Response to Senator Paul's "Spring 2019: Waste in Full Bloom"

The National Science Foundation (NSF) has been the backbone of America's science and engineering research enterprise for over 70 years. In fact, NSF is the only federal agency that supports all fields of fundamental science and engineering research and education. NSF supports cutting-edge research projects — many of which serve as bellwethers for solutions to the myriad complex issues facing society. NSF programs also traditionally integrate research and education, fast tracking innovation excellence via hands-on learning to train our next generation of researchers and innovators.

Each year, NSF competitively awards thousands of grants that collectively advance our nation's scientific capabilities and engage the talents of hundreds of thousands of researchers, postdoctoral fellows, technicians, teachers and students in every field of science and engineering.

NSF is the primary source of federal funding for non-medical basic research, providing approximately 12,000 new awards annually. Through its merit review process, NSF ensures that proposals submitted are reviewed in a fair, competitive and in-depth manner. Competition for funding is intense, with only about one out of five proposals ultimately being approved.

Each proposal submitted to NSF is reviewed by science and engineering experts well-versed in their particular discipline or field of expertise. All proposals submitted to NSF are reviewed according to two merit review criteria: *Intellectual Merit* and *Broader Impacts*. NSF's merit review process is widely considered to be the "gold standard" of scientific review. Perhaps the best evidence of NSF's success is the repeated replication of its merit review model for discovery, education and innovation around the globe.

The results of this process — funding the best and brightest ideas through competitive merit review — have been profound. NSF-supported research has underpinned multitudinous discoveries leading to new inventions — the Internet, web browsers, Doppler radar, Magnetic Resonance Imaging, DNA fingerprinting, and bar codes — to name a few. These diverse examples underscore NSF's significant contributions to our nation's prosperity, health and wellbeing. NSF-funded discoveries have expanded our understanding of the world in which we live, led to life-saving medical advances, enhanced our national security, improved our everyday lives and yielded insights into the creation of the universe.

NSF's task of identifying and funding work at the frontiers of science and engineering requires keeping close track of research around the United States and the world; maintaining constant contact with the research community to advance the horizons of inquiry; and choosing the most promising people to conduct the research.

The following grants cited in "Spring 2019: Waste in Full Bloom" illustrate examples of promising NSF-funded research awarded support through the merit review process.

Large scale structure in complex networks
NSF Awards 1407207 and 1107796
Spring 2019: Waste in Full Bloom: "Studied the habits of online dating app users"
University of Michigan – Ann Arbor

Many systems of scientific and technological importance can be represented as networks: the internet, the power grid, airline and road networks, biological networks, including metabolic networks in the cell or neuronal networks in the brain, social networks, to name just a few.

The research conducted under this funding has aimed to develop fundamental new mathematical tools for analyzing and understanding the structure of general networked systems. At the mathematical level, the funded research focused on two specific approaches. The first one captures the structure of networks as mathematical matrices then analyzes those matrices to shed light on the networks they represent. The second approach formulates mathematical models of the processes by which networks are created, then fits those models to observed network data. For example, for different types of classes of chemicals in a metabolic network in the cell, methods of this research allow to identify the types from network structure alone, without measuring them directly (which may be difficult or costly).

The two NSF awards highlighted in Sen. Paul's report have resulted in more than 30 research articles, many in leading physics journals, with the potential of applications to a wide selection of networked systems, including the internet, social networks, linguistic networks, protein-protein interaction networks in biology, web networks, ecological networks, genetic networks, and others. Computer codes for algorithms developed during the work have been made available to other researchers in many areas across the physical, biological, social, and information sciences. This interdisciplinary research also has provided critical training of the Science, Technology, Engineering, and Mathematics (STEM) workforce including postdoctoral fellows and doctoral students.

Summer Course on Grant Writing in the Social, Behavioral and Economic Sciences (SCG)
NSF Award: 1719500
Spring 2019: Waste in Full Bloom: "Paid to teach social scientists how to apply for grants"
University of Mississippi

The SBE Postdoctoral Research Fellowship (SPRF) program's Broadening Participation (BP) track seeks to increase the diversity of post-doctoral level researchers who participate in NSF programs in the social, behavioral and economic sciences and thereby increase the participation of scientists from underrepresented groups in selected areas of science in the United States. Data from the National Center for Science and Engineering Statistics have demonstrated that members of certain ethnic or racial groups (e.g., American Indians or Alaska Natives, Blacks or African Americans, Hispanics, and Native Hawaiians or Pacific Islanders) as well as individuals with disabilities are underrepresented in the SBE sciences in the U.S. The problem of underrepresentation in the nation's scientific enterprise has been well-documented and reported in the literature. The goal of the SPRF-BP track is to prepare underrepresented SBE scientists and others for positions of scientific leadership in academia, industry, and government.

