

# MEERC

MONTANA ENGINEERING EDUCATION RESEARCH CENTER | 5 YEARS OF IMPACT

```
nblocks = 1;
group_info = malloc(sizeof(*group_info) + nblocks*sizeof(gi
if (!group_info)
    return NULL;

group_info->ngroups = gidsetsize;
group_info->nblocks = nblocks;
atomic_set(&group_info->usage, 1);

if (gidsetsize <= NGROUPS_SMALL)
    group_info->blocks[0] = group_info->small_block;

else {
    for (i = 0; i < nblocks; i++) {
```

The mission of the MEERC is to **transform engineering education** through interdisciplinary, empirical research. The overarching research goals of the MEERC are:



Strengthen the engineering workforce by better preparing graduates to meet the grand challenges of the 21st century.



Strengthen the engineering workforce by recruiting more and diverse talent into the engineering community.



Improve the efficiency of engineering education.

**1**

**Significantly increase faculty productivity in the area of engineering education research at MSU.**

Measured by the number and amount of funded research projects and scholarly publications.

**2**

**Initiate large-scale research projects at MSU targeting the goals listed above.**

Measured by the number of ongoing projects and number of students impacted.

**3**

**Establish MSU as a leader within the American Society of Engineering Education (ASEE).**

Measured by the number of papers published in ASEE outlets, the number of leadership roles MSU faculty hold within ASEE, and the number of awards received from ASEE.

**4**

**Contribute to the training of tomorrow's professoriate.**

Measured by the quality of initiatives put in place at MSU to prepare engineering Ph.D. students to become professors who thrive in both research and teaching scholarship.

```
ks = nblocks ? : 1;
allocate at least one indirect block pointer
group_info = kmalloc(sizeof(*group_info) + nblocks*sizeof(gid_t)
if (!group_info)
return NULL;
```

# Welcome



**It's hard to believe that the MEERC is celebrating its five-year anniversary.**

It seems like just yesterday that a small group of us were discussing the possibility of expanding engineering education research at MSU. We knew there was interest among faculty, and that we had the ability to contribute to the field, but we didn't know how to make it work within the current structure of our college. As we began to collect feedback from faculty and administrators on this idea, we were overwhelmed by the positive support for our initiative at all levels.

It was decided that we should pursue "center" designation from the Montana Board of Regents. Becoming a center allowed our educational research to fall under a common umbrella that made more sense to outside funding agencies. It also provided administrative structure for new faculty that wanted to engage in education research. In September of 2016, our center status was officially approved by the Board of Regents and the MEERC was launched. Phase 1 of the MEERC focused on growing externally funded research by enabling faculty that had always wanted to propose educational research projects but didn't know the process.

The MEERC facilitated forming interdisciplinary proposal writing teams with the right combination of skills and passions. As these teams were formed and proposals started to be generated, magic started to happen. The only scientific analogy I can think of to explain what occurred is a nuclear chain reaction. Every team that worked on a proposal generated two more ideas for follow-on proposals. As grants began to be funded, other faculty took notice and wanted to join the MEERC and propose their own ideas. The number of faculty involved in the MEERC grew exponentially as did the number of proposals submitted and ultimately, the number of funded projects.

As we celebrate our fifth anniversary, the MEERC currently oversees **15 active grants**—14 from the National Science Foundation and one from the Kern Family foundation. These grants represent **\$9 million of external funding** that involves **35 faculty** spanning all departments within the Norm Asbjornson College of Engineering along with faculty from the College of Education, Health and Human Development, the Jake Jobs College of Business and Entrepreneurship, the College of Letters and Science, the Honors College and the Library.

As you'll see from the project summaries that follow, our research spans the entire spectrum of engineering education from the initial formation of engineering identity in elementary school to contributing value in the workforce. It has been an exhilarating process to watch. As we move into the next five years of the MEERC, we will continue to work on bringing in external funding for our projects, as well as how to implement programs at MSU that positively impact our students using the findings from our own educational research. It has been an honor to serve as Director of the MEERC through its formation and rocket-ship launch. While the future is always unknown, my personal opinion is that it will be awesome.

