



SCIENCE & TECHNOLOGY POLICY INSTITUTE

**The Evaluation of Engineering
Education Research: Emerging
Issues and Promising Developments**

Workshop Report

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Bhavya Lal
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Preface

Each year, U.S. colleges and universities prepare tens of thousands of talented individuals who wish to pursue careers in engineering. In 2006 alone, over 68,000 students earned a bachelor's degree in engineering; another 33,000, a master's degree; and 7,100, a doctorate.¹ As in other technical professions, great care is taken by the engineering community to assure that degree recipients receive their training at programs accredited by peers.² Nonetheless, educators have come to recognize that improvements are needed in engineering education to prepare future graduates for the opportunities and challenges facing the profession in the 21st Century – most notably the emergence of the global marketplace and the attendant demand for well-trained high-technology workers who will assure a continuing, strong U.S. presence.³

The cadre of scientists who conduct research in engineering education have responded to this concern over the future of engineering education by turning their attention to needed improvements in the curriculum as well as instructional issues involving such topics as cooperative learning and teamwork, the timing of student exposure to new technologies, and characteristics of student learning strategies and styles – especially given the greater diversity of students now pursuing careers in engineering.⁴

The National Science Foundation (NSF) represents a significant source of support for research in engineering education,⁵ and recently renewed its commitment to this area following the release of a report by the National Science Board outlining steps that might be taken to improve engineering education.⁶ To assure the efficient investment of public funds in the coming years, the NSF Engineering Education and Centers Division (EEC) of the Directorate for Engineering asked the IDA Science and Technology Policy Institute (STPI) to examine a sample of NSF grants programs in engineering education, while also developing a master plan for longer term support for research in engineering education.

An important first step in the STPI effort involved the organization of a workshop of key experts from two very different communities: engineering education research and the

¹ National Science Foundation, *Science and Engineering Degrees: 1966 – 2006 Detailed Statistical Tables*, NSF 08-321, Arlington, VA.

² ABET, Inc. is the recognized national accreditation body for colleges and universities providing training in applied science, computing, engineering, and technology. ABET currently accredits 2,800 programs at more than 600 US colleges and universities. See: www.abet.org.

³ See, for example, the National Academy of Engineering, *Educating the Engineer of 2020*, Washington DC: National Academies Press, 2005.

⁴ J. Heywood, *Engineering Education: Research and Development in Curriculum and Instruction*, Hoboken, NJ: John Wiley & Sons, Inc., 2005, provides a useful overview of research in engineering education.

⁵ See, for example, program announcement NSF 08-610 “Innovations in Engineering Education, Curriculum and Infrastructure” available at www.nsf.gov/2008/pubs.

⁶ National Science Board, *Moving Forward to Improve Engineering Education* NSB 07-122, Arlington, VA, 2007.

evaluation sector. The purpose of the meeting was to discuss ways to strengthen the use of contemporary evaluation methods as NSF enhances its support for research in engineering education.

The report that follows summarizes key observations from the “Thought Leaders’ Workshop” convened on May 29 and 30, 2008, at the National Science Foundation in Arlington, Virginia. The results of that informal discussion provide a useful context for future deliberations by educators, researchers, and policymakers alike.

Pamela Ebert Flattau, Ph.D.
Project Leader
IDA Science and Technology Policy Institute

Acknowledgments

The IDA Science and Technology Policy Institute (STPI) would like to express its gratitude to the scientists, engineers, and educators who made presentations during the workshop (in alphabetical order): Maura J. Borrego, Lori Breslow, Connie Chang, Elizabeth A. Corley, Joan Ferrini-Mundy, Jerald Hage, Aditya Johri, Ronald N. Kostoff, Jonathan Mote, Wendy Newstetter, Barbara Olds, and David F. Radcliffe. Biographical information for each of these participants may be found in Appendix B.

STPI would also like to thank Allen L. Soyster, NSF/EEC Division Director, and Susan C. Kemnitzer, NSF/EEC Deputy Director for Education, who provided important guidance throughout the organization of the workshop, and Margaret Boeckmann for her review of this report.

Finally, STPI would like to recognize the following STPI staff for their contributions to the project. Asha Balakrishnan ably served as the Task Leader for the workshop, while Bhavya Lal provided excellent technical support throughout the activity. Meredith Blake expertly oversaw all logistical arrangements, and Paul Lagasse assisted staff in the preparation of workshop summary materials.

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Executive Summary

On May 29 and 30, 2008, the National Science Foundation (NSF) convened a small group of eminent scientists and practitioners to discuss opportunities and challenges facing research in engineering education and its evaluation. Through a carefully structured dialogue, participants identified a number of factors driving contemporary research strategies – both in engineering education and in evaluation. (See Appendix A for the workshop agenda.) Workshop organizers encouraged participants to “think outside the box” as they explored ways NSF could adapt new tools and methods to evaluate and promote the integration of advances in engineering education research into practice.

Highlights of the workshop discussion follow.

Engineering Education Research

Engineering education research represents a unique component of education research.

