Cultivating a culture of scholarly teaching and learning: An ecological approach to institutional change in engineering education

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Introduction

Over the past two decades, there has been a significant increase in the production of engineering education research. Worldwide, this increase is reflected in the growing number of papers that are submitted to engineering education-focused conferences; engineering education-focused journal outlets; and the increasing number of new schools and departments of engineering education, and tenure-track faculty positions opening up in the United States.

In spite of these developments, it is often argued that there remains a gap between engineering education research and educational practice. Some studies attribute this gap to a focus on the dissemination of evidence-based practices, as opposed to working with instructors to adapt evidence-based practices to “fit” into new contexts (Froyd et al., 2017). Other research points to the need for broader cultural change, for example at the level of the school or department, in order to *create the conditions* that enable and encourage instructors to sustainably engage with scholarly teaching and learning practices (Henderson, Beach, & Finkelstein, 2011).

In this paper, we describe a novel institutional model, currently embodied in the Engineering Education Transformations Institute (EETI) at the University of Georgia (UGA), which is designed to create such conditions (Morelock, Walther, & Sochacka, 2019). Philosophically, our model is based on a propagation (versus a dissemination) paradigm (Froyd et al., 2017), grounded in a strengths (Saleebey, 2012) (versus a deficit) approach to existing instructional capacity, and broadly informed by complex systems theory (Laszlo, 1996; Meadows & Wright, 2008). Practically, the model leverages ecological design principles (Hemenway, 2009) to inform the day-to-day operations of the effort. This paper describes these philosophical and practical underpinnings and investigates the following research question:

> *How can ecological design principles be operationalized to cultivate a culture of innovative and scholarly teaching and learning in a college of engineering?*

Philosophical Underpinnings

Using a strengths perspective to move from dissemination to propagation

In 2017, Froyd and colleagues published what we regard as a watershed article entitled “From Dissemination to Propagation: A New Paradigm for Education Developers” (2017). In this article, the authors described the gap between research and practice in STEM education as follows:

> *Scholarly studies and national reports document failure of current efforts to achieve broad, sustained adoption of research-based instructional practices, despite compelling bodies of evidence supporting efficacy of many of these practices.* (p. 35)

The article then distinguished between two paradigms of educational change:

> *A* dissemination paradigm *characterizes patterns of these current, failing efforts. Change agents, working within the dissemination paradigm, try to convince adopters that their*

> *innovations can help their students…Alternatively, change agents, working within the* propagation paradigm*, engage with adopters early and often to understand their instructional systems and interactively develop a strong product adaptable to specific contexts.* (p. 35)

Put another way, a dissemination paradigm focuses on evidence and outcomes, whereas a propagation paradigm focuses on fit and usability (Froyd et al., 2017). Similarly, while those who engage in dissemination may focus on raising awareness, proponents of propagation prioritize supporting context-sensitive adaptation and adoption (Froyd et al., 2017).

Shifting from a dissemination to a propagation paradigm has important implications for how engineering education researchers perceive, approach, and engage with instructional colleagues. In a dissemination paradigm, engineering education researchers may position themselves as experts who have a responsibility to, at best, educate instructors about evidence-based, best practices or, at worst, overcome instructors' apparent resistance to change, disinterest in educational research, or willingness to improve their teaching methods. In our model, we reject this notion of experts and non-experts in favor of an orientation that is informed by a strengths perspective to existing instructional capacity. According to Saleebey (2012), a strengths perspective rests on the assumption that strengths and resources exist in every environment, and that change is best made through collaborations with clients and client systems which leverage these strengths. Put in the context of our institutional model, we assume that each of our faculty have diverse strengths and resources related to teaching engineering; our mission is to leverage these assets and to provide opportunities for our faculty to develop in the directions they have an interest in. As such, EETI has no explicit agenda concerning the dissemination of specific teaching practices, e.g., project-based or active learning, flipped classrooms etc. Rather, we seek to cultivate, or "propagate," a culture of scholarly teaching and learning where faculty members exercise choice in how to adapt relevant educational theories and evidence-based practices to their settings.

