

COLLEGE OF ENGINEERING  
**ENGINEERING EDUCATION**  
VIRGINIA TECH.

# Funded Research Portfolio

# 2022-23

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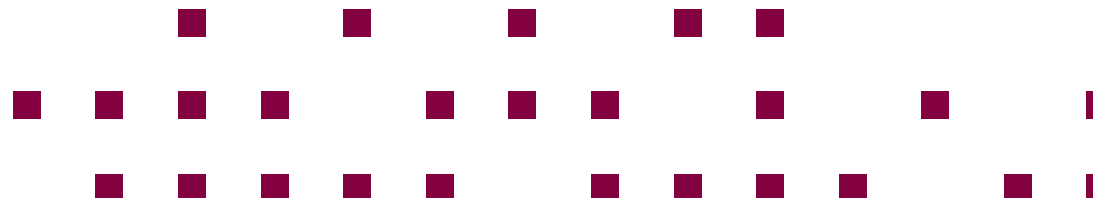
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# Accelerated Learning and Assessment in Engineering Mechanics

**Drs. Nicole Pitterson & Jake Grohs**

*Award Amount: \$298,535*

*Project Dates: March 2019 to Feb. 2023*

Repeated deliberate practice in problem-solving can increase students' understanding of difficult engineering concepts. In addition, students who receive frequent formative feedback are better able to identify and correct problems with their reasoning. Unfortunately, few undergraduate engineering courses provide students with such opportunities for repeated practice, targeted feedback, and focused tutoring.

This project aims to enable these opportunities by developing an automated educational intervention tool for learning engineering mechanics. This open-access, problem-solving interface will provide engineering students with feedback and tutoring, based on their performance on practice exercises. Since all developed materials will be open-source and open-access, the project can also inform and support the work of students and teachers beyond the local institution.

By focusing on developing strong analytical problem-solving skills, this project directly responds to industry and the federal government priorities for developing an engineering workforce that is capable of innovative problem solving. Thus, this project has the potential to contribute to the ability of the U.S. to maintain its economic competitiveness and position as a global leader in innovation.

*Read the full grant summary at [bit.ly/AccelLearn](https://bit.ly/AccelLearn)*

# Artificial Intelligence for All: A Framework for a College Certificate

**Dr. Sarah Rodriguez**

*Award Amount: \$119,592*

*Project Dates: Oct. 2021 to Sept. 2025*

This implementation and evaluation project from Miami Dade College (MDC) aims to serve the national interest by increasing community colleges' capacity to develop and offer courses in artificial intelligence (AI) with the AI for All project. MDC plans to attract and train more students in AI by creating a College Credit Certificate in AI Framework.

Innovative features of the project include an HSI community college adapting AI courses originally developed for a four-year university program and combining them with multiple on-ramps and supports for engaging students such as bootcamps, workshops, and mentoring. The interdisciplinary focus will allow for weaving AI engagement across MDC's colleges and programs providing students with a foundational literacy of AI that will inform whatever career path they follow. The long-term impacts will include increasing awareness and engagement for non-computer science students in AI courses, developing a four-year AI degree at an HSI community college; and broadening participation of groups historically underrepresented in computing careers.

The project's goal is to develop AI courses and an interdisciplinary certificate that will lead to successful student outcomes, while building capacity for the development of a four-year degree in AI at an HSI community college. The STEM education research will explore the computing identity development of students participating in the AI for All project activities, examining how multiple entry points into and paths through the certificate program function to build STEM identity and AI self-efficacy, particularly in Black and Hispanic students.

*This will be a subaward from Miami-Dade Community College to Virginia Tech.*

# Building Capacity to Support Career Acceleration and STEM Workforce Development

**Dr. Walter Lee**

*Award Amount: \$79,980*

*Project Dates: Oct. 2021 to Sept. 2023*

This project aims to serve the national interest by creating and then assessing the impact of a workshop series designed to engage students from underrepresented racial/ethnic groups to consider entering the corporate world. The goal is to build the capacity of the National Action Council for Minorities in Engineering (NACME) to advance knowledge related to broadening participation and STEM workforce development.

NACME is the largest provider of scholarships for college students from underrepresented racial/ethnic groups pursuing undergraduate engineering degrees. Through collaborations with partner institutions and corporate supporters across the country, NACME also provides students with other resources and professional development opportunities. Leveraging the NACME infrastructure, the project team will first develop a workshop series envisioned to better prepare students of color (e.g., African Americans, Hispanic Americans, Native Americans) to enter the corporate world.

An internship will also be part of the activities. Concurrent with the operation of the series the project team will collect information from participants that can help companies improve student internship experiences. The workshop series will begin before students report to their internship assignments and participating interns will be introduced to coping techniques for navigating corporate environments, including potentially hostile workspaces.

*Read the full grant summary at [bit.ly/CareerAccel](https://bit.ly/CareerAccel)*

# CAREER: Disrupting the Status Quo Regarding who gets to be an engineer

**Dr. Jeremi London**

*Award Amount: \$580,582*

*Project Dates: March 2021 to Feb. 2026*

While there has been extensive research on the barriers Black and brown students face as they strive to participate in engineering education and the workforce, there is less scholarship on solutions for addressing this complex challenge. One reason for this is because the scholarship on how change happens in engineering education tends to focus on course content and classroom instruction.

Unfortunately, such findings do not easily lend themselves to value-laden, systemic issues like diversity, equity, and inclusion (DEI). Fortunately, some Colleges of Engineering (COEs) throughout the U.S. have adopted change strategies that have resulted in consistently being named among the top-ten producers of Black and brown engineers. This project is motivated by a desire to learn from and follow their example.

This CAREER project will disrupt the status quo regarding who gets to be an engineer by investigating five COEs that have significantly changed the face of engineering over the last 20 years. This project will: (1) Advance our understanding of the change strategies that exemplary COEs have used to improve Black and brown students' access to engineering education and careers; (2) Identify evidence-based models for broadening participation of underrepresented racial/ethnic groups in engineering; and (3) Set COEs on a path to parity, such that the student body demographics in COEs across the country reflect the racial/ethnic makeup of the nation.

*Read the full grant summary at [bit.ly/LondonCAREER](https://bit.ly/LondonCAREER)*



## ***CAREER: Sustainable Racial Equity: Creating a New Generation of Engineering Education DEI Leaders***

**Dr. Homero Murzi**

*Award Amount: \$663,883*

*Project Dates: May 2022 to April 2027*

The Faculty Early Career Development (CAREER) program is a National Science Foundation-wide activity that supports early-career faculty who have the potential to serve as academic role models in research and education, to lead advances in the mission of their department or organization, and to build a foundation for a lifetime of leadership in integrating education and research.

This CAREER project aims to explore the beliefs, experiences, educational training, and research that supports the development of effective engineering education leaders who are assuming roles focused on diversity, equity, and inclusion (DEI). Advancing equity and broadening the participation of historically marginalized populations in engineering remain a priority for sustaining U.S. global leadership and economic progress.

DEI initiatives, programs, and research are increasing in number across the country in an effort to better understand and dismantle the challenges. However, many DEI efforts are developed in isolation and are not supported by strong institutional commitment and policy. Results from this work will advance understanding of DEI issues, approaches, and effective institutional implementation and will prepare the next generation of DEI leaders to promote long-term, sustainable racial equity initiatives.

*Read the full grant summary at [bit.ly/HomeroCareer](https://bit.ly/HomeroCareer)*

## ***Center for Equity in Engineering: Organizational Transformation for Graduate Education***

**Drs. Julia Ross, David Knight, Bevlee Watford,  
Holly Matusovich, & Walter Lee**

*Award Amount: \$1,199,981*

*Project Dates: Aug. 2022 to July 2024*

University-level administrators, College-level personnel, academic departments, graduate programs, and individual advisors all play important roles in graduate engineering education, but integrating those different influencers to achieve an overarching, coordinated goal is quite challenging.

