Building Engineering Education Research Capacity

Chronicles of a New Center at MSU

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(presenting)

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Mission:

*Transform engineering education through collaborative, empirical research.*
MEERC Overview

• Why Transform?
  – Look at what our current model has gotten us…
Why Transform Engineering Education?

- **Life is Good**
  - It might actually be **TOO** good.
  - **Good engineering is invisible**
  - Most of us don’t think about where any of our technology comes from.
Why Transform Engineering Education?

• Life is Good
  – When was the last time you thought about the lower levels of Maslow’s Hierarchy?

Technology is covering these.
Why Transform Engineering Education?

- **Life is Good**
  - When was the last time you thought about the lower levels of Maslow’s Hierarchy?

  ![Maslow's Hierarchy of Needs Diagram]

  - Living up here isn’t a **BAD** thing...
  - Technology is covering these.
Why Transform Engineering Education?

- Life is Good
  - When was the last time you thought about the lower levels of Maslow’s Hierarchy?

Living up here isn’t a BAD thing...

But this isn’t going away

Technology is covering these.
Why Transform Engineering Education?

• **Life is Good**
  
  – With a shift to living in cities, we have created “localized utopias”.
  – We push the negative side-effects of technology down the road *(or off-shore)*

College-Town USA
*the shining city upon a hill...*
Why Transform Engineering Education?

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*College-Town USA*

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Why Transform Engineering Education?

- Life is Good *for how long...*
Why Transform Engineering Education?

• Life is Good for how long…

Problems building on a grander scale than ever seen before:

• Global Warning
• Refugee crises
• Overpopulation
• Drought
• Extreme Weather
Why Transform Engineering Education?

• **Life is Good**  *for how long…*
  
  – Can our planet sustain 9B people by 2045?
  – 70% will live in urban areas
Why Transform Engineering Education?

• A call from the National Academy of Engineering

- Problems are getting more complex.
- Engineers will play an even more important role in the future.
What does Transformation look like?

• Four overarching themes:

  1. Preparing engineering students to meet the grand challenges of the 21st century
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  3. Improve Efficiency of Learning
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- We are on the precipice of a financial collapse.

- 1.3T Debt.
- #2 consumer debt behind mortgage.
- 44M overall borrowers.
- 22M with federal loans.
- $37k average debt.
What does Transformation look like?

**3. Improve Efficiency of Learning**

- More than money & time...
- Efficiency includes:
  - high impact pedagogical approaches
  - personalized learning using technology
  - lifelong learning in both formal & informal environments
What does Transformation look like?

• Four overarching themes:

1. Preparing engineering students to meet the grand challenges of the 21st century
2. Broadening Participation in the Engineering Workforce
3. Improve Efficiency of Learning
4. Aligning the Skills of our Graduates to the Needs of the Workforce
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- What is the engineering workforce calling for?
  - Technical Knowledge
  - Effective Communication Skills
  - Interpersonal Skills
  - Ability to work on an interdisciplinary team
  - Organizational Skills
  - Desire to Learn
  - Leadership and Management Skills
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  AKA “Professional Skills”

Often dismissed by engineering faculty as being “soft skills”
How do we get there?

• Solution 1 – The “Engineering Education Researcher”
  – 2006, the National Academy of Engineers calls for a new type of scholar.
  – This scholar will work across disciplinary boundaries never broached before.
  – This scholar will create systems and processes for engineering education.

Special Report
The Research Agenda for the New Discipline of Engineering Education

I. Introduction

Rapid changes in the worldwide engineering enterprise are creating a compelling rationale for us to rethink how we should educate future generations of engineers [1-4]. According to The Engineer of 2020 [5], tomorrow’s graduate will need to collaborate across disciplines and solve the challenges of global economic and scientific growth, environmental degradation, and the need to provide housing, food, water, and health care for eight billion people. This scholar will challenge the analytical skills and creativity of engineers. From a U.S. perspective, a continuing decline in interest in American engineering, a shrinking capacity for technological innovation, and an engineering research infrastructure in distress are overly warning signs that the nation’s prosperity and security are at stake if we fail to take action. Our leadership and capacity for ingenuity and position us to begin addressing national and global grand challenges.