Complex systems theory

A review of the literature on complex systems reveals a wide range of definitions and understandings. In our institutional model, we adopt the complex systems and systems thinking approaches encapsulated by the writings of Donella Meadows (Meadows & Wright, 2008), Ervin Laszlo (1996), Fritjof Capra (Capra, 1983, 1997, 2004; Capra & Luisi, 2014), and Paul Cilliers (2002). Each of these authors discuss a number of core definitional aspects of complex systems, which we summarize as follows:

1. Complex systems theory focuses on the relationships between different elements in a system, the properties of the system, and the resulting systemic behaviour that emerges from the whole.
2. These emergent behaviours arise through the dynamic and recursive interaction of the system's parts and cannot be predicted or controlled.
3. At the same time, these behaviours are not random or chaotic.
4. The behaviours of complex systems are informed by history and context; in a human system, this includes shared values and ways of seeing the world.
5. Complex systems are always open and connected to other systems.
6. The problematic phenomena produced by the systems' behaviour are unintended consequences of the system's functioning as designed.

The implications of these definitional aspects for our model are far reaching. For example, considering the first point, instead of focusing on specific evidence-based teaching and learning techniques (like promoting flipped classrooms), or other individual elements in the system (like individual courses), <u>we focus on building relationships</u> between faculty (tenure-track and non-tenure track), staff, and graduate students. Considering the sixth point, we suggest that low adoption rates of evidence-based STEM teaching and learning approaches (Landrum, Viskupic, Shadle, & Bullock, 2017) are <u>unintended consequences</u> of organizational cultures that, among other aspects, privilege research and individual excellence, and reinforce hierarchies, for example, between tenure track faculty and lecturers, and faculty and staff. Our model challenges these, and other, often unquestioned features of academic settings.

Practical Implementation

Ecological design principles

Our brief discussion of two of the above core definitional aspects of complex systems provides some insight into how our institutional change model puts the theory of complex systems into practice. Here, we introduce a set of ecological design principles, developed in the context of permaculture, which have informed the day-to-day operations of our Institute.

Permaculture is an approach to the design of sustainable human settlements (i.e., systems with social, ecological, and economic aspects) that is founded and expands on the core definitional aspects of complex systems theory outlined above. Originally developed by two Australians in the 1990s, Bill Mollison and David Holmgren, permaculture was inspired by observing the natural Australian landscape. As described by Hemenway (2009):

> *Inspired and awed by the life-giving abundance and rich interconnectedness of this ecosystem* [Tasmanian rainforests]*, he* [Mollison] *jotted in his diary, "I believe that we could build systems that would function as well as this one does."* (p. 5)

Some people mistake permaculture for a set of tools or techniques, such as organic gardening, recycling, or natural building. Permaculture, however, is better described as a design approach, or set of principles, which helps one consider when and how to use and connect different strategies and techniques. As further explained by Hemenway:

> *… permaculture practitioners… focus less on the objects themselves than on the careful design of relationships among them—interconnections—that will create a healthy, sustainable whole. These relationships are what turn a collection of unrelated parts into a functioning system, whether it's a backyard, community, or an ecosystem. (p. 5)*

In his book, "Gaia's Garden: A Guide to Home-Scale Permaculture," Hemenway outlined 14 core, ecological design principles. Due to space limitations, in Table 1, we adapt six of these principles to the context of our institutional change model. These examples are intended to provide readers with insight into how we initially envisioned ecological design principles might be operationalized to cultivate a culture of innovative and scholarly teaching and learning in a college of engineering. In the following sections, we describe one way in which we have examined the effectiveness of our efforts.

Methodology/Methods

We used ethnographic methods, specifically prolonged participant observation, to examine how the operationalization of ecological design principles have influenced the day-to-day programming of our Institute. In this paper, we share preliminary findings from this ongoing study through describing the impact of our Institute on the lived experiences of two instructors in our College of Engineering. The developmental trajectories of these two instructors were selected for this paper because their stories illustrate some of the affordances and limitations of our approach to systemic institutional change. We note that this study received the appropriate, university-level, ethics approval, and that the two faculty members in question were consulted during the preparation of this manuscript.

Results

From lone wolf to collaborator

The first instructor we report on in this paper, Dr. A, completed both his undergraduate and graduate degrees in engineering at UGA. During his time as a graduate student, Dr. A taught multiple sections of a freshman design course. In parallel to working on his dissertation and teaching undergraduate courses, Dr. A became involved in several after-school STEM programs with students in a neighbouring, under-privileged county. After completing his dissertation, Dr. A was hired as a full-time instructor in engineering and continued his outreach work.

