Engineering Education Research Networking Session

Connecting and Expanding the Engineering Education Research (EER) and Engineering Education Innovation (EEI) Communities

ASEE Headquarters Session T106E in partnership with the Rigorous Research in Engineering Education Initiative
(DUE 0817461)
http://CLEERhub.org

ASEE Annual Conference – June 25, 2013 – T106E – 7:00 am – 8:30 am

Facilitated By

Karl A. Smith
Purdue University and University of Minnesota

Ruth A. Streveler
Purdue University


<table>
<thead>
<tr>
<th>Activity</th>
<th>Time Allocated</th>
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<tbody>
<tr>
<td>Introduction of session and facilitators</td>
<td>5</td>
</tr>
<tr>
<td>Brief report on status of EER &amp; EEI</td>
<td></td>
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<tr>
<td>Update on RREE – CLEERHub.org (Collaboratory for Engineering Education Research), AERA, Featured Resources (Ruth); RREE network (Krishna Madhavan)</td>
<td>10</td>
</tr>
<tr>
<td>Updates - NRC DBER practitioner guide (Karl), ASEE (Norman Fortenberry or Rocio Chavela), JEE (Michael Loui), NAE (Beth Cady), EER Taxonomy (Cindy Finelli), EER Networkshop (Becky Bates and Lisa Benson), EER Website (Adam Carberry and Ken Yasuhara)</td>
<td>35</td>
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<tr>
<td>Participant Networking</td>
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<td>Rapid introductions around guided questions – Four to five conversations in groups of 3 – as a way to meet many people</td>
<td>25</td>
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<td>Identification of “intellectual neighborhoods” around research and innovation questions and opportunities – individual reflection and writing</td>
<td>5</td>
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<td>Brainstorming on strategies to connect, expand, and sustain the emerging EER and EEI communities</td>
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Expanding and sustaining research capacity in engineering and technology education: Building on successful programs for faculty and graduate students

Collaborative partners: Purdue (lead), Alverno College, Colorado School of Mines, Howard University, Madison Area Technical College, National Academy of Engineering
New Research Venue for EER

• American Educational Research Association (AERA) [www.aera.net](http://www.aera.net)
  – Division C – Learning and Instruction
    • Section E- Engineering and Computer Science Education

• Important Dates
  – Annual conference - April 3-4, 2014, Philadelphia
  – Submission Deadline – July 22, 11:59pm PT
    • Note that submissions for AERA are very different than for ASEE. Read the call for submissions for details.
Dataset

2003-2012
21 Journal and Conf. Publications
25,225 Documents
26,985 Authors

147 RREE Participants

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<th>CCLI</th>
<th>NAE</th>
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<td>10</td>
<td>31</td>
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Unfound, 41
Matched, 106

CCLI, 62
NAE, 44

Krishna Madhavan
RREE Authors Collaboration

- RREE-CCLI Author
- RREE-NAE Author

RREE Authors Highlighted in Overall Networks

- RREE-CCLI Author
- RREE-NAE Author
- Other Author
Network of 2012

Largest Connected Component: 19385 (71.84%) Authors

Network of 2012

99/106 RREE Authors are in the Largest Connected Component
Size of the Largest Connected Component
Growing over the Years

Size of the Largest Connected Component

No. of RREE Authors in the Largest Connected Component

Size of the Largest Connected Component
Growing over the Years
Degree: The number of links each node (author) in a network has.

Degree Distribution

Facebook Network Degree Distribution

Smooth Curve

Degree Distribution

Discipline-Based Education Research (DBER) Report Update

National Research Council
Discipline-Based Education Research (DBER)

Understanding and Improving Learning in Undergraduate Science and Engineering

http://www.nap.edu/catalog.php?record_id=13362

Undergraduate Science and Engineering Education: Goals

- Provide all students with foundational knowledge and skills
- Motivate some students to complete degrees in science or engineering
- Support students who wish to pursue careers in science or engineering
Undergraduate Science and Engineering Education: Challenges and Opportunities

• Retaining students in courses and majors
• Increasing diversity
• Improving the quality of instruction

What is Discipline-Based Education Research?

