

## **Integrating Sustainability Grand Challenges and Experiential Learning into Engineering Curricula: a TUES2 collaborative research project**

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Dr. Bilec is an assistant professor in the Swanson School of Engineering's Department of Civil and Environmental Engineering. Dr. Bilec's research program focuses on sustainable healthcare, the built environment, and life cycle assessment. She is interested in improving the overall environmental performance of buildings while connecting the occupants in a more thoughtful manner. She is the Principal Investigator in a multi-disciplinary and multi-institutional research project, NSF EFRI-Barriers, Understanding, Integration – Life cycle Development (BUILD). She has worked in the sustainable engineering arena since 2004. As the assistant director of education outreach in the Mascaro Center for Sustainable Innovation, Pitt's center for green design, she translates research to community outreach programs and develops sustainable engineering programs for K-12 education.

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Kristen Parrish is an Assistant Professor in the School of Sustainable Engineering and the Built Environment at Arizona State University (ASU). Kristen's work focuses on integrating energy efficiency measures into building design, construction, and operations processes. Specifically, she is interested in novel design processes that financially and technically facilitate energy-efficient buildings. Her work also explores how principles of lean manufacturing facilitate energy-efficiency in the commercial building industry. Another research interest of Kristen's is engineering education, where she explores how project- and experience-based learning foster better understanding of engineering and management principles. Prior to joining ASU, Kristen was at the Lawrence Berkeley National Laboratory (LBNL) as a Postdoctoral Fellow (2009-11) and then a Scientific Engineering Associate (2011-2012) in the Building Technologies and Urban Systems Department. She worked in the Commercial Buildings group, developing energy efficiency programs and researching technical and non-technical barriers to energy efficiency in the buildings industry. She has a background in collaborative design and integrated project delivery. She holds a BS and MS in Civil Engineering from the University of Michigan and a PhD in Civil Engineering Systems from University of California Berkeley.

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Dr. Landis joined ASU in January 2012 as an Associate Professor in the School of Sustainable Engineering and the Built Environment. She began her career as an Assistant Professor at the University of Pittsburgh, after having obtained her PhD in 2007 from the University of Illinois at Chicago under the supervision of Dr. Thomas L. Theis.

Dr. Landis' research focuses on Sustainable Renewable Biomaterials and she is highly engaged in Innovations in Engineering Education. Learn more at <http://faculty.engineering.asu.edu/landis/>

## **Integrating Sustainability Grand Challenges and Experiential Learning into Engineering Curricula: a TUES2 collaborative research project**

The next generation of engineering professionals must be prepared to solve complex and multidisciplinary problems in a sustainable and global context. To achieve this we must transform higher education, creating institutions that are committed to excellence, access and impact where students and faculty link to local and regional issues and undertake applied sustainability challenges that impact the social, environmental, and economic evolution of the nation. This Transforming Undergraduate Education in Science, Technology, Engineering, and Mathematics (TUES2) project begins to evaluate the ways in which universities can integrate the National Academy of Engineering's grand challenges and sustainability into curricula. Two strategies are being evaluated, herein termed the *stand-alone course method*, and the *module method*. In the *stand-alone course method*, engineering programs establish one or two distinct, stand-alone courses that address sustainability grand challenges in depth. In the *module method*, engineering programs integrate sustainability grand challenges throughout a host of existing courses. We discuss the development of ready-made, stand-alone sustainability courses and ready-made, sustainability-themed modules that employ experiential learning and evaluate the two different methods of integrating grand challenges into curricula by implementing and monitoring the strategies in five different engineering programs, from Research-Extensive Universities to Community Colleges. The collaborating institutions include the University of Pittsburgh, Community College of Allegheny College (located in PA), Arizona State University, Mesa Community College (located in AZ), and Laney College (located in CA). This poster summarizes the materials for three stand-alone courses and fourteen modules that are being evaluated in our TUES2. In addition, we summarize the assessments that will be utilized within our TUES2, including a longitudinal evaluation of students matriculating through five engineering programs as well as assessments for stand-alone classes and modules. Ultimately, we aim to develop succinct recommendations for other universities to best integrate sustainability and systems thinking into engineering curricula. This work is supported by the National Science Foundation Transforming Undergraduate Education in STEM (TUES) Type 2 program- DUE Award Nos 1323719 and 1323190.

### Summary

In this NSF TUES 2 project, we will develop modules and courses that utilize *experiential learning* on topics related to *sustainability grand challenges*. We will implement these modules and courses in the curricula in our five partner institutions (ASU, MCC, UPitt, CCAC, Laney) and evaluate the effectiveness of the modules and classes on student, faculty, and program performance. All materials developed in the proposed TUES 2 program (courses, modules) will employ well-known experiential learning pedagogies and build on the teams' sustainability engineering educational expertise. Flexibility will be built into the stand-alone course materials and modules to accommodate the resources of different faculty and facilitate the adoption of these courses across different universities. Our aim is to train students to think outside the box, connect their learning to the real world, and who are prepared to tackle the engineering challenges of a global economy. Specifically, through this proposal we plan to (1) create and (2) implement ready-to-use content for three new stand-alone sustainability courses and fourteen

modules, (3) evaluate the effectiveness of each course and module based on student and faculty feedback and performance, (4) evaluate the different degrees of program-wide curricula change: the *stand-alone course method* and the *module method*, and (5) disseminate the courses, modules, and findings to other institutions

### Intellectual Merit

The proposed project employs experiential learning, which has been shown in educational research to enhance the quality of student learning. We will develop engaging activities for students both within the classroom and in the real world and increase faculty expertise by mentoring numerous faculty over the four-year project. Though the proposed TUES 2 project we will evaluate the two different methods of integrating grand challenges into curricula (i.e. the *stand-alone course method* and the *module method*) by implementing and monitoring the strategies in five different engineering programs. We will also improve upon the assessment of learning outcomes. We will conduct a longitudinal evaluation of students matriculating through five engineering programs, and will create succinct recommendations to other universities to best integrate sustainability and systems thinking into engineering curricula. We will advance the understanding of faculty and institutional barriers to integrating sustainability and experiential learning into curricula.

### Broader Impacts

The proposed TUES 2 project will create a wealth of resources aimed at many different engineering courses across the range of undergraduate levels; throughout the four-year duration the program will reach hundreds of undergraduates at Research-1 and community colleges. We will have published materials for three courses and fourteen modules that ease the adoption of sustainability grand challenges and experiential learning into curricula. The modules and courses developed should improve the capabilities of future engineers to tackle challenges throughout the next century. The proposed project identifies and minimizes barriers to implementation of sustainability topics and experiential learning, which will aid other universities across the Nation in infusing sustainability grand challenges into their curriculum. Despite testing courses in Civil Engineering programs at ASU and UPitt, we have built in the flexibility to accommodate the resources of different faculty at different types of institutions and facilitate the adoption of these courses across different universities. We have outlined an aggressive and extensive dissemination plan to reach faculty across the Nation.