Table 1: Example ecological design principles and their translation to our institutional model

Ecological design principles	Translations to our model
1. Observe. Use protracted and thoughtful observation rather than prolonged and thoughtless action. Observe the site for its elements in all seasons. Design for specific sites, clients, and cultures.	*A. Observe*. Observe and become familiar with existing cultures, values, interests, and structures. Adopt a strengths perspective, and think about how site specific aspects will impact the "fit" (Froyd et al., 2017) of subsequent initiatives.
2. Connect. Use relative location, that is, place the elements of your design in ways that create useful relationships and time-saving connections among all parts. The number of connections among elements creates a healthy, diverse ecosystem, not the number of elements.	*B. Connect.* Develop a diverse range of activities that connect people in as many different ways as possible. Make it easy for people to participate when they have the time and inclination—ensure that invitations are as open and inclusive as possible. Leverage existing activities, such as mealtimes, and programs (such as CTL-managed FLCs) to facilitate "time-saving" connections and prevent commitment overload.
3. Catch and store energy and materials. Identify, collect, and hold useful flows. Every cycle is an opportunity for yield, every gradient (in slope, charge, temperature, and the like) can produce energy. Reinvesting resources builds capacity to capture yet more resources.	*C. Identify, collect, and share useful information.* Differences (i.e., gradients) in ENED expertise (research or practice) are opportunities for all to learn. Build capacity by capturing and making knowledge (e.g., how to search ENED literature; how to write an ENED conference abstract) easily accessible and widely available. "Reinvest" insights and lessons-learned by collecting, documenting, celebrating, and sharing them with others.
4. Make the least change for the greatest effect. Understand the system you are working with well enough to find its "leverage points" and intervene there, where the least work accomplishes the most change.	*D. Make the least change for the greatest effect.* Work first with faculty who are already interested in improving teaching and learning. Leverage that interest to introduce evidence-based practices that align with existing interests. Identify and share innovative teaching and learning efforts across the college to "seed" further interest, e.g., through "Showcases of Teaching and Learning."
5. Get a yield. Design for both immediate and long-term returns from your efforts: "You can't work on an empty stomach." Set up positive feedback loops to build the system and repay your investment.	*E. Get a yield.* Find ways to generate immediate and long-term rewards for participation in institute activities, e.g., through connecting participation in institute activities to annual review processes. Support intra- and extramural funding efforts. Share insights at ENED conferences and in journals. Share the rewards.
6. The biggest limit to abundance is creativity. The designer's imagination and skill usually limit productivity and diversity before any physical limits are reached.	*G. The biggest limit to abundance is creativity.* Endeavour to shift away from the individualistic focus of academia to creatively identify win-win-win scenarios of abundance.

We (EETI's leadership team) first learned of Dr. A's passion for working with high school students during the first EETI monthly forum, which was held in Fall 2016. This forum, which was one of a series of four forums over that semester, was designed to develop a shared understanding of existing strengths, assets, and interests that our faculty, staff, and graduate students had in our College in relation to engineering education research, teaching, and service activities. This beginning of Dr. A's engagement with EETI activities is illustrated on the left hand side of the trajectory in Figure 1.

