

Board 66: Reimagining Energy Year 1: Identifying Non-Canonical Examples of Energy in Engineering

Prof. Gordon D Hoople, University of San Diego

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. Joel Alejandro Mejia, University of San Diego

Dr. Joel Alejandro (Alex) Mejia is an assistant professor of Integrated Engineering at the University of San Diego. His current research investigates how the integration of the historically and culturally accumulated wealth of knowledge, skills, and practices - also known as funds of knowledge - and engineering design can serve as a pathway to and through engineering. Dr. Mejia is particularly interested in how Latinx adolescents bring forth unique ways of knowing, doing, and being that provide them with particular ways of framing, approaching, and solving engineering problems. Dr. Mejia's primary research interests lie at the intersection of engineering education and social justice. He is particularly interested in the integration of Chicana Cultural Studies frameworks and pedagogies in engineering education, and critical consciousness in engineering through social justice.

Dr. Diana A. Chen, University of San Diego

Dr. Diana A. Chen is an Assistant Professor of General 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. She earned her MS and PhD in Civil Engineering from Clemson University in South Carolina, and her BS in Engineering from Harvey Mudd College.

Dr. Susan M Lord, University of San Diego

Susan M. Lord received a B.S. from Cornell University and the M.S. and Ph.D. from Stanford University. She is currently Professor and Chair of Integrated Engineering at the University of San Diego. Her teaching and research interests include inclusive pedagogies, electronics, optoelectronics, materials science, first year engineering courses, feminist and liberative pedagogies, engineering student persistence, and student autonomy. Her research has been sponsored by the National Science Foundation (NSF). Dr. Lord is a fellow of the ASEE and IEEE and is active in the engineering education community including serving as General Co-Chair of the 2006 Frontiers in Education (FIE) Conference, on the FIE Steering Committee, and as President of the IEEE Education Society for 2009-2010. She is an Associate Editor of the IEEE Transactions on Education. She and her coauthors were awarded the 2011 Wickenden Award for the best paper in the Journal of Engineering Education and the 2011 and 2015 Best Paper Awards for the IEEE Transactions on Education. In Spring 2012, Dr. Lord spent a sabbatical at Southeast University in Nanjing, China teaching and doing research.

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Executive Summary

This NSF project focuses on the development of a new, required second-year energy course that considers ways to best include, represent, and honor students from all backgrounds using a collection of teaching practices known as culturally sustaining pedagogies (CSPs). It is sponsored through 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 typically 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 traditionally underserved students, but have yet to be explored in undergraduate engineering. CSPs encourage students to connect their lived experiences to course topics, broaden what is accepted as engineering knowledge, and help individuals acknowledge the differing values and perspectives of others.

This research seeks to (1) identify energy examples outside of those traditionally used in thermodynamics; (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 CSPs to engage their students. An overarching goal of this work is promoting inclusion within engineering to support broader participation and thus increased 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.

Non-Canonical Examples

In the first year of this project, the project team is focused on identifying non-canonical examples of energy that will form the basis of the new class. We sought input from the engineering education community at the 2018 ASEE conference when we presented a paper on this work [1]. We asked those in attendance to suggest examples of potential non-canonical examples of energy. We received many helpful suggestions and have combined these with our prior and further research to have a working list of non-canonical energy examples. We are working on developing pedagogical materials to incorporate these examples into our new energy class using CSPs.

Heat Transfer: Lorena Stove

Lorena stoves provide a low cost cooking option that minimizes dangerous air pollution compared to open flame biomass (wood, charcoal, or waste) options. We have discussed this example in more detail here [1]. Lorena stoves can be related to topics including insulation, thermal mass, conduction, convection, and efficiency when heating under specific constraints. It also exposes students to an inventive method used for many years by indigenous communities to heat their homes and provides an entry point to discuss the importance of safe cooking practices with students.