This project will establish a Center for Equity in Engineering focused on organizational transformation for graduate education at Virginia Tech (VT). Establishing such a center is important because the highly decentralized nature of graduate education in engineering makes integrated reform strategies extremely challenging and fosters inequities throughout the system. Importantly, the Center will reframe broadening participation such that the focus is on changing systems to promote student success rather than trying to “fix” graduate students.

We will focus on organizing, aligning, and integrating many interconnected systems and processes within the system of graduate education (e.g., recruitment, admissions, funding, research, professional development) to promote student success and wellbeing and disrupt systems of oppression across these systems.

Aligned with the vision for an ideal STEM graduate education system set forth by the National Academies and the objectives of the National Science Foundation’s Broadening Participation in Engineering program, we envision a more equitable and inclusive graduate engineering education where student experiences and outcomes are not predicted by demographic variables or citizenship.

*Read the full grant summary at [bit.ly/CenterforEquity](https://bit.ly/CenterforEquity)*

# *Cognitive Barriers to Understanding Complexity in Human-Technical Systems: Evidence from Engineering Students and Practitioners*

**Drs. Jake Grohs & David Knight**

*Award Amount: \$403,178*

*Project Dates: Sept. 2018 to Aug. 2023*

According to the National Academy of Engineering, poor understanding of complex human-technical systems, i.e., systems that have many interacting parts, has been a major cause of “man made disasters” that include, for example, the Fukushima Daiichi nuclear accident and the Deepwater Horizon oil spill in the Gulf of Mexico. Various studies show that even well-schooled engineers have difficulty understanding basic concepts of complex human-technical systems. This research will provide insights of the important cognitive (e.g. reasoning, thinking) skills for the understanding of complex systems for both engineering students and working professionals. Examples of cognitive barriers are for example, the experts’ tendency to look at details at the expense of looking at the big picture, and the human tendency to focus on short-term as opposed to the long-term outcomes, among others.

This research will address the needs of industry and government to educate and develop complex problem solvers for the US workforce so that the US maintains its economic competitiveness, national security, and position as a global leader in innovation. Given that engineers design, build and manage human-technical systems throughout their careers, it is important to study the effect of the cognitive barriers during and after their formal education. From an educational point of view, the research will integrate the results into engineering courses, case studies, team assignments and simulation platforms. From an outreach point of view, the research will use the results for the design and offering of company, government agency, and University workshops.

*Read the full grant summary at [bit.ly/CogBarriers](https://bit.ly/CogBarriers)*

# *Collaborative Research: Intelligently Connecting the Professional and Educational Communities to Prepare the Future Construction Engineering Workforce*

**Dr. Homero Murzi**

*Award Amount: \$2,163,084*

*Project Dates: Aug. 2022 to July 2024*

While universities equip students with theoretical knowledge for STEM, there can be challenges in employing those theories to solve real-life problems. This challenge has resulted in an imbalance between the preparation of graduates entering the workforce and the demands of the industry. This disconnection is persistent in the construction industry as construction practitioners continue to highlight skill shortages that have resulted in low performance and low productivity.

This research project is designed to connect learners with communities of practice thereby giving them access to expert ways of knowing, thinking, reasoning, and solving real-life problems. The research team will develop a tool that connects construction engineering programs with communities of practice thereby enabling instructors access to industry practitioners with the appropriate expertise to meet their practical course-support needs (e.g., site visits, guest lectures, and mentors for capstone projects). As learners interact with communities of practice, this has the potential to inform the ways learners perceive the profession and the development of their own professional identity. These two phenomena will be examined through a qualitative study.

This project is designed to create a collaborative network (called ConPEC) to investigate how the accessibility of construction industry practitioners to instructors, influences construction engineering students’ disciplined perception and professional identity development.

*Read the full grant summary at [bit.ly/ConnectingPro](https://bit.ly/ConnectingPro)*

# ***Collaborative Research: Intersections between Diversity, Equity, and Inclusion (DEI) and Ethics in Engineering***

**Dr. Andrew Katz**

***Award Amount: \$49,339***

***Project Dates: March 2021 to Feb. 2024***

Efforts focused on diversity, equity, and inclusion (DEI) and ethics are often siloed in engineering. While generally pursued as separate lines of investigation, we hypothesize that the aims, objectives, and goals pertaining to ethics and DEI often overlap. By investigating this potential overlap, we hypothesize that we can help improve overall efforts at promoting DEI and ethics in engineering.

Our primary research objective is to synthesize intersections between ethics and DEI among engineering academic and workforce communities. In this study, we begin with a systematic literature review that explores potential overlap in literature in ethics and DEI. Second, we will study how engineering academics view (consciously and subconsciously) ethics and DEI as related. Finally, we will study how industrial practitioners view (consciously and subconsciously) the potential overlap between ethics and DEI.

Collectively, this study will enable us to compare how literature, academics, and practitioners view ethics and DEI as related. We will use findings to generate curricular and workforce training efforts to better integrate ethics and DEI in engineering. This study will benefit society by promoting the formation of engineers who can engage with different values and perspectives in ethical ways.

Despite various models, initiatives, and pockets of innovation by scholars and programs, we have not realized widespread changes in the diversification of the engineering workforce. We theorize that one barrier to change is the disjuncture between lines of scholarship from engineering education researchers in the intersecting spaces of DEI and engineering ethics.

***Read the full grant summary at [bit.ly/IntersectsDEI](https://bit.ly/IntersectsDEI)***

# ***Collaborative Research: Research Initiation: Leveraging Design Thinking to Deal with Ambiguity Embedded in Data-Driven Engineering Problems***

**Dr. Jeremi London**

***Award Amount: \$74,814***

***Project Dates: July 2021 to June 2023***

We are in the midst of a data revolution.

Whether it is analyzing sensor data collected from a complex manufacturing process, customer preference data harvested from Facebook or Amazon, or real-time patient health data transmitted via wearable technology like an Apple Watch or Fitbit; today's engineers are routinely asked to leverage large data sets to solve problems that are increasingly complex and abstract in nature. However, there has been little corresponding change in the way that undergraduate engineers are trained and, as a result, many are not adequately prepared to confidently address such problems when they enter the workforce.

Moreover, there is a dearth of researchers adequately trained to study such pedagogical problems in higher education. The research team for this project, which seeks to address both issues, pairs a seasoned engineering education researcher with a less experienced engineering education researcher in a mentor-mentee relationship.

We aim to explore the use of design thinking to train engineering students to solve abstract problems that are data-rich and include elements of uncertainty and ambiguity. While much of the existing scholarship and practice surrounding engineering design is centered around the development of a physical artifact, we argue that its potential has been largely untapped as applied in this novel, data-centered context.

***Read the full grant summary at [bit.ly/LevDesignThinking](https://bit.ly/LevDesignThinking)***



## ***Collaborative Research: Responsible Engineering across Cultures: Investigating the Effects of Culture and Education on Ethical Reasoning and Dispositions of Engineering Students***

**Dr. Qin Zhu**

**Total Award Amount: \$404,205**

**Project Dates: June 2021 to Aug. 2026**

The goal of this project is to identify educational interventions with the greatest effects on ethical reasoning and dispositions of engineering students, whether these effects differ among cultural and national groups, and if/how to modify these interventions to respond effectively to cultural and national differences. To do so, researchers from Colorado School of Mines, University of Pittsburgh, Delft University of Technology, and Shanghai Jiao Tong University will implement mixed-method, quasi-experimental, longitudinal, and cross-sectional research to: (1) determine the effects of culture and foreign language on the ethical perspectives of first-year engineering students; (2) assess the relative effects of culture and education on these perspectives over four years; (3) use engineering ethics assessment tools across cultures and countries to examine their cross-cultural validity.

