Crafting Competitive Proposals for NSF Programs Related to Engineering and Computing Education

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***Abstract*— The goal of this workshop is to provide guidance to participants on engineering and computing education funding opportunities at NSF and provide insights on preparing competitive proposals. This will be accomplished through a series of engaging activities including (i) interactive presentations by NSF program directors; (ii) a lively mockproposal review session in which participants work in smallgroups on a real NSF proposal previously emailed to registrants; (iii) an interactive question and answer sessionin which participants will have the opportunity to hear from a panel of current NSF grantees and (iv) conversations with NSF program directors about funding opportunities. The workshop will describe current funding opportunities related to improving engineering education. Guidance will be provided on how to write persuasive and competitive proposals. Participants will have the opportunity to network with peers and connect with NSF program directors.**

Keywords—National Science Foundation, engineering education, innovation, funding opportunities, proposal submission, merit review

I. INTRODUCTION

Challenging engineering, scientific, and societal problems occurring at the interfaces of multiple fields have created a need for professionals with disciplinary expertise who can also work effectively at these interfaces [1]. Convergent approaches that address these complex problems require integration of procedural and declarative knowledge from engineering, mathematics, science, and social science.

One example is the Quantum Information Science and Engineering Network (QISE-NET), which is led by the University of Chicago and Harvard University and is funded by NSF in response to the NSF Quantum Leap challenge [2]. This project includes a convergent education approach that provides graduate students with industry and faculty mentors from multiple disciplines including materials science, chemistry, device engineering, physics, and computer science.

Another example is a project at Bucknell University that will help undergraduate engineering students learn how to address convergent problems [3]. The project will integrate convergent problems into undergraduate courses, improve students' technical and professional skills, and align assessment practices with the abilities students will need to solve convergent problems.

A recent NSF funded workshop was held to examine the need for convergence education at all educational levels [4]. The workshop identified action items for implementing convergence education including developing communities of practice, providing faculty development to support involvement in the NAE Grand Challenges [5], and creation of new opportunities for increasing interaction between students and faculty with expertise from transdisciplinary fields.

Several divisions at NSF offer a suite of grant programs that constitute a comprehensive approach to improving content and revolutionizing delivery to strengthen engineering education at multiple educational levels. Four of these divisions are the divisions of Undergraduate Education (DUE), Graduate Education (DGE), Research on Learning (DRL), and Engineering Education and Centers (EEC). These programs represent a broad portfolio of investments in engineering education research and development which place NSF in a

strategic position to (i) support the transformation of engineering and science education, (ii) support efforts to broaden participation in the engineering and scientific workforce, and (iii) encourage bold long-term ideas for future engineering and science education investment. NSF program directors from these and other divisions regularly engage in outreach to the engineering and science education communities including colleges, professional societies, and industry groups. These outreach efforts occur through pre-conference workshops such as the one described in this paper with the goal of sharing information about current funding opportunities and how to craft competitive NSF proposals.

II. WORKSHOP GOALS

The major goals of the workshop are to:

1. Help participants make informed decisions about which programs are aligned with their proposal ideas.
2. Provide guidance to participants on how to craft a compelling and realistic proposal that is well-reasoned, well-organized, and based on a sound rationale.
3. Provide opportunities for participants to learn from Principal Investigators (PIs) of NSF-funded projects.
4. Give participants an opportunity to engage directly with (i) NSF program directors and (ii) to have authentic exchanges regarding proposal submission and post-award project execution experiences
5. To provide participants with an opportunity to experience the merit review process first-hand, through application of approved merit review criteria to actual proposals submitted to NSF

The content and format of the workshop are similar to previous workshops conducted by NSF.