**Brock J. LaMeres,**  
*Director, Montana Engineering Education Research Center  
Boeing Professor of Engineering Education  
Professor of Electrical and Computer Engineering*

# Why don't more engineers think of themselves as leaders?



**PI: William Schell**  
Mechanical and  
Industrial Engineering

**Co-PI: Bryce Hughes**  
Education

*Industrial engineering seniors Tessa Sybesma, left, and Monika Kwapisz, are researching how engineering students can better understand their leadership potential.*



**Engineers are talented problem-solvers, and the more we can give them leadership opportunities, the more potential there is for better solutions to the problems facing society.**

However, national surveys indicate a widespread tendency for engineering undergraduates to overlook their leadership potential—likely a result of cultural stereotypes as well as how engineering is traditionally taught. With a \$330,000 grant from the National Science Foundation, William Schell, associate professor in the Department of Mechanical and Industrial Engineering, and Bryce Hughes in the Department of Education have worked to pinpoint why more engineering students don't readily think of themselves as leaders and develop ways to change that. The project, likely the most comprehensive yet of its kind, involves analyzing the results of national surveys as well interviewing small groups of engineering students at MSU and elsewhere.



# Teaching computer science through storytelling

- PI: Brittany Fasy**  
*Computer Science*
- Co-PI: Mike Wittie**  
*Computer Science*
- Co-PI: Sweeney Windchief**  
*Education*
- Co-PI: Barbara Komlos**  
*English*
- Co-PI: Stacey Hancock**  
*Math*

*Brittany Fasy leads an interdisciplinary project to explore storytelling as a culturally responsive way to engage middle school American Indian and rural Montana students in learning computer science and computing skills. Clockwise from top left: Suzie Hockel, Connie Chang, Jachike Madubuko, Allison Theobald, Sweeney Windchief, Brittany Fasy and Brendan Kristiansen.*

## Teachers in states like Montana are trying to respond to the increasing importance of computer programming in the modern classroom and workplace.

Teachers in states like Montana are trying to respond to the increasing importance of computer programming in the modern classroom and workplace. In Montana, they're also trying to fulfill the state's promise to teach the heritage of American Indians in a culturally responsive manner to all students. With a \$1.2 million grant from the National Science Foundation, an interdisciplinary MSU team is customizing interactive software that allows for storytelling, an important part of American Indian tradition, as a way to engage American Indian and other middle school students with computer science. "It's easing the barrier to learning computer science," said project lead Brittany Fasy, assistant professor in MSU's Gianforte School of Computing. "The students really love doing this, creating a story in their own way."



# Bridging the gap in spatial skills

**PI: Nick Lux**  
Education

**Co-PI: Bryce Hughes**  
Education

**Co-PI: Shannon Willoughby**  
Physics

**Co-PI: Brock LaMeres**  
Electrical and  
Computer Engineering

*Along with other researchers, MSU students, from left, Amanda Kotila, Elaine Westbrook, along with associate education professor Nicholas Lux, Cotton Real Bird and Clarissa De Leon are working to develop a curriculum based on the popular game Minecraft to improve the spatial intelligence of middle schoolers.*

**The ability to make spatial judgments and to perceive visual images accurately has been shown to be a strong indicator of students' future achievement in STEM courses.**

But there is also evidence of a spatial intelligence gap between male and female students emerging as early as elementary school. Fortunately, there is also evidence that targeted training can quickly close this gap. With a \$450,000 grant from the National Science Foundation, an MSU research team led by Nick Lux, professor of education, is developing a new curriculum that uses a video game to help teach middle schoolers those important spatial skills. "Our hope is that this system we develop will dramatically improve spatial skills, which could result in higher STEM achievement and increase broader participation in STEM for all learners, especially females," Lux said.

# Speaking power



**PI: Shannon Willoughby**  
*Physics*

**Co-PI: Leila Sterman**  
*MSU Library*

**Co-PI: Kent Davis**  
*Honors College*

**Co-PI: Bryce Hughes**  
*Education*

**Co-PI: Brock LaMeres**  
*Electrical and  
Computer Engineering*

**Co-PI: Jennifer Green**  
*Mathematical Sciences*

**Co-PI: Chris Organ**  
*Earth Sciences*



*Kent Davis explains improving to STEM students*





**Graduate STEM education rigorously prepares students to innovate in their fields but often falls short of preparing them to effectively communicate those innovations to others.**

Whether explaining one's research to a government official or reporter, conducting a job interview or giving a presentation to the public, being able to clearly articulate the nature and relevance of one's scientific expertise is a vital skill. Drawing from the performing arts, a project led by Shannon Willoughby, associate professor in the Department of Physics, is exploring how to teach oral communication to STEM graduate students. Backed by a \$500,000 grant from the NSF, the project seeks to facilitate a deeper understanding of the importance of science communication and provide practice in public speaking, improvisational techniques and other skills.