• Emerging from various parent disciplines
• Investigates teaching and learning in a given discipline
• Informed by and complementary to general research on human learning and cognition
Study Charge

• Synthesize empirical research on undergraduate teaching and learning in physics, chemistry, engineering, biology, the geosciences, and astronomy.

• Examine the extent to which this research currently influences undergraduate science instruction.

• Describe the intellectual and material resources that are required to further develop DBER.

Committee on the Status, Contributions, and Future Directions of Discipline-Based Education Research

• SUSAN SINGER (Chair), Carleton College
• ROBERT BEICHNER, North Carolina State University
• STACEY LOWERY BRETZ, Miami University
• MELANIE COOPER, Clemson University
• SEAN DECATUR, Oberlin College
• JAMES FAIRWEATHER, Michigan State University
• KENNETH HELLER, University of Minnesota
• KIM KASTENS, Columbia University
• MICHAEL MARTINEZ, University of California, Irvine
• DAVID MOGK, Montana State University
• LAURA R. NOVICK, Vanderbilt University
• MARCY OSGOOD, University of New Mexico
• TIMOTHY F. SLATER, University of Wyoming
• KARL A. SMITH, University of Minnesota and Purdue University
• WILLIAM B. WOOD, University of Colorado
Structure of the Report

• Section I. Status of Discipline-Based Education Research
• Section II. Contributions of Discipline-Based Education Research
• Section III. Future Directions for Discipline-Based Education Research

Section I. Status of Discipline-Based Education Research
Status of DBER: Goals

- Understand how people learn the concepts, practices, and ways of thinking of science and engineering.
- Understand the nature and development of expertise in a discipline.
- Help to identify and measure appropriate learning objectives and instructional approaches that advance students toward those objectives.
- Contribute to the knowledge base in a way that can guide the translation of DBER findings to classroom practice.
- Identify approaches to make science and engineering education broad and inclusive.

Status of DBER: Types of Knowledge Required To Conduct DBER

- Deep disciplinary knowledge
- The nature of human thinking and learning as they relate to a discipline
- Students’ motivation to understand and apply findings of a discipline
- Research methods for investigating human thinking, motivation, and learning
Status of DBER: Conclusions

- DBER is a collection of related research fields rather than a single, unified field. (Conclusion 1)

- High-quality DBER combines expert knowledge of:
  - a science or engineering discipline,
  - learning and teaching in that discipline, and
  - the science of learning and teaching more generally.
  (Conclusion 4)

Section II. Contributions of Discipline-Based Education Research
### Contributions of DBER: Conceptual Understanding and Conceptual Change

- In all disciplines, undergraduate students have incorrect ideas and beliefs about fundamental concepts. (Conclusion 6)
- Students have particular difficulties with concepts that involve very large or very small temporal or spatial scales. (Conclusion 6)
- Several types of instructional strategies have been shown to promote conceptual change.

### Contributions of DBER: Problem Solving and the Use of Representations

- As novices in a domain, students are challenged by important aspects of the domain that can seem easy or obvious to experts. (Conclusion 7)
- Students can be taught more expert-like problem-solving skills and strategies to improve their understanding of representations.
Contributions of DBER: Research on Effective Instruction

• Effective instruction includes a range of well-implemented, research-based approaches. (Conclusion 8)

• Involving students actively in the learning process can enhance learning more effectively than lecturing.

Section III. Future Directions for Discipline-Based Education Research
Future Directions for DBER: Translating DBER into Practice

- Available evidence suggests that DBER and related research have not yet prompted widespread changes in teaching practice among science and engineering faculty. (Conclusion 12)
- Efforts to translate DBER and related research into practice are more likely to succeed if they:
  - are consistent with research on motivating adult learners,
  - include a deliberate focus on changing faculty conceptions about teaching and learning,
  - recognize the cultural and organizational norms of the department and institution, and
  - work to address those norms that pose barriers to change in teaching practice. (Conclusion 13)

Future Directions for DBER: Recommendations for Translating DBER Into Practice

- **RECOMMENDATION:** With support from institutions, disciplinary departments, and professional societies, faculty should adopt evidence-based teaching practices.