- Unlike most undergraduate education, accreditation requirements play a significant role in determining the pedagogical approaches used by U.S. colleges and universities in the education of an engineer.
- Educational strategies in engineering place significant emphasis on “team learning,” as well as problem-solving for innovation.

Research in engineering education emphasizes both research and discovery, but also reform and implementation.

- Contemporary research in engineering education focuses not only on learning processes and individual versus team learning, but also on educational techniques for use in the classroom setting.
- Research in engineering education is highly interdisciplinary, involving engineers, educators, and social scientists, as well as experts from business, industry, and the humanities.

Engineering education research faces two important challenges.

- The incomplete integration of engineering education research into the field of engineering.
- The slow diffusion of research findings into the engineering classroom.

Advances in Evaluation Research

Theoretical advances in evaluation research increasingly assist practitioners in the design of their evaluations.

- Contemporary evaluators look beyond measures of program effectiveness for those factors contributing to that effectiveness.
- Evaluators ask whether findings can be applied beyond the project to the program, the classroom, and society.

Evaluators select a research design based on whether the expected outcomes are near-term, medium-term, or longer-term.

- The specification of expected outcomes suggests the type of evaluation techniques and/or measures that might be adopted by the evaluator.
- However, a type of outcome often overlooked in the design of evaluations involves “spillovers” – that is, downstream effects of new educational strategies in terms of translation.

A variety of evaluation methods exist and can be accessed by engineering education researchers to document the outcomes and impacts of their work.

- Many methods build upon advances in scientometrics and data mining techniques.

Workshop Conclusions and Recommendations

Workshop participants concluded that the “time is right” for engineering education researchers to work more closely and effectively with evaluators.

- Continue the dialogue between the engineering education research and the evaluation research communities through a national consensus conference to enrich engineering education research and its evaluation.
- Provide the highest level of support at the National Science Foundation to assure that evaluation research becomes a stronger, more visible component of grants awarded for engineering education research.

Workshop participants offered several suggestions to the Foundation as it promotes the greater application of evaluation methods to assess the outcomes of engineering education research grants:

- NSF should include in its program announcements and funding criteria clear statements regarding the agency’s expectations for an evaluation component in reports filed by engineering education research grantees.

- In its program announcements, NSF should also describe the expected outcomes of its funding for engineering education research.
- NSF should explore ways to analyze the longer-term outcomes of its engineering education research investments, beyond those reported by grantees.
- NSF should broaden its portfolio in engineering education research to allow for a greater mix of high-risk/high-impact research together with more traditional education research, given the availability of longer-term evaluation research methods.
- NSF should communicate research success stories through fact sheets or other mechanisms -- not only to disseminate research results more widely in the engineering education community, but also throughout the education research community more broadly defined.

The report that follows presents highlights from the two-day workshop, and is organized around the sequence of topics addressed by the agenda.

Engineering Education Research

Engineering education research is a small but growing field in engineering. Scientists may be located in Departments of Engineering Education Research within Schools of Engineering; but, more often they may be found in university-based independent research units or in education research departments located in schools or colleges other than engineering. The American Society for Engineering Education (ASEE) serves as a professional focal point for these researchers and its *Journal of Engineering Education* provides a vehicle to communicate the results of research activities to the scientific and education communities.⁷

Engineering Education Research Represents a Unique Component of Education Research

A national accreditation process shapes student learning strategies in engineering.⁸ Over 300 U.S. colleges and universities award degrees in engineering through programs accredited by ABET, Inc. An example of accreditation guidelines may be drawn from a 2004 listing of professional skills that *all* engineering baccalaureates are expected to possess at the conclusion of their studies:

1. *an ability to apply knowledge of mathematics, science, and engineering;*
2. *an ability to design and conduct experiments, as well as to analyze and interpret data;*
3. *an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturing, and sustainability;*
4. *an ability to function on multidisciplinary teams;*
5. *an ability to identify, formulate, and solve engineering problems;*
6. *an understanding of professional ethical responsibility;*
7. *an ability to communicate effectively;*
8. *the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;*
9. *a recognition of the need for, and an ability to engage in, lifelong learning;*
10. *a knowledge of contemporary issues; and*

⁷ For further information about ASEE and its role in promoting research in engineering education, see: <http://www.asee.org/publications/jee/>

⁸ See, www.abet.org for further information regarding the accreditation process in engineering education.

11. *an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.*⁹

Engineering educators must further interpret accreditation guidelines within the context of their disciplinary specialties, such as electrical, mechanical, civil, or chemical engineering – just to name a few.¹⁰ Thus, professional guidelines and practices represent very real parameters within which innovations in engineering education will take place, making engineering education research a unique component in the field of education research.

Research in Engineering Education Emphasizes Both Research and Discovery, but Also Reform and Implementation

Research in engineering education is highly interdisciplinary and lies at the intersection of engineering, education and the learning sciences. Research conducted in engineering education, according to one workshop participant, "... can be viewed as use-inspired research based on Pasteur's quadrant."¹¹

Innovative research in engineering education today focuses on issues of creativity, originality, and innovation:

- Does creativity happen individually or can it happen in groups?
- What are the learning challenges and conceptions that students bring to the classroom – and how robust are those conceptions?
- Are student conceptions compatible with the pedagogy in place?