# Fostering an entrepreneurial mindset



**PI: William Schell**  
*Mechanical and Industrial Engineering*

**Co-PI: Bryce Hughes**  
*Education*

**Co-PI: Paul Gannon**  
*Chemical and Biological Engineering*

**Co-PI: Brock LaMeres**  
*Electrical and Computer Engineering*

**Co-PI: Chatanika Stoop**  
*Center for Faculty Excellence*

**Co-PI: Kregg Aytes**  
*Business*

**Co-PI: Scott Bryant**  
*Business*

**Co-PI: Agnieszka Kwapisz**  
*Business*

*Bill Schell shares his experience working in industry with his students.*



**With entrepreneurial spirit and skills, engineers can recognize the full scope of engineering challenges and their solutions, understand market potential and impact,**

then take action to generate value for society. With a \$600,000 grant from the Kern Family Foundation, MSU is advancing its goal of graduating those engineers. The three-year funding will support faculty development and interdisciplinary research on engineering education. “It sets us up to become an exemplar of how to integrate entrepreneurial thinking into how we teach engineering,” said project lead William Schell, associate professor in the Department of Mechanical and Industrial Engineering. The grant comes less than a year after MSU joined the nationwide Kern Entrepreneurial Engineering Network or KEEN.



**For years, researchers have known that it's hard to attract and retain women and some minorities in STEM fields.**

Now, MSU researcher Bryce Hughes is exploring how the same problem applies to sexual minorities. With an NSF Faculty Early Career Development (CAREER) grant, Hughes is examining the participation of LGBTQ students in undergraduate STEM programs to understand how their experiences affect their career goals and decisions. The research is aimed at providing STEM students, educators, administrators and policymakers the tools to create LGBTQ-inclusive learning environments. "What we're seeing is broader patterns of exclusion in STEM fields," Hughes said.

*Bryce Hughes, PI.*



# Enhancing engineering career pursuits in rural and reservation communities

**PI: Rebeka Hammack**  
Education

**Co-PI: Nick Lux**  
Education

**Co-PI: Paul Gannon**  
Chemical and  
Biological Engineering

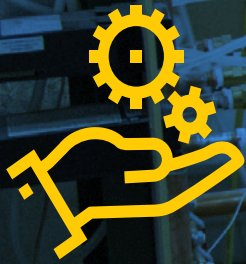
**Co-PI: Brock LaMeres**  
Electrical and  
Computer Engineering

*Students from the Crow Indian Reservation engage with technology to learn about STEM.*

**Many students are capable of becoming engineers but don't pursue engineering education or careers because they aren't fully aware of it as an option or because they doubt their abilities.**

This can result from lack of exposure to engineering in grades K–12, and is particularly common among underrepresented groups such as females and minorities. Backed by a \$400,000 grant from NSF, a team of MSU researchers led by Rebeka Hammack, assistant professor in the Department of Education, is fostering partnerships between tribal and community colleges and the surrounding rural and tribal school districts to engage students in place-based engineering-focused activities that will help motivate and prepare them for engineering careers. As part of the project, students and their families document their views about learning, knowledge and engineering through photo journals that explore students' perceptions of engineering.

# Supporting engineering identity



**PI: Abbie Richards**  
Chemical and  
Biological Engineering

**Co-PI: Carrie Meyers**  
Education

**Co-PI: Ryan Anderson**  
Chemical and  
Biological Engineering

*Abbie Richards explains the role of engineering in modern society to her students.*



**On average, at least a third of college freshman change their majors.**

Unfortunately for the engineering profession, students in STEM majors are even more likely to change majors than their non-STEM counterparts. With a \$200,000 grant from the NSF, a team of MSU educators led by Abbie Richards, head of the Department of Chemical and Biological Engineering, is addressing this by piloting a program aimed at supporting the formation of engineering identity early in students' undergraduate experience. Freshman and sophomores are connected with seniors who serve as role models, and course material from senior capstone courses is integrated into lower-division core classes.

