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Reimagining Energy Year 4: Lessons Learned

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Reimagining Energy Year 4: Lessons Learned

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 based 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 can be a valuable 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 final year of this project, this poster and associated paper reports lessons learned from this project. We explore these lessons through the lens of the three high level goals in our original proposal.

Identify energy examples outside of those traditionally used in the engineering canon

A core objective of our project was to identify examples we could use in class outside of those traditionally found in engineering textbooks related to energy. Many of the examples in energy engineering emphasize stereotypically White male interests (e.g. car engines and rockets) [1]. Furthermore the examples we often use in engineering tend to be abstracted and remove the social elements of the problem [2].

For this course we developed new examples of varying levels of complexity [3]. The smallest examples could be included on a single slide to emphasize a particular concept. For example, we included a slide about units that showed the ways in which units are cultural and have historically been based on the length of different body parts. We also identified examples that could be incorporated into energy courses in the span of a single class and homework assignment. For example, we developed a single day activity exploring environmental justice and how it intersects with energy policy. Lastly we developed some large-scale examples spanning multiple classes. Our campus has a small renewable energy generating station (EnergiPlant) that we spent several weeks analyzing to explore concepts of both solar and wind energy. We also introduced The Seven Generations principle, a conception of sustainability from the Haudenosaunee (Iroquois) Confederacy, and used it as a framing for multiple conversations throughout the semester [4].

Reflecting on this experience we are keenly aware how much effort was required to identify the examples and incorporate them into our class. Four faculty collaborated on the development of this course over four years, a substantial investment of time that would not have been possible without NSF support. The good news is that we all agree regardless of the content area examples exist that can be used to broaden the engineering canon. The challenge is that faculty need the interest, time, and incentives to seek them out and incorporate them into their courses.

Develop and teach a course that integrates these non-traditional examples using CSPs

Over the course of this grant we have successfully offered this course three times (2020, 2021 and 2022) reaching a total of 47 students. Due to the COVID-19 pandemic the class has been offered using both in-person and online formats. Each offering has seen us improve on how we incorporated our learnings from CSPs into the curriculum. For example, during the first offering we discovered we unintentionally reinforced student misconceptions about sustainability [5]. We refined and grounded the course with a start in sustainability informed by an indigenous perspective [6] that helped prepare students for later coursework.

Importantly we discovered in our research on CSPs the importance not only of diversifying our examples, but also how a range of pedagogical approaches should be used to help students build their critical consciousness [1]. We found a sociotechnical framing to be particularly beneficial in helping students achieve this goal [7]. We identified a few key new activities to support this effort. One important framing we incorporated was the PESTEL (political, economic, social, technical, environmental, and legal) analytical framework. This framework, developed organically over the last few decades with contributions from many scholars, is typically found in business courses [8]. We found it ideally suited for engineering students as it is a simple framework that helps students deconstruct complex nature of engineering practice.

We also incorporated several critical literacy exercises to help students develop their ability to interrogate both the validity and bias of a source as well as unpack the complexities of controversial energy topics. One exercise we did with students was a collaborative reading of a news article on the Keystone XL pipeline. We took the article and put it into a Google Document and asked the students to first simply read through the article. We then assigned them a particular PESTEL category (e.g. Political) and had them re-read the document and add a comment anytime the article touched on a political issue. This laid the groundwork for a fruitful discussion about this complex topic and helped students to move beyond dogmatic responses and explore more nuanced viewpoints.

Lastly, building on the extensive literature around metacognition [9], we incorporated time and space for students to reflect on their own positionality, learning, and viewpoints. Importantly we did not push a particular narrative in this class. We did not want students to leave with our viewpoint, but instead emphasized the importance of developing their own point of view with regard to energy and sustainability based on a nuanced and well informed understanding of the current state of affairs in the world. We had short activities in class asking students to reflect on quick questions, each homework incorporated a reflection question at the end, and the final paper asked students to think about their future selves and the role they would have in addressing the global challenges related to energy. These activities both supported student learning and helped us to better understand how our pedagogical approach was impacting their development as critical thinkers.