- **RECOMMENDATION:** Institutions, disciplinary departments, and professional societies should work together to prepare current and future faculty to apply the findings of DBER and related research, and then include teaching effectiveness in evaluation processes and reward systems throughout faculty members’ careers. (Paraphrased)
Future Directions for DBER: Advancing DBER through Collaborations

• Collaborations among the fields of DBER, and among DBER scholars and scholars from related disciplines, although relatively limited, have enhanced the quality of DBER. (Conclusion 15)

Future Directions for DBER: Research Infrastructure

• Advancing DBER requires a robust infrastructure for research. (Conclusion 16)

• **RECOMMENDATION:** Science and engineering departments, professional societies, journal editors, funding agencies, and institutional leaders should:
  - clarify expectations for DBER faculty positions,
  - emphasize high-quality DBER work,
  - provide mentoring for new DBER scholars, and
  - support venues for DBER scholars to share their research findings.
Future Directions for DBER: Some Key Elements of a Research Agenda

• Studies of similarities and differences among different groups of students
• Longitudinal studies
• Additional basic research in DBER
• Interdisciplinary studies of cross-cutting concepts and cognitive processes
• Additional research on the translational role of DBER

Acknowledgements

• National Science Foundation, Division of Undergraduate Education (Grant No. 0934453)
• Various volunteers:
  – Committee
  – Fifteen reviewers
  – Report Review Monitor (Susan Hanson, Clark University) and Coordinator (Adam Gamoran, University of Wisconsin-Madison)
• Commissioned paper authors
• NRC staff (Natalie Nielsen, Heidi Schweingruber, Margaret Hilton)
http://www7.nationalacademies.org/bose/DBER_Homepage.html

ASEE

Connecting and Expanding the Engineering Education Research and Innovation Communities

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American Society for Engineering Education
rchavela@asee.org

June 25, 2013
National Science and Technology Council
Committee on STEM Education

Five-year Strategic Plan:

“...identify and broaden implementation of evidence-based instructional practices and innovations to improve undergraduate learning and retention in STEM . . .”

Gathering Community Input

- Transforming Undergraduate Engineering Education
  Phase I: An effort to understand desired knowledge, skills, and abilities sought in engineering undergraduates and to better define the curricular, co-curricular, and practice-based experiences that will enhance those KSAs. (May 9-10, 2013, Arlington, VA)

- Understanding and Surmounting Impediments to Diversification
  Exploring the social, economic, political, and other impediments to implementing the recommendations that have been made for over four decades to enhance the participation of underrepresented minority populations in engineering. (September 26-69, 2013, Washington, DC)

- Transitioning Veterans to Engineering Related Careers
  What measures have to be taken and by which actors in order to enhance the participation and success of military veterans in careers in engineering and engineering technology? (February 25, 2013, Washington, DC)
  http://www.asee.org/Final_Report_-_Transitioning_Veterans_to_Engineering_Related_Careers.pdf
Retention Project
http://www.asee.org/retention-project

- Data Collection Committee (EDC)
- Best approaches for collecting student success data
- Online survey
  - Summer ’12 → 97 schools
  - Meeting in D.C.
  - Aggregate data available online
- Schools complete survey annually
- Use fee structure to support survey administration
- 31 public and 12 private institutions

Dialogue  Pilot Study  Scale-up  Full Implementation
2008  2009  2011  2013  2014

Support from Intel and Alfred P. Sloan Foundation

Virtual Communities of Practice (VCP)
http://www.asee.org/asee-vcp

Objectives:
- Develop a sustainable VCP model for faculty development that will enable relatively inexperienced faculty members to gain an understanding of research-based instructional approaches and to implement these approaches in their classrooms
- Identify VCP best practices by characterizing the operation of VCP implementations and relating these VCP characterizations to VCP effectiveness
International Activities

• 2013 ASEE International Forum
  Saturday June 22, 2013
  http://www.asee.org/conferences-and-events/conferences/international-forum/2013/program

• 2014 ASEE International Forum
  Join us in Indianapolis next year! Saturday June 14, 2013

• 2016 ASEE Global Colloquium
  Submission deadline: Friday, August 29, 2014
  Proposals must be sent as a PDF document via email to aseeexec@asee.org