# Supporting interdisciplinary research



**PI: Robert Mokwa**  
Civil Engineering

**Co-PI: John Sample**  
Physics

**Co-PI: Dave Klumpar**  
Physics

**Co-PI: Yves Idzerda**  
Physics

**Co-PI: Angela Des Jardins**  
Physics

**Co-PI: Brock LaMeres**  
Electrical and  
Computer Engineering

*Angela Des Jardins (third from left), assistant research professor in MSU's Department of Physics and director of the MSU-led national Eclipse Ballooning Project, helps with a balloon launch leading up to the total solar eclipse on Aug. 21, 2017.*





**Often university administrative structures hinder the hiring of faculty that do research in areas that do not fall within the purview of any particular department.**

Space science is one of these areas as it straddles the fields of physics, electrical engineering, astronomy, and applied mathematics. The National Science Foundation has established a program to assist universities in bringing on space science faculty by providing support for the first five years of salary in addition to funding for an interdisciplinary mentoring network. Building on a strong track record of conducting space science and engineering, MSU has tapped a \$1.5 million NSF grant to hire a new space science faculty member and create a support structure to help navigate the first few years of being a professor in an interdisciplinary field.



# Portal into engineering

**PI: Paul Gannon**  
*Chemical and  
Biological Engineering*

**Co-PI: Nick Lux**  
*Education*

**Co-PI: Amanda Obery**  
*Education, Central Washington  
University*

## Studies show that students who aren't able to envision themselves as engineers at an early age are less likely to pursue engineering careers later in life.

This can be especially true of students who don't have ready access to academic and extracurricular activities. Research has shown that incorporating engineering-related educational games into middle school curricula can help students develop an engineering identity. With a \$350,000 grant from NSF, a team led by Paul Gannon, professor in the Department of Chemical and Biological Engineering, is working with teachers to develop and introduce educational games for fourth graders that demonstrate engineering concepts. The researchers are studying how students' sense of engineering change as a result of playing the games.



# Writing for the client

**Effective communication skills are highly valued in the engineering industry, yet incorporating them into engineering curricula has proven challenging.**

With a new \$300,000 grant through NSF's Improving Undergraduate STEM Education program, associate professors of chemical engineering Jennifer Brown and Stephanie Wettstein adapt, improve and incorporate evidence-based practices in technical communication instruction. The project will involve collaborating with MSU's Writing Center to develop methods for assessing technical communication skills, comparing assessments of student technical writing by instructors and industry partners, implementing role-playing scenarios, embedding Writing Center tutors trained in discipline-specific genre into the courses, and more.

**PI:** Jennifer Brown

**Co-PI:** Stephanie Wettstein

*The MSU Writing Center partners with community members to support and develop the practice of writing at MSU.*



**Because computer science standards are new to Montana, teachers need support to bring computer science into their classrooms.**

Backed by a \$635,000 NSF grant, a team led by Brittany Fasy, associate professor of Computer Science, have partnered with Montana education stakeholders to develop a new computer science curriculum for grades 4-8 that integrates with other school curricula, including Montana's Indian Education For All curriculum. The project provides support through two novel approaches to computing: storytelling using the Alice programming platform, and physical computing with textiles that are embedded with electronics and then programmed by students. By striving to make computing more fun and accessible, the project makes an important contribution to developing a culturally responsive computing curriculum for Montana students.

# Indian education in computing: a Montana story



*Brittany Fasy shares computing concepts with elementary school students.*

**PI: Brittany Fasy**

*Computer Science*

**Co-PI: Stacey Hancock**

*Mathematical Sciences*

**Co-PI: Travis Peters**

*Computer Science*

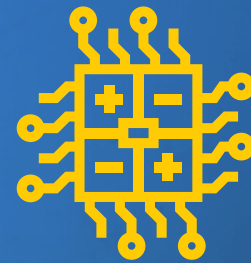


**It is well known that student difficulties in STEM courses such as electric circuit analysis are often rooted in conditioned patterns of thinking that struggle to close conceptual gaps.**

