

# How To Prepare Competitive NSF Engineering Education Proposals

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***Abstract***—The goal of this workshop is to provide guidance to participants on engineering education funding opportunities at the National Science Foundation (NSF). This will be accomplished through a combination of activities including (i) interactive and dynamic mini-presentations by NSF program directors; (ii) a mock proposal review session by participants working in small groups and (iii) an interactive question and answer session in which participants have the opportunity to cross-examine a panel of current NSF grantees. In describing the various funding opportunities relevant to engineering education, the workshop will place emphasis on fostering innovation through diversity (consistent with the FIE 2018 conference theme) and give guidance on how to write persuasive and competitive proposals. Participants will experience rich peer interactions and also have the opportunity to connect directly with NSF program directors.

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

## I. INTRODUCTION

This is an exciting time for engineering education nationally and globally, a period of fundamental and disruptive change. Enrollments are peaking in the nation's colleges of engineering and the role of engineering educators is changing rapidly [1]. Engineering students expect learning experiences that are not only increasingly engaging but also highly personalized. More than ever before, engineering faculty are recognizing that students are highly complex human beings whose performance in a class is a function of a large number of factors including motivation, self-confidence, personal life circumstances and instructional approach. The NSF Division of Undergraduate Education (DUE) and the Division of Engineering Education and Centers (EEC) offer grant programs that constitute a comprehensive approach to

strengthening engineering education at the nation's colleges. These programs represent a broad portfolio of investments in engineering education research thus placing DUE and EEC in a strategic position to not only enhance the practice of engineering education but also to foster innovation through diversity. NSF program directors from DUE and EEC regularly engage in outreach to the engineering education community including colleges, professional societies and industry groups. These outreach efforts occur through workshops such as the one described in this paper with the goal of sharing information about current funding opportunities as well as de-mystifying the processes involved in crafting competitive NSF proposals.

## II. WORKSHOP GOALS

The major goals of the workshop are to:

1. Present a coherent and concise account of NSF funding programs in engineering education (including examples of successful projects) in an interactive and engaging manner in order to equip participants to make informed decisions on where to submit proposals.
2. Equip participants with a good understanding of how to put together a compelling and realistic proposal that is innovative and well planned.
3. Give participants an opportunity to engage directly with (i) NSF program directors and (ii) Principal Investigators (PIs) of NSF-funded projects in order to have authentic exchanges regarding proposal planning and submission as well as post-award project execution and reporting.
4. To provide participants with an opportunity to experience the merit review process first-hand, through transparent application of approved merit review

criteria on actual proposals previously submitted to NSF.

### III. WORKSHOP TOPICS

The primary anticipated audience for the workshop consists of engineering and computing faculty, faculty from other STEM fields, 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 a rich mixture of engaging presentations, discussions and panel sessions jointly conducted by NSF program directors, NSF grantees and workshop participants themselves. The topics are as follows:

1. Engineering Education Programs from the Division of Undergraduate Education (DUE)
2. Engineering Education Programs from the Division of Engineering Education and Centers (EEC)
3. Extending the Frontiers of Knowledge – Education Research
4. Preparing Competitive Engineering Education Proposals – Dos and Don'ts
5. The NSF Merit Review Process
6. Experiences and Insights from Recent NSF Grantees (Grantee Q&A Panel Session)
7. Mock Proposal Review (Review of Previously Submitted NSF Proposal)
8. NSF's "10 Big Ideas" for Future Investment

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

#### IV. ENGINEERING EDUCATION PROGRAMS FROM THE DIVISION OF UNDERGRADUATE EDUCATION (DUE)

Three important engineering education funding opportunities from DUE are available through the following programs:

- (i) Improving Undergraduate STEM Education (IUSE)
- (ii) Scholarships in STEM (S-STEM)
- (iii) Advanced Technological Education (ATE)

These programs, briefly described below, will be presented during the workshop and examples of actual projects shared.

##### *A. Improving Undergraduate STEM Education: IUSE*

The IUSE supports projects that have the potential to improve undergraduate student learning in STEM through development of new curricular materials and new approaches to teaching. Projects that focus on the development of new assessment tools to measure student learning are supported. Additionally, projects that aim to produce knowledge about the transferability of findings of research studies from one institution to another are also supported. The IUSE program features two approaches or "tracks": 1) Engaged Student

Learning (ESL) and 2) Institutional and Community Transformation (ICT). The ESL track focuses on the development and implementation of resources for increasing the engagement of undergraduate students in STEM. These resources might include education research studies, tools for personalized tutoring and faculty professional development activities. The ICT track supports projects that aim to propagate effective approaches to STEM teaching and learning using innovative approaches to increase the use of evidence-based STEM teaching and learning practices across and/or within disciplinary communities.

##### *B. Scholarships In STEM Program (S-STEM)*

Another program within DUE that is relevant to engineering education is the S-STEM program which provides awards to fund scholarships for students majoring in STEM who are both academically talented and financially needy. The expectation is that partly as a result of the scholarships, an increased number of low-income students will be recruited and retained in STEM programs. However, since giving money to a financially needy student is often not enough to guarantee improved persistence, the S-STEM program also funds the implementation of evidence-based curricular and co-curricular activities that support the retention and persistence of students.