III. WORKSHOP TOPICS

The primary anticipated audience for the workshop includes engineering, technology, and computing faculty, faculty from other STEM fields, K-12 instructors, education researchers, individuals from industry and engineering professional societies. The workshop topics have been selected to focus on the needs of this audience and will be delivered through an engaging presentations as well as discussions and panel sessions conducted by NSF program directors in concert with NSF grantees and workshop participants. The topics are as follows:

1. Engineering Education Programs from the NSF divisions referenced in section I - EEC, DRL, DUEand DGE. Presentations will include examples of projects that align with the FIE conference theme ofEnvisioning Convergence in Engineering Education
2. Extending the Frontiers of Knowledge – EducationResearch
3. Preparing Competitive Engineering EducationProposals – Dos and Don'ts
4. The NSF Merit Review Process
5. Experiences and Insights from Recent NSF Grantees(Grantee Q&A Panel Session)
6. Mock Proposal Review (Review of a PreviouslySubmitted NSF Proposal)
7. NSF's "10 Big Ideas" for Future Investment

A brief description of each of the above topics is provided in sections IV - XIII below.

IV. ENGINEERING EDUCATION PROGRAMS FROM THE DIVISIONOF ENGINEERING EDUCATION & CENTERS (EEC)

EEC supports engineering education research in four main programs: RFE, RIEF, CAREER, and RED. Research in the Formation of Engineers (RFE; PD 19-1340) is the core program supporting research and design and development projects in engineering formation; this program has no deadline. Research Initiation in Engineering Formation (RIEF, NSF 20-558) provides a mentored research experience for individuals who are new to education and social science research. Candidates for RIEF grants are typically engineering disciplinary faculty with strong interests in engineering education. CAREER (NSF 20-525) is the agency-wide program that supports early career researchers who propose a compelling vision for research, education, and career trajectory. Revolutionizing Engineering Departments (RED, NSF 19-614) focuses on cultural change within an academic unit and provides funding over five years to engineering departments or small colleges to enact fundamental change to their culture, including changes to curriculum, policy, and other dimensions of the undergraduate student experience. EEC also participates in closely allied programs in Research on Emerging Technologies for Teaching and Learning (RETTL) (NSF 20-612), and ethical and responsible research (NSF 19-609), among others.

V. ENGINEERING EDUCATION PROGRAMS FROM THE DIVISIONOF RESEARCH ON LEARNING (DRL)

The Division of Research on Learning in Formal and Informal Settings supports engineering education research and development projects through several programs. The Advancing Informal STEM Learning (AISL, NSF 20-607) funds projects that advance new approaches to and evidence- based understanding of STEM learning in informal learning environments for learners of all ages. Discovery Research PreK-12 (DRK-12, NSF 20-572) focuses on learning and teaching of STEM by preK-12 teachers and students. The Innovative Technology Experiences for Students and Teachers (ITEST, NSF 19-583) program also focuses on pre- college STEM learning in either school or out-of-school settings, with a particular focus on underserved populations. Each of these programs also supports computing education, while Computer Science for All (CSforAll, NSF 20-539) specifically supports CS and CT education in preK-12 schools. DRL also supports engineering and computing education research through the CAREER program, where proposals should align with one of

DRL's programs. The Education and Human Resources Core Research program (ECR, NSF 19-508) and the Building Capacity for STEM Education Research (BCSER, NSF 20-521) are two programs that support work across DRL, DUE and DGE and are described in section VII.

VI. ENGINEERING EDUCATION PROGRAMS FROM THE DIVISIONOF UNDERGRADUATE EDUCATION (DUE)

Funding opportunities for engineering education include the Improving Undergraduate STEM Education (IUSE), Scholarships in STEM (S-STEM), and Advanced Technological Education (ATE) programs. The goal of the IUSE program (NSF 21-579) is to promote novel, creative, and transformative approaches for generating and using new knowledge about STEM teaching and learning to improve STEM education for undergraduate students. The goals of the S-STEM program (NSF 21-550) are to increase the number of low-income academically talented students that graduate from STEM degree programs and to generate knowledge to advance our understanding of how evidence-based interventions affect the success of low-income students. The ATE program (NSF 18-571) is designed to train qualified science and engineering technicians to meet workforce demands and provide professional development to educators in technical education programs. ATE projects must be led by faculty in two-year technical education programs.

