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Reimagining Energy Year 3: Reflections on a Course Offering

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Dr. Gordon D. Hoople is an assistant professor and one of the founding faculty members of integrated engineering at the University of San Diego. He is passionate about creating engaging experiences for his students. His work is primarily focused on two areas: engineering education and design. Professor Hoople's engineering education research examines the ways in which novel approaches can lead to better student outcomes. He is the principal investigator on the National Science Foundation Grant "Reimagining Energy: Exploring Inclusive Practices for Teaching Energy Concepts to Undergraduate Engineering Majors." He has also co-developed a unique interdisciplinary course, Drones for Good, where engineering students partner with peace studies students to design a quadcopter that will have a positive impact on society.

Dr. Diana Chen, University of San Diego

Dr. Diana A. Chen is an Assistant Professor of Integrated Engineering at the University of San Diego. She joined the Shiley-Marcos School of Engineering in 2016. Her research interests are in areas of sustainable design, including biomimicry and adaptability in structural, city, and regional applications. Additionally, her scholarship includes topics such as curriculum development, contextualization of fundamental engineering sciences and integrating social justice into engineering education. She earned her MS and PhD in Civil Engineering from Clemson University, and her BS in Engineering from Harvey Mudd College.

Dr. Joel Alejandro Mejia, University of San Diego

Dr. Joel Alejandro (Alex) Mejia is an assistant professor in the Department of Integrated Engineering at the University of San Diego. His research has contributed to the integration of critical theoretical frameworks and Chicano Cultural Studies to investigate and analyze existing deficit models in engineering education. Dr. Mejia's work also examines how asset-based models impact the validation and recognition of students and communities of color as holders and creators of knowledge. His current work seeks to analyze and describe the tensions, contradictions, and cultural collisions many Latino/a/x students experience in engineering through testimonios. He is particularly interested in approaches that contribute to a more expansive understanding of engineering in sociocultural contexts, the impact of critical consciousness in engineering practice, and development and implementation of culturally responsive pedagogies in engineering education.

Dr. Laura Ann Gelles, University of Texas at Dallas

Laura Gelles is a postdoctoral research associate at the University of Texas at Dallas within the Erik Jonsson School of Engineering and Computer Science where she is studying retention of undergraduate engineering students. She has extensive experience using qualitative and mixed-methods research in Engineering Education. Before joining UTD in September 2020, Laura worked at the University of San Diego on their RED grant to study institutional change efforts and redefine the engineering canon as sociotechnical. She has a background in environmental engineering and received her Ph.D. in Engineering Education at Utah State University with a research focus on the ethical and career aspects of mentoring of science and engineering graduate students and hidden curriculum in engineering.

Dr. Susan M. Lord, University of San Diego

Susan M. Lord received a B.S. from Cornell University in Materials Science and Electrical Engineering (EE) and the M.S. and Ph.D. in EE from Stanford University. She is currently Professor and Chair of Integrated Engineering at the University of San Diego. Her research focuses on the study and promotion of diversity in engineering including student pathways and inclusive teaching. She is Co-Director of the National Effective Teaching Institute (NETI). Her research has been sponsored by the National Science Foundation (NSF). Dr. Lord is among the first to study Latinos in engineering and coauthored The Borderlands of Education: Latinas in Engineering. Dr. Lord is a Fellow of the IEEE and ASEE and is active

in the engineering education community including serving as General Co-Chair of the Frontiers in Education Conference, President of the IEEE Education Society, and Associate Editor of the IEEE Transactions on Education (ToE) and the Journal of Engineering Education (JEE). She and her coauthors received the 2011 Wickenden Award for the best paper in JEE and the 2011 and 2015 Best Paper Awards for the IEEE ToE. In Spring 2012, Dr. Lord spent a sabbatical at Southeast University in Nanjing, China teaching and doing research. She is on the USD team implementing "Developing Changemaking Engineers", an NSF-sponsored Revolutionizing Engineering Education (RED) project. Dr. Lord is the 2018 recipient of the IEEE Undergraduate Teaching Award.

Reimagining Energy Year 3: Reflections on Course Offering

Overview

This National Science Foundation (NSF) project focuses on the development of a new, required energy course, "An Integrated Approach to Energy," for second-year students that considers ways to best include, represent, and honor students from all backgrounds using a collection of pedagogical approaches known as culturally sustaining pedagogies (CSPs). It is sponsored by the Division of Undergraduate Education (DUE) Improving Undergraduate STEM Education: Education and Human Resources (IUSE: EHR) program. Energy is a modern and foundational concept across engineering disciplines, but it is often introduced to students in notoriously disengaging Thermodynamics courses. Many of these courses have roots in the Industrial Revolution and are characterized by particularly ethnocentric (White), masculine, and colonial knowledge. CSPs have been used successfully in K-12 settings, yielding particular benefits for historically marginalized students, but have yet to be fully explored in undergraduate engineering. CSPs in this project encourage students to connect their lived experiences to course topics, broaden conceptualizations of energy, and help students acknowledge the differing values and perspectives of others.

