Institutional Mentoring to Incite a Revolution through NSF's RED Program

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Abstract
A recent initiative from the National Science Foundation (NSF), IUSE/PFE: REvolutionizing engineering and computer science Departments (RED), is serving as a catalyst to encourage widespread, revolutionary, and radical change in engineering and computer science departments across the nation. After two years and 13 RED awards being funded, there is little diversity in the types of institutions—one is private, two are undergraduate-focused, and two are Hispanic-serving institutions. To address this lack of institutional diversity in funded RED projects, previous awardees of the program utilized a framework developed by the team, termed institutional mentoring, to develop a series of webinars aimed at helping diverse institutions envision a revolutionary idea for radically changing their program, assembling a team capable of realizing this vision, and using change strategies to help increase the likelihood of success and lasting change. This team deliberately reached out to Historically Black Colleges and Universities (HBCUs) and minority-serving institutions in an attempt to make more diverse institutions aware of this opportunity, with the hopes of increasing submissions of proposals to the RED program and the quality and likelihood of success for these proposals. In this paper, we describe the institutional mentoring framework, the process used in developing the seminars, and a synopsis of the sessions that made up the webinar.

Introduction
The National Science Foundation (NSF) IUSE/PFE: REvolutionizing engineering and computer science Departments (IUSE/PFE: RED hereinafter referred to as RED) program has ambitious goals to radically change the landscape of engineering education. This includes promoting "revolutionary" cultural change in traditional engineering and computer science departments throughout the U.S. To achieve this goal, it is essential that diverse institution types and department-level programs are included in the RED program. As shown in Table 1, in the first two cohorts, thirteen institutions have been funded—all of these institutions are research intensive; one is private, only two are undergraduate-focused, and two are Hispanic Serving Institutions (HSIs). Students obtain engineering degrees from a variety of institution types (Ellis, 2008). In order for the RED program to achieve its ambitious goals, it is important to include a variety of institution types. Thus, there is a need to reach out to a wider community and to mentor people at other institutions who are interested in developing competitive RED proposals.

Table 1 Institutions in NSF RED Cohorts 1 and 2.

Cohort 1 (2015)	Cohort 2 (2016)
Arizona State University	Boise State University
Colorado State University	Iowa State University
Oregon State University	Rowan University
Purdue University	University of Illinois
University of North Carolina, Charlotte	University of New Mexico
University of San Diego	University of Texas at El Paso
	Virginia Tech

In October 2016, a group of researchers from RED projects collaborated on a web-based conference titled, "Developing a Competitive NSF RED Proposal" to encourage institutional mentoring and help others envision and eventually enact a revolution of their own. This conference promoted exchanges of revolutionary ideas, stimulated new directions well-aligned with the RED program description, and cultivated innovative potential in the production of RED grant proposals. The conference offered faculty leaders a better understanding of how to scale their projects, aiming to produce the widest possible impact at universities across the country.

This model of institutional mentoring can be used to achieve the desired outcome of radically changing the landscape of engineering education and can be used as a model for others attempting to change campus cultures. This paper describes an overview of the conference goals, design, and content.

Institutional Mentorship Framework
Science, Technology, Engineering, and Math (STEM) education has been heavily invested in producing changes to the educational system to become more innovative and relevant, as evidenced by calls for action from professional societies (Danielson, Kirkpatrick, & Ervin, 2011; Jamieson & Lohman, 2009; Russell & Lenox, 2013), specials issues of journals such as the *Journal of Engineering Education* (JEE) ("Special Issue: The Complexities of Transforming Engineering Higher Education," 2014), funding agencies (Gonzalez, 2012), and national agencies (Fairweather, 2008; National Academy of Engineering, 2004; American Association for the Advancement of Science, 2004). The NSF, through the RED program, is invested in producing risk-taking, adaptive, and inclusive communities of professional engineers. The question is, how can we stimulate this mentality to produce scalable and revolutionary change? Can the RED program serve as a tipping point to help us realize desired changes to the engineering and computer science education system?