Research in engineering education also involves the identification of conceptual models and the contexts within which learning takes place. As one participant stated, "...to have a broad impact, the knowledge gained by conducting engineering education research must contribute to and influence fields outside of engineering, such as research in learning sciences and education."

Similarly, participants felt that engineering education research must draw upon innovations and advances in the fields of education and learning sciences to strengthen their own research. Interdisciplinary teams are needed to address many of the contemporary research questions in engineering education.

⁹ From S. Richerson, *et alia*: "A Portfolio Approach to Learning Professional Skills," 37th ASEE/IEE Frontiers in Education Conference, Milwaukee WI, October 2007. Those outcomes in *italics* "represent the professional skills subset...that has been most difficult for many programs to teach as well as assess."

¹⁰ A list of engineering specialties may be found at: www.engtrends.com/IEE/0903A.php

¹¹ Pasteur's quadrant recognizes "the importance of use-inspired basic research" that frames a new compact between science and government. See D. Stokes, 1997 at <http://www.brookings.edu/press/Books/1997/pasteur.aspx>.

Engineering Education Research Faces Two Important Challenges

Two factors are seen as challenges to the advancement of research in engineering education:

1. The incomplete integration of research in engineering education into the field of engineering, and
2. The slow diffusion of the knowledge gained through that research to its application in the classroom.

Workshop participants noted that engineering education research is not well integrated within the field of engineering. While some Schools of Engineering have created departments devoted to the area, many have not. The situation is exacerbated in part by the general lack of incentives or a rewards structure for the implementation of pedagogical innovations in the field of engineering, despite a call by the National Academy of Engineering for departments to explore innovative instructional methods.¹²

Nonetheless, workshop participants noted that a strong engineering education research knowledge base has evolved over the years and it is ready for application in classroom settings. Interdisciplinary research teams will be needed to implement some of the education reforms suggested by the research. Again, there is a lack of a rewards structure to encourage engineering educators and researchers to engage in the multidisciplinary research needed for those reforms.

The field of engineering will need to tackle these twin issues of diffusion and implementation before it is possible to fully gauge the impact of research in engineering education.

¹² NAE 2005, *op. cit.*

Advances in Evaluation Research

Evaluation research has long provided the federal government with a means to monitor the outcomes and impacts of its investment in education research. A recent report by the National Science and Technology Council's Subcommittee on Education notes that evaluation studies have the potential to improve outcomes and that agencies "are actively engaged in implementing" a shared understanding of contemporary evaluation research methods.¹³

Evaluation experts participating in this workshop described some of these new tools and discussed how they might be used to strengthen the evaluation of NSF's engineering education research programs in the coming years.

Theoretical Advances in Evaluation Research Increasingly Assist Practitioners in the Design of Their Evaluations

An important advance in contemporary evaluation research is to reach beyond the documentation of the effectiveness of a program to document the factors behind that effectiveness. For example, evaluators must often consider relevant information from both internal and external sources as it bears on educational outcomes. Therefore, an especially promising evaluation research method in engineering education might be the use of "multiple criteria" of effectiveness to measure research outcomes.

Evaluation researchers are often interested in assessing quality in education, in terms of such outcomes as relative or absolute achievement. Workshop participants described the potential use of a model for assessing quality in engineering education based on consensus panels. Consensus panels are especially useful for initiating a dialogue among stakeholders and creating partnerships to formulate a unified set of priorities.

¹³ See: Finding Out What Works: Agency Efforts to Strengthen the Evaluation of Science, Technology, Engineering and Mathematics (STEM) Education Programs, December 2008, available at: http://www.ostp.gov/galleries/NSTC%20Reports/NSTC_Education_Report_Complete.pdf A separate report by the National Research Council (NRC) describes the potential use of expert panels by the U.S. Environmental Protection Agency, for example, to evaluate both investment efficiency and process efficiency. See: NRC, Evaluating Research Efficiency in the U.S. Environmental Protection Agency, Washington DC: National Academies Press, June 2008.

Evaluators Select a Research Design Based on Whether the Expected Outcomes are Near-Term, Medium-Term, or Longer-Term

In order to conduct an effective evaluation, the expected outcomes of a project, program, or portfolio must be clearly delineated. According to workshop participants, engineering can readily incorporate outcome-based evaluation into its education research activities because of the specificity of the ABET accreditation process (described earlier). For example, outcome analysis in engineering education research could focus on the near-term measurement of the extent to which improvements in educational delivery resulted in increased baccalaureate acquisition of the expanded set of professional skills promulgated by ABET in 2004.

Participants distinguished between outcome-based and capacity-based measures. An example of a medium-term or longer-term measurement strategy that involves outcome analysis might be recording the number of new researchers entering the workforce as a result of an innovative education strategy, or evaluating the number of research publications or patents produced by those new researchers.