Findings from this project will be essential to develop educational interventions that effectively respond to the globalized environments of contemporary engineering practice. They will also contribute to the development of more inclusive engineering education, by identifying perspectives potentially marginalized in the reigning paradigms. Finally, this project has implications for the development of responsible research education at the graduate level. Despite the fact graduate student bodies in STEM fields have become increasingly international, limited work has focused on developing culturally responsive ethics curricula for graduate students from diverse backgrounds.

*This is a subaward from Colorado School of Mines to Virginia Tech.*

## ***Collaborative Research: RFE: An exploration of how faculty mentoring influences doctoral student psychological safety and the impact on work-related outcomes***

**Dr. Mark Huerta**

**Award Amount: \$197,016**

**Project Dates: June 2023 to May 2026**

There is a need to better understand how engineering departments can cultivate more inclusive, psychologically safe environments in which doctoral students feel safe to engage in interpersonal risk-taking, especially in research settings.

A psychologically safe environment is characterized by people who feel safe to voice ideas and concerns, willingly seek feedback, have positive intentions to one another, engage in constructive confrontation, and feel safe to take risks and experiment, all of which are inherently risky interpersonal behaviors. In academic research environments, faculty have a major leadership role in cultivating a psychologically safe environment within research groups.

While engineering faculty possess strong research skills, they often receive minimal to no training on how to effectively provide psychosocial support to graduate students and how to create a positive team climate. The literature suggests women and other underrepresented groups still frequently encounter “chilly” academic climates in STEM, or experience a lack of sense of belonging, leading to negative outcomes such as increased psychological distress and/or a fear of intellectual risk-taking that is essential to learning, creativity, and innovation.

These outcomes hamper graduate students’ ability to fulfill their academic responsibilities, may dissuade them from continuing with their degree program, and contribute to a growing mental health crisis that is already plaguing graduate education.

***Read the full grant summary at [bit.ly/FacMentor](https://bit.ly/FacMentor)***



## ***Collaborative: IUSE: SensDat: End-User Development for Advancing Sensor Data Analytics and Computational Thinking in CEM Education***

**Dr. Homero Murzi**

***Award Amount: \$477,340***

***Project Dates: June 2021 to May 2024***

This project aims to serve the national interest by creating a tool to help students learn computational thinking skills in construction engineering and management courses. The project focuses on active learning experiences in which students learn how to extract meaningful information from large datasets and use the results to make informed engineering decisions.

These experiences can help better prepare students to address construction industry needs, such as increasing productivity, reducing waste, and improving worker safety. The use of sensors on construction sites is a growing trend because they provide real-time data showing what is happening on a site. Students need to develop skills in data analytics and computational thinking so that they can process sensor data, perform data analyses, and develop an understanding of construction site operations.

To accomplish these aims, the project team will develop a web application that provides students with a graphical interface to select, analyze, and display sensor data. Students will be able to explore a construction site in real-time to understand behaviors and relationships between objects on a site and how they relate to construction project safety and productivity. The web application software will be made available to the engineering education community through public software repositories. By addressing the computational skills gap in the construction industry, this project will benefit construction workers and the economic competitiveness of construction companies.

## ***Collaborative: Research Initiation: Assessing Global Engagement Interventions to Advance Global Engineering Competence for Engineering Formation***

**Dr. Homero Murzi**

***Award Amount: \$23,973***

***Project Dates: July 2022 to June 2025***

Engineering students live and work in an increasing global environment. Graduates with experience in understanding, interacting with and valuing differing cultures have advantages in the workplace compared with those who will need to learn those skills post-graduation. This underlying global learner mindset is a key ingredient in cultivating a global engineering competency.

Most intercultural competence research and associated global engineering education is focused on developing the global engineering skillset of students through long-term travel experiences such as study abroad programs. These programs can be expensive, requiring a significant investment of time and money, limiting the participation to more privileged members of a community, and are not scalable to support participation from large numbers of engineering students.

The proposed work will fill a gap in the research by focusing on the development of the students' global learner mindset without requiring extensive international travel. Specifically, the project will investigate how four different global engagement interventions (the use of engineering case studies, the intentional formation of multi-national student teams, a Collaborative Online International Learning (COIL) research project, and a community engaged project within a short course) can develop a global learner mindset.

Four engineering educators who are new to the field of engineering formation research will be trained by social science and engineering education researchers in research methods in order to assess the global engagement interventions that will be developed and implemented in this study.

***Read the full grant summary at [bit.ly/CultureEd](https://bit.ly/CultureEd)***

# Developing a Quantification System for Robot Moral Agency

Dr. Qin Zhu

*Award Amount: \$13,099*

*Project Dates: Aug. 2022 to 2024*

Establishing when, how, and why robots should be considered moral agents is key for advancing human-robot interaction (HRI). Whether a robot is considered a moral agent has significant implications for how researchers, designers, and users can, should, and do make sense of robots and whether their agency in turn triggers social and moral cognitive and behavioral processes in humans. Robotic moral agency also has significant implications for how people should and do hold robots morally responsible, ascribe blame to them, develop trust in their actions, and determine when these robots wield moral influence. Measuring or quantifying moral agency is thus of critical importance for human-robot interaction research.

Although there have been some recent attempts to develop scales that might achieve this goal, these approaches do not align with the philosophical literature on machine moral agency, and moreover, mistake agency (which we argue to be an ontological state of being) for a psychological construct. In this work, we thus seek to develop a tool for quantifying moral agency that better aligns with the philosophical literature which offers rigorous frameworks for conceptualizing machine moral agency. Specifically, we aim to create new methods for quantifying Moral Agency in which researchers (1) separately assess the core constructs of moral agency: capacity for moral action, autonomy, interactivity, and adaptability (the MIAA scales), and (2) logically combine the outputs of those scales. We will draw upon experimental psychological approaches for construct measure development and merge them with techniques rooted in mathematical logic and philosophical theory for determining robots' ontological status as moral agents. We will also demonstrate the usefulness of the MIAA scales to assess moral agency of artificial agents and the logical procedures for combining the four constructs measured with the scales in empirical studies.

# Developing Effective & Culturally Appropriate Alaskan Housing: Performance Metrics for Future Builds Based on an Interdisciplinary Ethnography of Past Projects

Dr. Lisa McNair

*Award Amount: \$300,000*

*Project Dates: Sept. 2021 to Aug. 2023*

This SAI EAGER award supports an interdisciplinary team of anthropologists, educators, builders, and engineers investigating the successes and failures of past housing projects in remote Alaskan communities. They are working with local research assistants to combine building diagnostics, local insights, socio-economic data, and culturally specific housing design. The team is working towards the creation of a repository of designs and findings that is available on an open-source platform.

The data produced from this study will inform and strengthen future Alaskan infrastructure investments, and the research methods will lay the groundwork for similar research investigations in dozens of communities. The project broadens participation in engineering through collaborative research activities, makerspace activities, and community engagement.

The housing security crisis in rural Alaska, exacerbated by climate change and highlighted by the recent pandemic, places immense burdens on resource-strapped communities. While large-scale investments to address these problems may be on the horizon, there is a clear need for cutting-edge research and socially rich data on rural Alaskan housing to guide future projects and avoid mistakes of the past.

This research project tackles this knowledge deficit with an experimental collaboration of experts and community members from inside and outside Alaska who are developing integrated techniques and ethnographically informed understandings of the infrastructural impacts that recent cold-climate demonstration homes have on the lived experiences of Alaskans.