The Engineering Education Research Colloquies (EERC) were designed with this transformational charge in mind [9]. Representing a collaborative effort of more than 20 engineering, science, and mathematics educators and researchers, learning scientists, and practitioners, EERC participants worked to address the challenges and future needs of engineering education. This report presents five research areas that will collectively serve as the foundation for the new discipline of Engineering Education. We envision a synergistic research agenda that will profoundly enhance the U.S. capacity to educate future engineers by shaping our understanding of what content (knowledge and skills in context) future engineers must possess, how said content is being learned, and how learning of the content should be assessed. This research in turn will inform how the content should be taught as well as how future learning environments should be designed. Finally, undertake these five areas:

Special Report
The National Engineering Education Research Colloquies

The Steering Committee of the National Engineering Education Research Colloquies

I. The Process

Will the U.S. have engineers prepared to collaborate and lead in a rapidly changing world? The answer to that question, in part, relies on our ability to transform how we educate our future engineers. Our premise is that we need fundamental knowledge of how engineers learn to underpin these transformational decisions. With support from the National Science Foundation, the Engineering Education Research Colloquies (EERC) were designed to collaboratively develop a national research framework and agenda to conduct rigorous engineering education research. The endeavor represents the collective effort of more than seventy engineering, science, and mathematics education researchers. Innovating education.

We believe these research areas will ensure a coherent, rigorous and innovative foundation for systemic and sustained transformation of our engineering education system. Thus, better preparing our graduates to adapt to the rapidly evolving technical, social, and global environment and to be leaders in addressing societal challenges.

II. The Participants

Robb Adams, Purdue University
Duygu Alaldir, Mercer University
Cindy Antoun, University of Washington
Leda Barker, University of Colorado at Boulder
Mary Boerstler Swift, University of Pittsburgh
Scotti Braddock, CASEE
John Bridges, University of Washington
How do we get there?

• Solution 1 – The “Engineering Education Researcher”

  – Research across five areas should create knowledge in:
    • Engineering Epistemologies
    • Engineering Learning Mechanisms
    • Engineering Learning Systems
    • Engineering Diversity and Inclusion
    • Engineering Assessment

  – This research should:
    • Continuously shape engineering curriculums
    • Provide faculty pedagogical tools
How do we get there?

• Solution 1 – The “Engineering Education Researcher”

Engineering

Knowledge

Grand Challenges
  - global context, ethics, sustainability, geo-political issues

Broadening Participation
  - social justice, diversity

Learning Efficiency
  - pedagogy, learning, cost impact

Workforce Skills
  - management, leadership
How do we get there?

- **Solution 1 – The “Engineering Education Researcher”**

  Engineering

  ![Diagram showing knowledge areas]

  - **Knowledge**
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  Fields
  - political science, sociology, philosophy
How do we get there?

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- **Solution 1 – The “Engineering Education Researcher”**

  **Engineering**

  ![Diagram of Engineering Education Researcher with knowledge and fields]

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  **Fields**
  - political science, sociology, philosophy
  - psychology, social psychology
  - education
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Knowledge

Fields

- political science, sociology, philosophy
- psychology, social psychology
- education
- business
How do we get there?

• Solution 2 – Dynamic Engineering Curriculums
  – Curriculums that can make continual tweaks to research findings.
  – Faculty that are engaged in continual change.
How do we get there?

- **Solution 3 – Engineer Leadership**
  - How does the world change if the “global-thinking engineer”:
    - Engages in policy discussions?
    - Engage in discussions about state funding of higher education?
    - Engages in integrating engineering in the K-12 continuum?
    - Brings ethical thinking to the highest levels of corporate America?
• The MEERC’s Mission to contribute to the NAE call.

