

Work In Progress: Developing Changemaking Engineers (Year 2)

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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 Electrical Engineering at the University of San Diego. Her teaching and research interests include 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 Best Paper Award 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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WIP: Developing “Changemaking Engineers” (Year 2)

Abstract

With funding from a National Science Foundation (NSF) IUSE/PFE: Revolutionizing Engineering and Computer Science Departments (IUSE/PFE: RED) grant, we aim to "revolutionize" engineering education, by preparing students to practice engineering using a contextual framework that embeds humanitarian, sustainable and social justice approaches alongside technical engineering skills. This research will produce and disseminate a model for redefining the “engineering canon” to include a professional spine threaded throughout the curriculum with the goal of developing “Changemaking Engineers”. The revised engineering canon will build upon engineering technical skills to include the knowledge and professional skills needed to empower our graduates to impact society and enhance the common good. The model will provide a template for change for similar institution-types and create a platform for change that moves away from narrowly-constructed and techno-centric epistemological approaches. This work in process provides a descriptive overview of our progress to date.

Introduction

Traditionally, engineering students are trained technically, with less focus on critical examinations of assumptions within engineering practice, and less emphasis on the larger contexts in which engineering is embedded. With funding from a National Science Foundation (NSF) IUSE/PFE: Revolutionizing Engineering and Computer Science Departments (IUSE/PFE: RED) (hereinafter referred to as RED) grant, our project team is working to create a curriculum to develop “Changemaking Engineers.” This enhanced curriculum will be rooted in the nexus of humanitarian practice, sustainability awareness, social justice, and professional practice. It will emphasize student teamwork, along with greater consideration of social and economic factors, improved communication with diverse constituents, and reflection on an ethical understanding of their decisions and solutions. It also requires that faculty members be empowered to mirror these values and skills in their instruction and mentoring. The RED grant connects professional skills directly to the ability to develop and evaluate solutions within these broader contexts.

In this work in progress (WIP), we review our progress towards achieving this vision including:

- Establishing a foundation for a revised engineering canon that includes greater integration of professional practices and societal responsibilities
- Developing a faculty that embraces the redefined engineering canon and the professional spine
- Establishing partnerships to develop a culture of change within the school, across campus, and outside of the university.

Developing a Revised Engineering Canon

We propose to establish a foundation for a revised engineering canon that goes beyond the usual emphasis on disciplinary engineering to include broader understanding of the ways that successful engineers work to achieve transformative results in all areas of society. This canon will help students develop the knowledge and skills needed to apply their technical knowledge through sustainable practice to promote advancement in many areas including social justice and

humanitarian practice. We believe that this canon will also bring new students to engineering who will be attracted by the opportunity to become Changemaking Engineers.

We also proposed to develop a learning environment where disciplinary knowledge and social perspective are purposefully connected to professional practice. To achieve this goal, the canon will weave co-curricular experiences throughout the curriculum by including both formal learning (e.g. in classroom or lab) and informal learning through internships, community service learning and extracurricular activities.

At the beginning of the grant, we conducted a survey of all engineering faculty to establish baseline data on their attitudes to a changemaking curriculum and their interest in, and commitment to developing changes to the canon. In the baseline survey, we found that:

- Many of the faculty do not find this goal important, nor have a good understanding of how to infuse some of the context into their courses.
- Some faculty felt that their classes or programs already develop the competencies needed to become Changemaking Engineers.

After reviewing the survey results, the RED team concluded that the faculty did not fully understand the extent of changes needed to transform engineering education to meet the goals of the project. Consequently, a significant effort is needed to help faculty embrace the changes, and develop the capacity to innovate their curricula.

In conceptualizing a revised canon, we seek faculty support through the following strategies. The first strategy is the development of faculty so that they both value the integration of broader contexts for engineering and have the capacity to implement the curriculum. The second strategy is to partner engineering faculty with faculty from other schools outside of engineering who have expertise in social justice, peace, humanitarian advancement, and sustainable practices. Our third strategy is to develop a set of courses in a new General Engineering (GE) program that will introduce the disciplinary content typically taught in core sophomore and junior level classes through the Changemaking Engineers theme and integration of professional skills.

Faculty Collaboration and Development of Instructional Capacity

We proposed to engage the faculty in a collaborative model of leadership to achieve our revolution of engineering education and we proposed to provide faculty with opportunities to acquire the skills, attitudes, and behaviors that would help drive the desired curricular change. To accomplish these goals we are offering collaborative leadership workshops and events and faculty empowerment workshops and events.