*This will be a subaward from George Mason University to Virginia Tech.*

*Read the full grant summary at [bit.ly/AlaskaHousing](https://bit.ly/AlaskaHousing)*

# Diversifying Paths through Engineering with Extra-/Co-Curricular Participation

**Dr. Holly Matusovich**

*Award Amount: \$59,898*

*Project Dates: Sept. 2019 to May 2023*

While most current research in teaching and learning is performed in the classroom, evidence suggests that the quality of a student's learning is also affected by experiences outside of the classroom (i.e. extra-/co-curricular experiences). Engineering students in particular have available to them a rich variety of learning opportunities outside of the classroom - such as competition teams, undergraduate research experiences, and service learning organizations - which reinforce and strengthen the knowledge they gain through engineering coursework.

The goal of this project is to determine the impact of engineering students' participation in extra-/co-curricular activities on their development into professional engineers. Understanding the specific benefits that engineering-focused extra-/co-curricular programs offer to students will allow those in career and academic advising positions to provide targeted advice to students on how to personalize their pathways through college engineering program, focusing on topics that are interesting to them and finding avenues for strengthening existing skills or learning new ones.

The extra-/co-curricular setting also gives students a relaxed, enjoyable opportunity to practice engineering skills in an authentic environment, leading to improved confidence - a feature that is particularly important for students from underrepresented groups in engineering - and a more technically competent engineering workforce. Further, although certain features of the engineering-focused extra-/co-curricular experience may be challenging to reproduce in a classroom setting, other features may provide inspiration for alternative teaching practices which can enhance learning within the classroom.

*Read the full grant summary at [bit.ly/HollyPath](https://bit.ly/HollyPath)*

# EAGER International Type II: Collaborative Research: Reimagining International Research for Students in a Virtual World

**Dr. David Knight**

*Award Amount: \$110,000*

*Project Dates: May 2021 to April 2023*

International research collaborations provide important opportunities to support innovative research and address the significant global challenges facing the world today. To develop U.S. researchers who are both interculturally competent and able to navigate global research networks within their field, it is important to provide international research experiences for students.

Reimagining international research programs for students in a virtual environment will ensure the resilience of future international engagement to sudden changes such as COVID-19 and potentially broaden access to such opportunities. This project will explore the future of international research experiences for STEM students in the post-COVID era. Building on prior research of student experiences and program structures for these programs, we will convene stakeholders to think creatively about how similar experiences can be provided for students in a virtual environment.

To strengthen the international research collaborations of the future, we need to understand the challenges, benefits, and supports necessary to provide international research experiences for students in a virtual environment. Developing virtual programs that maintain the learning outcomes students gain from the traditional format will require intentional design based on the experiences and best practices of the community of educators who have coordinated international research experiences for students previously.

This project will explore the design of international research experiences for STEM students in virtual environments.

*Read the full grant summary at [bit.ly/InternationalVirtual](https://bit.ly/InternationalVirtual)*

## ***EAGER: Collaborative Research: Changing the Paradigm: Developing a Framework for Secondary Analysis of EER Datasets***

**Dr. Jenni Case**

*Award Amount: \$252,650*

*Project Dates: March 2021 to Feb. 2023*

To help develop the nation's engineering workforce, the National Science Foundation has invested substantial public funding in engineering education research over the past twenty years. This investment has helped markedly improve courses and programs at many universities by testing and sharing research-based practices that promote active learning, increase student motivation and engagement, diversify the field, and better prepare students for work. At the same time, the investment has typically focused on researchers collecting new data, resulting in hundreds of data sets that remain underexplored.

These existing data sets have significant potential to be analyzed and even combined in new ways to further support large-scale changes in how we recruit, teach, and prepare engineering students for the demands and challenges of the 21st century. Currently, however, engineering education researchers do not have productive and effective ways for sharing and analyzing data beyond the original project. Thus, the full potential of these data sets remains untapped.

This project will address that gap by developing and promoting a viable approach that will enable researchers to leverage the rich data currently available. In doing so, it will simultaneously improve engineering education nationally and increase the return on investment of public funds. The project will bring experienced researchers together with those just beginning their careers to identify the major roadblocks to sharing and re-using data, develop strategies and practices for overcoming those roadblocks, and conduct a series of test cases that demonstrate how to put those strategies and practices into action.

*Read the full grant summary at [bit.ly/EERDataset](https://bit.ly/EERDataset)*

## ***EAGER: Natural Language Processing for Teaching and Research in Engineering Education (NLPTREE)***

**Dr. Andrew Katz**

*Award Amount: \$299,647*

*Project Dates: March 2022 to Feb. 2024*

In ecosystems that form professional engineers, community members produce text through many activities such as end-of-semester feedback to instructors, transcripts of instruction, open-ended survey items, and interviews. In each case, there is abundant text available to educators and researchers that could provide insight into how we form engineers. Unfortunately, while these texts have the potential to provide novel insights, traditional analytic techniques do not scale well.

Time investments, bias, interrater reliability, and interrater reliability each present significant challenges. To address this problem, we aim to develop and characterize approaches for human-in-the-loop (HITL) natural language processing (NLP) systems to augment human analysis, facilitating and enhancing the work of one person (or team). Such systems can help reduce the amount of time needed to analyze texts by grouping similar texts together.

The human user can utilize these groupings for further analysis and identify meanings in ways only a human could. The system will also improve consistency by analyzing across the entire collection of texts simultaneously and grouping similar items together. This is in contrast with a single person or a team that would analyze responses sequentially, creating the potential for inconsistencies across time.

We will accomplish this work in three phases. In Phase 1, we will conduct a series of experiments to test potential system configurations. The goal will be to identify optimal components and parameter settings for four of the steps in the proposed pipeline. We will use datasets from (i) students' written responses to an instrument for assessing their systems thinking and (ii) students' responses to open-ended course feedback surveys.

*Read the full grant summary at [bit.ly/NLPTREE](https://bit.ly/NLPTREE)*

# Energy, Environment, and Future Electric Transportation Systems (E-FETS)

**Dr. David Knight**

*Award Amount: \$360,000*

*Project Dates: March 2019 to Feb. 2023*

Approximately 95% of all land, sea and air vehicles in the world today rely on petroleum to move passengers and freight both locally and internationally. This transportation fuel mix produces ~25% of all greenhouse gas emissions and is projected to grow in the future with modernization of developing countries. International energy agencies note that if transport is to contribute to CO<sub>2</sub> reductions to meet the 2 degree C global average temperature target, use of technologies such as hybrid electric and all electric transportation will have to increase in the future.

Thus, advances in transportation technologies are clearly a national and international issue, and require globally-minded engineers and scientists to advance interdisciplinary technologies to develop cleaner regional and global transportation systems. Virginia Tech (VT) proposes to expand upon the Future Electric Transportation Systems (FETS) IRES partnership with the University of Nottingham (UoN), with a broadened scope and stronger engagement with industry and the UK government to establish the Energy, Environment, and Future Electric Transportation Systems (E-FETS) IRES program.

E-FETS cohorts of ~9 per year will investigate next generation electrical power systems for environmentally-friendly fuels and extraction methods; energy-efficient, hybridized power train vehicles and systems; light-weighting of vehicle structures; and the human factors issues that accompany their use and adoption. Among the broader impacts of this IRES program are the promotion of international research collaborations that foster innovative technical leaders capable of creating and effectively integrating electric transportation systems into our society as a means to address efficient energy use.

# Engineering Pathways for Appalachian Youth: Design Principles and Long-term Impacts of School-Industry Partnerships

**Dr. Jake Grohs**

*Award Amount: \$724,031*

*Project Dates: Feb. 2020 to Jan. 2025*

Engineering-related industries can be vital to rural communities, yet many youth in these communities do not commonly have educational experiences that introduce them to locally relevant engineering career pathways. In this project, engineers from local manufacturing companies will partner with educators to co-design learning innovations spanning in-school and out-of-school settings for over 2,500 high school youth from Appalachian counties.