JOURNAL OF ENGINEERING EDUCATION

Michael Loui
Editor
JEE publishes original research on engineering education

- Articles should significantly advance knowledge about engineering education, with implications for practice or research
- Two kinds of articles: empirical investigations, research reviews
- Quantitative, qualitative, and mixed methods studies are welcome

JEE is now based at the University of Illinois at Urbana-Champaign
I thank the members of the JEE Editorial Board for their service

Deputy editor: Donna Riley
Senior associate editors: Jeff Froyd, Lisa Lattuca, Ann McKenna, Barbara Moskal, Jim Pellegrino, Sheri Sheppard
Associate editors: Caroline Baillie, Maura Borrego, Sean Brophy, Alan Cheville, Ton de Jong, Elliot Douglas, Jenefer Husman, Jennifer Turns

ASEE now publishes JEE in partnership with John Wiley & Sons

Wiley handles
• Institutional subscriptions
• Typesetting, artwork
• Online access, search

ASEE members can access JEE at www.jee.org via asee.org login
Frontiers of Engineering Education

- Fifth symposium will be held October 27-30, 2013
  - Nominations have closed
  - Applications due 6/28
- Brings together faculty who are developing innovative approaches in engineering education
- Creates a community to share knowledge, encourage collaboration, and promote dissemination of innovative practice in engineering education
- Opportunities to share work, get feedback on own educational approaches, and provide feedback to others
- Several opportunities to network with peers and with speakers and committee members
Infusing Real World Experiences into Engineering Education

- 29 exemplar programs that provide students with real-world experiences
- Includes a discussion on potential barriers and ways of overcoming them
- Also available at www.nap.edu

https://www.nae.edu/Projects/Events/2012Events/62374.aspx
Web-based Resources

• CASEE Website [www.nae.edu/casee](http://www.nae.edu/casee)
  • Extensive set of research-to-practice documents, reports from CASEE projects, videos, and other resources
  • Equity-related resources at [www.nae.edu/casee-equity](http://www.nae.edu/casee-equity)

• COMING SOON: FOEE website (www.naefoee.org)
  • Will have a public side for links to presentations, directories, videos, and uploaded resources
  • Will also have a password-protected area for community members to allow for collaboration and resource-sharing
  • Will have both public and private social network components
Developing and Refining a Taxonomy for Engineering Education Research

Cindy Finelli
University of Michigan

cfinelli@umich.edu
Rationale for a Taxonomy

- Engineering education research is:
  - Broad-based
  - Rapidly-evolving
  - Diverse
  - Interdisciplinary, and
  - International

- We need a standardized terminology and organizational system to map and communicate research initiatives.

Audiences for the Taxonomy

- Researchers and community members
  - Situate individual research initiatives in the broader field
  - See connections with others
  - Plan future work

- Funding agencies
  - Classify research portfolios
  - Identify areas for capacity building, frame solicitations
  - Recruit reviewers for panels

- Journal editors
  - Organize related research or authors and readers
  - Create a reviewer database
Project Goals

1. Create a taxonomy that is:
   - A concise and comprehensive map for the field
   - A complete enough outline to describe any research initiative using four to six keywords
   - A useful tool for multiple audiences
   - Not an exhaustive list of every idea

2. Establish a process that is inclusive of the diverse national and international community

People Involved

- **The Planning Committee**
  - Cindy Finelli. U Michigan
  - Maura Borrego. Virginia Tech
  - Marjorie Hlava. Access Innovations

- **The Advisory Board**
  - Stephanie Adams. Virginia Tech
  - Cindy Atman. U Washington
  - Erik de Graaff. EJEE & Aalborg University
  - Jeff Froyd. IEEE Trans Ed & Texas A&M University
  - Ahmad Ibrahim. IJEE
  - Euan Lindsay. Central Queensland University
  - Tom Litzinger. Penn State
  - Michael Loui. JEE & U Illinois
  - David Radcliffe. Purdue
  - Sheri Sheppard. Stanford

- 3 commissioned authors and 85 participants from across the world
Progress to Date

- Commissioned Outlines
- Draft Taxonomy v. 1
- Mapping the Field Conference
- Draft Taxonomy v. 2
- ASEE Workshop