Collaborative Leadership Workshops

Collaborative leadership workshops and events are related to creating shared vision, imagining a revised canon, and methods and tools for shared leadership. These events also are envisioned to develop ideas for interdisciplinary team-based teaching in collaboration with other schools/colleges on campus. We have held eight collaborative workshops/events.

1. *Speed Networking*: The goal of these events is to begin to explore potential partnerships between engineering and other schools and colleges on campus that could lead to new

curricula and course delivery models. The events focused on discussions to identify opportunities for engineering faculty to collaborate with faculty from other units to develop interdisciplinary curriculum in the areas of professional skills, social justice, humanitarian practice, peace, and sustainability. We characterize these events as Collaborative Leadership since we needed to provide a forum for different faculty to meet and begin to develop their contributions to the new canon. We have held two such events. Some of the new courses discussed below are a direct result of these events.

2. *Social Justice and Humanitarian Engineering Workshops*: Juan Lucena and Jessica Smith of Colorado School of Mines presented the first workshop that focused on incorporating humanitarian perspectives in classroom activities. A second workshop delivered by Caroline Ballie emphasized the nexus between engineering and social justice. The objectives of the workshops were to develop an understanding of the barriers, mindsets, and ideologies that get in the way of integrating humanitarian engineering and social justice in the engineering curriculum and strategies for how to overcome them. As part of the workshop, participants began to develop an understanding of how standard questions from core engineering topics such as statics can be reframed to include humanitarian and social justice perspectives.
3. *The Origins of Changemaking Engineers*: This workshop, from Virginia Tech's Matthew Wisnioski, focused on the history of Changemaking Engineering including prior attempts to infuse humanitarian engineering and social justice issues into the engineering curriculum. Wisnioski provided an important set of lessons on the history of social innovation in engineering practice, the roles faculty have played in narrating social change through the lens of engineering, and the sustainability of these change initiatives. We learned the importance of social actors in creating a discourse of change within engineering, the conditions that produced successes, and that resources must be mobilized and structures must accommodate changes in order for them to succeed.
4. *Strategic Planning*: The university has recently conducted a strategic planning process that has resulted in six pathways including *Changemaking* and *Care for Our Common Home*. We have leveraged this institutional initiative by conducting three strategic planning sessions in the school that emphasized developing a shared meaning of Changemaking Engineering. Faculty members performed a SWOT analysis, identifying the most important opportunities that we should pursue under the theme of Changemaking Engineering.

Faculty Empowerment Workshops

To develop the most meaningful faculty capacity building workshops, we surveyed the faculty to identify areas for development. Based on these findings, we delivered two faculty capacity building workshops and conducted a faculty cluster hire.

1. *Teaching Student Teams*. This workshop from Matthew Ohland at Purdue University was designed to help faculty design, implement, and evaluate positive team-based learning experiences for their classes. The workshop focused on the CATME [1] model of teamwork to present proven strategies for forming, teaching, and managing teams for small assignments and large class projects.
2. *Leading Effective Discussions in Engineering Classes*. This workshop was developed for

engineering faculty by our university's Center for Teaching and Learning to address the faculty-identified need to learn how to sustain high-quality classroom discussions about non-technical aspects of engineering practice. This workshop offered opportunities to engage different facilitation styles using a case study approach. It was the first workshop developed specifically for engineering faculty by the CEE demonstrating a productive collaboration across campus.

3. *Cluster Hire*. We designed a cluster hire to bring in faculty that desired to be part of the vision for re-contextualizing engineering. We have hired three faculty members into a RED cluster within a new general engineering program; two are women, one is a senior leader in social justice and engineering. Cluster hiring has made a significant change in the pool of candidates who apply for engineering positions [2].

Course Development with RED Content

After the first networking event with colleagues from across campus, we circulated a call for new course development that would create curricular materials for the new canon. Proposed courses had to meet the following criteria:

1. The course development had to be accomplished with an engineering faculty member and a non-engineering faculty member with expertise in one of the areas aligned with our RED proposal.
2. The team had to identify materials in their course (e.g. modules) that could fit with the traditional engineering curriculum at the sophomore or junior level.
3. The team had to agree to make the materials public (to become part of the revised canon).

We accepted three proposals and provided seed funding to develop the courses. The three courses are currently being developed and will be taught in the coming years. They include:

1. *Engineering Peace with Drones*. An engineering faculty member and a faculty member from another school on campus are developing this course. The course focuses both on the design and use of drones while focusing on cultivating empathy across disciplinary boundaries [3].
2. *Diplomacy and Negotiations in Humanitarian and Environmental Engineering Projects*. This course is being designed by two engineering faculty members and a faculty member from the Joan Kroc School of Peace studies at USD. The course focuses on teaming skills and the impact of internal team negotiations and negotiations with those impacted by engineering designs.
3. *Power and Power Module: Legacies of Apartheid in South Africa*. An engineering professor, a sociology professor, and a political science professor are designing this module where "Power and Power" is a word play on the engineering meaning of power (energy per time) and the power resulting from privilege (social injustice). Students will examine the intersection of the two in a study abroad course in South Africa.