As part of these learning innovations, industry partners will introduce youth to the many applications of engineering that are present in their communities. Across a range of formal and informal spaces, such as schools and libraries, the youth will then have opportunities to use engineering practices and computer programming skills to address local issues of their choosing.

Longitudinal research will determine whether and how different groups of rural youth develop and maintain interest in engineering career pathways over a sustained duration of time, from middle school through the period after high school graduation. This project will advance knowledge and practice by generating empirically-based findings that illuminate the features of innovative and responsive approaches for broadening participation in engineering careers among youth from rural communities.

This project, submitted to the Faculty Early Career Development Program (CAREER), will generate knowledge regarding how rural youth develop, maintain, or shift engineering interest pathways in the context of sustained engineering activities provided across formal and informal settings.

*Read the full grant summary at [bit.ly/EFETS](https://bit.ly/EFETS)*

*Read the full grant summary at [bit.ly/NSFCJAKE](https://bit.ly/NSFCJAKE)*

# Examining the impact of mechanical objects in students learning of thermodynamics-related engineering problems

**Dr. Diana Bairaktarova**

*Award Amount: \$338,798*

*Project Dates: May 2018 to April 2023*

As technology quickly advances in modern society, it is important that the engineers of tomorrow fully learn the basic concepts of engineering so that they can apply these concepts throughout their careers to a range of new applications. Many engineering courses in college involve teaching abstract concepts that are often difficult for students to understand. For example, “Thermodynamics” is an important course that involves learning about relationships between heat, energy, and mechanical work.

Thermodynamics is known to be a difficult course for many students since some of the concepts in the class, such as heat and energy, are abstract. One method for teaching difficult engineering subjects is to use physical or mechanical objects that a student can touch and manipulate in order to demonstrate important concepts. This project examines new approaches for the use and evaluation of mechanical objects as teaching tools in a thermodynamics course with the idea that results from this work can then be applied to additional engineering courses.

This project examines person-object interactions, a significant and critical aspect of engineering, to examine how these interactions affect comprehension of challenging concepts. The primary question to be addressed in the project is fundamental to engineering education and practice: What is the value of mechanical objects in learning engineering related concepts? This study uses quasi-experiments in a mixed methods design where different mechanical objects are used in several problem-solving activities in Thermodynamics classes.

# Faculty Assessment Mental Models in Engineering Education

**Drs. Andrew Katz & Holly Matusovich**

*Award Amount: \$349,157*

*Project Dates: Sept. 2021 to Aug. 2024*

The process of forming engineers is an iterative one that requires feedback to indicate developmental progress and identify areas for improvement. A primary source of feedback comes from assessment, which can play many roles in engineering education: a signal to students of what they do and do not understand about a concept; feedback to instructors about students’ conceptual understanding as well as what may or may not be working regarding their own teaching approaches; and information to administrators and prospective employers evaluating students’ abilities.

Although assessments function as a linchpin in the formation of engineers, it is unclear how faculty members - i.e., the individuals typically designing and implementing these assessments - think about this pertinent signaling mechanism. Because faculty members often have autonomy in making course decisions, understanding how they think about assessments is essential to establish the foundation on future efforts in promoting diverse and improved assessment approaches in engineering education. To better understand how faculty think about and make decisions on assessment, we have designed a three-phase study that uses interviews, surveys, and natural language processing techniques to gather extensive data from a diverse sample of faculty who will undoubtedly have diverse views on students and assessment.

The outcomes of this study will include characterizing faculty mental models of assessment and how those models inform instructional decisions. In developing these outcomes, we will also identify potential biases, misconceptions, and problematic, systemic patterns in assessment implementation. The knowledge generated through this project will inform better faculty training and policies to advance this vital area in the formation of engineers.

*Read the full grant summary at  
[bit.ly/ThermoEngProb](https://bit.ly/ThermoEngProb)*

*Read the full grant summary at  
[bit.ly/FacultyMentalModel](https://bit.ly/FacultyMentalModel)*

# Growing a Community of Compassionate Higher Education Teachers in Science, Technology, Engineering, & Mathematics (STEM)

**Dr. Qin Zhu**

*Award Amount: \$41,499*

*Project Dates: Feb. 2020 to Jan. 2025*

Our project aims to develop a community of compassionate teachers who are dedicated to bringing a loving mindset into their classrooms. This proposal targets STEM higher education teachers, but we hypothesize that shifts in teacher classroom attitudes and practices will affect student character development.

In the future, insights from this project can be further extended to education in other fields and at different levels, particularly K-12 education. We are interested in exploring the following lines of inquiry: (1) What does a character of love (heart) in the STEM-classroom in higher education mean, and in what ways might it be expressed to be beneficial for students and teachers? (2) How can we grow a character of love in STEM teachers in higher education, and how is this shaped by their beliefs and practice? (3) How can a character of love be nurtured in STEM higher education teachers?

Teaching with a Heart will use workshops and subsequent community building among participants to assist teachers to become aware of their beliefs and attitudes about their teaching roles, to reframe these beliefs and attitudes in a positive way, and to incorporate a character of love into their teaching practice in STEM higher education.

*Sponsor: John Templeton Foundation. This will be a subaward from Colorado School of Mines to Virginia Tech.*

# Impact of Interactive Holographic Scenes in Developing Engineering Students' Competencies in Sensing Technologies

**Dr. Diana Bairaktarova**

*Award Amount: \$299,976*

*Project Dates: July 2021 to June 2023*

With support from the NSF Improving Undergraduate STEM Education Program: Education and Human Resources (IUSE: EHR), this project aims to serve the national interest by preparing construction engineering and management students to use modern sensor technologies at construction sites. Over recent years, the construction industry has adopted widespread use of sensing technologies at construction sites, with resulting operational and safety benefits. The use of these sensing technologies has triggered a demand for construction engineering graduates who can enhance industry operations, innovation, and safety through successful deployment of sensor systems.

However, it is difficult to prepare a future workforce that is technologically competent in the use of sensing technologies because safety, schedule, and weather-related constraints limit student access to construction sites. This proposal aims to overcome these limitations, in part, by using a mixed reality pedagogical framework combined with holographic telepresence technology.

This educational approach is intended to equip construction engineering and management students with competencies in sensor technologies. The project promotes academia-industry partnerships by involving industry practitioners in determining the relevant construction engineering competencies and in developing an appropriate pedagogical approach. The learning activities developed for undergraduate students will also be adapted for use in K-12 programs.

*Read the full grant summary at [bit.ly/HoloScenes](https://bit.ly/HoloScenes)*



## ***Institutional Transformation: Cultivating an ethical STEM culture through an integrated undergraduate general education***

**Dr. Diana Bairaktarova**

***Award Amount: \$599,282***

***Project Dates: Aug. 2017 to July 2023***

This project will study the implementation and effectiveness of a university wide ethical reasoning curriculum. The project will identify and assess the culture of ethics education that emerges from “Pathways to General Education” at Virginia Tech. The project will do a systematic analysis of institutional transformation. It will focus on the culture of STEM ethics by tracing the implementation of ethical reasoning into a new general education curriculum.

The research will evaluate the transferability of this approach to other institutions. The project will contribute to broadening students’ expertise beyond their field of study and to provide competencies that will transfer to the workplace. Summer institutes, webinars, on-line training modules and workshops will be developed for faculty to promote ethical considerations in teaching and doing STEM. The findings of this project will be of interest to faculty members, students, university administrators and businesses.

The project will include multi-pronged evaluations of the efficacy of a new curriculum program at Virginia Tech. It will understand the dynamics of the individual, collective, and institutional processes evident in their implementation; and test the overall utility of the ABCD theory of change as employed in this transformation effort.