Capacity-based measures involve the analysis of the social processes by which new knowledge is learned/produced/valued by the wider communities of students and scholars. It focuses on measuring changes in the capacity of the system to produce new researchers or foster their productivity. A significant commitment of time and resources would be involved in certain of these "spillover" effects.

A Variety of Evaluation Methods Exist and Can Be Accessed By Engineering Education Research to Document the Outcomes and Impacts of Their Work

Participants identified a variety of evaluation strategies of potential interest to engineering education researchers, including:

- **Innovation Indicators:** a focus on the development and measurement of indicators of innovation and creativity within the unit of evaluation (e.g., a discipline, classroom, or university-based science center)
- **Science Impact:** a focus on measuring the impact of the science that is generated by researchers on the larger scientific community
- **Social Network Analysis:** typically informed by either informal (e.g., survey data collection) or formal (e.g., publication data) collaboration data that gives the evaluator some measure of the development and change of faculty and student networks, research collaborations, and sharing of knowledge

- Survey Data Collection: a technique that could be used to explore the experiences of students within engineering fields
- Case Study Analysis: in-depth interviews and other forms of qualitative data collection that can inform the development of cases studies to capture information that cannot be fully captured through quantitative data collection
- Curriculum Vitae Analysis: a data source becoming more prevalent for the evaluation of productivity, collaboration patterns, interdisciplinarity, and career trajectories
- Bibliometric Analysis: to document changes in research activity over time – in the form of publication patterns¹⁴
- Data Mining: to identify predictive (sometimes hidden) information from databases, publications and text materials.

The evaluation strategies needed to assess the outcomes and impacts of engineering education research are both complex and demanding. In the end, the success of the selected design will revolve around the answers to the following types of questions:

- Has the evaluator selected the appropriate higher-order objectives?
- Has the evaluator selected the right methodology?
- Has the evaluator generated the right set of products?

¹⁴ Adapted from the background statement prepared by Workshop participant Elizabeth A. Corley, 2008.

Workshop Conclusions and Recommendations

During a final plenary session, workshop participants presented conclusions and recommendations generated during earlier break-out group discussions. Several themes emerged during this final session, each of which is treated in the sections that follow.

Synergy

The time seems right for the effective collaboration of engineering education research with evaluation science. It would be useful for the National Science Foundation to convene a national “consensus conference” to expand the dialogue that took place at this workshop to include the broader engineering education and research communities.

NSF Role in Fostering the Evaluation of Research in Engineering Education

Workshop participants agreed the Foundation is viewed by the community as a critical resource for the advancement of research in engineering education. It is, therefore, important to the future success of this research investment for NSF to include support for the evaluation of research outcomes in engineering education and to make evaluation a more visible component of the grants process.

Program announcements and funding criteria should be clear with regard to the Foundation’s expectations relative to the evaluation of research outcomes. The framework for evaluations at the project, program, and portfolio levels should be put into place as early as possible in the grants process. Evaluations should be structured consistently across projects and programs, but the Foundation should not restrict flexibility in the selection of evaluation methods.

NSF should require principal investigators from the outset to specify the objectives of their research and the types of analyses that would be performed to demonstrate that the research goal has been reached.

Analyzing Longer-Term Outcomes of NSF’s Engineering Education Research Investments

The Foundation needs to put into place a clear strategy for evaluating investments in engineering education research. Workshop participants suggested the formulation of goals within which a range of outcomes and methods could be pursued:

- Immediate Goal: The immediate goal of research supported by the Division of Engineering Education and Centers (EEC) is to gain insights into the learning mechanisms involved in engineering education.

Research activities principally involve the support of basic and applied research, and interdisciplinary collaboration. Research goals would include an expansion of the knowledge base in engineering education research, and increased collaborations, as might be measured by traditional techniques such as bibliometrics (e.g., papers, citations, co-authorship) and more radical outcome metrics such as knowledge inventories or social network analysis (e.g., mapping interactions between disciplines).

- Intermediate Goal: The intermediate goal of the EEC research program is to support research that promotes the application of new knowledge in engineering education and other disciplines.

Outcome analyses might focus on the extent to which educational insights are adopted by the education community. Metrics might include traditional measures of how many new ideas were adopted by faculty/schools of engineering, and more radical outcomes such as influence diagrams/public value mapping to determine why certain ideas were adopted and how they were implemented.

- Longer-Term Goal: The longer-term goal of EEC research funding is to increase both the number and the diversity of the engineering workforce.

Evaluation strategies would necessarily reflect the greater level of complexity inherent in this research funding goal.

Diffusion of Research Findings to the Engineering Classroom

The National Science Foundation must play a more active role in pushing new ideas “to the next level.” Many participants noted that it is not unusual for a discovery to be “left on the shelf.” Active dissemination of important research discoveries is essential for diffusion to take place, perhaps through the development of fact sheets produced by the NSF or other dissemination methods.

