

# Designing Transformative Engineering Education Projects Towards National Science Foundation Funding Success

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**Abstract** — The National Science Foundation (NSF) awards millions annually to transform and continuously improve STEM education and engineering education in the United States. In order to position the engineering education community towards funding success, this session is designed to help investigators who are new to NSF and new to funded engineering education projects. Following common guidelines towards effective education research projects (from foundational research to design and development research to efficacy research to scale-up research), session attendees will learn about the critical elements that lead to successful engineering education projects and learn about a variety of NSF Programs that support engineering education transformation initiatives, from course-level innovations to curricular transformations to institutional transformations.  
**Keywords**—*engineering education, National Science Foundation, common guidelines education research.*

## I. INTRODUCTION

Engineering education transformations can vary from curricular innovations across one course to entire engineering curricula, to pedagogical innovations that span one course or entire curricula, to advising and extra-curricular innovations to better the educational experiences of students, to mentoring models that support student success, to fundamental research that enable us to understand the student or educator experiences, to institutional transformations that build bridges across programs, to building partnerships with industry, to building partnerships across diverse institutions, etc. This list of engineering education transformations is not exhaustive and

simply points to just some of the ways that educators, academic leaders, and researchers aim to improve engineering education.

The National Science Foundation (NSF) annually funds millions to transform STEM education from kindergarten through higher education and beyond. Specific to engineering education, there are several NSF programs that target engineering education projects spanning research types, engineering disciplines, student populations, partnerships, impacts, etc. Just some of these programs include:

- NSF Improving Undergraduate Engineering Education (IUSE)
- NSF IUSE/Professional Formation of Engineers: Revolutionizing Engineering Departments (RED)
- NSF STEM Education (EDU) Core Research (ECR)
- NSF Faculty Early Career Development Program (CAREER)
- NSF Experiential Learning for Emerging and Novel Technologies (ExLENT)
- NSF Racial Equity in STEM Education
- NSF Advancing Informal STEM Learning (AISL)
- NSF Advanced Technological Education (ATE)
- NSF Scholarships in STEM (S-STEM)
- NSF Robert Noyce Teacher Scholarship Program (Noyce)
- NSF ADVANCE: Organizational Change for Gender Equity in STEM Academic Professions
- NSF Hispanic-Serving Institutions (HSI): Enriching Learning, Programs, and Student Experiences (ELPSE)

- NSF Historically Black Colleges and Universities Undergraduate Program (HBCU-UP)
- NSF Tribal Colleges and Universities Program (TCUP)
- NSF Broadening Participation in Engineering (BPE)
- NSF Engineering Research Initiation (ERI)
- NSF Industry-University Cooperative Research Centers (IUCRC)
- NSF Research Initiation in Engineering Formation (RIEF)
- NSF Research in the Formation of Engineers (RFE)
- NSF Research Experiences for Undergraduates (REU)
- NSF-Lemelson Initiative on Environmental and Social Sustainability in Engineering Education

The NSF funding opportunities are many, and while program funding levels, success rates, and target areas vary by NSF programs, the process of crafting a strong NSF proposal offers many benefits even if funding is not possible. This session will focus on helping new investigators in the preparation of engineering education projects that could be positioned for NSF submission.

This session is built on the assumption that most engineering educators who teach in undergraduate engineering education programs have a MS or PhD in an engineering discipline but may lack education research expertise to support key initiative to transform engineering education. Although many new engineering faculty hires bring an incredible amount of technical engineering expertise, they often lack teaching experience and pedagogical know-how. In time, they gain teaching and pedagogical expertise that can support transforming and continuously improving engineering education. Similarly, many engineering education academic leaders (e.g. chairs, heads, deans) may lack the expertise to look holistically at the undergraduate engineering experiences and navigate the complexity of higher education systems to deliver improved or transformative engineering education experiences. Developing new initiatives to transform and improve engineering education is not trivial and requires planning and strong teams. Traditionally trained engineering educators simply lack the full qualifications and foundational knowledge to turn engineering-specific knowledge to transformations that will better engineering education cultures, classroom environments, learning approaches and pedagogies, student experiences holistically, curricular structures, inclusive environments, curricular structures, advising and mentoring models, institutional transformations, authentic partnerships, etc. Engineering educators need to bring effective expertise, project teams, research methods and plans, assessment practices, implementation strategies, and feedback methods in support of purposeful and impactful engineering education transformation efforts.

## II. SESSION DETAILS

In this section, we provide details about the session including the goals of the session, the anticipated audience, and the relevance of this session to conference attendees.