Refrigeration: Pot in Pot Cooling Device

The "pot-in-pot" cooling device is an elegant, low-cost solution for maintaining fresh produce using evaporative cooling [2], [3]. Developed by Nigerian teacher Mohammed Bah Abba based upon a design from the ancient Egyptians, the "pot-in-pot" makes it possible to "refrigerate" food without requiring electricity. This device can be related to energy topics including heat and mass transfer, the first law of thermodynamics, and insulation materials. In addition, students could engage in discussions of Abba's innovative business model that engages the local community in making and selling the product. This example also presents a good opportunity to discuss issues with Western appropriation of technology. In 2009 a British student received acclaim for "inventing" a pot-in-pot cooling device. The media portrayal provides a way to engage students in discussions around intellectual property, appropriate terminology for developing nations, and the challenges of the "savior complex".

Heat Treatment: Hair Care Products

Hair drying and straightening are examples of energy that are not typically examined in an engineering classroom. Research led by Mechanical Engineering professor Dr. Tahira Reid at Purdue University examines the heat transfer of hair care products [4]. The thermal characterization of hair dryers and straighteners is an area that may have more personal relevance to female engineering students. This topic can connect to students' everyday lives and demonstrate technical aspects of energy, establishing the legitimacy of stereotypically non-male products can have in engineering.

Energy Distribution: Mini-grids in Developing Contexts

Roughly 1 billion people across the globe are still without access to electricity [5]. The International Energy Agency (IAE) projects that to meet the UN's Sustainable Development Goal of electricity for all by 2030, mini-grids are the most cost effective approach to provide electricity to roughly half of those without it today. Mini-grids are localized power networks that are not connected into a national grid. Many recently installed solutions incorporate renewable energies like solar and wind due to their modular nature, allowing for easy scaling as demands for power increase. (For example, solar energy in Ghana [6]) Another example is the "sunshine box" which provides portable solar energy for electronics and a venue for local business to make a living [7].

External Advisory Board

We have formed an External Advisory Board (EAB) with experts in various areas to assist the project team and supplement the areas of expertise of the project team. The EAB will meet annually to evaluate and advise the team about the progress of the project. Members include:

- Dr. Wendy Newstetter, Georgia Tech, is an expert in cognitive science and will chair the advisory board [8]–[10].
- Dr. Erin Cech, University of Michigan, has expertise in critical analyses of engineering and Native Science [11]–[13].
- Dr. Ananda Marin, UCLA, is an expert in Native Science and CSPs [14]–[17].
- Dr. Juan Lucena, Colorado School of Mines (CSOM), has expertise in social justice and engineering [18]–[20]

- Scott Anders is the director of the Energy Policy Initiatives Center at the USD School of Law, his work focuses on policy and regulatory issues related to developing efficient and low-carbon energy sources [21]–[24].

Future Work

As we move into Year 2 of the project, we plan to develop the learning objectives and course materials for the energy course to be offered in Spring 2020. We will explore opportunities for hands-on student engagement with data analysis techniques, innovative homework problems, and lab activities. We will conduct assessment and evaluation to determine the impact of CSPs and make improvements for the next offering of the course in Spring 2021.

