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Building Engineering Education Research Capacity – Chronicles of a New Center at Montana State University

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Building Engineering Education Research Capacity – Chronicles of a New Center at Montana State University

Abstract

This paper presents efforts to contribute to the field of Engineering Education Research (EER) via the creation of the Montana Engineering Education Research Center (MEERC) at Montana State University (MSU). This center was established in 2016 and within its first year increased funded EER expenditures by 400%, tripled the number of faculty engaged in EER, and doubled the number of authors submitting papers to the American Society of Engineering Education (ASEE) Annual Conference. This paper will detail the steps that were taken, both formally and informally, to rapidly increase EER productivity at MSU. This paper will also discuss the barriers that must be addressed to maintain this level of productivity including how to engage graduate students in EER, how to integrate EER within the contexts of traditional promotion and tenure procedures, and overcoming cultural stigmas about education research. This paper will be of interest to faculty wishing to engage in EER, faculty already engaged in EER that wish to increase productivity at their universities, or faculty have already established a thriving EER program and have advice to share with the MEERC leadership.

Introduction

To meet the grand challenges facing our society, we need more engineers, more diverse engineers, and engineers that think in a global context. Work in the area of engineering education research promises to create knowledge on how to better prepare our graduates by studying five broad areas: (1) engineering epistemologies; (2) engineering learning mechanisms; (3) engineering learning systems; (4) effectively promoting student diversity and inclusion; and (5) assessment techniques. The call for more engineering faculty engaged in EER was first stated by the National Academy of Engineering (NAE) in 2004 through a variety of national reports and white papers. One of the themes of these reports was that engineering education needs to apply knowledge from other fields (i.e., education, social psychology, political science, philosophy, & business) in order to prepare our graduates to solve the complex, open-ended, cross-disciplinary problems they will face when entering the workforce. This knowledge can only be brought into engineering by a new type of scholar, the "engineering education researcher". Without this type of scholar, knowledge will continually be generated outside of engineering on how to effectively educate, motivate, and think globally, but will not effectively penetrate our engineering curriculums. A second theme of these reports was that engineering curriculums should be more malleable in order to quickly adopt findings from engineering education researchers. The onus of changing these curriculums also falls on the engineering education researcher. As such, this new area of scholarship encompasses more than research on education, but also on theories of institutional change and leadership. During this time, the infrastructure began being laid at federal funding agencies to support this type of scholarship, thanks in part to the NAE and universities at the forefront of this field (i.e., Purdue, Virginia Tech, Utah State). Nearly a decade later, the EER field is reaching universities across the nation through the creation of research centers and new programs.

The Montana Engineering Education Research Center

In 2016, The Montana Engineering Education Research Center was approved by the Montana Board of Regents. The mission of the MEERC is to transform engineering education at MSU and become a national leader in engineering education research. This center will enable MSU faculty to tackle the big research questions and challenges facing engineering education today with an overarching vision of improving student success. In support of this mission, our center established the following overarching goals.

- **Significantly increase the research productivity** in the area of engineering education at MSU. This includes increasing both the amount of externally funded research in EER and the number of scholarly articles published on EER.
- **Initiate large-scale research studies** at MSU to generate empirical findings to address the challenges facing engineering education. The center will initially target efforts on
    - Improve student learning of complex engineering concepts.
    - Improve efficiency of engineering education to reduce time-to-graduation.
    - Broaden participation of underrepresented groups within engineering, specifically women and Native Americans.
    - Increase motivation toward persisting to graduation and entering the engineering workforce.
- **Implement large-scale educational interventions** at MSU to address the challenges facing engineering education. These interventions will create data-driven strategies to enhance student success with specific emphasis on improving student learning, increasing student retention, and broadening participation.
- **Establish MSU as a leader** within the American Society of Engineering Education (ASEE). This will include increasing the number of faculty publishing and attending the ASEE annual conference, increasing the number of MSU faculty serving in leadership roles within ASEE divisions, and moving toward hosting the PNW section meeting in Bozeman by 2022.
- **Contribute to the training of tomorrow's professoriate** by increasing the number of students pursuing doctoral degrees at MSU through funding by external grants and by providing pedagogical training for Ph.D. students desiring to pursue academic careers.

A number of strategies were identified to achieve these goals, which are shown in Figure 1.