Engineering education has a long history of producing changes to specific programs. These efforts have been funded by agencies such as NSF and have been instigated through changes, as an example, of accreditation systems (ABET, 2004; Lattuca, Terenzini, & Volkvein, 2006). Most of these changes have been incremental and reformist approaches to change (Henderson, Beach, & Finkelstein, 2012) and include the introduction of first year and capstone design experiences (Froyd & Ohland, 2005), first year computer programming experiences (Brannan & Wankat, 2005), community service learning (Coyle, Jamieson, & Oakes, 2005), active learning (Borrego, Froyd, & Hall, 2010; National Research Council, 2012; Fairweather, 2008; Handelsman et al., 2004; Seymour, 2002; Boyer Commission on Educating Undergraduates in the Research University, 1998), and design-based learning (Puente, Van Eijck, & Jochems, 2011; Reynolds, Mehalik, Lovell, & Schunn, 2009). Most of these, however, are institutionally or individually enacted—the goal of the RED program is to build these efforts at a broader scale with radically different approaches which will result in disruptions in engineering and computer science education with the aim of producing lifelong learners devoted to radical change.

To take the next step and to allow our revolution to spread, we as current RED recipients used a framework that we call "institutional mentorship" to share knowledge with those who are willing

to start making large scale changes to their engineering education programs but who are not yet equipped with the knowledge of what a revolution is and which key players will help catalyze their revolution. Institutional mentorship is a strategy for sharing successes and supporting innovation of institutional transformation across the landscape of higher education. The goals of institutional mentorship include disseminating knowledge about structures and policies across campuses, establishing collaborations, addressing potential resources, demystifying perceptions of barriers, and sharing diverse visions for innovation. The RED program offers a template for galvanizing a diverse panel of experts who together collaborate on difficult initiatives to disrupt the status quo of engineering education. The institutional mentorship of the conference structure offered multiple perspectives and case studies as a framework to stimulate creative ideas, with the aim of leading a conversation about revolutionary change. The conference enabled early adopters (Rogers, 2003) to design and successfully enact a revolution in their particular context. It also helped them begin to develop a network beyond their institution to provide support while starting their revolution.

Designing the Conference: A Collaborative Effort
NSF is a leader in the conversation on broadening participation and access into STEM fields. The RED grants engage with this mandate, and our conference structure endeavored to expand the widest reach to encourage the widest institutional participation. For this conference, we adopted one of the four change strategies as proposed by Henderson, Beach, and Finkelstein (2012). The "Developing share vision: empowering leadership" change strategy helped frame the design of this workshop as the role of the change agent is "to catalyze or empower individuals to come together and work toward collectively envisioned change." While NSF provided an initial seed for a revolution in engineering education with the RED Request for Proposals, there is still a need to develop a collective vision for revolutionary change. As described above, there are teams who would like to be a part of this revolution, but are still lacking the prerequisite knowledge of what revolutionary change is, how to build a team that can enact that revolutionary change, and how a change model can help make that change sustainable and scalable. The current RED teams collaborated as "change agents" on this conference whose goals were threefold: 1) to cover the scope of the RED program, addressing what revolutionizing Engineering and Computer Science departments means 2) to explain the nuances of institutional and team diversity, and 3) to stimulate further conversation about research progress and pitfalls in the context of institutional transformation.

The idea of this conference emerged during an on-site meeting at the NSF in Washington, D.C. in response to an NSF program officer's desire to enhance the quality and diversity of the pool of submissions to RED. Members of several teams brainstormed on what could be useful and then wrote a proposal to obtaining workshop funding. In particular, collaborators designed with the goal of promoting the opportunity to a wider-range and diversity of institution-types.

To collaboratively develop content for the online conference modules, current leaders on RED grants gathered for an onsite meeting at one of the currently funded RED institutions with the goal of producing creative content to enhance the pool of RED submissions. Seven RED teams were represented and members of other teams provided feedback and input. The facilitators for the final conference included seven of the thirteen RED teams, a former NSF program officer, and a change expert.

In an effort to include Historically Black Colleges and University (HBCU) institutions and other minority-serving institutions, we directly emailed all ABET accredited institutions that identify as HBCU (there are 14), and reached out to other minority-serving institutions. The yield was a diverse pool of conference attendees. Such outreach is part of the institutional mentorship that we advocate, particularly for extending the range of opportunities to other institution-types (non-Research Intensive or R1, for example). In total, 190 attendees participated synchronously in the webinar series. The majority (56%, n=107) only attended one of the three webinars; 25% (n=48) attended two and 18% (n=34) attended three. Video recordings of the workshop sessions were made available after the webinars so that more people could view the webinars asynchronously.