##### *C. Advanced Technological Education Program (ATE)*

A third major funding opportunity for engineering education within DUE is the Advanced Technological Education Program (ATE). The ATE program promotes improvements in the education of technicians at the undergraduate level to meet workforce demands. While the focus is on colleges that award two-year degrees in advanced technology fields, partnerships with four-year institutions, K-12, industry and government are strongly encouraged. Fields of technology supported by the ATE program include advanced manufacturing, energy, environmental and information technologies.

#### V. ENGINEERING EDUCATION PROGRAMS FROM THE DIVISION OF ENGINEERING EDUCATION AND CENTERS (EEC)

Two EEC programs of particular interest to the engineering education community that will be addressed in the workshop are described below.

##### *A. Research in the Formation of Engineers (RFE)*

The goal of the Research in the Formation of Engineers (RFE) program is to advance and deepen our understanding of professional formation and to demonstrate how it can be accomplished. RFE welcomes proposals in two categories: (i) Research Projects and (ii) Design and Development Projects. Research Projects address fundamental questions of professional formation, while Design and Development Projects provide new approaches to achieving professional formation. Projects in both categories should address the iterative cycle in which research questions that advance understanding are informed by practice and the results of research are, in turn, translated into practice.

### *B. Broadening Participation in Engineering (BPE)*

The broadening participation in engineering program specifically seeks to create a more inclusive engineering environment. Recognizing the value of diverse perspectives, BPE funds projects that support the increased participation of individuals who are members of underrepresented groups. Examples of funded projects include workshops to explore the barriers to broadening participation and funding to support mentoring and participation of diverse groups in professional meetings.

## VI. EXTENDING THE FRONTIERS OF KNOWLEDGE – EDUCATION RESEARCH

The purpose of education research is to enlarge the body of scientific knowledge in the field of education through rigorous investigation that contributes to generalizable knowledge. In this interactive mini-presentation, participants will experience how to incorporate education research into their projects in simple but effective ways. Using an experimental design example, volunteers from among the workshop participants will help NSF program officers guide the group through the setting up of a research study on the effects of virtual tutoring on engineering student achievement and attitude. 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. Key ideas central to experimental designs such as random assignment, pre- and post-tests and outcome measures will be considered. Participants will be encouraged to familiarize themselves with the Common Guidelines for Education Research and Development [2] a collaborative publication from the NSF and the Department of Education.

## VII. PREPARING COMPETITIVE ENGINEERING EDUCATION PROPOSALS: DOS AND DON'TS

Proposers often ask questions such as “How soon should I begin work on my engineering education proposal?” and “Should I hire a consultant or use an advisory board for evaluation?”. This mini-presentation will offer participants valuable guidance with regard to these and other practical questions pertaining to proposal planning and preparation. Vivid charts and timelines will be employed to demonstrate the importance of timing and the need for proposers to be proactive. Simple but illustrative tools will be employed to underscore importance of communicating spoken and written ideas clearly and concisely. Emphasis will be placed on the importance of adhering to solicitation guidelines and the NSF Proposal Awards Policies and Procedures Guide [3].

## VIII. THE MERIT REVIEW PROCESS

When a funding opportunity is announced, proposals are received and NSF program directors conduct high integrity merit review of proposals in order to determine which projects to recommend for funding. In this five-minute interactive mini-presentation, the NSF merit review principles and criteria

[3] will be described and an overview of the merit review process provided. These two criteria are:

1. Intellectual Merit: The Intellectual Merit criterion encompasses the potential to advance knowledge
2. Broader Impacts: The Broader Impacts criterion encompasses the potential to benefit society and contribute to the achievement of specific, desired societal outcomes.

Emphasis will be placed on the fact that the two criteria are given equal consideration during the review and decision-making processes. A number of poignant examples of proposal elements that represent strong intellectual merit (IM) and good broader impacts(BI) criteria will be shared. Furthermore, rather than simply listing the IM and BI activities, participants will be reminded to clearly articulate their impact.

## IX. EXPERIENCES AND INSIGHTS FROM RECENT GRANTEES

In this highly interactive session, workshop participants will have the rare opportunity to hear directly from recently funded NSF grantees about their experience with the process of planning, crafting and submitting an engineering education proposal to NSF. In addition grantees will describe their post-award experiences including project execution successes and challenges and the submission of progress reports. During the session, four grantees, each of whom is a PI on an engineering education project awarded within the last five years, will introduce themselves and briefly describe their projects. Workshop participants will then be invited to pose questions. In past outreach efforts, this activity has proved extremely popular giving workshop participants an authentic glimpse of proposer interaction with the NSF proposal grants system.