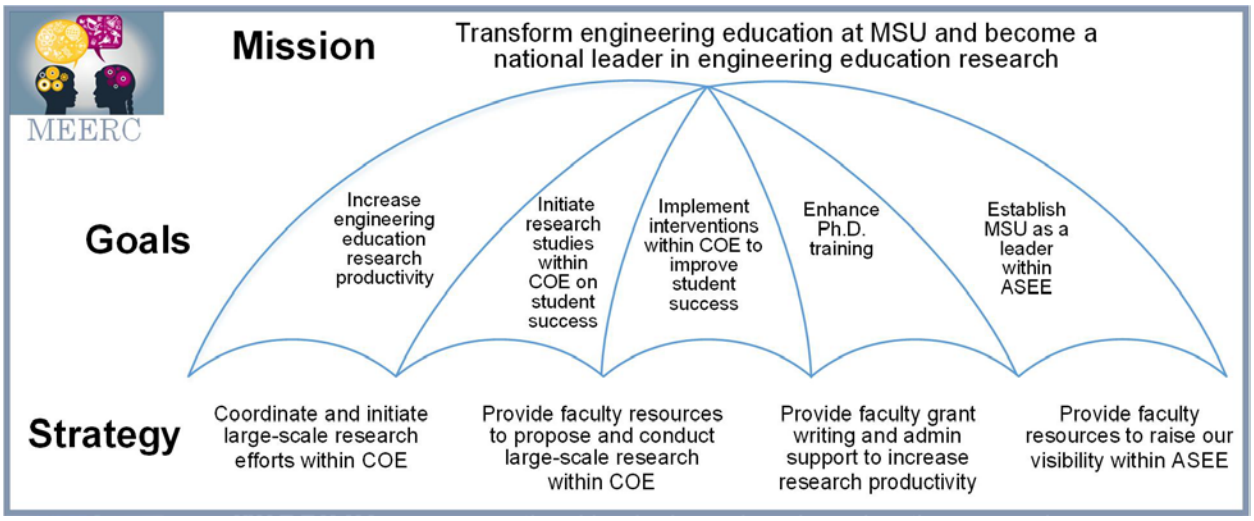

Figure 1. Flow-Down Diagram in Support of the MEERC Mission

The Challenges Encountered

Upon embarking upon achieving the MEERC's lofty goals, we encountered challenges that are likely common to other universities taking on a new research initiative.

In the resource-scare university environment of a public university, any new initiative must be evaluated in terms of the resources needed to get it off the ground versus the resources needed to maintain existing programs. Prior to approval of the MEERC, a survey was sent out to all college of engineering faculty (101 faculty) to gauge their levels of support in the goals of the MEERC and whether it was a worthy endeavor for the college to engage in. Five questions were given, each on a 5-point Likert scale. The results are shown in the following figure. These responses were generally encouraging, and participation was high with 66 responses out of ~101 engineering faculty (~65% participation). The comments on the survey did reveal one emerging concern about EER as a scholarly pursuit in that it may not be perceived as "rigorous" as traditional technical research.