Synopsis of Conference
The conference included two-hour conference sessions presented over three days. This format was chosen to enhance participation given the amount of content to be included, the likelihood that interested attendees are busy, and the recognition that two hours is about the maximum that people could stay focused during an online session. Each day began with an introduction to the conference and concluded with a question and answer session.

A summary of each of the conference presentations is included below.

Day 1: Keynote and "What is revolutionary and not-so-revolutionary?"

Day 1 of the workshop was designed to help guide potential proposal writers as they develop their revolutions and how these revolutions align with expectations in the RED program. Insight was provided by Dr. Donna Riley, a former NSF program officer, who gave an overview of the RED program as a keynote. According to Riley, the NSF Engineering Directorate was seeking "ground-breaking, sustainable, and scalable ideas" in the RED solicitation, with the aim of creating and supporting an "innovative and inclusive engineering profession for the 21st Century." Riley distinguished "revolutionary," rather than "reformist," change by its salient characteristics: radically, suddenly, or completely new; producing fundamental, structural change; going outside of or beyond existing norms and principles.

In addition to a revolutionary concept for change, the proposal writer also needed, Riley stated, to assemble an appropriate project team with specific attributes, as well as related knowledge, skills, and abilities (examples below):

- A clear demonstration of the PI, i.e., the chair/head (or equivalent), as an innovative leader of systemic change in the department to achieve the stated goals of the RED activities.
- An understanding of the role of each of the RED team members in creating change, demonstrating clear and significant contributions from the department head or dean, the engineering or computer science education expert, and the social scientist attuned to departmental dynamics.
- An understanding of the research on how students of diverse backgrounds learn engineering or computer science and what has been previously attempted.
- An understanding of how engineering education research connects to practice and of barriers to faculty adoption of engineering and computer science education innovations.

- An appreciation that faculty participation, engagement, development, and belief in the scholarship of learning are critical to success.
- An understanding of the importance of linking to professional practice through involvement of the department's or college's existing Industrial Advisory Board (or equivalent);
- An acknowledgement of additional example strategies, such as increasing the stature of professor(s) of engineering practice and their role as change agents or connecting the work with professional master's programs.
- An incorporation of scalability and adaptability considerations.

After Riley's keynote, the webinar transitioned to the panelists who discussed questions, such as What is revolutionary and not-so-revolutionary? What does it mean to start and sustain a revolution? The panelists were Elsa Villa from University of Texas at El Paso, Milo Koretsky from Oregon State University, Noah Salzman from Boise State University, and Nadia Kellam from Arizona State University. Kellam is a social scientist on her RED team and the other three panelists are the engineering education researchers on their respective teams. The purpose of this session was to help participants conceptualize revolutionary change within engineering and computer science departments. The intent was not to provide a recipe or prescription for a revolution, but to provoke thinking about how to look at one's ideas and evaluate where they are on the not-so-revolutionary to revolutionary continuum. This session started with an explanation of what a revolution is and what it means to be revolutionary. It then moved into examples from three current RED projects. Next it moved into two hypothetical cases, to allow for an in-depth discussion of revolutionary and not-so-revolutionary ideas. The session concluded with tips for a revolution.

In this session, Villa began by explaining that a revolutionary curriculum is one that substantially shifts fundamental understandings of learning and the content, practices, and structures of education. This includes a systems level approach that addresses social, contextual, and organizational processes in addition to curriculum. The approach needs to address core entrenched historical and cultural norms and core beliefs and values of faculty, students, and other stakeholders in the community.

Next Koretsky and Salzman discussed traditional ways of thinking about engineering and how these ideas compare to revolutionary ways of thinking about engineering. Koretsky began with a discussion of traditional views that are rooted in the historical and cultural norms of engineering education programs (see Table 2). He then contrasted this with a revolutionary perspective that emerged from understandings gleaned from learning sciences and science and technology studies literature. Next, Salzman moved beyond learning (curriculum and classroom experiences) to discuss broader structures of the system that influence student learning (see Table 3). This broader systems perspective involves changes to the broader faculty and departmental culture including how we value and evaluate teaching, how we conceptualize diversity and recruitment, and how we promote lasting change that benefits our students, colleagues, universities, and communities.

Table 2: Discussion of paradigm shifts (Koretsky et al., 2016)

Characteristics and conceptions of traditional learning	Characteristics and conceptions of revolutionary learning
Engineering involves technical work	Engineering involves social work and technical work
Learn principles before doing (just in case learning)	Learn principles by doing (just in time learning)
Engineering problems have a correct answer	Engineering problems have multiple solution paths
Certainty	Ambiguity
There is one way to be smart	There are multiple ways to contribute productively to a team
"How many points do I get for this?"	"How does this prepare me for practice?"