While we set out to teach a course that incorporated non-canonical examples informed by CSPs, we discovered that the examples were really just the tip of the iceberg. As we learned more about the wide range of culture centered pedagogies [1] we found our teaching in all of our classes benefitting. We believe these approaches are broadly beneficial for engineering faculty and more professional development is needed in this area.

Deepen educators' understanding of how CSPs impact student learning

We began work on this goal by taking a deep dive into the CSPs and surrounding literature. We found these pedagogies to be incredibly helpful in informing how we can approach broadening the engineering canon to support 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 [1].

As we implemented our CSPs informed pedagogy in the classroom, we found students continued to learn the technical content, a common objection to implementing these types of pedagogies. Perhaps more importantly, we also found that students began to make the sociotechnical

connections we find to be missing in so many of our engineering classes. Students were excited and engaged with the course, as evidenced by course evaluations, attendance, assignment completion. Students were most engaged by course content that tied directly to and showcased the role of people -- either the impacts engineers had, or the people that were impacted by engineering. In examining our students' response to emergency remote teaching during COVID-19, we also found that our CSPs informed compassionate and flexible pedagogy was important for supporting students in this difficult period. In particular this was especially important for female students who were disproportionately impacted by the effects of the pandemic [10].

While our approach taken in this project certainly shows promise, it is clear that a single course cannot completely reshape students' conceptions of engineering [11]. We have learned that the examples are just the start. To do this work effectively, we argue that it is necessary for instructors to examine their own positionality and develop their own critical consciousness. This learning is not easy, but it is essential if we are to make engineering education a more inclusive and supportive space.

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Bibliography

[1] B. Momo, G. D. Hoople, D. A. Chen, J. A. Mejia, and S. M. Lord, "Broadening the engineering canon: How Culturally Responsive Pedagogies can help educate the engineers of the future," *Murmurations Emerg. Equity Educ*, vol. 2, pp. 6–21, 2020.

[2] J. A. Leydens and J. C. Lucena, *Engineering Justice: Transforming Engineering Education and Practice*. John Wiley & Sons, 2017.

[3] G. D. Hoople, D. A. Chen, S. M. Lord, L. A. Gelles, F. Bilow, and J. A. Mejia, "An Integrated Approach to Energy Education in Engineering," *Sustain. Sci. Pract. Policy*, vol. 12, no. 21, p. 9145, Nov. 2020.

[4] D. Brookshire and N. Kaza, "Planning for seven generations: Energy planning of American Indian tribes," *Energy Policy*, vol. 62, pp. 1506–1514, Nov. 2013.

[5] L. A. Gelles, J. A. Mejia, S. M. Lord, G. D. Hoople, and D. A. Chen, "Is It All about Efficiency? Exploring Students' Conceptualizations of Sustainability in an Introductory Energy Course," *Sustain. Sci. Pract. Policy*, vol. 13, no. 13, p. 7188, Jun. 2021.

[6] R. W. Kimmerer, *Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge and the Teachings of Plants*. Milkweed Editions, 2013.

[7] G. D. Hoople and A. Choi-Fitzpatrick, "Drones for Good: How to Bring Sociotechnical Thinking into the Classroom," *Synthesis Lectures on*, 2020, [Online]. Available: https://www.morganclaypool.com/doi/abs/10.2200/S00984ED1V01Y202001ETS024

[8] B. H. Pm, "A Review of PESTLE Analysis History and Application," Dec. 22, 2010. https://www.brighthubpm.com/project-planning/100279-pestle-analysis-history-and-application/ (accessed Feb. 02, 2022).

[9] "Consortium to Promote Reflection in Engineering Education, CPREE,." http://cpree.uw.edu/category/resource/ (accessed Feb. 02, 2022).

[10] L. A. Gelles, S. M. Lord, G. D. Hoople, and D. A. Chen, "Compassionate flexibility and self-discipline:

Student adaptation to emergency remote teaching in an integrated engineering energy course during COVID-19," *Education Sciences*, 2020, [Online]. Available: https://www.mdpi.com/2227-7102/10/11/304

[11] D. A. Chen, S. M. Lord, J. A. Mejia, and G. D. Hoople, "A Critical Reflection on the Challenges of Implementing Culturally Sustaining Pedagogy," in *2021 IEEE Frontiers in Education Conference (FIE)*, Oct. 2021, pp. 1–5.