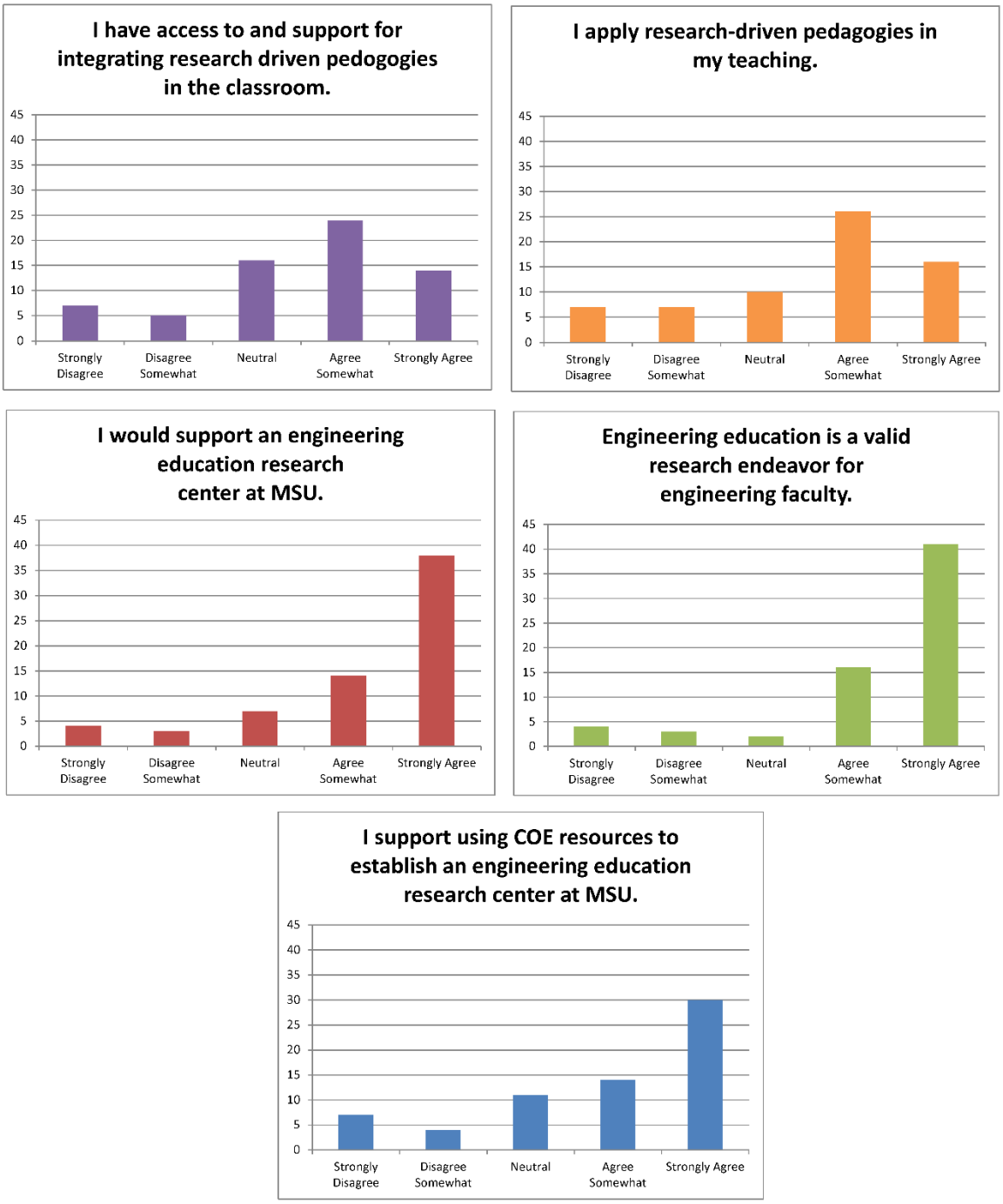

Figure 2. Pre-Approval Faculty Buy-In Survey Responses

After center approval, the first formal event held was a brainstorming *charrette* in which all COE faculty were invited to a round table lunch discussion. The charrette was attended by 32 faculty with 20 from the college of engineering (20%) and the rest from the departments of education, psychology, English, and physics. The questions posed to the participants were: 1) how can this center serve the college? and 2) what obstacles do you see that will prevent us from increasing

research productivity in this area? Comments were recorded by a table scribe and then compiled into themes. The top categorial responses are summarized below:

Question 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.

These top responses revealed an interesting misconception about EER centers. The intent of the MEERC was to conduct empirically-based research in order to produce original data that can advance engineering education. EER centers are often misperceived as 1st year engineering programs or student success centers. While engineering education programs at larger universities certainly have built models that include both academic and research activities under one administrative unit, for center in their start-up stage it is often too much of an undertaking to support both these roles. The intent of the MEERC was conducting educational research, not necessarily providing faculty training in instruction.

Question 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. The majority of engineering faculty at our college have spent their careers being trained in a discipline-specific technical area. To engage in a new research area, there would need to be training in educational research methods. This could be a time-consuming activity and may not be appropriate for untenured faculty.

- Negative Impact on Promotion & Tenure. There is concern about engineering education research being perceived as a less "rigorous" form of research compared to traditional technical research that may result in faculty not achieving promotion & tenure (PnT). Regardless of the rules laid out in policy documents, if there is a negative institutional stereotype about engineering education research, it will come through in the peer-reviewed approval committees. This is of special concern for pre-tenure faculty that may see EER as an impediment to achieving tenure.

- Lack of Graduate Students. For an institution that does not have a Ph.D. program in engineering education, there are not engineering graduate students that are in a position to work on research projects. This has two impacts. The first is that this puts additional onus on the faculty to do the day-to-day research activities. Additionally, since graduate student mentoring is considered evidence of research productivity, lack of EER graduate student supervision may be viewed negatively by PnT committees.

Approaches and Initial Signs of Success

During the first year of the MEERC, nearly all center activities focused on assembling interdisciplinary proposal teams to develop proposals. This resulted in a number of non-traditional collaborations including faculty from psychology, education, English, and performing arts working with engineering faculty on educational proposals. During the first year of center operation, MEERC affiliates won four new grants from the National Science Foundation. The four grants are listed below:

- "Improving the Pipeline for Rural and American Indian Students Entering Computer Science Via Storytelling"
  PI: Brittany Fasy, Assistant Professor, Computer Science
  NSF Division of Research on Learning
  NSF Innovative Technology Experiences of Students and Teachers (iTEST)
  Award No. 1657553, $1,166,000

- "Designing a Middle Grades Spatial Skills Curriculum"
  PI: Nick Lux, Associate Professor, Education
  NSF Division of Research on Learning
  NSF Discovery Research K-12 (DRK12)
  Award No. 1720801, $445,499

- "Fostering Effective Oral Communication Skills for STEM Graduate Students"
  PI: Shannon Willoughby, Assistant Professor, Physics
  NSF Division of Graduate Education
  NSF Research Traineeship
  Award No. 1735124, $481,482

- "The Formation of Undergraduate Engineers as Engineering Leaders"
  PI: William Schell, Assistant Professor, Industrial Engineering
  NSF Division of Engineering Education and Centers
  NSF Research in the Formation of Engineers (RFE)
  Award No. 1664231, $298,159

These four new awards became active concurrent with the four existing grants that MEERC affiliate faculty had prior to center approval (listed below).