There are four categories of anticipated impacts from this project: 1) evaluation for direct improvement in faculty ethics teaching competency, 2) evaluation of students’ ethics learning competency, 3) estimation of changes to ethical climate in an R1 STEM focused university, and 4) dissemination of findings and best practices from this project’s research to other institutions. The project will collect qualitative and quantitative data through interviews, surveys and participant observation.

## **Leveraging Design Thinking to Deal with Ambiguity Embedded in Data-Driven Engineering Problems**

**Dr. Jeremi London**

***Award Amount: \$74,814***

***Project Dates: July 2021 to June 2023***

We introduce a pedagogical approach to promote engineering design thinking in conceptual courses to better prepare engineering students to join a contemporary STEM workforce. Using a case study approach, our specific aim is to advance our understanding of how engineering design can be leveraged to solve ambiguous, data-driven engineering problems presented in an undergraduate probability and statistics course while influencing students’ approach to conceptualizing, solving, and communicating solutions to introductory probability and statistics problems.

There are two research questions guiding this study. First, “In what ways might the content, assessment, and pedagogy of an introductory probability and statistics course be modified to facilitate design thinking and tolerance for ambiguity among undergraduate engineering students?” Second, “To what extent can the development of design thinking influence engineering students’ tolerance for ambiguity when dealing with data-driven engineering problems?”

The proposed case study includes three phases. During the redesign phase, the research team will critically examine an existing probability and statistics course design and adapt the content, assessment, and pedagogy to reimagine how the course concepts are introduced and evaluated in a way that also includes an emphasis on design thinking. Then, the course will be redesigned around a semester-long project that will require student teams to: select among options for an open-ended project, leverage design thinking and course concepts learned to address the problem, and communicate their results to stakeholders.

***Read the full grant summary at [bit.ly/LevDesignThink](https://bit.ly/LevDesignThink)***

# MAKER: An Ethnography of Maker and Hacker Spaces Achieving Diverse Participation

**Dr. Lisa McNair**

*Award Amount: \$344,033*

*Project Dates: Aug. 2016 to July 2023*

Maker spaces have been widely touted as a potentially liberative moment for science, technology, engineering, and math (STEM) education, presenting an opportunity to bring traditionally underrepresented groups into STEM fields by engaging them in spaces that are open, creative, and supportive of people from all backgrounds. At the same time, early reports indicate that many maker and hacker spaces are already enacting certain norms that are more conducive to participation of white, male, middle-class, able-bodied hobbyists.

Despite this trend, there are spaces that explicitly stand out in their inclusion of homeless makers, women, people of color, and people with different kinds of abilities. This project examines how diverse makerspaces welcome groups traditionally underrepresented in STEM, and how these practices can inform the design and operation of campus and community maker or hacker spaces that presently struggle to achieve diversity.

Ethnographic methods and Critical Discourse Analysis (CDA) are used to understand these spaces in terms of their physical and linguistic artifacts. This Participatory Action Research (PAR) includes ethnographies at 6 to 8 inclusive maker and hacker spaces, an Open Space Technology (OST) workshop focused on identifying and analyzing core attributes of transferable inclusive practices, and CDA that reflexively summarizes and propagates this information in applicable ways to academic and community sites.

*Read the full grant summary at [bit.ly/LisaMaker](https://bit.ly/LisaMaker)*

# Motivating Successful Advising: Creating Productive Doctoral Advising Relationships in Engineering

**Dr. Holly Matusovich**

*Award Amount: \$15,919*

*Project Dates: Oct. 2021 to Sept. 2023*

While many studies have identified factors that potentially cause doctoral attrition, the most commonly cited factor is the student and doctoral advisor's relationship (Bair & Haworth, 2004). This statement is particularly true for engineering and other STEM disciplines as they practice the 'science model of advising' where the faculty and the student are close collaborators (Crede & Borrego, 2012; Maher et al., 2020; Zhao et al., 2007). While faculty and students are close collaborators on research, developing a positive, productive, and mutually beneficial relationship is a time-consuming endeavor that is often not rewarded in traditional faculty evaluations. Although significant research describes the student and faculty experience within the advising relationship, little research discusses the supports that promote and the barriers that prevent faculty from developing and adopting student-centered advising practices while meeting faculty members' personal satisfaction and productivity needs.

Although it seems obvious for advisors to develop positive and successful relationships with students that lead to degree completion, many advisors do not approach doctoral advising in this way (Artiles & Matusovich, 2020b; Gardner, 2009). Research follows suit as most prior work on doctoral advising takes a unilateral approach towards advising; they focus on either positive practices for student success (Barnes et al., 2010; Burt et al., 2016; Curtin et al., 2013; Joy et al., 2015; Perkins et al., 2020) or positive practices for faculty productivity (Bozeman & Gaughan, 2011; O'Meara & Niehaus, 2013; Waychal, 2018). We argue that within contexts that practice the science model of advising, it is imperative to synergize positive advising practices to create value for both faculty and students.

*This grant is funded via  
Arizona State University.*

# Non-Academic Career Paths of Master's and Ph.D. Engineers

**Dr. David Knight**

*Award Amount: \$191,434*

*Project Dates: Sept. 2021 to Aug. 2024*

Most engineering Master's and PhD graduates will enter careers in sectors such as industry and government, yet research and resources focused on graduate education have historically focused on preparation of future faculty members in academia. This project will meet the call for enhancing the professional preparation of engineers by focusing on non-academic career pathways of both Master's and PhD students in engineering.

Advanced engineering degrees are becoming increasingly important in these non-academic sectors for both individual career trajectories as well as for continued competitiveness within the global innovation landscape. The project will identify how graduate programs can better support students for these careers so that they may successfully and quickly make contributions in their new positions. Additionally, both industry and government have emphasized the need to broaden participation in engineering, and this project will pay particular attention to the experiences of how minoritized graduate students may be best supported on their career paths.

The project aligns closely with the goals of the Professional Formation of Engineers funding program "to create and support an innovative and inclusive engineering profession for the 21st century." At its core, the project aims to understand and identify ways to enhance the professional formation of engineers at the graduate level so that they are best prepared to transition successfully into the non-academic workforce. This project will seek to understand: 1) how recent alumni of engineering graduate programs describe being exposed to, preparing for, and making decisions about non-academic careers, and 2) how engineering faculty, staff, and administrators support students to prepare for such careers.

*Read the full grant summary at [bit.ly/NonAcCareer](https://bit.ly/NonAcCareer)*

# NRT: Disaster Resilience and Risk Management (DRRM)

## Creating quantitative decision making frameworks for multi-dimensional and multi-scale analysis of hazard impact

**Dr. Marie Paretti**

*Award Amount: \$3 million*


*Project Dates: Sept. 2017 to Aug. 2023*

Every human being can be impacted by a disaster, especially in coastal areas. At present, six out of ten people live near the coast and are susceptible to hurricanes, tsunamis, and other hazards. Coastal and other hazards also threaten economic and geopolitical stability, and national security. Hurricanes Sandy (2012) and Katrina (2005) and the Tohoku tsunami (2011) and Typhoon Haiyan (2013) are reminders of the immense long-term impacts such hazards pose. Despite the accelerating risk of such events, resource allocations and coping strategies are often complicated and by varying stakeholder interests.

This National Science Foundation Research Traineeship (NRT) award to Virginia Tech will synthesize expertise in science, engineering, planning, and business to address the critical issue of growing disaster losses attributed to both natural and man made hazards. The program will train a new community of multi-disciplinary researchers, practitioners, and leaders at the master's and doctoral levels.

Over five years, the project will support 26 trainees on NSF stipends, and an estimated 150 additional students will participate in at least one element of the program. Each trainee will pursue a degree through existing academic entities at Virginia Tech or through the university's new Individualized Interdisciplinary PhD program.