1. Preparing engineering students to meet the grand challenges of the 21st century.
3. Improve Efficiency of Learning.
4. Aligning the Skills of our Graduates to the Needs of the Workforce.
MEERC Timeline

- **2006-2014** - Organic growth of engineering education research at MSU. Four independent Education Grants (2x IUSE, 2x RIEF).

- **2015** - Engaged faculty decide to organize.
  - Begin year long approval process to form center.

- **2016** - MT Board of Regents approve center.
What We Want To Do

- **Build Engineering Education Research Capacity**

  **Phase 1**
  
  - Building connections between faculty with similar interests from across disciplines (engineering, social psychology, education).
  
  - Start writing proposals. Grow research expenditures in EER.

  **Phase 2**
  
  - Use funded EER to fuel increased publications, increased participation in EER, and interventions to increases success of MSU.
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But as things get going, there are rumblings among engineering faculty about this not being a worthwhile scholarly pursuit.
Polling the COE Faculty

- In November 2016, a COE survey is sent to COE faculty to gauge opinions about EER as a new initiative in the college. (66 responses out of 101 faculty)
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Questions Regarding Using Modern Pedagogies in their Own Classes

- I have access to and support for integrating research driven pedagogies in the classroom.
- I apply research-driven pedagogies in my teaching.
Polling the COE Faculty

Questions Regarding EER as a Worthy Scholarly Pursuit

1. I would support an engineering education research center at MSU.

2. Engineering education is a valid research endeavor for engineering faculty.

3. I support using COE resources to establish an engineering education research center at MSU.
In February 2017, a charrette was held with 32 COE faculty. The questions guiding the discussions were:

1) How can this center serve the college?

2) What obstacles do you see that will prevent us from increasing research productivity in this area?
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1) **How can this center serve the college?**

   - Provide training on effective pedagogical methods to the engineering faculty
   - Serve as a central point of contact for all questions related to teaching and learning.
• In February 2017, a charrette was held with 32 COE faculty. The questions guiding the discussions were:

2) What obstacles do you see that will prevent us from increasing research productivity in this area?

• Lack of training in engineering education research methods.

• Negative Impact on Promotion & Tenure

• Lack of Graduate Students
Solutions

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Some Early Successes

- Increased External EER Funding 400% within 1st year. ($800k to $3.2M)
PFE:RIEF Program Fuels Expansion of Engineering Education Research at Montana State University

In 2015, two PFE:RIEF grants to MSU set in motion a series of events that has resulted in an expansive community of researchers studying engineering education. Dr. LaMeres and Dr. Gannon each received research initiation grants from the PFE:RIEF program to enhance their ability to conduct education research. As the two began collaborating on workshop ideas, they discovered that there were other faculty at MSU that had similar interests and wanted to join forces. The growing community decided to establish a formal Center to serve as the infrastructure for their research. In September of 2016, the “Montana Engineering Education Research Center”, or MEERC, was approved by the MT Board of Regents.

In the first 10 months of MEERC’s operation, four NSF education research proposals have been selected for funding by NSF. MSU now has $3.2M of active NSF funding supporting efforts to create knowledge and test strategies to improve engineering education.

In July 2017, the directors of the MEERC (LaMeres, Gannon, and Schell) received funding from the MSU College of Engineering for a project titled “Expanding Engineering Education Research Capacity in the COE”.

The MEERC now has 20 active affiliate faculty.

MEERC affiliates published 9 papers at the 2017 ASEE Annual Conference.
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- Increased papers accepted at ASEE Annual Conference (12 in 2018, 9 in 2017)
In Closing… The Next Steps

• **Continue to write proposals to engage more faculty in EER.**
  (there is a limit)

• **Push for publishing results in peer reviewed journals.**

• **Figure out a strategy for engaging graduate students in EER within the constructs of Montana State University.**
Questions