## X. MOCK PROPOSAL REVIEW

In this team-oriented workshop session, participants are given the opportunity to conduct high integrity transparent reviews a proposal previously submitted to NSF. The 15-page project description section of an engineering education proposal, appropriately sanitized for proposer anonymity, is provided to participants at the beginning of the session. Working in teams, participants will review, discuss and rate the proposal using the merit review criteria. Following this, a spokesperson from each team will summarize the team's discussion and ratings to the entire group of participants. The mock proposal review format is a highly effective approach that has proved to be quite popular for communicating the nuances of the NSF merit review process.

## XI. NSF BIG IDEAS FOR FUTURE INVESTMENT

What skills will be needed by the US workforce in order to succeed in future work environments? This mini-presentation directs the attention of workshop participants away from the present to potential future NSF investments. Recently, NSF unveiled a set of “Big Ideas” - ten bold, long-term research ideas that identify areas for future investment at the frontiers of science and engineering. This mini-presentation will focus on two of the Big Ideas relevant to engineering: i) Harnessing Data and ii) Shaping the New Human-Technology Frontier.

Workshop participants will brainstorm questions on how to develop appropriate educational pathways to ensure a future data-capable workforce and to find solutions to research challenges associated with educating future engineers who will design human-centered automated systems.

## XII. WORKSHOP AGENDA

The above topics will be presented during the engaging three hour NSF workshop through a series of interactive mini-presentations and vibrant panel sessions. Table 1 is the workshop agenda that depicts a chronological listing of the rich array of workshop activities ranging from mini-presentations and discussions to mock proposal review and grantee panel sessions. While NSF program directors will facilitate overall workshop proceedings, session leadership will be inclusive with active participation from workshop participants, NSF grantees and NSF program directors.

Specifically, the format of the five NSF-led mini-presentations will be highly interactive 5-10 minute powerpoint presentations interspersed with informative video clips, thoughtful reflection questions and appropriate small group activities.

The grantee-led Q&A panel session will be conducted by three NSF grantees each of whom is a PI on an engineering education project awarded within the last five years (grantees will be identified well before the conference for confirmation of their willingness to participate). Following brief self-introductions of the grantees and their projects, questions will be taken from workshop participants during the informal 50-minute session.

The mock proposal review session is a 50-minute long team-based activity orchestrated by workshop participants. Urged to gather in freshly formed teams, participants organize themselves into proposal review panels tasked with reviewing and rating a real (anonymized) proposal previously submitted to NSF. An actual NSF panel review template will be provided to each participant for completion during review. A spokesperson for each team will report team findings to the general workshop audience. The session concludes with an opportunity for thoughtful reflections about the proposal merit review process. Approximate session timings are:

- (i) Reading & Rating proposal 25min
- (ii) In-Panel Discussions 10min
- (iii) Report-Out & Reflections 20min

## XIII. 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.

## XIV. INTENDED AUDIENCE & KNOWLEDGE ACQUIRED

The anticipated audience is engineering and other STEM faculty as well as college administrators, sponsored program officers, graduate students and post-docs. At the end of the workshop, participants will have acquired extensive knowledge about NSF funding programs in engineering education as well as a good understanding of how to prepare a persuasive engineering education proposal.

### Workshop Agenda

Activity	Details of Activity		
	Description	Lead Facilitator	Time
Mini Presentation 1	Engineering Education Programs from DUE	NSF PDs	10min
Mini Presentation 2	Preparing Competitive Engineering Education Proposals	NSF PDs	10min
Grantee Q&A Panel	Experience & Insights from Recent Grantees	NSF Grantees	50 min
	----- BREAK -----		10min
Mini Presentation 3	Engr Educ Programs from EEC	NSF PDs	5min
Round Table Discussion	Extending Knowledge Frontiers: Educ. Research	Workshop Participants	15min
Mini Presentation 4	The Merit Review Process	NSF PDs	5min
Mock Proposal Review Panel	Team-Based Review of Previously Submitted NSF Proposals	Workshop Participants	55min
	----- BREAK -----		5min
Mini Presentation 5	NSF Big Ideas for Future Investments	NSF PDs	5min
Concluding Activities	Closing Discussions	All	10min

## XV. ACKNOWLEDGEMENTS

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## XVI. REFERENCES

- [1] National Academy of Engineering, "Educating Engineers: Preparing 21<sup>st</sup> Century Leaders in the Context of New Modes of Learning", Washington DC, The National Academies Press. Retrieved April 25, 2018 from <https://www.nap.edu/catalog/18254/educating-engineers-preparing-21st-century-leaders-in-the-context-of>
- [2] U.S. Department of Education and the National Science Foundation. (2013). Common Guidelines for Education Research and Development: A Report from the Institute of Education Sciences, U.S. Department of Education and the National Science Foundation, NSF 13-127, Arlington, VA: National Science Foundation. Retrieved April 24, 2018 from [https://www.nsf.gov/publications/pub\\_summ.jsp?ods\\_key=nsf13126](https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf13126)
- [3] Proposal Award Policies and Procedures Guide. Retrieved April 24, 2018 from [https://www.nsf.gov/pubs/policydocs/pappg18\\_1/nsf18\\_1.pdf](https://www.nsf.gov/pubs/policydocs/pappg18_1/nsf18_1.pdf)