### A. Session Goals

The goals of the session are to enable participants to:

- (1) Gain knowledge about NSF funding opportunities related to engineering education transformations.
- (2) Understand the elements of effective education research projects.
- (3) Generate action items to plan and put together effective education research projects towards NSF funding.

### B. Anticipated Audience

The anticipated audience is engineering educators, computing educators, STEM educators, and all others (e.g. program evaluators, social scientists, academic leaders, etc.) who impact engineering education in diverse ways. Although new investigators would benefit most from this session, existing NSF investigators who are looking to seek NSF funding from other NSF programs can benefit as well. This session is relevant to all engineering and computing educators and not only those who teach. Anyone who touches in any way engineering education can benefit from attending this session.

### C. Topics to be Covered

In this session, NSF Program Directors will share knowledge about NSF Programs and share elements that are critical to successful NSF engineering education projects. A major component of the session is to leverage common guidelines for conducting education research [1] which offers a framework to understand a spectrum of education research types (e.g. foundational research, early stage or exploratory research, design and development research, efficacy research, effectiveness research, and scale-up research) and guidelines pertaining to project purpose, significance, theoretical or empirical basis, outcomes, research plan, and feedback plan.

## III. SESSION AGENDA

The special session will be interactive to allow small-group and large-group discussion. The session will be guided by the following agenda and sequencing:

- 1. Introduction and Framing (10 mins)**
- 2. Interactive Participation Part I**
  - a. Individual thinking and Reflection (5 mins)
  - b. Small-Group Discussion and Activity (10 mins)
  - c. Large-Group Discussion (10 mins)
- 3. Common Guidelines to Education Research (10 mins)**
- 4. Interactive Participation Part II**
  - a. Individual thinking and Reflection (5 mins)
  - b. Small-Group Discussion and Activity (10 mins)
  - c. Large-Group Discussion (10 mins)

## 5. Overview of NSF Programs Pertinent to Engineering Education (10 mins)

## 6. Closing and Concluding Remarks (5 mins)

To support the session attendees, handouts and guiding documents (e.g. templates and resources) will be provided and shared with attendees.

### IV. EXPECTED OUTCOMES

Expected outcomes of the session include: (1) new knowledge to understand the critical elements of effective education research projects in support of transformative engineering education initiatives, (2) project planning and scoping to support engineering education transformation initiatives that could be positioned for NSF funding, and (3) understanding better how to navigate the wide-array of NSF programs that support engineering education projects and initiatives.

### V. FACILITATOR BIOGRAPHIES

There are five facilitators for this session and their biographies are provided herein.

**Dr. Olga Pierrakos** is a rotating NSF Program Director for a second stint in the Division of Undergraduate Education in the Directorate of STEM Education. Olga supports currently or has supported previously programs like NSF IUSE, S-STEM, ATE, POSE, CAREER, IUSE RED, ECR, INCLUDES, GRFP, PAIR. NSF Olga is also a Professor of Wake Forest Engineering and served as the Founding Chair of Wake Forest Engineering (2017-2022). Olga is an engineering education researcher, biomedical and mechanical engineer, and national leader in transforming the undergraduate engineering education. She has served as founding faculty of two brand new engineering programs and served on several national roles, including as Program Director at the National Science Foundation, to re-envision engineering education. She has led the founding of Wake Forest Engineering from the ground level to accreditation with a focus on Inclusive and Transformational Innovation. Under her leadership, Wake Forest Engineering has been recognized for the diversity of students (40% women, 25% racial/ethnic diversity), diversity of faculty (50% women, 25% racial/ethnic diversity), curricular and pedagogical innovation, research excellence, and Inclusive Excellence. She is so proud that Wake Forest Engineering was ranked 14<sup>th</sup> Best Undergraduate Engineering Program by US News Report in 2023 across a pool of 275 institutions. Olga is an NSF-funded engineering education researcher that includes a NSF CAREER award.

**Dr. Matthew Verleger** is a rotating Program Director, working in the Engineering Education and Workforce Development clusters of the Engineering Education & Centers Division at the National Science Foundation. He directly

oversees the RIEF, RFE, RED, and CAREER programs. He also has responsibilities with the REU & RET programs. He is a member of the Clean Energy, RITEL, Ethical and Responsible Research (ER2) and Advance AI working groups. He also ran the Ideas Lab on Personalized Engineering Learning. He is currently on rotation from Embry-Riddle Aeronautical University in Daytona Beach, FL where he is a Professor of Engineering Fundamentals. As a faculty member, his research has been in educational software development with direct classroom applications, flipped classrooms, and in the models and modeling space.