VII. ENGINEERING EDUCATION PROGRAMS FROM THE DIVISIONOF GRADUATE EDUCATION

There are four DGE programs that are related to engineering education. The goal of the NSF Research Traineeship program (NRT, NSF 21-536) is to encourage the development and implementation of new and potentially transformative models for STEM graduate education and training. The Innovations in Graduate Education (IGE, NSF 20-595) projects are intended to generate the knowledge required for customization, implementation, and broader adoption of models for graduate education training. The goal of the Graduate Research Fellowship program (GRFP, NSF 20-587) is to help ensure the vitality and diversity of the STEM workforce through the award of three-year fellowships for graduate study. As the oldest federal fellowship program, GRFP provides a graduate student stipend and covers tuition. The CyberCorps Scholarship for Service program (SFS, NSF 19-521) offers scholarships to students enrolled in cybersecurity programs to increase the production of quality cybersecurity professionals. The Education and Human Resources Core Research program (ECR, NSF 19-508) supports fundamental research on STEM learning and learning environments, broadening participation in STEM, and STEM workforce development. Finally, the Building Capacity for STEM Education Research (BCSER, NSF 20-521) supports activities that enable early and mid-career researchers to acquire the requisite expertise and skills to conduct rigorous fundamental STEM education research.

VIII. EXTENDING THE FRONTIERS OF KNOWLEDGE - EDUCATIONRESEARCH

The purpose of educational research is to advance our understanding of how people learn, how different structures, systems and people support student learning, and how to measure learning. In this interactive mini-presentation, participants will experience how to incorporate educational research into their projects in simple but meaningful ways. Using an example of a qualitative approach, volunteers from among the workshop participants will help NSF program officers guide the group through the setting up of a research study on students' experiences with online learning. Working in teams, participants will engage in brief discussions on the formal statement of research questions, data collection as well as analysis and interpretation of data. Participants will be encouraged to familiarize themselves with the Common Guidelines for Education Research and Development [6] a collaborative publication from the NSF and the Department of Education.

IX. PREPARING COMPETITIVE ENGINEERING EDUCATIONPROPOSALS - DOS AND DON'TS

Competitive proposals for engineering education programs should possess at least two important characteristics. First, alignment with the program opportunity as specified in the program solicitation. This may include, in some programs, requirements with respect to educational research through posing one or more research questions that will be answered by selection of an appropriate research methodology. In other programs, evaluation of project activities, impacts, or outcomes may be more appropriate. A second important characteristic of a competitive proposal is the clear articulation of project goals, tasks to be undertaken and investigations planned. This is important from the standpoint of the proposal review process. Proposers should not assume that reviewers have detailed knowledge of the specific STEM discipline(s), educational/institutional context, or methodologies to be employed. Reviewers for engineering education programs come from many disciplines (including non-engineering ones), work in diverse organizations, and bring multiple perspectives to the review panel. More details of these and other tips for preparing competitive proposals will be shared during this part of the workshop.

X. THE MERIT REVIEW PROCESS

Each proposal submitted to an NSF program is evaluated on its own merit using the NSF merit review process. In this part of the workshop, the NSF merit review principles and criteria will be presented along with an overview of the merit review process [7]. NSF reviewers evaluate proposals against two merit review criteria. The first criterion is Intellectual Merit which asks the question "What is the potential of the proposed project to advance the frontiers of knowledge within its own field or across other fields?" The second criterion is Broader Impacts which asks the question "What is the potential to benefit society and contribute to the achievement of specific, desired societal outcomes?" Reviewers also consider the extent to which the

proposed activities are creative, original, or potentially transformative, the quality of the project plan, the mechanism to access success, the expertise of the project team and the available resources to support the project. Some programs also include solicitation- specific review criteria. One example is the ITEST program (NSF 19-583) which asks reviewers to also consider four additional questions related to how the proposal serves (an) underserved population(s) and how the proposed activities are developmentally appropriate.