- "Engineering a Culture of Engagement"
  PI: Brock LaMeres, Associate Professor, Electrical & Computer Engineering
  NSF Division of Engineering Education and Centers
  NSF Research Initiation in Engineering Formation (RIEF)
  Award No. 1544174, $150,000

- "Effectively Integrating Sustainability within an Engineering Program"
  PI: Paul Gannon, Associate Professor, Chemical & Biological Engineering

NSF Division of Engineering Education and Centers
NSF Research Initiation in Engineering Formation (RIEF)
Award No. 1544147, $150,000

- "Promoting the Development of Metacognition and Combating Robust Misconceptions in a Gateway STEM Course Using an Intelligent Web-based Homework System"
  PI: Jim Becker, Associate Professor, Electrical & Computer Engineering
  NSF Division of Undergraduate Education
  NSF Improving Undergraduate STEM Education (IUSE)
  Award No. 1504880, $249,724

- "Deploying Adaptive Learning Environments to overcome Background Deficiencies and Facilitate Mastery of Computer Engineering Content"
  PI: Brock LaMeres, Associate Professor, Electrical & Computer Engineering
  NSF Division of Undergraduate Education
  NSF Improving Undergraduate STEM Education (IUSE)
  Award No. 1432373, $298,102

At the end of the first year of center operation, the MEERC had eight active NSF education grants. This represented a 400% increase in the amount of actively funded EER at MSU ($800k to $3.2M) and tripled the number of faculty formally engaged in EER (6 to 18).

This initial success resulted in internal funding to support EER methods training. In August of 2017, the MEERC directors were awarded an internal grant funded by an endowment left by alumni Donald Thorson. This grant supported a series of seven workshops on educational research methods to engineering faculty and also provided incentives for faculty to submit abstracts to the 2018 ASEE annual conference. The incentives put in place by the Thorson grant resulted in 22 abstracts being accepted to the 2018 ASEE annual conference (compared to 9 in 2017 and 7 in 2016).

Simultaneous to these achievements, the MSU faculty handbook had been re-written to more clearly acknowledge the place and value of educational research. Prior to this revision, faculty going up for promotion and tenure were required to select an area of expertise in either research **or** teaching. The area of *research* refereed to basic science or applied technical research. The area of *teaching* included both instruction and educational research. This put engineering faculty interested in EER at a disadvantage because they would most often have accomplishments in both technical research and educational research. By choosing to be reviewed for accomplishment in teaching, the technical accomplishments would not be weighted as greatly. At the same time, if the faculty chose to be reviewed for accomplishment in research, then the EER accomplishments would not be weighted as greatly. The new MSU PnT policies have gotten rid of the selection process and instead defined a new area of activity called *scholarship* that all faculty are reviewed under. This new area represented the fundamental creation of knowledge whether it be technical or educational. This now allowed faculty moving into the

area of EER to have all of their accomplishments acknowledged in the PnT review process. It should be noted that the MEERC did not have anything to do with the changes to the PnT policies at MSU; however, the changes had a significant impact on the number of faculty willing to engage in EER as an area of scholarship.

Conclusion and Future Challenges

The MEERC has currently been in operation for 1.5 years and has seen impressive success in increasing the amount of funded EER research, the number of faculty engaged in EER, and the number of faculty submitting abstracts to the ASEE annual conferences. Moving forward, the MEERC still faces challenges on how to engage graduate students in EER. Without a Ph.D. in engineering education, MEERC faculty have instead engaged Ph.D. students in education to work on EER projects. While this is good from an interdisciplinary research viewpoint, it does put engineering faculty at a disadvantage for PnT as they are not the committee chair of these students so their mentoring is not weighted as greatly in the review process. As more projects are funded and the scope of their impact continues to grow, MEERC affiliates must find a way to engage more graduate students in their research while also finding administrative ways to allow mentorship outside of the college of engineering to be counted as accomplishment toward PnT. The second challenge/opportunity is how to advance papers presented at the ASEE annual conference into manuscripts submitted and published in educational journals. Publishing research findings in peer-reviewed journals will serve as the strongest evidence that EER is as *rigorous* as traditional technical scholarship and make the greatest gains in eliminating the negative stigma of EER.