*Read the full grant summary at [bit.ly/DRRMimpact](https://bit.ly/DRRMimpact)*



## **RAPID: COVID-19, Remote Ethnography and the Rural Alaskan Housing Crisis: An Ethnographic Study**

**Dr. Lisa McNair**

*Award Amount: \$200,000*

*Project Dates: Jan. 2021 to Jan. 2023*

This RAPID award supports the real-time study of the impacts of COVID-19 on housing insecurity and off-site residential modular construction design in rural Alaska. Preliminary research conducted by the PI team demonstrates that COVID-19 has already changed how builders and architects work with rural Alaska communities to design, construct and install off-site modular construction projects. The PIs propose to document and analyze how new models of virtual consultation and collaboration are being deployed, what roles resilience and innovation play in the development of new building practices, and how new building solutions affect family and community structure. This award lays the foundation for subsequent research on how transformations in housing construction intersect with broader concerns over limited rural infrastructure in Alaska.

The PI team will conduct remote interviews and participatory workshops with stakeholders to document the effects of the pandemic on off-site residential modular construction practices. The proposed work draws upon five months of preliminary research and existing partnerships with builders, architects and engineers working on cold climate housing. RAPID funding will enable the PIs to observe the initial stages of project design and development, tracking logistical strategies and solutions employed by builders working with remote rural communities. Initial focus will be on two off-site modular building projects: elder pods in Unalakleet and a women's shelter in Allakaket. Broader impacts include greater responsiveness of builders to expressed needs of rural and Indigenous residents in cold climates and support for the development of more culturally appropriate and sustainable housing in Alaska.

## **Responsive Support Structures for Marginalized Students: Interrogation of Navigational Strategies**

**Dr. Walter Lee**

*Award Amount: \$570,901*

*Project Dates: May 2020 to April 2025*

Fostering educational environments that empower every student to access available and necessary resources in their pursuit of undergraduate engineering degrees is a national imperative. To support this goal, colleges and universities provide numerous forms of student support intended to increase the retention and graduation rates of its undergraduate engineering students (e.g., peer mentoring programs).

Because of the current lack of diversity in engineering, support often focuses on marginalized groups, such as Black and Latinx students. However, student outcomes and previous research reveals the need for more responsive student support tailored to individual students' needs. Accordingly, the aim of this CAREER project is to advance the extent to which the engineering education community understands how marginalized students 1) navigate undergraduate engineering programs, and 2) make decisions with respect to seeking help.

The study will provide information directly to student support services. By understanding the experiences and decision-making of Black and Latinx students, colleges and universities can support educational environments that are more responsive to the potential diversity of the student populations. The impact of this work will be the more intentional use of university investments and resources focused on broadening participation in engineering.

*Read the full grant summary at [bit.ly/WalterCareer](https://bit.ly/WalterCareer)*

# Rising Doctoral Institute

**Dr. Holly Matusovich**

*Award Amount: \$370,948*

*Project Dates: Jan. 2021 to Dec. 2025*

Research has shown that underrepresented historically underrepresented racial and ethnic groups (African American, Hispanic American, Native American, and Pacific Island) are finishing the doctorate in engineering in lesser rates than their majority peers. For every seven doctorates in engineering granted to majority students, only one minority will obtain one.

To address this problem, we developed the Rising Doctoral Institute (RDI) which aims to provide a timely and preparatory experience for rising doctoral students in engineering to address issues related to transitioning into the PhD encountered by underrepresented students. However, we understand that a single intervention will not change the landscape for underrepresented PhD students. For this reason, our proposed project aims to develop a research-based intervention model of this preparatory experience and develop a community of practice among institutional partners to develop and adapt this model for local contexts. Integral to the project is an investigation of the dynamics of academic systems and how implementing programs like the RDI can influence systemic change within the institution.

Thus, the goals of the proposed project are to (1) research the effect of early interventions for doctoral students on the transition into the engineering doctorate, and (2) develop sustainable models for institutions to implement on their campus to help underrepresented students? transition into the doctorate.

The intellectual merit of this project lies in the integrated research-to-practice design. Using quantitative and qualitative research methods, we will uncover the factors that lead to a successful transition into the doctorate among underrepresented students as well as strategies for designing context-appropriate local RDIs.

*Read the full grant summary & view publications at [bit.ly/RisingDocInstitute](https://bit.ly/RisingDocInstitute)*

# *S-STEM Organizational Partnerships Research Hub: Inter- and intra-institutional partnerships to support low-income engineering students*

**Drs. David Knight, Walter Lee,  
Jacob Grohs & Bevlee Watford**

*Award Amount: \$2,399,501*

*Project Dates: Jan. 2022 to Dec. 2026*

This S-STEM Research Hub will contribute to the national need for well-educated engineers by supporting the retention and graduation of high-achieving, low-income students with demonstrated financial need. The research hub is a collaboration between Virginia Tech, Northern Virginia Community College, Weber State University, and the University of Cincinnati.

This project will reframe the many challenges associated with these students to be “organizational” challenges as opposed to “student-related” challenges, working on making the complex web of student supports work better for students. This research hub’s explicit focus on both first-time-in-college and transfer students ensures that this research will support ongoing efforts to broaden participation in STEM and identify more cost-effective ways for students to earn a bachelor’s degree.

The hub will support a series of integrated activities, each designed to engage a diverse set of programs with a core focus on low-income engineering students. This hub will support accelerator grants from the Scholarships in STEM (S-STEM) program community (40 total) focused on understanding the efficacy of their partnership designs, processes, and structures; four cohorts of grant teams will receive structured mentoring from hub leadership.

*Read the full grant summary at [bit.ly/ENGEResearchHub](https://bit.ly/ENGEResearchHub)*

# Scholarships to Support a Co-Op Based Engineering Education

**Dr. Michelle Soledad**

*Award Amount: \$1,499,808*

*Project Dates: Oct. 2022 to Sept. 2027*

This project will contribute to the national need for well-educated scientists, mathematicians, engineers, and technicians by supporting the retention and graduation of high-achieving, low-income students with demonstrated financial need at Minnesota State University, Mankato.

Over its six-year duration, this project will fund scholarships to 120 unique full-time students who are pursuing Bachelor of Science degrees in engineering. First-semester junior, primarily transfer, students will receive scholarships for one semester.

The Iron Range Engineering (IRE) STEM Scholars Program provides a financially sustainable pathway for students across the nation to graduate with an engineering degree and up to two years of industry experience. Students typically complete their first two years of engineering coursework at community colleges across the country. Students then join IRE and spend one transitional semester gaining training and experience to equip them with the technical, design, and professional skills needed to succeed in the engineering workforce.

During the last two years of their education, IRE students work in industry, earning an engineering intern salary, while being supported in their technical and professional development by professors, learning facilitators, and their own peers. The IRE STEM Scholars project will provide access to a financially responsible engineering degree for low-income students by financially supporting them during the transitional semester, which has two financial challenges: university tuition costs are higher than their previous community college costs, and the semester occurs before they are able to earn an engineering co-op income. In addition, the project will provide personalized mentorship throughout students' pathway to graduation, such as weekly conversations with a mentor.

*Read the full grant summary at [bit.ly/ScholCoOp](https://bit.ly/ScholCoOp)*

# The Computer Science as a Career (CSAC) Scholarship Program

**Dr. Sarah Rodriguez**

*Award Amount: \$408,884*

*Project Dates: Aug. 2022 to July 2027*

This project will contribute to the national need for well-educated scientists, mathematicians, engineers, and technicians by supporting the retention and graduation of high-achieving, low-income students with demonstrated financial need at Texas A&M University (Commerce) and two community colleges in northeast Texas (Collin College and Dallas College).

Over its 5-year duration, this project, the Computer Science as a Career (CSAC) Scholarship Program, will provide 179 scholarships to students who are pursuing degrees in Computer Science. The goal of this project is to increase the recruitment, retention, transfer, and graduation of academically talented students with demonstrated financial needs from diverse sociodemographic backgrounds.