XI. EXPERIENCE AND INSIGHTS FROM RECENT NSF GRANTEES

This is a highly interactive session during which workshop participants will have the opportunity to hear directly from recently funded NSF grantees about their experience with the pre-award process of writing and submitting an engineering education proposal to NSF. In addition, grantees will describe their post-award experiences including project execution challenges. During the session, a panel of grantees selected from a broad range of engineering education programs will briefly describe their projects. Workshop participants will then be invited to pose questions to the panel. This component of the workshop is usually well received as it provides participants with an authentic glimpse of the NSF grant proposal processing system from the perspective of the PI.

XII. MOCK PROPOSAL REVIEW

This is another very interactive component of the workshop in which participants review and discuss real proposals submitted to NSF Engineering Education Programs. The format will be a mock-panel designed to demystify the NSF merit review process by mimicking an NSF review panel. Each participant will serve in the role of reviewer, reading an actual NSF proposal and evaluating its components. Using the two merit review criteria by which NSF judges all proposals, participants will obtain valuable insights into the review process and gain an appreciation for the attributes that distinguish a competitive grant proposal. Working in teams, participants will rate the proposal using the merit review criteria, discussing the strengths and weaknesses of the project. The team will assign a facilitator, scribe, and speaker to share feedback with the larger group about the proposal's strengths and weaknesses. An NSF program officer will debrief the exercise and share with participants reviewer perspectives from the actual review panel. A reflection on the process, with opportunities to for comments and questions, will close this portion of the workshop.

XIII. NSF BIG IDEAS FOR FUTURE INVESTMENT

This mini- presentation directs the attention of workshop participants to potential future NSF investments, in particular, the "Big Ideas" - ten bold, long-term research ideas that identify areas for future investment at the frontiers of science and engineering. This component of the workshop directs the attention of participants toward two of the Big Ideas - Harnessing the Data Revolution and Shaping the New Human-Technology Frontier. The presentation will focus on requirements for the education of the next generation of scientists and engineers for the future job market highlighting the need for proposals that target specific educational research questions as well as proposals (involving research partnerships between stakeholders) that investigate technological advances for which future workers need to be trained.

XIV. WORKSHOP AGENDA

Activity	**Details of Activity**		
	Description	***Lead Facilitator***	***Time***
Mini Presentation 1	Engineering Education Programs from EEC & DRL	NSF PDs	10 min
Mini Presentation 2	Engr Educ Programs from DUE & DGE	NSF PDs	10 min
Q&A Session	Questions from Participants (Breakout groups)	Workshop Participants	10 min
	--------- BREAK -------		10 min
Grantee Q&A Panel	Experience & Insights from Recent Grantees	NSF Grantees	40 min
Round Table Discussion	Educ Research Extending Knowledge Frontiers	NSF PDs & Participants	20 min
Mini Presentation 3	The Merit Review Process	NSF PDs	10 min
Mock Proposal Review Panel	Team-Based Review of Previously Submitted NSF Proposals (Breakout groups)	NSF PDs & Workshop Participants	40 min
	--------- BREAK --------		10 min
Mini Presentation 4	NSF Big Ideas for Future Investments	NSF PDs	10 min
Concluding Activities	Closing Discussions and Final Questions	All	10 min

XV. QUALIFICATIONS OF PRESENTERS

Presenters are experienced program directors employed by the National Science Foundation. All have Ph. D degrees in engineering or engineering education and extensive teaching, research, and industry experiences. Each program director is responsible for managing a subset of the funding the programs described including development of solicitations, proposal review, proposal administration and outreach to the PI community.

XVI. INTENDED AUDIENCE AND EXPECTED OUTCOMES

The intended audience for the workshop includes K-12 instructors, faculty in engineering and engineering technology programs, college administrators, sponsored program officers, graduate students, and post-docs. By the end of the workshop,

participants should have a better understanding of NSF funding programs in engineering and technology education aswell as a better understanding of how to prepare a compellingproposal that is aligned with NSF program objectives.

XVII. ACKNOWLEDGMENT

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