References

- [1] G. D. Hoople, J. A. Mejia, D. A. Chen, and S. M. Lord, “Reimagining Energy: Deconstructing Traditional Engineering Silos Using Culturally Sustaining Pedagogies,” in *ASEE Annual Conference Proceedings*, 2018.
- [2] M. Bah Abba, “Ancient Technology Preserves Food,” 2005. [Online]. Available: http://www.rolexawards.com/profiles/laureates/mohammed_bah_abba/project. [Accessed: 04-Mar-2018].
- [3] D. Riley, *Engineering Thermodynamics and 21st Century Energy Problems: A Textbook Companion for Student Engagement*. Morgan & Claypool Publishers, 2011.
- [4] J. Hahn, T. Dandridge, P. Seshadri, A. Marconnet, and T. Reid, “Integrating Design Methodology, Thermal Sciences, and Customer Needs to Address Challenges in the Hair Care Industry,” in *Volume 7: 27th International Conference on Design Theory and Methodology*, 2015.
- [5] S. Vinci *et al.*, “Energy Access Outlook 2017: From poverty to prosperity,” *Int. Energy Agency*, 2017.
- [6] S. Asumadu-Sarkodie and P. Asantewaa Owusu, “A review of Ghana’s solar energy potential,” *AIMS Energy*, vol. 4, no. 5, pp. 675–696, 2016.
- [7] C. Hazelrigg, “Sunshine Box,” 2018. [Online]. Available: <https://www.1773innovationco.com/>. [Accessed: 11-Jan-2018].
- [8] T. Litzinger, L. R. Lattuca, T. Hadgraft, and W. Newstetter, “Engineering Education and the Development of Expertise,” *J. Eng. Educ.*, vol. 100, pp. 123–150, 2011.
- [9] W. C. Newstetter, “Designing cognitive apprenticeships for biomedical engineering,” *J. Eng. Educ.*, vol. 94, no. 2, pp. 207–213, 2005.
- [10] C. M. Eastman, W. M. McCracken, and W. C. Newstetter, *Design knowing and learning : cognition in design education*. Elsevier Science B.V, 2001.
- [11] E. A. Cech, “Culture of Disengagement in Engineering Education?,” *Sci. Technol. Human Values*, vol. 39, no. 1, pp. 42–72, 2014.
- [12] E. A. Cech, “the (mis)framing of social justice: Why ideologies of depoliticization and meritocracy hinder engineers’ ability to think about social injustices,” in *Engineering Education for Social Justice: Critical Explorations and Opportunities*, Springer, 2013, pp. 67–84.
- [13] E. A. Cech, A. Metz, J. L. Smith, and K. deVries, “Epistemological Dominance and Social Inequality: Experiences of Native American Science, Engineering, and Health Students,” *Sci. Technol. Hum. Values*, vol. 42, no. 5, pp. 743–774, 2017.
- [14] M. Bang and A. Marin, “Nature-culture constructs in science learning: Human/non-human agency and intentionality,” *J. Res. Sci. Teach.*, vol. 52, no. 4, pp. 530–544, Apr. 2015.
- [15] A. Marin and M. Bang, “Designing Pedagogies for Indigenous Science Education: Finding Our Way to Storywork,” *Journal of American Indian Education*, vol. 54. University of Minnesota Press, pp. 29–51, 2015.
- [16] M. Bang, L. Curley, A. Kessel, A. Marin, E. S. Suzukovich, and G. Strack, “Muskrat theories, tobacco in the streets, and living Chicago as Indigenous land,” *Environ. Educ. Res.*, vol. 20, no. 1,

- pp. 37–55, Jan. 2014.
- [17] D. L. Medin, B. Ojalehto, A. Marin, and M. Bang, “Culture and Epistemologies: Putting Culture Back Into the Ecosystem,” in *Advances in Culture and Psychology*, Oxford University Press, 2013.
 - [18] J. A. Leydens and J. C. Lucena, *Engineering justice : transforming engineering education and practice*. Wiley-IEEE Press, 2017.
 - [19] J. C. Lucena and J. A. Leydens, “From Sacred Cow to Dairy Cow: Challenges and Opportunities in Integrating of Social Justice in Engineering Science Courses,” in *ASEE Annual Conference Proceedings*, 2015.
 - [20] E. H. Bauer, B. M. Moskal, J. Gosink, J. C. Lucena, and D. Munoz, “Faculty and Student Attitudes Toward Community Service : A Comparative analysis,” *J. Eng. Educ.*, no. April, pp. 129–140, 2007.
 - [21] S. J. Anders, D. O. De Haan, N. Silva-Send, S. Tanaka, and L. Tyner, “Applying California’s AB 32 targets to the regional level: A study of San Diego County greenhouse gases and reduction strategies,” *Energy Policy*, vol. 37, no. 7, pp. 2831–2835, Jul. 2009.
 - [22] S. Anders, T. Day, and C. Adi Kuduk, “Hey, Your Tree Is Shading My Solar Panels: California’s Solar Shade Control Act,” *J. Sustain. Real Estate*, vol. 2, no. 1, pp. 361–381, 2010.
 - [23] J. Kaatz and S. Anders, “The role of unspecified power in developing locally relevant greenhouse gas emission factors in California’s electric sector,” *Electr. J.*, vol. 29, no. 9, pp. 1–11, Nov. 2016.
 - [24] N. Silva-Send, S. Anders, and A. Narwold, “Cost effectiveness comparison of certain transportation measures to mitigate greenhouse gas emissions in San Diego County, California,” *Energy Policy*, vol. 62, pp. 1428–1433, Nov. 2013.