The 2017 Report on the National Science Foundation's Merit Review Process indicates that fewer than 5% of grant proposals are received from individuals who identify as members of an underrepresented group, thus revealing a significant disparity. Therefore, the award — and the SPRF-BP program as a whole — is focused on growing diversity and broadening participating in our nation's scientific enterprise. Additionally, the researcher leading this work is at the University of Mississippi, which is an EPSCoR (Established Program to Stimulate Competitive Research) jurisdiction meaning that it is a state that receives fewer than 0.75% of NSF research support funding, based on the prior 3-year total.

This award is consistent with NSF's priorities to leverage opportunities in STEM for all Americans and to establish a nation of scientists that is representative of the U.S. population.

The main goal of the S-STEM program is to enable low-income, talented domestic students to pursue successful careers in promising STEM fields. Ultimately, the S-STEM program wants to increase the number of low-income students who graduate and contribute to the American innovation economy with their STEM knowledge. Recognizing that financial aid alone cannot increase retention and graduation in STEM, the program provides awards to Institutions of Higher Education (IHEs) to fund scholarships and to adapt, implement, and study effective evidence-based curricular and co-curricular activities that support recruitment, retention, transfer (if appropriate), student success, academic/career pathways, and graduation in STEM.

The S-STEM program seeks to 1) increase the number of low-income academically talented students with demonstrated financial need obtaining degrees in S-STEM eligible disciplines and entering the US workforce or graduate programs in STEM; 2) improve support mechanisms for future scientists, engineers, and technicians, with a focus on low-income academically talented students with demonstrated financial need; and 3) advance our understanding of how interventions or evidence-based curricular and co-curricular activities affect the success, retention, transfer, academic/career pathways, and graduation of low-income students in STEM.

The Science Scholars for Social Justice S-STEM program builds on Cabrini University's Justice Matters curriculum[1] which links civic and social responsibility with student learning. Justice Matters provides "a sequence of developmentally linked, writing-intensive courses taken in the first, second, and third years, as well as a capstone project in the major during the fourth year."[2] The project aims to "cultivate a new generation of scientists with a deep understanding of social justice issues."[3] This project is based on the hypothesis that engaging the S-STEM scholars in STEM learning and career exposure through a framework of social justice will help to secure their retention to graduation and placement in graduate or professional positions in STEM fields. The project investigates how a social justice curriculum impacts students' STEM career and higher education choices, and while also examining how a mentoring program contributes to student success. The project used undergraduate research, career preparation activities, and community service projects bridge science to themes related to social responsibility. Faculty and students share results from the project at Faculty Development Workshops and Cabrini's annual ART and Research Symposium. Community service projects included research on best practices for campus-based community food pantries, which was presented at the 2021 American Chemical Society (ACS) annual meeting and the 2021 National Conference on Undergraduate Research.[4]

[1]Cabrini University Justice Matters Curriculum:
https://www.cabrini.edu/undergraduate/programs/justice-matters-core-curriculum
[2]Cabrini College Core Curriculum description:
https://www.cabrini.edu/about/departments/academic-affairs/core-curriculum
[3]Cabrini Receives National Science Foundation Grant for Science Scholars for Social Justice Project: https://www.cabrini.edu/about/media-hub/news/2016/cabrini-receives-national-science-foundation-grant-for-science-scholars-for-social-justice-project

[4]SSSJ (Science Scholars for Social Justice) (cabrini.edu): https://www.cabrini.edu/about/departments/academic-departments/school-of-natural-sciences-and-allied-health/science/sssj-science-scholars-for-social-justice

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Workshop: Summer School on Decision-Making in Design and Systems Engineering; University of Southern California, Los Angeles, California; June 18-22, 2018
NSF Award: 1751340
Spring 2019: Waste in Full Bloom: "Funded a week of summer school for grad students"
University of Southern California

The educational effort supported under this workshop grant is primarily aimed at providing doctoral students in engineering additional and deeper instruction on the topic of decision making in design and systems engineering contexts. The workshop supported 22 students for an intensive course on the above topic from experts in decision making theory.

Decision making is a critical part of all design processes – from those that result in a product to manufacture to those that yield a process that drives the supply chain or public policy. Rational decisions making is a mathematically based approach that is aimed at removing biases and superfluous issues (i.e., irrationality) from consideration and focusing the decision on relevant and objective measures that contribute to the performance of the end product or process. Advanced study that examines the mathematical foundations of decision making is not available at every university and this workshop was an attempt to more widely educate the next generation of engineering designers and systems engineers.

Engineers and scientists with the above knowledge are needed at the highest levels of research labs, federal and state agencies and industry in order to keep the US competitive globally and this knowledge is essential in dealing with supply chain disruptions associated with the COVID-19 pandemic. Intensive educational experiences such as this workshop course have broad and long-lasting impact in students' educational experiences and strengthen the pipeline of a highly-qualified US workforce.