Table 3: Discussion of traditional and revolutionary structures that support learning

Traditional structures that support learning	Revolutionary structures that support learning
Standard course evaluations	Evaluation of teaching that reflects learning and practice
Buying out of teaching	Buying into teaching
One size fits all faculty evaluation and rewards	Context-based individualized evaluation
Counting underrepresented minorities (URMS)	Developing ways to create an inclusive, equitable, and welcoming community
Metaphor of the educational process as a pipeline	Metaphor of the educational process as a tributary
Industrial advisory board	Innovative partnerships with industry
Unfunded mandates for change	Revolutions need support
Change is directed	Change is emergent

Next the presenters discussed three concrete examples from current RED projects to illustrate how different departments conceptualized their revolutions. Kellam then discussed two hypothetical cases that both involved flipping classrooms—one was a top-down approach where the department head mandated a change to all classes in his program and the RED grant would support (through financial resources and research) the development of the videos. The other case focused on an idea that emerged from the faculty after attending a summer workshop; their cohesive approach was at a systems-level that addressed social, contextual, and organizational processes in addition to curriculum. The purpose of these two cases was to show that the pedagogical tool alone, in this case flipping, is not what makes a proposal idea revolutionary or not-so-revolutionary. Instead, a revolution, involving widespread and sustainable change, and can be achieved through focusing on changing the social, cultural, and institutional norms.

At the conclusion of this presentation Villa provided the following tips for a revolution:

- Think about "flipped classroom" and other curricular approaches as a tool, not as the revolution
- Students respond to systems – let's change the system, not blame the student (this applies to faculty too)
- Every proposal team needs a Che!
- Some revolutions lead to change for the better; some just lead to change
- The team responsibilities and budget should align with the proposed work
- This RFP is not for reformists; it's for revolutionaries

Day 2: Assembling a Winning RED team

The second day focused on addressing questions such as Who is needed to start a revolution? How do you put the right people into the required roles of PI, engineering education researcher, social scientist, and evaluator? The facilitators for this day were Geoffrey Herman from the University of Illinois at Urbana-Champaign, Jeremi London from Arizona State University, and Susan Lord from the University of San Diego. All three are engineering education researchers on their RED teams. The session began with an overview of who needs to be on the RED team drawing on the NSF call for proposals. Then the presenters described more about the role of the social scientist, the engineering/computer science education researcher, and the evaluator or evaluators. They interwove stories of successful RED teams drawing on their own experiences and those of other teams who provided input. These stories were intended to serve as examples of possible ways to assemble a team and to illustrate the variety of approaches that might be adopted. Then they shared advice from successful RED teams.

Herman, London, and Lord emphasized that the RED program is different than other NSF grant programs. To create and sustain a revolution is truly a team effort and requires different types of expertise. The RED call includes someone with the power to make change (department head), someone who is knowledgeable about culture and change (social scientist), and someone who knows what is happening in CS/engineering education research so it is critical to include all of these people when compiling a RED team.

According to the RED Request for Proposals (RFP), the Principal Investigator must be a department head or a Dean. The NSF call says that this is to "establish institutional accountability." For change to occur, it is critical to have someone in administration who can support change or provide leverage. An expert in engineering education or computer science education research is needed--this person should be familiar with the literature in this area and be able to ground the project plan within that literature. For example, have similar ideas been tried at other institutions? What are best practices? An expert in social science must be included--this person could be from a number of different departments including sociology or education. This person should be familiar with the literature on organizational change. They need to be able to advise the team on change processes, developing a culture of change, and creating meaningful ownership among faculty, students, and staff. According to NSF, this person also should help with evaluating departmental dynamics and monitoring change processes. The presenters later discussed each of the roles on a RED team, how to find someone with this expertise, and how they might contribute on the project.

The presenters also discussed the role of the evaluator(s) including some innovative roles for RED using the example of the Arizona State University team. They gave some recommendations on how to build an evaluation team and distinguished between an advisory board, which is required for the RED program, and external evaluation.

Finally, they presented their "Top 10 Tips" gathered from the current RED teams.