At the conclusion of the workshop, NSF staff thanked participants for their thoughtful comments and acknowledged that a report of the workshop would be prepared and would serve as the basis for further discussions within the agency on ways to strengthen the use of evaluation methods to advance research in engineering education.

Appendix A: Workshop Agenda

Evaluation of Engineering Education Research Programs: Thought Leaders' Workshop

National Science Foundation
4201 Wilson Boulevard
Conference Room 380
Arlington, Virginia 22230

May 29–30, 2008

Agenda:

Thursday, May 29, 2008

8:15 – 8:45 am

Arrival / Breakfast

8:45 – 9:45 am

Session I: Background and Introduction to NSF Evaluation

The NSF Engineering Directorate is actively exploring new methods of evaluating its Engineering Education Research programs. This effort is taking place at the same time the National Science and Technology Council's Committee on Science is furthering education evaluation strategies throughout the federal government. The purpose of this session is to introduce conference participants to some of these developments.

Participants:

- **Sue Kemnitzer**, Deputy Division Director of Education, Engineering Education Centers Division (ENG/EEC), NSF
- **Joan Ferrini-Mundy**, Division Director, Division of Research on Learning in Formal and Informal Settings (EHR/DRL), NSF

9:45 – 10:00 am

Coffee Break

10:00 am – 12:00 pm

Session II: Emerging Issues in Engineering Education Research and Its Evaluation

The purpose of this session is to inform the participants of the challenges that face engineering education research and programs.

What are the most significant challenges in engineering education research? What challenges do engineering education researchers face when developing formal evaluations of their research? What distinguishes engineering education from other disciplines? What is the balance between research and practice in engineering education and how is that different from other fields? In what way has the engineering education research field adapted to address ABET 2000, the National Academy of Engineering's "Educating the Engineer 2020," and the community's research agenda?

Moderator:

- **Maura Borrego**, Assistant Professor, Department of Engineering Education, Virginia Institute of Technology, VA

Participants:

- o **Barbara Olds**, Professor, Liberal Arts and International Studies, Colorado School of Mines, CO
- o **Aditya Johri**, Assistant Professor, Department of Engineering Education, Virginia Institute of Technology, VA
- o **David Radcliffe**, Professor, Department of Engineering Education, Purdue University, IN
- o **Lori Breslow**, Director, Teaching and Learning Laboratory, Massachusetts Institute of Technology, MA

Rapporteur: Asha Balakrishnan

12:00 – 1:00 pm
1:00– 3:00 pm

Lunch Break

Session III: Evaluation Methods of Probable Interest to the Engineering Education and Research Community

This session will explore new frameworks and tools that could strengthen the evaluation of NSF's engineering education research programs in the coming years.

How can evaluation be used to address the challenges faced in engineering education research? What are the methodologies within the field of evaluation that are best suited for engineering education projects and programs? How can these methods be implemented to improve the evaluation of engineering education research?

Moderator:

- o **Jerry Hage**, Director, Center of Innovation, University of Maryland, College Park, MD

Participants:

- o **Connie Chang**, Director, Ocean Tomo Federal Services
- o **Elizabeth Corley**, Associate Professor, School of Public Affairs, Arizona State University, AZ
- o **Jonathan Mote**, Research Associate, Center of Innovation, University of Maryland, College Park, MD
- o **Ron Kostoff**, MITRE Corporation

Rapporteur: Pamela Flattau

3:00 – 3:30 pm

Coffee Break

3:30 – 5:00 pm

Breakout Sessions

The purpose of these parallel sessions is to stimulate dialogue between engineering education researchers and evaluators to articulate steps that might be taken by the NSF Engineering Education Research program to strengthen evaluation activities in the coming years.

Group I

Jerry Hage
Lori Breslow
Connie Chang
Barbara Olds
Pamela Flattau

Group II

David Radcliffe
Maura Borrego
Jonathan Mote
Bhavya Lal

Group III

Aditya Johri
Ron Kostoff
Wendy Newstetter
Elizabeth Corley
Asha Balakrishnan

6:00 pm

Dinner

Friday, May 30, 2008

9:00 – 10:45 am

Session IV: Strengthening the Evaluation Process within Engineering Education Research

The purpose of this final session is to receive reports from each of the breakout groups and to formulate a set of recommendations for consideration by the staff of the NSF Engineering Education Research programs.

Moderator:

- o **Wendy Newstetter**, Director, Learning Sciences Research, Department of Biomedical Engineering, Georgia Institute of Technology, GA

Evaluation experts and engineering education researchers will create a set of recommendations on how to incorporate evaluation more effectively at the grant, program, and portfolio levels. Based on the valuable information presented in Sessions II and III, how can NSF and the engineering education research community use evaluation most effectively?

Each breakout group will report back to the entire group on their recommendations for the engineering education community and NSF and a broader discussion will follow.

