, liaison to the **Advisory Committee for Cyberinfrastructure (ACCI)**, described the committee's focus, which has moved from supercomputers to forward-looking cyberinfrastructure research on middleware, hardware, software, ecosystems, and workforce. He provided updates on ACCI's three working groups. The final report of the Cyber Infrastructure Research and Innovation working group is complete. The Reproducibility and Sustainability working group will present a draft report for final approval on at their April 2022 meeting. The Cyberinfrastructure Workforce working group continues to develop a survey for NSF principal investigators. ACCI is considering a possible future working group on polar programs scenarios and pilots.

Dr. Kimberly Jones, liaison to the **Advisory Committee for Environmental Research and Education (AC-ERE)**, introduced the committee objective, scope, members, and recent reports, including sustainable urban systems which led to SRS, and last year's reports, "Environmental and Human Health Research Priorities" and "Environmental Changes and Human Security: Research Directions for the National Science Foundation." Two other reports — on engaging with communities on environmental research and on opportunities and challenges in green infrastructure — are in development. Upcoming meeting will focus on integrating justice and equity into NSF's environmental research programs and on strategic planning over the next few years. Dr. Jones is now the chair of the AC-ERE.

Dr. James Martin, liaison to the **Committee on Equal Opportunities in Science and Engineering (CEOSE)**, introduced the history and purpose of CEOSE. At their last meeting in February, the committee noted that the STEM higher education community moved quickly with the pandemic and can bring that same urgency to increasing access. CEOSE discussed the design and impacts of the EPSCoR program, which will be expanding to include more states and may get additional funding. The committee discussed broadening participation in STEM education and careers using the analogy of "braided streams," which can help elucidate ways to improve the system (rather than "fixing" individuals). Efforts continue to increase the quality of data, such as new tools from the National Center for Science and Engineering Statistics and a student portal from the NSF Education and Training Application. CEOSE continues to work on its next biennial report, which will cover 2021-2022.

Discussion

Committee members supported the idea of integrating equity and justice and noted that better tools are needed to deliver optimal solutions. They also compared the "braided streams" model to the "pipeline" and "pathways" models of STEM education and careers.

WRAP UP

The committee reviewed the next day's agenda and decided to highlight critical ENG activities for the Office of the Director.

The meeting adjourned for the day at 6:00 p.m.

Thursday, April 7, 2022

The meeting reconvened at 10:30 a.m.

MOVING THE NEEDLE ON ENGINEERING DIVERSITY: CURRENT DATA AND TRENDS

Dr. Amy Burke, Program Director, Science and Engineering Indicators Program, National Center for Science and Engineering Statistics, presented information from the National Center for Science and Engineering Statistics (NCSES). The number of engineering degrees awarded continues to grow. Engineering degrees to women and Black and Hispanic individuals are not represented proportionally to the U.S. population, and the percentages of engineering bachelor's degrees to Black and Hispanic individuals have been relatively flat over the past 10 years. The percentage of college educated women in engineering occupations has risen to approximately 16 percent, but engineering lags among science and engineering occupations. Black and Hispanic individuals are also underrepresented in engineering occupations; the percentage of Hispanic individuals in engineering occupations has increased but remains below their share of the U.S. adult population.

Discussion

The committee noted that disparities begin to show up in data on K-12 students. They discussed multiple and systemic reasons such as recruitment, retention, lack of mentoring and inclusion, and barriers for advanced degrees. Issues are multiple and systemic, and engineering is behind on the whole.

They expressed interest in seeing how the pandemic will affect engineering data. They also would like data broken out by engineering disciplines and by gender for Hispanic and Black individuals. A forthcoming NCSES report will have some analysis on intersectionality. Data on pre-college interest in engineering would be interesting to compare to the undergraduate majors chosen and to degrees awarded. Longitudinal studies on persistence in engineering are needed. Some potential factors, such as being part of community or having diversity within a peer group, are not often measured and seem to affect retention in industry too.

Societal messages and global events affect interest in engineering. The convergence of engineering with other disciplines and engineering's beneficial impacts on people's lives may be used as opportunities to grow and diversify engineering education and careers. Committee members wanted to learn more about effective NSF programs and activities, such as education hubs that provide research on what works.

MOVING THE NEEDLE ON ENGINEERING DIVERSITY AND INCLUSION

Ms. Dawn Jones, Chief Diversity and Inclusion Officer and Vice President of Social Impact at Intel, said that engineering has many opportunities to drive better outcomes. Intel has a new \$20-billion investment in Ohio to create semiconductor manufacturing facilities and will hire thousands of people. Diverse talent is top talent, and industry cannot recruit and diversify separately. Intel is partnering with NSF on a \$50-million investment in Ohio to train and graduate people for the semiconductor

manufacturing workforce. It's important to engage community colleges, which have diverse students who may follow alternative paths; for example, on-the-job training can lead people back to college for degrees. Industry needs to understand the needs of communities and connect with educational institutions to build true partnerships; for example, student scholarships at HBCUs also support faculty and administration. Industry has spent hundreds of millions on individual activities that could create a powerful collective impact if they came together.