Since the curriculum in the new general engineering program at our institution has not yet been fully defined, there is an opportunity to begin development of courses having a focus on RED themes. We proposed to also develop courses that would contain modules designed specifically

for the new engineering canon inside of a new general engineering program and then to migrate modules to other disciplinary engineering programs. This approach was adopted because of a history of engineering culture that has been characterized by organizational problems that inhibit change such as fixed ideals about engineering content, antiquated pedagogical approaches that lack creative design elements and teamwork, and habits that establish who belongs in engineering and who does not [4, 5, 6, 7]. We similarly found resistance to curricular change from some of the faculty in disciplinary programs. We believe that it will be easier for these faculty to adopt modules related to their courses after they have seen them successfully used in related courses in the general engineering program. These courses are currently under design.

Engaging Stakeholders

We proposed to establish partnerships with industry, community, and students that value our vision of Changemaking Engineers. External stakeholders will help inform our work and they will become participants in the development programs and the canon. NSF asks RED programs to move beyond traditional reform, therefore we asked ourselves, “How can we make our interface with industry partners more revolutionary?” This resulted in reciprocal exchanges and yielded tremendously useful content produced by teams of industry leaders. We also recognize that the participation and commitment of the students are critical to the success of our RED initiative. We have worked with industry, community, and students in several stakeholder forums. Activities include:

1. *Student Surveys and Focus Groups.* We have conducted surveys and focus groups with the students to gather baseline data on their skills, attitudes, and behaviors. This data will be used to help drive the new canon. As with the faculty surveys, we will repeat the surveys in the final year of the grant to assess the effectiveness of our implementation.
2. *Creation of a RED Advisory Board.* We have spent several sessions with members of the community and industry to socialize the RED grant and to develop engagement activities for the grant. Both groups were enthusiastic about the RED goals and are represented on the RED advisory board. The board has identified the professional skills that they believed were most frequently missing from our engineering graduates. They then developed a pilot program called “Industry Scholars” that will develop and deliver workshops for first and second year students and engineering faculty members. The program will also provide internships to some of the first and second year students. In the pilot program, there will be approximately six workshops where the students and faculty work together with industry and community partners to recognize the professional skills, attitudes, and behaviors that will help make students successful.

Summary and Conclusion

We have begun the process of developing a collaborative faculty model of change. Progress has been made toward developing a revised engineering canon and in engaging stakeholders to inform our work. We anticipate that the research from this grant will produce and disseminate a model for redefining the engineering canon with the goal of developing Changemaking Engineers. A revised engineering canon builds upon engineering technical skills to include the

knowledge and skills needed to empower our graduates to impact society by innovating within the contexts of social justice, peace, humanitarian advancement, and sustainable practices.

Acknowledgements

The authors thank the National Science Foundation for support of this work (Award #1519453). The views expressed herein are solely those of the authors.

References

1. Comprehensive Assessment of Team Member Effectiveness (CATME) information available at <https://info.catme.org/about/overview/>
2. Sgoutas-Emch, S., Baird, L., Myers, P., Camacho, M., & Lord, S. (2016). We're Not All White Men: Using a Cohort/Cluster Approach to Diversify Faculty Hiring in STEM. *Thought and Action*, 32(1-Summer 2016), 91-107, 2016. http://www.nea.org/assets/docs/HE/TA2016_Full_2.pdf
3. Hoople, G. & Choi-Fitzpatrick, A. Engineering Empathy: A Multidisciplinary Approach Combining Engineering, Peace Studies, and New Technology, ASEE Annual Conference and Exposition, Columbus, OH, June 2017.
4. Faulkner, W. (2007). Nuts and bolts and people: gender-troubled engineering identities. *Social Studies of Science*, 37(3), 331-356.
5. Godfrey, E. G. & Parker, L. (2010). Mapping the cultural landscape in engineering education. *Journal of Engineering Education*, 99(1), 5-22.
6. Seymour, E., & Hewitt, N. M., (1997). *Talking about leaving: Why undergraduates leave the sciences*. Boulder, CO: Westview Press.
7. Tonso, K. L. (2007). *On the Outskirts of Engineering: Learning Identity, Gender, and Power via Engineering Practice*, Rotterdam, The Netherlands: Sense Publishers.