1. RED is not like most other NSF programs
2. Read the RFP carefully
3. The PI (department head or dean) needs to be actively engaged
4. Choose team members strategically
5. Build a team that enjoys working with each other

6. Build mutual respect, especially for the engineering education researcher and social scientist.
7. Collaborate
8. Iterate! Iterate! Iterate!
9. Identify the local factors that can make you a national model for departmental change
10. Be sure your change is something that you want to do no matter what

Day 3: Change model required

The third day focused on change models providing examples of change models as well as ideas for developing models and a rationale for why change theories can help revolutions succeed. As noted in the RED RFP, "A theory of change is a model that links your desired long-term outcomes to medium- and short-term outcomes and specific activities." The facilitators for this day included Vanessa Svihla from University of New Mexico, Charles Henderson from Western Michigan University, and Julia Williams from Rose-Hulman Institute of Technology.

In this session, Williams began with an overview of integrated models of change. Henderson continued with a discussion of change models as a mechanism to bring people together, "…the way an individual understands and appreciates the nature of knowledge affects the way he or she collaborates with colleagues in different academic disciplines, especially when the disciplines are fundamentally different" (Borrego and Newswander, 2008). Svilha applied current RED change approaches to the frameworks provided by Henderson.

In sum, the change model required by NSF should be a strategy to guide the development of change tactics (specific actions) to take a department from the current situation to a desired situation. This requires understanding the gaps between current status and desired status, and deciding on where the change will be targeted (individual, departmental, college-wide, etc.). Gaps and barriers must also be identified. In the case of USD, for example, faculty complain of a lack of "bandwidth" – with limited additional time for new innovations; there may be fear of new innovations, a lack of direct connection to rewards; among other barriers. Henderson suggested analyzing the scope of change and mapping the proposed tactics within one of the four quadrants, displayed in Figure 1.

Drawing on Figure 1 as a template, Svilha reminded participants that it is useful to adapt the change model to fit within the larger institutional operations, accounting for all elements of the proposed change. This may include not only faculty and students, but careful consideration of culture, curriculum, processes and procedures.

Importantly, cross-team collaborations among RED recipients form a unique meta-opportunity to engage in institutional mentorship. Rather than receiving grants and working in isolation, institutional leaders meet regularly, collaborate, and share information and tools. RED offers a new model for catalyzing change, as well as a new strategy for dissemination.
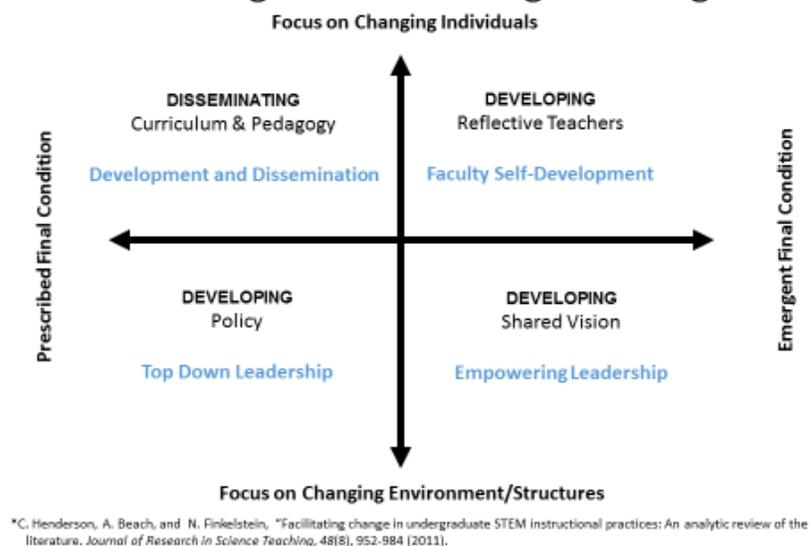
Figure 1 Facilitating Change (Henderson, Beach, and Finkelstein, 2011).

Further Information

To provide a resource after the conclusion of the workshop, the three sessions were recorded and posted to the Making Academic Change Happen website (https://academicchange.org/). The accessibility of the webinars plus transcripts should assist potential proposal writers in their preparation of a RED proposal. This will allow for an even broader audience and for potential proposers to choose those sessions most relevant. Technical support for the workshop, registration assistance, and assessment/evaluation of the workshop was provided by Rose-Hulman Institute of Technology.

More information about the 2017 RED program is available at the NSF RED program announcement: https://www.nsf.gov/pubs/2017/nsf17501/nsf17501.pdf.

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