Dr. Louis Martin-Vega, Dean of the College of Engineering at North Carolina State University, said his focus has been on creating a critical mass of diverse faculty. At the University of South Florida, the student body was diverse, but the engineering school had hardly any Black or African American faculty. With resources, a leadership commitment to diversity, and an open mindset about where to recruit from, Dr. Martin-Vega hired six Black faculty members (three men and three women) in one year. At NC State's engineering school, he doubled the number of tenure-track women faculty in engineering with the hiring of eight women in 2007-2008. Now, 25-30 percent of tenure-track faculty are women, and three of nine department heads are women, and this has impacted enrollment. At the same time, the school invested deliberately in its educational programs. NSF has invested significantly in research and culture change and has exciting new opportunities for broadening participation in engineering.

Discussion

The committee discussed ways for industry to partner with K-12 education, for example, through science challenges or hands-on experiences. One key to reaching under resourced communities is to support activities that align with their interests, such as agriculture for some Native American communities.

Committee members asked Dr. Martin Vega what can be learned from engineering disciplines that are more diverse, such as biomedical/bioengineering and environmental engineering. He advised not to focus on disciplines but instead on societal challenges. Students are concerned about urgent, major issues, such as climate change. Faculty can be hired around grand challenges, which can be addressed in many fields and can spur the interest of diverse students.

MOVING THE NEEDLE ON ENGINEERING DIVERSITY AND INCLUSION: DISCUSSION

Committee members discussed the need to understand educational choices before college and career trajectories and to provide support such as long-term projects. The integration of data sets, like Nebraska's statewide initiative for educational data, could be useful. NSF can serve as an example by publishing demographic data about the agency and the people it supports.

Dissemination of effective practices needs to expand beyond the engineering education and broadening participation research communities. What changes supported by NSF ADVANCE and RED programs have really made a difference? NSF can put greater emphasis on Broader Impacts during merit review of proposals and annual reporting by principal investigators – they must be central, not peripheral to projects.

In addition, initiatives aimed at different educational and career levels need to be coordinated and integrated, rather than treated as hand-offs; universities can learn from and collaborate more deeply with K-12 schools and industry. Connections with the Department of Education will be important for reaching K-12 students. Engineering needs pathways for people who want to enter or return later in life, such as bridge programs. Experiences that provide supportive peer cohorts for students and professionals help sustain diverse talent flow. NSF can set expectations for diversity and inclusion in education and industry environments.

To attract students to engineering, students need to see themselves as engineers and clearly understand the societal benefits of engineering careers. Engineering is the only discipline that provides a practical, problem-solving approach.

PREPARATION FOR DISCUSSION WITH THE DIRECTOR'S OFFICE

The committee decided to focus the discussion on the opportunity for engineering to address climate change and clean energy, the parallels to engineering opportunities to improve human health, and the central importance of diversity, equity, and inclusion for the future of engineering.

PERSPECTIVE FROM THE DIRECTOR'S OFFICE

Dr. Jamieson welcomed Chief Operating Officer Karen Marrongelle. Everyone introduced themselves.

Dr. Karen Marrongelle thanked the committee members for their service. She highlighted NSF's recent FY 2023 budget request and the widespread, bipartisan support for NSF and its work. NSF recently launched the Directorate for Technology, Innovation, and Partnerships (TIP), which she expects to have strong ties and partnerships with Engineering.

Dr. Margulies shared ENG's strategic planning context.

Dr. Gregory Keoleian stated the need for cross-disciplinary engineering research to address climate change and clean energy with a systems-of-systems approach and with industry and community engagement to hasten the deployment of solutions at scale.

Dr. Bruce Tromberg noted important parallels for engineering and health, which made unprecedented technological advances during the pandemic. The Engineering Directorate already has close ties with industry to accelerate the translation of discoveries into useful technologies.

Dr. Robin Coger stated that diversity, equity, and inclusion are critical to the nation's competitiveness, and they should be central to NSF's investments, the work of the research community, and partnership efforts. The systems-of-systems approach can help create cultural shifts and grow pathways or streams for people to join engineering.

Dr. Marrongelle appreciated the committee's thoughts, recognized opportunities for engineering and for integration with other parts of NSF, and acknowledged the urgency of these problems.

ROUNDTABLE ON STRATEGIC RECOMMENDATIONS FOR ENG

Dr. Jamieson invited the committee members to share recommendations.

The committee made several recommendations in the area of diversity, equity, and inclusion in engineering, such as: creating shared goals and metrics, increasing information about student choices at all levels, giving greater attention to pre-college education, creating multiple pathways to the engineering workforce, and recognizing faculty for their broadening participation work. NSF has an important role in convening the community and synthesizing what's understood.

The committed supported ENG's strategy. They advised the Directorate to focus on top priorities and take small, calculated risks. Broader impacts of research should include human aspects. Regarding partnerships, engineering has an essential role in technology transfer and should pursue collaborations with NSF's multidisciplinary activities and TIP, the Department of Energy, and others that augment engineering strengths. Engineering should emphasize the importance of integrating disciplines for making progress on national challenges. At the same time, it's important to communicate what is unique about engineering, such as the systems approach.

In the area of climate change and clean energy research, engineering can accelerate a sustainable and equitable transition and partner with other agencies to speed implementation. Energy drives the modern world, and the goals of the developing world must be supported to address this global challenge.

CLOSING REMARKS

Dr. Jamieson thanked the committee members and the NSF team and recognized Tilak Agerwala and Sarah Rajala for their service to the committee. **Dr. Margulies** added her thanks to the committee.

The meeting adjourned at 3:15 p.m.