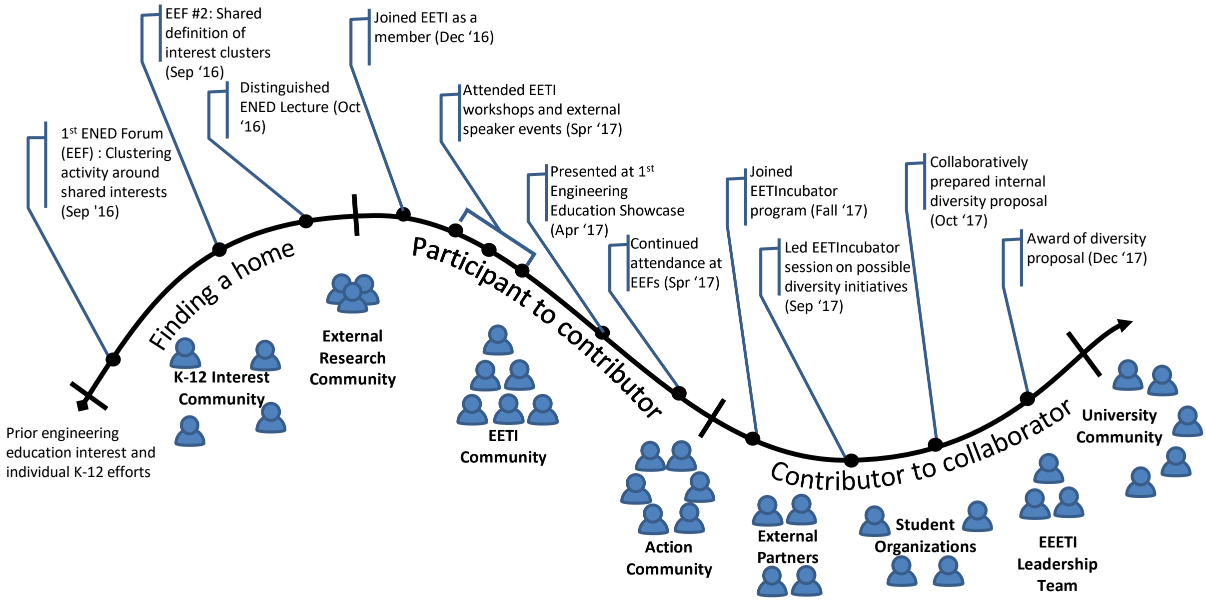

Figure 1. Dr. A's participation in EETI activities from Fall 2016 to Fall 2017.

After participating in the first Engineering Education Forum, which was held in September 2016, Dr. A found a community of faculty members who shared an interest in K-12 outreach activities. Based on this existing shared interest, or strength, Dr. A, continued to participate in EETI activities; he attended workshops, external speaker events, shared his passion for K-12 outreach through a presentation at the first EETI Engineering Education Showcase, and joined the Institute's research incubator program in Fall 2017. Dr. A's involvement in the incubator led to the writing of a collaborative proposal (~10K), which was submitted to the university's Office of Institutional Diversity. This project was designed to support and further enhance Dr. A's existing STEM outreach activities.

Dr. A's trajectory provides an example of how cultivating the conditions for engagement with scholarly teaching and learning can lead to emergent institutional change. In this case, a series of EETI events, and the relationships that were developed at those events, enabled a faculty member to share his interest in K-12 outreach with other interested colleagues and work together to secure funding to further enhance his efforts.

In the language of the Hemingway's ecological design principles, the first forum provided an opportunity for EETI members to "become familiar with existing cultures, values, interests, and structures" (Principle 1). The later forums, particularly the Engineering Education Showcase, provided further occasions for faculty members to connect over these existing and shared interests (Principle 2). The incubator program then provided a setting for faculty to share relevant information, in this case, the call for proposals from the Office of Institutional Diversity, as well as skills, in this case an experienced proposal writer in engineering education research worked with Dr. A to prepare the submission (Principle 3). When the incubator participants considered what ideas to put forward for this funding opportunity, they explicitly focused on "making the least change for the greatest effect" or, put another way, leveraging and enhancing an existing effort (Principle 4). Dr. A's connection with the local school was one of two ideas that met this criterion (incidentally, the second idea also received funding through the same program). Finally, we might consider the awarded grant as a "yield," which directly benefited the high school students and teachers who were the recipients of the funds, as well as the faculty members involved in writing the proposal (Principle 5).

Navigating perceptions of scarcity and abundance

We refer to the second instructor we report on here as Dr. B. Dr. B's trajectory, which we do not illustrate here due to space limitations, shares many similar features to that presented in Figure 1. Dr. B also attended forums, presented at an Engineering Education Showcase, participated in the incubator program, and built relationships with other EETI members. Three years after first getting involved in EETI, Dr. B and two other colleagues were awarded an extramural grant from the National Science Foundation (NSF) – the first such award in the history of the college to include a lecturer as the Principle Investigator (PI) of the project. What we wish to focus on here, however, is a series of tensions that emerged as the co-investigators navigated the different goals, constraints, and epistemological beliefs of the research team. In the following paragraphs, we describe these tensions and how they stemmed from beyond the particulars of the faculty involved in this initiative to touch on broader cultural considerations that must be taken into consideration when implementing an institutional change model such as the one we describe in this paper.

Navigating differences in knowledge and perceived levels of power

One tension that arose in this collaboration stemmed from perceptions of power and control over the project. In the United States, there is a perceived hierarchy between tenure-track and non-tenure-track faculty, with the former holding the more esteemed position. In this project, however, a non-tenure track faculty member was the PI of the project. This decision was made for two reasons. First, the idea for the project originated from Dr. B and, second, the NSF program that funded the project is designed to build the community of scholars who conduct research in engineering education, i.e., while tenure-track faculty members in engineering education are encouraged to serve as mentors, they cannot lead projects in this program. This perceived hierarchy was compounded with real differences in knowledge and experience in engineering education research methods. More specifically, at times it was difficult for the non-tenure track member to take leadership of a project in a broader cultural system that seems to place more value on some positions over others, and where they had less formal experience in education research methods.