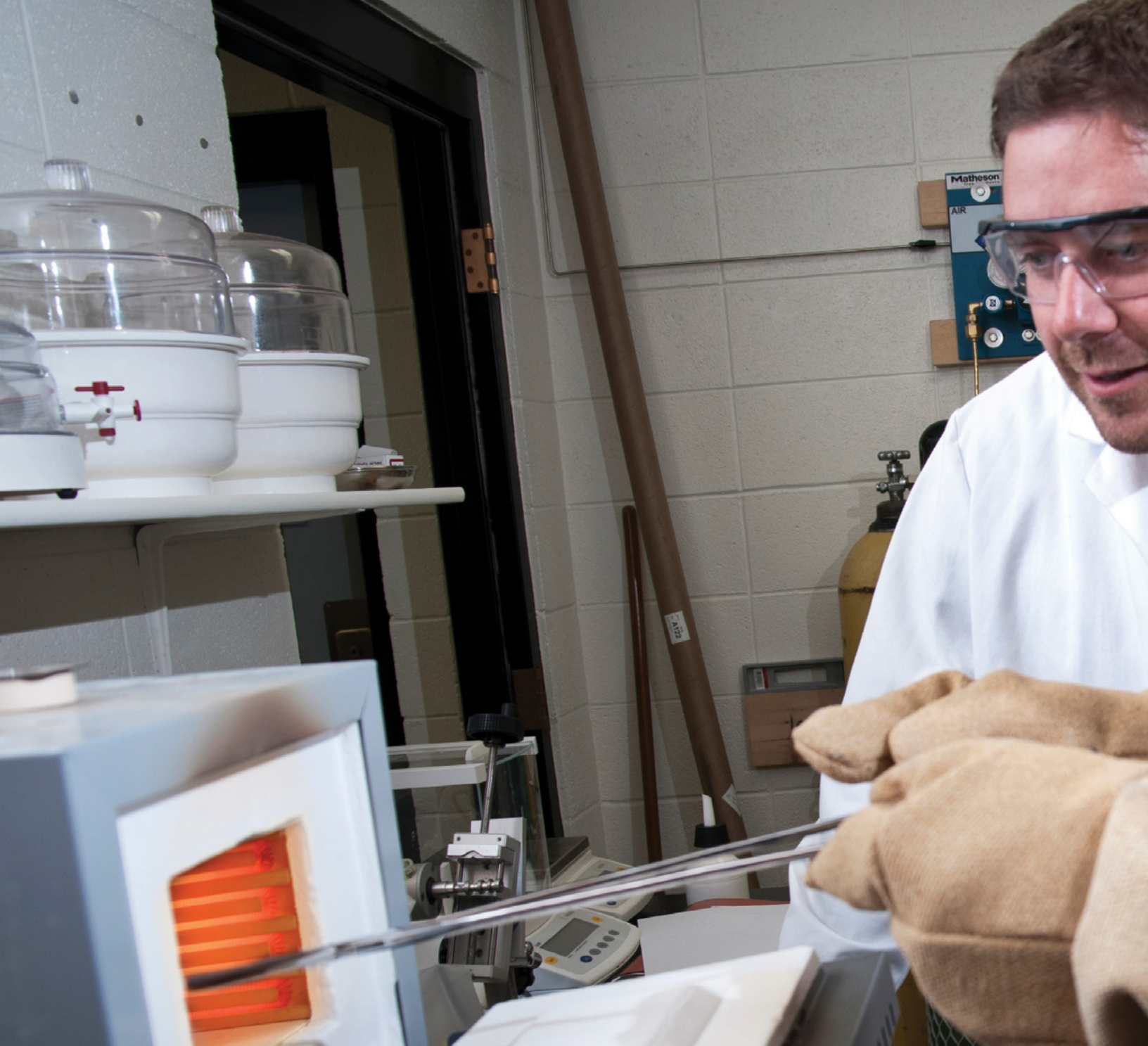
With a \$300,000 NSF grant, electrical engineering professor Jim Becker will explore new instruction methods involving short writing exercises designed to help students become aware of and improve their conceptual thinking. The project will create web-based software applications that give students instantaneous and personalized feedback.



# Closing conceptual learning gaps in STEM



*Jim Becker focuses on conceptual understanding over facts and figures in his classes.*



**Elementary teachers are in a unique position to instill in their students a curiosity and excitement about engineering.**

With a \$600,000 grant from the National Science Foundation, a team of MSU researchers will provide unique professional development opportunities for at least thirty rural and reservation elementary teachers. An immersive six-week experience will combine hands-on energy research at MSU with customized field trips to energy industry facilities such as conventional power plants, wind farms and community-scale solar PV arrays. The trips will also include cultural sites, with a focus on helping teachers meaningfully fulfill Montana's Indian Education for All. A diverse advisory board comprised of regional energy industry representatives will facilitate the tours. By empowering teachers, the program will reach hundreds of rural and reservation elementary students.