This goal will be accomplished by providing co-curricular activities and programs that recruit students to computing and related fields, increase the rate of transfer from local community colleges to universities, and improve the retention and graduation rates of computing students. This program will contribute to the pool of career ready professionals capable of supporting a globally competitive technical workforce.

The project will encourage students to pursue and complete computing degrees and improve computational thinking skills through many existing high-quality, evidence-based program elements such as summer camps, workshops, and student mentoring programs.

*This will be a subaward from Texas A&M University – Commerce to Virginia Tech*

# The Skillful Learning Institute

**Dr. Holly Matusovich**

*Award Amount: \$724,031*

*Project Dates: Feb. 2020 to Jan. 2025*

The Skillful Learning Institute is a virtual short course experience for 25-30 engineering educators to expand the explicit engagement of engineering students in their metacognitive development. Such intentional engagement with students, helping them become more skillful learners, is critically lacking at present. Metacognition is instrumental in being able to independently assess and direct one's learning - a lifelong skill to propel ongoing growth and development. As such, metacognition is important for engineers because it empowers them (i.e., builds their agency and self-efficacy) to handle ambiguity inherent in navigating and solving engineering problems.

The ultimate goal is to enhance the education of engineers through explicit metacognitive training, and the focus is on educators for their enduring and multiplicative impact on current and future engineering students, and, secondary impacts on their colleagues. The experience is designed to build educators' capacities to teach metacognition and to continue to use and develop engaging metacognitive activities. Intentional elements are included to build a sense of community and mutual support where participants are actively engaged with each other and the facilitators. The aim is to enhance the translation of the resulting metacognitive activities into practice and to develop a lasting community of support after the completion of the short course.

This project will create a diverse virtual community of scholars organized around the desire to see metacognition explicitly integrated into existing curriculum. By eliminating the time and cost of travel, this project will enable populations that might otherwise be limited in attendance such as professional-track faculty, teaching focused faculty, community college faculty, adjunct faculty.

*Read the full grant summary at [bit.ly/SkillfulInstitute](https://bit.ly/SkillfulInstitute)*

# The Use of Mobile Technology & Innovative Pedagogy to Improve Undergraduate Thermal-Fluid Science Learning

**Dr. Diana Bairaktarova**

*Award Amount: \$42,912*

*Project Dates: Sept. 2021 to Aug. 2023*

Student retention remains a problem in science, technology, engineering and mathematics (STEM) programs. This project will utilize mobile technologies and a technology-enhanced curriculum to improve student engagement and learning in STEM undergraduate courses. The technology-enhanced curriculum will be fully integrated in the thermal-fluids course to deliver content and to facilitate student engagement with the content, instructor, and peers.

This research project will measure how mobile technology, when purposefully integrated into engineering teaching, impacts student engagement, enhancement, and extension of learning to real-life problems. Through the full integration of mobile devices, findings from this research will transform the teaching and learning of the thermal-fluid science curriculum. The study will be led by a researcher who is new to the field of engineering education research who will be mentored through research methods by an engineering education researcher.

This aligns with the Research Initiation in Engineering Formation program's goal of initiating new researchers into engineering formation research to meet the needs of a diverse workforce. Undertaking such research project will supplement the lead researcher's experience in developing and implementing mobile learning in the classroom while using social science research approaches to advance both the professional formation of future engineers.

*Read the full grant summary at [bit.ly/MobileTechPed](https://bit.ly/MobileTechPed)*

# The Virginia Tech Network for Engineering Transfer Students (VT-NETS)

**Drs. Bevlee Watford, David Knight & Walter Lee**

*Award Amount: \$5.4 million*

*Project Dates: June 2017 to May 2023*

The Virginia Tech Network for Engineering Transfer Students (VT-NETS) is a collaborative effort between Virginia Tech, Virginia Western Community College, and Northern Virginia Community College. This S-STEM project will establish stronger networks between Virginia Tech and the Virginia Community College System to increase the success of engineering transfer students following the community college-to-bachelor's degree pathway.

The total number of scholarships awarded across all three institutions is 336 over five years. Community colleges are cost-effective gateways to four-year universities for academically talented, low-income students. The creation of a strong partnership, including early and frequent interaction between the student and the four-year institution, will enhance the potential for successful student transfer and timely completion of a baccalaureate degree. VT-NETS creates this partnership and serves as a research-based model for future collaboration between community colleges and four-year institutions.

The goal of this project is to design, implement, and empirically test curricular and co-curricular activities that support the transfer of students following the community college-to-bachelor's degree pathway to an engineering degree. Aligned with the mission of the NSF S-STEM program, the research team will use an embedded case study approach organized around the transfer student capital framework to advance understanding of how various factors affect the success, retention, transfer, and graduation in engineering for low-income students.

The results of this project will help educators develop new interventions and fine-tune current efforts (e.g., making them more sustainable, efficient, and effective) to add value to existing strategies. Such integration with current student support practices will more broadly increase the success of transfer students in engineering nationwide.

# Understanding of Engineering Core Concepts Contextualized in Domain-Specific Settings Through Active Exploration

**Dr. Diana Bairaktarova**

*Award Amount: \$38,902*

*Project Dates: Sept. 2021 to Aug. 2023*

The long history of experiential learning in engineering education shows the significant potential of cognitive development through direct experience and reflection on what works in practice. However, active exploration in a real-life situation may not be always feasible. Recent advances in computer science help educators develop virtual environments and game platforms that allow students to explore various scenarios and learn from their experiences.

This project will explore students' learning of two engineering core concepts: design of a system and optimization contextualized in domain-specific settings. Further, it will examine students' ability to discover systematic solutions for fundamental engineering problems through active exploration in a digital game environment. An online game-based platform will be developed and used to empirically examine the effectiveness of active learning pedagogy. The game will expose users to the two engineering core concepts in the context of construction planning and scheduling through scenario-based problems. The game will be used in a graduate level construction engineering course and the final version of the game will be available for free to download and to play to anyone in the world through a dedicated website and app stores.

The outcomes of the project and the game-based platform can be used in outreach programs to engage and inspire underrepresented and K-12 students in pursuing STEM education. In addition, this project will prepare and train the PI to take a leadership role in social science research on the professional formation of engineers through a mentored, collaborative research project which will expand the community of engineering education researchers.

*Read the full grant summary at [bit.ly/EngCoreConcept](https://bit.ly/EngCoreConcept)*





# vObjects - Understanding their Utility to Enhance Learning of Abstract and Complex Engineering Concepts

**Dr. Diana Bairaktarova**

*Award Amount: \$229,562*

*Project Dates: Aug. 2017 to Dec. 2022*

Thermodynamics is a subject that often features engineering problems that are not well-defined and abstract concepts that are often hard for students to understand. In addition, the scale at which thermodynamic phenomena occur makes it difficult, if not impossible, for students to interact with authentic physical objects that exhibit such phenomena.

To address these challenges, this project will use virtual objects (vObjects) to enhance learning by closely mapping the learner experience to real-life engineering scenarios. This study will be one of the first to systematically evaluate characteristics and features of a virtual learning environment designed to support the “messiness” of real-world problem solving.

This project will employ technological advancements for manipulation of vObjects to help students apply foundational knowledge to the solution of ill-defined problems and to address the improvement of virtual learning for future engineering curricula. A comprehensive understanding of the utility of vObjects in engineering will contribute to the development of online learning environments, including augmented reality environments.

Virtual learning of engineering skills can also be used as a tool for broadening participation in STEM by providing the opportunity for greater access by diverse students. In broad terms, this research will contribute to improving and transforming undergraduate engineering education by enhancing student learning of theoretical and abstract engineering concepts.



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