**Dr. Lulu Sun** is a rotating Program Director in the Division of Undergraduate Education within the Directorate of STEM Education. She oversees the IUSE, S-STEM, NOYCE programs. She is also a member of the Future Manufacturing working group, and Innovation in Education interagency working group. She serves as a Professor of Engineering Fundamentals in the College of Engineering at Embry-Riddle Aeronautical University (ERAU) in Daytona Beach, FL where she has been teaching since 2006. Dr. Sun earned her Ph.D. in Mechanical Engineering from the University of California, Riverside in 2006. Prior to joining ERAU, she worked as a fire engineer for Arup in Los Angeles, California. Dr. Sun particularly focuses on educational innovation to enhance the learning experiences of STEM students. She promotes an entrepreneurial mindset to encourage innovation and creativity through her gamified flipped classroom.

**Dr. Christine Delahanty** is an NSF Program Director in EDU/DUE. She supports the IUSE, ATE, ITYC, S-STEM, PFE/RED, IDEAS Lab (PEL) programs and is the engineering lead on IUSE and ATE programs. Her background is in electrical engineering and STEM education, and her research focuses on creative self-efficacy and mindset of engineering students, with a focus on increasing gender diversity. She is an Emeritus Professor of Engineering and Physics and former Area Coordinator for Science and Engineering at Bucks County Community College. She developed an engineering technology program, and an advanced technician education program with NSF funding from two ATE grants, to prepare students to enter directly into the workforce. She was advisor to two student teams that made the final round of the AACC Community College Innovation Challenge (CCIC). Prior to her teaching career, Dr. Delahanty was a communications systems engineer at General Electric Co. in both military and commercial satellite operations and has been a consultant for private industry.

**Dr. Nasser Alaraje** is a rotating Program Director in the Division of Undergraduate Education. He supports the ATE, IUSE, S-STEM, ETSTE, RITEL, and ReDDDoT programs and serving as the Data Science lead on IUSE, and as the lead program director for ETSTE. He began his professional career in industry, spending seven years as a senior hardware design engineer with a focus on Embedded Systems design and FPGA design at Lucent Technologies and vLogix. Subsequently, he spent fourteen years at Michigan Technological University as a

faculty member and as chair of the Electrical Engineering Technology program (including a sabbatical year pursuing international outreach activities as a 2013-2014 US Fulbright scholar at Qatar University), followed by his role as a full professor and chair of the Engineering Technology Department in The University of Toledo's College of Engineering. Dr. Alaraje's research focuses on engineering/engineering technology education, with primary interests in curriculum development, workforce development, program outcomes assessment, and continuous improvements; his research has been funded by a variety of federal and state agencies, industrial, and foundation sponsors.

**Dr. Alice Pawley** (she, her, hers) is a Program Director in the Engineering Education and Centers Division of the National Science Foundation, Professor in the School of Engineering Education and an affiliate faculty member in the Women's, Gender, and Sexuality Studies Program, and Environmental and Ecological Engineering, at Purdue University. She received a B.Eng (Chemical – Distinction) from McGill University in Montreal, QC in 1999, a MS (Industrial Engineering) from University of Wisconsin-Madison in 2003 and a PhD (Industrial and Systems Engineering) from University of Wisconsin-Madison in 2007. She was co-PI of Purdue's ADVANCE program from 2008-2014, focusing on the underrepresentation of women in STEM faculty positions. She was a National Academy of Engineering CASEE Faculty Fellow and ASEE ERM Apprentice Faculty recipient in 2007, a CAREER awardee in 2010 and a PECASE awardee in 2012 for her project on

“Learning from Small Numbers.” She received the Denice Denton Emerging Leader award from the Anita Borg Institute in 2013, and the Sterling Olmsted Award in 2020 from the Liberal Education/Engineering and Society Division of ASEE. She has been author or co-author on papers receiving 4 best paper awards from national and international conferences and has received her school's Awards for Excellence in Mentoring, Leadership, and Graduate Teaching. She was president of Purdue's chapter of the American Association of University Professors from 2020-22 and received a special distinguished service award from the Indiana AAUP State Conference in 2024. She helped found, fund, and grow the PEER Collaborative, a peer mentoring group of early career and recently tenured faculty and research staff primarily evaluated based on their engineering education research productivity.

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#### REFERENCES

- [1] 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 13-126. Arlington, VA: National Science Foundation