This research seeks to (1) identify energy examples outside of those traditionally used in the engineering canon; (2) develop and teach a course that integrates these non-traditional examples using CSPs; and (3) deepen educators' understanding of how CSPs impact student learning, mindsets, and attitudes. These materials are being disseminated so that other faculty may use a CSPs approach to engage their students. An overarching goal of this work is to promote inclusion within engineering to support broader participation and thus increase diversity. CSPs may be a key tool in changing the dominant discourse of engineering education, improving the experience for those students already here and making it more welcoming to those who are not. Now in the third year of this project, we offered the course for the first time in Spring 2020 for students in Integrated Engineering. We are currently offering the course for the second time in Spring 2021 and incorporating lessons learned during the first offering.

This poster and associated paper reports on students' response to our new approach and instructor and researcher reflections from two offerings. We have designed the course collaboratively among four engineering faculty and collaborated with a postdoctoral scholar for observations, interview, and qualitative analysis. We will highlight areas that have been successful as well as identify areas that need further refinement and improvement. While Spring 2020 was certainly not the semester we had planned due to disruptions from COVID-19, we are overall quite pleased with this initial offering of the course.

What worked well?

First and foremost, we should acknowledge we had a small and highly engaged group of 18 students enrolled in this course. During the first weeks of the semester, students were able to build a strong bond with each other and the instructor. This served as an excellent foundation when we transitioned to emergency remote teaching (ERT) roughly halfway through the semester. We capitalized on the opportunity to explore students' response to COVID and ERT as well as their response to the course itself [1].

One lesson we took from our research into CSPs was the importance of connecting course materials to students' lived experiences [2]. When considering what course topic to focus on for implementing a CSPs-oriented approach within engineering education, one reason we opted for an energy course was that there are many ways to connect to students' lived experiences. For example, in one activity students analyzed their own energy bills. In another, we asked students to review the power specifications for their electronic devices and analyze their daily power usage. When energy demand plummeted due to COVID-19 stay at home orders, students came to class with questions about the impact the pandemic was having on the energy landscape. Overall we were pleased to see the ways in which students brought their own knowledge and passion to the classroom.

Another goal of our project is to broaden the engineering canon by including class activities and examples not typically found within engineering. For example, on the first day of class we lead students through an activity in defining the term "energy." We helped students to see that the concept of energy is a social construct with no simple definition. We also implemented many small tweaks in the examples used in the class that challenged traditional militaristic depictions of engineering - for example replacing the common illustration of a bullet with that of a child on a swing in kinetic energy calculations. Overall these changes provided a different contextualization for students and were well received by students. These small, but significant changes, delivered on our goal to broaden students' perceptions of what "counts" as engineering in an energy context.

Another tenet we drew on from CSPs was the importance of treating students as co-creators. When planning the course we sent a survey to those students likely to enroll in the course the following year. This survey explored their interest in a range of energy topics [3]. One surprising finding (for us) from this survey was that students were quite interested in nuclear energy. While we had not originally planned to have much content focused on nuclear energy, we developed several classes on the topic. Students found this to be one of their favorite parts of the semester. More details on the design of the course and student response are available in previously published work [4].

What areas are there for improvement?

One of our major goals in this project is to help individuals acknowledge the differing values and perspectives of others. While we made important strides towards this goal, there is more work to be done in future offerings of the course. We acknowledge that this is complex work that requires not only a change in the curriculum but also a change of mindset. Such change requires enough time for reflexivity, recognition of the centrality of whiteness in engineering, and a continuous effort to reframe engineering work and curricula. We approached this topic by including examples that exposed students to different points of view; however, upon reflection by the team, we feel we did not fully integrate this content into the overall flow of the course. For example, in the module on wind turbines, we started with an example of traditional turbines developed in Iran (and still in use today) that were the progenitor of the more famous Dutch windmills. While in theory this seemed to be an excellent example, when the lesson was delivered it was not sufficiently integrated into the curriculum. Although some students found it to be a memorable example, others perceived it as somewhat superfluous to the course flow and saw it as a historical artifact rather than an example of engineering knowledge outside of Western culture. We are working on ways to better integrate this type of content seamlessly within the course flow.

Another challenge area we identified was that students left the course with a very narrow conception of sustainability that was primarily based on efficiency. Sustainability was not a primary focus of our course development, indeed we have another entire course devoted to the topic in our curriculum; however, during the semester it became clear that students were constructing a definition of sustainability based on what they were being exposed to in class. In our next offering we are planning to explicitly define sustainability early on in the semester to provide students with a framework that better presents the complex political, economic, societal, technical, environmental, and legal factors that go into our modern concept of sustainability. It is our intent that this framing of sustainability will also offer an opportunity to talk more broadly about examples that could potentially better align with CSPs. We plan to highlight the most commonly quoted definition of sustainability from the 1987 Brundtland Report, but also will highlight the much older seventh generation principle of the Haudenosaunee Confederacy: “decisions we make today should result in a sustainable world seven generations into the future” [5]. (This Indigenous group was called the “Iroquois Confederacy by the French, and the League of Five Nations by the English, the confederacy is properly called the Haudenosaunee Confederacy meaning People of the long house” [6].)

Additional Directions

Although not initially planned, given our goals and the national discourse on systemic racism in the USA in 2020, the research team also developed and delivered a workshop on Antiracism and Engineering Education [7]. This will be offered at the ASEE 2021 conference in the faculty

development division [8]. Our poster presentation will report on the first and second offerings of this course. We hope that we will be able to successfully address the shortcomings we identified in our first offering as well as build upon our successes. As this grant concludes, we are starting to turn our attention to the overall lessons we have learned from our experience with this pedagogical approach and consider the ways in which our such lessons can be scaled beyond our local context.

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