Rapporteur: Bhavya Lal

10:45 – 11:00 am

Break

11:00 - 11:45 am

Formulation of Recommendations

11:45 am – 12:00 pm

NSF Closing Remarks

12:00 pm

Adjournment

Appendix B: Biographical Information for Workshop Participants

Maura Jenkins Borrego is an assistant professor of Engineering Education at Virginia Tech. Dr. Borrego holds an M.S. and Ph.D. in Materials Science and Engineering from Stanford University. Before starting on the tenure track, she worked for one year as Retention Coordinator in Engineering Student Affairs at the University of Southern California. Her current research interests center around interdisciplinary collaboration at the faculty and graduate student levels. Most of her recent publications describe engineering education and associated faculty development as a specific case of interdisciplinarity. Her Journal of Engineering Education article, "Conceptual Hurdles Experienced by Engineering Faculty Becoming Education Researchers," received the 2008 Best Publication Award from the American Educational Research Association's Division I. In 2006, Dr. Borrego was awarded an NSF CAREER grant to study interdisciplinarity in engineering graduate programs nationwide, with manuscripts currently in preparation.

Lori Breslow has been the director of the Teaching and Learning Laboratory (TLL) at MIT since its inception in 1997. TLL has three main functions: help faculty and graduate students improve their teaching; collaborate with faculty and others on curricular, pedagogical, and technological innovation; and conduct applied research to assess how effective those innovations are in improving learning. Other ways in which Dr. Breslow is involved in engineering education and engineering education research include: member of Journal of Engineering Education Editorial Advisory Board; MIT's representative to CASEE; and member of the internal advisory board for the Bernard M. Gordon Engineering Leadership Program at MIT. Dr. Breslow is also a Senior Lecturer in MIT's Sloan School of Management. She teaches courses in professional communication, cross-cultural communication, and a Ph.D.-level course on teaching university-level science and engineering.

Connie Chang is Director of Ocean Tomo Federal Services, LLC ("OTFS"), an integrated Intellectual Capital Merchant Banc firm. OTFS provides a full range of services—valuation, investment, risk management, technology transfer, and Expert Testimony—to domestic and foreign state, local, and federal governments and their primary government contractors to help manage, commercialize and monetize their intellectual capital. Previously, Ms. Chang spent thirteen years in the U.S. Department of Commerce where she most recently served as Research Director and Chief of Staff to the Under Secretary of Commerce for Technology at the Technology Administration (TA). Prior to her government career, Ms. Chang worked for three years at Credit Suisse First Boston (CSFB), formerly known as The First Boston Corporation, a premier Wall Street investment banking firm in New York City. Ms. Chang is a member of the International Advisory Board on Evaluation and Impact Analysis for VINNOVA, the Swedish Governmental Agency for Innovation Systems and serves as the Chair of the Board of Directors for the non-profit organization, AIRLEAP (the Association for Integrity and Responsible Leadership in Economics and Associated Professions.)

Ms. Chang earned a master's degree in International Management and Comparative Politics from the School of International Relations and Pacific Studies at the University of California, San Diego, and a bachelor's degree in Economics, with honors, from Wellesley College. She completed doctoral studies and passed her qualifying exams in Political Economy and Science, Technology, and Public Policy at MIT's Department of Political Science. She is an Adjunct Assistant Professor of Economics at Georgetown University.

Elizabeth A. Corley is an Associate Professor in the School of Public Affairs at Arizona State University. Elizabeth's research interests focus on science & technology policy and the evaluation of publicly-funded R&D. Dr. Corley's published research has appeared in book chapters and peer-reviewed journals, including Review of Policy Research, Research Policy, Evaluation & Program Planning, Evaluation Review, Policy Studies, Journal of Technology Transfer, Society & Natural Resources, Journal of Agricultural & Environmental Ethics, Research in Higher Education, Environmental Science & Technology, Scientometrics, and Nature Nanotechnology. Dr. Corley received three engineering degrees and a Ph.D. in Public Policy from the Georgia Institute of Technology. Before joining ASU, she held teaching and research positions at Georgia Tech, Bucknell University, and Columbia University.

Jerald Hage is Evaluation Director of the Center for Innovation, University of Maryland. Dr. Hage's major goal is to write a theory of societal change that respects alternative pathways and distinct historical periods. The focus is on the interface between organizations and institutions. The problem is to predict path dependencies in the organizational form as a consequence of the institutional context and moments of institutional change. Dr. Hage has served as a consultant over the past eight years with Sandia National Laboratories and the STAR division of the National Oceanographic and Atmospheric Administration where the Center for Innovation has conducted a number of evaluation studies. In this work, he has developed a simple set of evaluation metrics for assessing the obstacles and blockages that prevent the realization of the full benefits of investments in scientific research. Dr. Hage has also developed a metric system for measuring the returns on investment in medical research for the Canadian Academy of Health Sciences. His objective is to create a new concept called the gross domestic innovation benefit (GDIB) that aggregates the benefits of scientific and technological research for society.

Aditya Johri received his Ph.D. in Learning Sciences and Technology Design from Stanford University in 2007. His teaching interests are learning sciences, global and virtual teams, design of technology, and engineering fundamentals. Some of Dr. Johri's research interests include ethnographic studies of work practices; global work teams in services and innovation; design and use of technology; building and sustaining communities and networks of practices; and growth of digital media in engineering practices.

