Lessons learned about fostering curricular change

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Introduction
Despite the numerous calls for institutional change to engineering curriculum, the way engineering has been taught has not changed significantly over the last century [1], [2]. To counter this, the National Science Foundation put out a call for proposals to design and enact new approaches to engineering education focused on organizational and cultural change within the departments [3]. To achieve this, institutional change must be produced through concentrated and shared efforts with support from leadership, allies, and invested change-agents [4], [5]

Engineering leadership and faculty at the University of San Diego have responded to efforts to enact institutional change at a school of engineering by using the change strategy of developing shared vision [4]. This leadership team, which included the dean and department heads, proposed a vision through a strategic alignment of the university's mission, external and internal collaborations, and industry partnerships to innovate the existing structure, policies, and curriculum of engineering. Specifically, they attempted to integrate social and humanitarian content into engineering courses, connect professional values and skills to technical content, and empower faculty to use innovative pedagogical practices.

This paper will describe the five lessons learned on how faculty successfully mobilize curricular change as well as barriers to these efforts. These lessons learned will be presented through faculty perceptions, which were solicited through 29 semi-structured qualitative interviews and 1 focus group conducted by a postdoctoral research associate and a social scientist at two to three years in of a five year grant intended to foster institutional change. These interviews encompass both the leadership team of the change initiative and the general faculty who responded to those change efforts within all five departments in the school of engineering. These interviews were qualitatively analyzed and coded using thematic analysis [6], [7]. The five lessons learned presented below represent preliminary findings of a larger analysis on the politics, processes, and potential involved in institutional change.

Lessons Learned
(1) Not all faculty members consistently felt included, nor invited to the table
Some of the faculty members felt that they were already engaged in this type of work, but did not consider themselves to be a part of this concentrated institutional change effort. These included both faculty who were already involved with individual initiatives that align with this change effort and also new faculty who were hired with this change initiative in mind. When first applying for this grant, the leadership team did not solicit potential collaborators within the school of engineering already engaged in work aligned to their goals. Additionally, faculty were not included in any project-specific team meetings and communication between the leadership team and faculty about this project was limited. Some faculty perceived that the leadership team was taking credit for their work in incorporating social content into engineering courses, which was exacerbated by the feeling of not being included. For example, one faculty stated, "So, I do feel like we are a very, I can't think of a better word, we were integrated with the [project] but at the same time like it's not ours."

(2) Simply hosting workshops was insufficient

As part of the grant, several Faculty Empowerment and Collaborative Leadership workshops were developed and delivered with varying levels of attendance by engineering faculty. The Faculty Empowerment workshops were designed to give faculty the tools and skills necessary to incorporate more social and humanitarian content into their courses. This included content on effective pedagogies such as active learning and project based learning. The Collaborative Leadership workshops were intended to facilitate engineering faculty's embrace of the new culture cultivated by change efforts by teaming up engineering faculty with non-engineering faculty members who had expertise in areas such as social justice, peace, and humanitarianism. These workshops included how to create a shared vision and methods and tools for shared leadership. The workshops were voluntary, and most of the faculty who attended were already engaged with this type of work and were on board with the need for this type of change. When asked whether the workshops were effective, a member of the leadership team stated,

> *Well, I'd just say we effectively ran them, but are they effective? I'd have to say no based on the participants who were there. I would say it wasn't caught on, yet; still very much you look at the core team members, and then general faculty, the general engineering faculty were hired and who were more . . . who have more buy in to this process, they showed up. And so, I just say while those are some of the stuff that we've done tangentially but if they were a success or not I wouldn't say yes. I wouldn't say they are a success.*

The leadership team also perceived that faculty acceptance of the workshop material was also dependent on the way it was presented and who was presenting it. For example, workshop presenters who incorporated and acknowledged that technical content did not have to be sacrificed to include contextual examples of social justice were much better received than a focus strictly on social justice. Workshops that also allowed participants time to implement these ideas in an active way with mentoring support were also perceived to be more effective than a lecture based workshop.

(3) Having authority figures come to speak to faculty was an ineffective approach

The leadership team believed that bringing in experts on issues of incorporating social content to contextualize technical engineering content (e.g., issues of social justice in engineering) would add legitimacy to their changemaking effort in the eyes of the faculty. These experts came from backgrounds such as History, Science and Technology Studies, and an NSF officer associated with changemaking in engineering efforts. However, bringing in these guest authorities was implemented through workshops which had low faculty turnout. Within their interviews, faculty did not mention the workshops and the leadership team postulated that even with an engineering background, these authorities were not seen as 'real' engineers. Without that highly technical engineering background, specifically a Ph.D. in engineering, faculty perceived that these guest speakers did not have the legitimacy to suggest any change to technical curricular content. As a member of the leadership team stated, "I think the messenger matters".

(4) "Knowledge Brokers"

One method of producing change emerged organically through individuals on campus that were associated with this institutional change effort but were seen as non-threatening. These

individuals most closely resemble a "knowledge broker". A knowledge broker is someone who facilitates the exchange of information by developing relationships and networks between producers of knowledge (in this case technical engineering and social context) who transfer, translate, and transform that information [8]. This is especially important when bridging research, policy, and practice [9]. These "knowledge brokers" included visiting professors, industry partners, postdoctoral research associates hired through the grant, and non-tenure track faculty. They reached out and listened to faculty concerns in one-on-one meetings both informally and formally and took the time to listen to faculty members' 'wish list' of potential new curricular changes. Postdoctoral research associates, in particular, were able to help facilitate this change by assisting with curricular development. The "knowledge brokers" had varied backgrounds in engineering, engineering education, and social science and were well-suited to bridge the divide between technical engineering knowledge, pedagogical practice, and social context. While top-down mandates from leadership were perceived as threatening in some cases, "knowledge brokers" could potentially help faculty adjust curriculum to their specific needs and strengths. Similar engineering education initiatives have also benefited from using knowledge brokers that span informational boundaries [10].

(5) Cluster Hire

A cluster of new tenure-track faculty were hired who were interested in integrating sociotechnical content into engineering curriculum to form a new department within the school of engineering. They have successfully developed and taught several new courses that align with the goals of the institutional change effort and even incorporated social content into courses such as Statics. However, these faculty have expressed exhaustion and vulnerability when taking the lead in these change efforts. While their change efforts are supported and encouraged by leadership such as department chairs and the dean, they can encounter critiques from tenured faculty who perceive these curricular changes as "fluff" or not real engineering. Additionally, it is predominantly faculty who are underrepresented minorities in engineering who have taken the lead in these change initiatives and so they bear the greater burden [11].

Summary

Change is an evolving process where established definitions, boundaries, practices, and even identities must be renegotiated over time and communicated through relationships maintained through trust and authenticity. While workshops can be valuable, special consideration needs to be taken into account about who leads these workshops, how well they can span the boundaries of technical and social, what pedagogical techniques are used during these workshops, and how to attract or incentivize faculty who have not already bought into the change initiative. Lasting change requires sustained and long term efforts, which cannot be achieved through one-time workshops [4]. Having a shared vision is important, but that the vision needs to be shared frequently and consistently over time with faculty. Lastly, invested faculty have to be supported and protected when initiating these change efforts, especially if they are untenured.

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