# Engineering research experience for teachers



*Paul Gannon mentors  
teachers in his lab.*

**PI: Paul Gannon**  
*Chemical and  
Biological Engineering*

**Co-PI: Abbie Richards**  
*Chemical and  
Biological Engineering*

**Co-PI: Rebeka Hammack**  
*Education*

**Co-PI: Nick Lux** *Education*

# Transforming environmental engineering education



**PI: Craig Woolard**  
*Civil Engineering*

**Co-PI: Ellen Lauchnor**

**Co-PI: Adrienne Phillips**

**Co-PI: Catherine Kirkland**

**Co-PI: Kathryn Plymesser**

## **With a \$1 million grant from the NSF,** MSU is transforming its undergraduate environmental engineering degree to better position graduates to excel in professional practice and serve communities. The five-year funding through NSF's Revolutionizing Engineering Departments program enables several MSU faculty to focus on developing innovative curricula as well as for research and evaluation that could make the MSU degree a model for other programs. "There's a lot of evidence that integrated, project-based learning throughout a student's four years is a better way to prepare engineers for the realities they face in the workplace," said project lead Craig Woolard, head of the Department of Civil Engineering. Under the new bachelor of science in environmental engineering program, courses will be structured around real-world, multifaceted projects that incorporate technical subjects as well as community engagement, economics and writing for general audiences.

Under the new bachelor of science in environmental engineering program, courses will be structured around real-world, multifaceted projects that incorporate technical subjects as well as community engagement, economics and writing for general audiences.

*Katey Plymesser (right) works in the field with students.*

# MEERC Leadership

## Director

**Brock J. LaMeres**, Ph.D. Professor, Electrical and Computer Engineering Boeing Professor of Engineering Education

LaMeres was appointed the Director of the MEERC in October of 2016. He received his Ph.D. in electrical engineering from the University of Colorado in 2005. LaMeres joined the MSU faculty in 2006 where his scholarly interests are in digital systems and education research.

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## Associate Director

**Paul Gannon**, Ph.D. Professor, Chemical and Biological Engineering

Gannon was appointed as Associate Director of the MEERC in January of 2017. He received his Ph.D. in engineering from Montana State University in 2007. Gannon joined the MSU faculty in 2008 where his scholarly interests are in material science and education research.

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[chbe.montana.edu/sofc/People/Gannon.html](http://chbe.montana.edu/sofc/People/Gannon.html)

## Associate Director

**William Schell**, Ph.D. Associate Professor, Mechanical & Industrial Engineering

Schell was appointed as Associate Director of the MEERC in January of 2017. He received his Ph.D. in industrial and systems engineering from the University of Alabama in Huntsville in 2010. Schell joined the MSU faculty in 2012 where his scholarly interests are in engineering management and education research.

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The image shows a yellow rectangular box containing a logo on the left and a QR code on the right. The logo depicts a hand holding a gear. To the right of the logo, the text "Give to MEERC" is written in a bold, sans-serif font. The QR code is a standard black and white square code.

## MEERC Affiliates

*Pictured on back cover left-to-right, top to bottom*

- Kevin Amende
- Ryan Anderson, Ph.D.
- Kregg Aytes, Ph.D.
- James P. Becker, Ph.D.
- Jennifer Brown, Ph.D.
- Scott Bryant, Ph.D.
- Kent Davis
- Angela Des Jardins, Ph.D.
- Brittany Fasy, Ph.D.
- Paul Gannon, Ph.D.
- Becky Hammack, Ph.D.
- Stacey Hancock, Ph.D.
- Jeff Heys, Ph.D.
- Andrew Hill, Ph.D.
- Bryce Hughes, Ph.D.
- Yves Idzerda, Ph.D.
- Kristen Intemann, Ph.D.
- Todd Kaiser, Ph.D.
- Gilbert Kalonde, Ph.D.
- Catherine Kirkland, Ph.D.
- David Klumpar, Ph.D.
- Barbara Komlos
- Wan-Yuan Kuo, Ph.D.
- Agnieszka Kwapisz, Ph.D.
- Brock LaMeres, Ph.D.
- Ellen Lauchnor, Ph.D.
- Nicholas Lux, Ph.D.
- Joseph Menicucci, Ph.D.
- Michelle Miley, Ph.D.
- Bob Mokwa, Ph.D.
- Scott Monfort, Ph.D.
- Carrie Myers, Ph.D.
- Christopher Organ, Ph.D.
- Travis Peters, Ph.D.
- Adrienne (Adie) Phillips, Ph.D.
- Carolyn Plumb, Ph.D.
- Katey Plymesser, Ph.D.
- Abbie Richards, Ph.D.
- John Sample, Ph.D.
- William J. Schell, Ph.D.
- Lelia Sterman
- Chatanika "Nika" Stoop
- Craig Woolard, P.E., Ph.D.
- Stephanie Wettstein, Ph.D.
- Shannon Willoughby, Ph.D.
- Sweeney Windchief, Ph.D.
- Mike Wittie, Ph.D.

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