Ronald N. Kostoff received a Ph. D. in Aerospace and Mechanical Sciences from Princeton University in 1967. After a long technical career at NASA and DOE, he became the Director of Technical Assessment for the Office of Naval Research from 1983-2008. He managed the selection, resource allocation, and review of Accelerated Research Initiatives, funding-enhanced multi-disciplinary programs that constituted about 40% of ONR's budget. He invented and patented (1995) the Database Tomography process, a computer-based textual data mining approach that extracts relational information from large text databases. After managing the Navy Laboratory Independent Research Program for five years, he established a new effort in textual data mining. His interests continue to revolve around improved methods to assess the impact of science and technology, incorporating maximal use of the massive amounts of data available. He has recently (2005) received a full-spectrum text mining system patent. He is presently employed at the MITRE Corporation, where he continues his work in textual data mining. He has published many papers on technical, evaluation, and text mining topics, and has edited four journal special issues since 1994 (Evaluation Review [February 94], Scientometrics [July 96], Journal of Technology Transfer [Fall 97]; TFSC [2008]).

Jonathon Mote is an Assistant Research Scientist with the University of Maryland's Center for Innovation. Dr. Mote's primary research interests include Economic Sociology, Social Networks, Organizational Theory, focusing on how the problem of societal change necessitates a multi-level approach, with an emphasis on the role of organizations and social networks in mediating between the micro- and macro-levels of society. His work at the Center for Innovation has connected to some of these interests by attempting to measure innovation in real time rather than relying upon papers or patents, studying experiments in organizational change, and exploring the intersection between organizational environments and social networks. An outgrowth of this work has been the development of performance management frameworks of R&D, focused primarily on fostering radical innovation, at both the meso- and the macro- levels, which would allow for immediate feedback for managers and policy makers.

Wendy Newstetter is the Director of Learning Sciences Research in the Wallace H. Coulter Department of Biomedical Engineering at Georgia Tech. Dr. Newstetter's research focuses on understanding cognition and learning among disciplines with an eye toward designing educational environments that support the development of integrative problem solving. Her ethnographic investigations of three interdisciplinary research laboratories have informed the design of problem-driven learning (PDL) classrooms at Georgia Tech designed to foster integrative model-based reasoning. With support from the Spencer Foundation, she has investigated the experiences of under-represented minorities in university research settings to better understand how gender and race are enacted at the bench top. She is also working with a statistics professor at Georgia Tech to design web-based learning supports that aim to make engineering attractive to women and minorities. She works with faculty both at Georgia Tech and throughout the nation through Project Kaleidoscope to create and develop more effective science, math, and engineering educational environments informed by learning

and cognitive science research. Dr. Newstetter has published in numerous journals and conference proceedings, including the Journal of Engineering Education, Research in Engineering Design and the Annals of Biomedical Engineering. She is an Associate Editor for the Journal of Engineering Education.

Barbara Olds is the Associate Provost for Educational Innovation and Professor of Liberal Arts and International Studies at the Colorado School of Mines (CSM) where she has been on the faculty since 1984. From 2003 to 2006 she was on leave at the National Science Foundation where she served as the Division Director for the Division of Research, Evaluation and Communication (REC) in the Education and Human Resources Directorate. During the 2006-2007 academic year, Barbara was a part-time visiting professor in Purdue University's Engineering Education Department. Her research interests focus primarily on understanding and assessing engineering student learning, including recent work developing concept inventories for engineering topics with colleagues from CSM and Purdue. She has participated in a number of curriculum innovation projects and has been active in the engineering education research and assessment communities. Barbara is a Fellow of the American Society for Engineering Education (ASEE), currently serving as the Chair of the International Advisory Committee of ASEE. She is also a member of the Advisory Committee for NSF's Office of International Science and Engineering, and was a Fulbright lecturer/researcher in Sweden.

David F. Radcliffe is the Epistemology Professor of Engineering Education in the School of Engineering Education at Purdue University where he is taking a leading role in shaping the strategic direction of the School as it continues to grow and to influence the future direction of engineering education and scholarship. Dr. Radcliffe conducts research-in-practice in the places where engineers work and learn using contingent immersion with a focus on design thinking, learning histories, knowledge creation, innovation, sustainability, competence formation, and new practices in engineering. This work is interdisciplinary and has multi-national and multi-cultural dimensions. He also conducts research on the design of creative learning places and ways to foster distributed communities of research practice in engineering education. David was formally the Thies Professor of Engineering Education and Professional Development in the School of Engineering at the University of Queensland and Director of the Catalyst Research Centre for Society and Technology.