Community engagement
Professional taxonomist

Draft Taxonomy v. 2

- 14 branches, 6 levels, 971 total terms

1. Assessment
1.1. Organizational assessment
1.2. Professional accreditation
1.2.1. Chartered engineer accreditation
1.2.2. Professional engineer accreditation
   a. Fundamentals of Engineering exam
1.3. Program evaluation
   1.3.1. Accreditation
      a. ABET
         i. ABET criteria
         ii. ABET outcomes
      b. Program educational objectives
1.3.2. Advisory boards
1.3.3. Course assessment
1.3.4. External evaluation
1.4. Student assessment
1.4.1. Assessment criteria
   a. Academic performance
   b. Body of knowledge
   c. Evidence-based improvement
   d. Performance measures
1.4.2. Assessment methods
   a. Assessment reliability
   b. Assessment validity
   c. Assessment biases

2. Collaboration
2.1. Collaborative design
   2.1.1. Team based design
   2.1.2. Informal collaboration
   2.2. Teamwork
   2.2.1. Group functioning
      a. Group decision making
      b. Nominal group technique
   2.2.2. Development
   2.2.3. Interdisciplinary teamwork
   2.3. International teamwork
   2.4. Professional teamwork
   2.5. Social and task dimensions
   2.6. Team activities
      a. Collaborative engineering
      b. Collaborative reverse engineering
   2.7. Team formation
   2.8. Team performance
   2.9. Team leadership
   2.10. Teamwork training
   2.11. Team experience

3. Communication
3.1. Audience
3.2. Communication skills
3.2.1. Written communication
3.2.2. Oral communication
   a. Listening
   b. Oral presentations
   c. Speaking
3.2.3. Visual communication
   a. Graphic communication
   b. Engineering graphics
   c. Sketching
   d. Computer-aided design
   e. Drafting
   f. Engineering drawing
      a. Feature based representation
      b. Freehand

4. Design
4.1. Design activities
4.2. Creative design
4.2.1. Design benchmarking
4.2.2. Design process
4.2.3. Design for manufacturing
   a. Design needs analysis
   b. Design portfolio
   c. Design research
   d. Design approaches
   e. Human centered design
   f. Product development
   g. Life cycle assessment
   h. Reverse engineering
   i. Sustainable design
   j. Systems based design
   k. User centered design
4.3. Design outcomes
4.4. Design practice
4.5. Conceptual design
4.6. Design problem definition
4.7. Design problems
4.8. Design testing and evaluation
4.9. Design verification and validation
4.10. Product design
4.11. Product realization
4.12. Prototyping
   a. Rapid prototyping
Future Opportunities for Engagement

- Online interactions and public comment periods at the website: [http://taxonomy.engin.umich.edu/](http://taxonomy.engin.umich.edu/)
- Open conference sessions
  - 2013 Research in Engineering Education Symposium. 07/06/13, 3:00 – 4:40 pm, Kuala Lumpur, Malaysia
  - Other possible sessions:
    - SEFI. 09/16/13 – 09/20/13, Leuven, Belgium
    - Frontiers in Education. 10/23/13 – 10/26/13. Oklahoma City, OK
    - Australasian Association for Engineering Education. 12/08/13 – 12/11/13. Queensland, Australia

Engineering Education Research Leaders NetWorkshop

Rebecca Bates and Lisa Benson
NSF Award # EEC-1314725
EER Leaders NetWorkshop

Goals

• **Community:** building a community of EER leaders; preparing new community members rising in academic leadership ranks
• **Communication:** building skills to "manage up," and deal with power differentials
• **Action:** identifying strategies for moving the emerging field forward and supporting rising EER leaders

Outcomes (so far)

• 13 attended pre-ASEE NetWorkshop
• Sustain virtual community – virtual “book club”
• Expand community through formal and informal meetings at future conferences
• Please look forward to an upcoming survey

bates@mnsu.edu  lbenson@clemson.edu
This engineering education wiki is a resource created by the American Society for Engineering Education’s Student Division (ASEE Student). In collaboration with the Center for Engineering Learning & Teaching (CELT). The resource offers lists of programs, centers, researchers, societies, publication venues, etc., intended to help in the exploration of the engineering education field. We hope that ultimately this wiki will encourage community members to expand this resource as a place to inform students and other interested individuals new to engineering education about the research happening in this field at institutions and centers all over the world.