Navigating conflicting goals of instructional and research faculty: What's good for students vs. what's good for research

Another tension that surfaced in the early stages of this project concerned different priorities and understandings around producing "rigorous research" and making a positive impact on students. Dr. B is a passionate instructor who is wholeheartedly committed to improving the experience of his students. The tenure-track faculty member involved in the project is also a dedicated teacher, though their success will be primarily judged based on research dollars awarded through grants and publications. This tension was further compounded by the different time scales that are associated with these two goals. Students move through classes on a semester basis, while a research paper in engineering education may take years to write and publish.

Different time commitments and constraints

Finally, a third tension that impacted the team dynamics concerned the different time commitments and constraints of the research team. Dr. B teaches full time during the semester and, therefore, has a concentrated block of time in the summer to work on research activities. The tenure-track faculty member and third member of the research team both have more flexibility to work on research projects during the academic year. These differences further accentuated perceived levels of urgency that any challenges that arose in the project had "to be worked out" by the end of the summer.

Application of ecological design principles

These three tensions presented the three faculty members in the research team with an opportunity to experiment with applying the ecological design principles to solve a nested problem, i.e., a project nested in an academic system. The first step in this process was to recognize that, beyond the individuals involved, the challenges the team faced, at least in part, stemmed from the system within which they operated (see point 6 above under "Complex systems theory": "The problematic phenomena produced by the systems' behaviour are unintended consequences of the system's functioning as designed"). Next the EETI leadership team sought to impress upon the project team three further principles of systems thinking and ecological design, namely, i) to prioritize relationships over outcomes (see point 1 above: "Complex systems theory focuses on the relationships between different elements in a system"); ii) to acknowledge the value and importance of diversity (e.g., diversity of perspective and experience; see also Principle 2 in Table 1); and iii) to adopt an attitude of abundance rather than scarcity (see Principle 6).

The focus on relationships over outcomes changed the nature of the conversations that ensued after the tensions emerged. Rather than focusing on "getting the project done," the project and EETI leadership team focused on (re)building the relationship between the instructor and tenure-track faculty member. An important part of this process was to acknowledge the value of the different perspectives and experiences that each faculty member brought to the project. The question was not "which perspective is right," or "more important," but "how can these perspectives complement each other and strengthen the project?" Finally, a focus on the relationship and on valuing diversity opened up a space to question the often assumed zero-sum nature of academic reward structures. Instead, the project team sought to leverage their differences to identify win-win opportunities where research and teaching goals could complement each other to lead to stronger outcomes in both areas.

Discussion and Generalizability to Other Contexts

These two examples show how the success of our institutional change model is informed by a propagation paradigm, a strengths perspective, ecological principles, and complex systems theory. An orientation toward propagation and the strengths that reside in a system enabled change agents to capitalize on the potential that already existed in the system. Ecological design principles helped to create the conditions to support emergence, while both ecological design principles and complex systems theory guided us when tensions arose.

In discussing this model, it is important to consider its generalizability to other contexts. This model has been implemented in an institutional and national context that prioritizes funded research. It was the EETI leadership team's success based on this criterion that enabled College-level administration to justify the initial and continued outlay of the annual operating budget that supports the institute. Looking forward, the sustainability of EETI will likely be determined both by the ability of EETI members to continue to secure extramural funding, and the sustained interest (i.e., perceived relevance and value by many who do not participate in the winning of grants) by EETI members in the institute's professional development activities. As such, there is an inherent discontinuity in value propositions: with administrators and reward systems emphasizing extramural funding and most faculty members seeing EETI as a space for connection with others of similar interests and professional development. EETI will likely have to inhabit this contentious space for as long as it exists. Ecological systems, however, also exist in dynamic states of balance.

Conclusions and Recommendations

This paper shows how ecological design principles can be used to cultivate the conditions that support a culture of scholarly teaching and learning. Much like the attention gardeners must pay to their soil, and the unexpected joys of the emergence of self-seeded plants that grow in good soil, our model attends to the existing structure of the engineering education system and seeks to leverage interests and strengths within it. We offer the theoretical constructs described in this paper, namely, a propagation vs. dissemination paradigm, a strengths vs. a deficit perspective, systems thinking, and ecological design principles as the building blocks of an institutional change model that is appropriate for transforming systems of engineering education. We offer the two examples we described as concrete examples of the affordances and challenges that may be encountered when embarking on this approach to institutional change. We welcome the opportunity to engage with others who are also curious about how to create change in engineering education in ways that honour the strengths that already reside in our workplaces.

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