STPI Staff Participating in the Workshop:

Asha Balakrishnan joined STPI in October 2007 after completing her Ph.D. in Mechanical Engineering from MIT. Her research focused on the experimentation and the development of models to predict the behavior of brain tissue when exposed to high-impact blasts causing traumatic brain injury. Her background is mainly in solid mechanics and design. In addition to research, Dr. Balakrishnan spent three semesters as a teaching assistant in mechanical engineering. She developed new labs for teaching basic mechanics, and was involved in the i-Campus project through the MIT-Microsoft Alliance in 2002. She also served on the board of advisors at Cambridge Rindge and Latin High School for their "Project Lead the Way" pre-engineering program. At STPI, Dr. Balakrishnan's work has been focused on understanding current trends in participation of women and underrepresented minorities in STEM field, foreign student enrollments, and degree production in STEM fields, and workforce shortage concerns as they relate to U.S. competitiveness.

Pamela Ebert Flattau serves as the Senior Analyst in the area of Behavioral & Social Sciences and Education for the IDA Science and Technology Policy Institute (STPI). In that capacity, Dr. Flattau has led STPI projects supporting the National Mathematics Advisory Panel (including a national analysis of the U.S. algebra curriculum); the National Science Foundation/National Science Board (including the design and content of the NSB *Digest of Key Science and Engineering Indicators 2008*); and the White House Office of Science and Technology Policy on the outcomes and impact of the National Defense Education Act of 1958. Previously, Dr. Flattau served as the Director of the Studies and Surveys Unit of the NRC Office of Scientific and Engineering Personnel, leading Congressionally mandated and other studies over her 16-year career at the NRC, and worked as a policy analyst for the NSF Science and Engineering Indicators Unit.

Bhavya Lal serves as the STPI Senior Analyst in the area of Innovation, Competitiveness, and International Science and Technology. Ms. Lal has worked on and led evaluation projects for the NSF's EEC Division for over a decade. Most recently, she completed an international benchmarking study for the Division to inform the design of the next generation of the NSF Engineering Research Centers program. Over the last fourteen years, Ms Lal has also evaluated programs that involve: multidisciplinary and collaborative research, centers programs; S&E workforce issues; innovation and competitiveness; international R&D activities; and industry-university partnerships. Major sponsors include: Office of Science and Technology Policy, National Science Foundation, National Science Board, National Institutes of Health, Department of Commerce (including NIST and ATP), U.S. Environmental Protection Agency, and the U.S. Agency for International Development.

Appendix C: Sample Letter of Invitation



National Science Foundation
4201 Wilson Boulevard
Arlington, Virginia 22230

May 8, 2008

Dear Dr. Borrego:

We are pleased to invite you to join us in thinking about the most promising developments in the evaluation of engineering education research. As you know, the National Science Foundation Directorate for Engineering has recently begun to consider ways to strengthen the breadth and quality of our program in engineering education research through the effective application of evaluation methods. We are gathering a small group of thought leaders for a 1-½ day workshop on May 29th and 30th at the National Science Foundation in Arlington, VA. We hope you will be able to participate in this important workshop.

We have structured the meeting to address key issues in evaluating engineering research and education. A preliminary copy of the agenda is enclosed. The purpose of the workshop is to:

1. Discuss the latest developments in the fields of Engineering Education Research and Evaluation Methods
2. Explore a synergy that will advance both fields
3. Provide recommendations to the NSF and the Engineering Education Research community to strengthen evaluations of their programs.

We hope that you can think about the topic and the questions presented in the agenda prior to the workshop, and come prepared to speak at the panel discussion on how to move the field of engineering education research forward.

The meeting will convene in NSF Conference Room 380 at 8:30 a.m. on Thursday, May 29th, and will conclude around 1 pm on Friday, May 30th. We have asked the IDA Science and Technology Policy Institute (STPI) to organize this important workshop. Dr. Asha Balakrishnan serves as the STPI point of contact for the meeting. She will contact you in the next few days to verify your availability to participate in the meeting, and can provide you with further details regarding arrangements for the meeting. STPI will pay for your travel within the government travel guidelines. In addition, all participants will be given a \$500 honorarium for participating in this workshop.

We have also invited STPI to summarize the meeting in a report for circulation with the Foundation as well as the engineering education research community. We look forward to your participation at the meeting.

Dr. Susan C. Kemnitzer
Deputy Division Director for Education
Division of Engineering Education and Centers
Engineering Directorate

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14. ABSTRACT To assure the efficient investment of public funds in the coming years, the NSF Engineering Education and Centers Division (EEC) of the Directorate for Engineering asked the IDA Science and Technology Policy Institute (STPI) to examine the results of a sample of NSF grants program in engineering education, while also developing a master plan for longer term support for research in engineering education. An important first step in the STPI effort involved the organization of a workshop of key experts from two very different communities: engineering education research and the evaluation sector. The purpose of the meeting was to discuss ways to strengthen the use of contemporary evaluation methods as NSF enhances its support for research in engineering education. The report that follows summarizes key observations from the "Thought Leaders' Workshop" convened on May 29 and 30, 2008, at the National Science Foundation in Arlington, Virginia. The results of that informal discussion provide a useful context for future deliberations by educators, researchers, and policymakers alike.					
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