Note about user registration: All site content is public. You do not need to request access or create a user to view the site. If you are interested in helping maintain the site, we welcome you to request access or contact the co-maintainers listed below.

The resource currently consists of lists in the following categories:

- Engineering Education Departments and Programs
  - Graduate level
  - Undergraduate level

Groups, centers, departments...

- Engineering Education Centers — Australia: UICEE, UNESCO International Centre for Engineering Education; Denmark: UCPBLEE, UNESCO Chair in Problem Based Learning in Engineering Education; Hong Kong: E2I, Engineering Education Innovation Center; Hong Kong University of Science and Technology; Pakistan: Center for Engineering Education Research, NUST, National University for Science and Technology; South Africa: CREE, Centre for Research in Engineering Education, U of Cape Town; Sweden: Engineering Education Research Group, Linköping U; UK: ESC, Engineering Subject Centre, Higher Education Academy; USA: CELT, Center for Engineering Learning and Teaching, U of Washington; CRLT North, Center for Research on Learning and Teaching, U of Michigan; Faculty Innovation Center, U of Texas-Austin; Engineering Learning Center, U of Wisconsin-Madison; CASEE, Center for the Advancement of Scholarship in Engineering Education, National Academy of Engineering; EEIC, Engineering Education Innovation Center, Ohio State University; CEEER, Center for Engineering Education Research, Michigan State University, EECs, Engineering Education Centers in Korea.

- Engineering Education Degree-granting Departments — USA: School of Engineering Education, Purdue U; Department of Engineering Education, Virginia Tech; Department of Engineering and Science Education, Clemson U; Department of Engineering and Technology Education, Utah State U; Malaysia: Engineering Education PhD program, Universiti Teknologi Malaysia; India: National Institute for Technical Teacher Training and Research; Mexico: Universidad de las Americas, Puebla.
Engineering education societies...


Participant Networking
EER & STEM Centers and Programs

- Arizona State University
- University of California-Berkeley
- Clemson University
- University of Cincinnati
- University of Georgia
- Georgia Tech
- University of Kentucky
- Linkoping University (Sweden)
- Michigan State University
- University of Michigan
- University of Minnesota
- North Carolina State University
- The Ohio State University
- Pennsylvania State University
- University of Pittsburgh
- Purdue University
- Tufts University
- Universidad de las Americas Puebla (Mexico)
- Universiti Teknologi Malaysia
- University of Texas – Austin
- Uppsala University (Sweden)
- Utah State University
- Virginia Tech
- Washington State University
- University of Washington
- Wichita State University

Participant Networking Activity (~25 min)

- Introductions with Guided Format
- Three (~8 min) Conversations in Groups of 2-3
  - Your Name & Organization
  - Status of EER Center or PhD Program/Interest in EER & EEI
  - Suggestions for Starting/Questions About Starting
  - Exchange Business Cards/Contact Information
  - Identify “intellectual neighborhoods” around common research, organization or other questions and interests
  - Talk about ways to follow up
- Bell will ring once after 7 min and twice after 8 min
- Move to a New Group
Connecting, Expanding & Sustaining the Emerging EER Community (~10 min)

- Small Group (2-3) Brainstorming
  - Ideas for (1) local, (2) national, (3) international Community
  - Ideas for Virtual Community
  - Further Ideas
- Summarize Ideas and Record

Next Steps (~ 5 min)

- Silently reflect on your interests and plans for engineering education research
- Jot down
  - What do you plan to do next?
  - What are your longer range plans?
- Continue the conversation during the FIE conference and beyond
  - EER Networks – CLEERhub, REEN, SEFI
  - Meet again at ASEE Conference, June, 2012
Acknowledgement

- We acknowledge the National Science Foundation for funding Karl Smith and Ruth Streveler’s participation (DUE 0817461)
  - COLLABORATIVE RESEARCH: Expanding and sustaining research capacity in engineering and technology education: Building on successful programs for faculty and graduate students
- And ASEE Headquarters for hosting

Thank you!
An e-copy of this presentation will be posted to:
http://CLEERhub.org
http://www.ce.umn.edu/~smith/links.html

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