Instigating a Revolution of Additive Innovation: An Educational Ecosystem of Making and Risk Taking

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SHAWN JORDAN, Ph.D. is an Assistant Professor of engineering in the Ira A. Fulton Schools of Engineering at Arizona State University. He teaches context-centered electrical engineering and embedded systems design courses, and studies the use of context in both K-12 and undergraduate engineering design education. He received his Ph.D. in Engineering Education (2010) and M.S./B.S. in Electrical and Computer Engineering from Purdue University. Dr. Jordan is PI on several NSF-funded projects related to design, including an NSF Early CAREER Award entitled “CAREER: Engineering Design Across Navajo Culture, Community, and Society” and “Might Young Makers be the Engineers of the Future?” He has also been part of the teaching team for NSF’s Innovation Corps for Learning, and was named one of ASEE PRISM’s ”20 Faculty Under 40” in 2014.

Dr. Jordan also founded and led teams to two collegiate National Rube Goldberg Machine Contest championships, and has co-developed the STEAM Labs™ program to engage middle and high school students in learning science, technology, engineering, arts, and math concepts through designing and building chain reaction machines. He has appeared on many TV shows (including Modern Marvels on The History Channel and Jimmy Kimmel Live on ABC) and a movie with his Rube Goldberg machines, and worked as a behind-the-scenes engineer for season 3 of the PBS engineering design reality TV show, Design Squad. He also held the Guinness World Record for the largest number of steps – 125 – in a working Rube Goldberg machine.

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Jennifer M. Bekki is an Associate Professor in The Polytechnic School within the Ira A. Fulton Schools of Engineering at Arizona State University. Her research interests include topics related to engineering student persistence, STEM graduate students (particularly women), online learning, educational data mining, and the modeling and analysis of manufacturing systems. She holds a bachelor’s degree in Bioengineering and graduate degrees in Industrial Engineering, all from Arizona State University.

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Dr. Jeremi London is an Assistant Professor of Engineering at Arizona State University. She holds B.S. and M.S. degrees in Industrial Engineering and a Ph.D. in Engineering Education, all from Purdue University. She employs mixed methods research designs and computational tools to address complex problems relevant to her research interests. She leads projects related to her research interest in primary research interests, which are focused on the characterizing and communicating the scientific and societal impact of federal investments in STEM education R&D; the use of cyberlearning tools to facilitate personalized learning experiences for students; applications of simulation and modeling tools to address undergraduate engineering education research problems; broadening the participation of underrepresented groups in engineering and computer science; advancing the scholarship on teaching and learning in engineering education. Prior to joining the ASU faculty, she worked as a Post-doc at ASU, spent several summers at the National Science Foundation, and worked in various traditional industrial engineering roles at Anheuser-Busch and GE Healthcare.
Instigating a Revolution of Additive Innovation: An Educational Ecosystem of Making and Risk Taking

Introduction

In 2015, the National Science Foundation (NSF) created a new program called “revolutionizing engineering departments” (RED), and awarded six grants to universities in the United States. The RED project within the Polytechnic School at Arizona State University (ASU), entitled “Instigating a Revolution of Additive Innovation: An Educational Ecosystem of Making and Risk Taking,” focuses on empowering faculty to be agents of change to expand our project-based learning pedagogy throughout the mezzanine engineering fundamental courses and the upper division concentration area disciplinary courses. The project team approaches this challenge by attending to the larger ecosystem of people and organizations within which change happens and by using evidence-based methods to make revolutionary advances within ASU’s engineering program. The specific objectives of the project are to:

I. Characterize the ecosystem within The Polytechnic School (TPS; one of six schools within the Ira A. Fulton Schools of Engineering; FSE) at ASU to establish the foundation for enacting faculty change and impacting students and other stakeholders.

II. Realize a mindset of additive innovation in the students and faculty to promote sharing, scaling, sustainability, and propagation of unique understandings within our community.

III. Establish an understanding of the engineering program culture and dynamics to assess the catalysts and barriers to establishing a culture that is risk seeking.

IV. Identify and implement administrative structures to support radical cultural change and remove perceived barriers that may inhibit innovation.

The objectives require a variety of methodological approaches and data collection strategies because they span investigation at multiple levels including faculty mindset, department/school culture, administrative structures, and instrument development over a multi-year period. For example, the unit of analysis of capturing culture is very different from the unit of analysis of an individual faculty member or an administrative structure. The corresponding research questions, as outlined below, span the educational ecosystem of students, faculty, classroom, and school.

1. What influence do faculty development programs and administrative changes have on the teaching practices of engineering faculty?
2. What types of administrative structures lead to a supportive ecosystem to realize change?
3. What is the culture of the TPS faculty, and how does the culture evolve in response to our RED activities?
4. What influence do changes have on students’ outcomes/experiences in the classroom?
5. What are catalysts & barriers faculty members identify to help/hinder changes to teaching practices?

The team has organized into six current working groups in order to manage the range of research foci and provide structure to our project activities. These working groups focus on the following topics: 1) capturing the culture, 2) characterizing the ecosystem, 3) coordinating a NEXUS (a term used to signify the intersection of project objectives) to realize an additive innovation mindset, 4) studying how introducing making-related activities may enhance the mezzanine courses, 5) measuring pedagogical risk taking by the faculty, and 6) tracing impact. Each of the project areas inform and interact with one another, but are currently segmented to allow for targeted work that advances specific research questions and serves as a guide to develop activities. The working groups are useful for the early stages of the project, but we recognize that the structure may evolve as the project continues to advance. This paper provides an overview of each of these six areas, describes how they advance the goals of the project, and presents results to-date. The paper mentions, where applicable, specific lessons learned in order to provide context that may benefit other projects engaged in similar multi-level and multi-method investigation.

Capturing the Culture

The working group is focused on capturing the culture of The Polytechnic School to establish an understanding of the engineering program culture and dynamics to assess the catalysts and barriers to fostering a risk seeking culture. The current activities include: 1) creating procedures for sharing data across sub teams to help inform other aspects of the project, 2) developing and piloting interview protocols, and 3) developing and testing a coding book.

Very early into this aspect of the project, the team became aware of a few issues that needed to be addressed to ensure proper research protocol. The interviews are structured as narrative interviews, which tend to elicit personal accounts and stories of the interviewee. The potential for revealing personal information raised concern that faculty may not be comfortable with sharing their personal stories to a research team made up of seven faculty member peers in the program as well as the director (administrative head) of the program. To help alleviate concern for revealing personal information too broadly, the team assigned one member of the RED team to conduct all interviews, and enlisted the project’s external evaluation team to help with thematically coding the interviews. By doing so, data can be distributed among the team members by theme, while limiting access to identifying information, or to excerpts that should not be shared broadly. This process is made transparent to the faculty interviewees prior to the interview through discussion and informed consent.

Another issue the team noted was the potential for “interview fatigue” as a result of multiple, individual working groups conducting their own interviews with faculty, which could result in
reluctance to engage with the RED team’s future workshops or other data collection. Given that
the narrative interviews cover topics related to all six working groups, the team determined that
rather than conduct separate interviews, each of the working groups can access the data by theme
as appropriate. The project team is currently conducting the interviews for year one. The next
stage will involve thematically coding the interviews, aggregating the data across themes, and
providing de-identified data to the overall ASU RED team members.

The narrative interview protocol was developed and piloted with four RED team members using
standard qualitative interviewing procedures. The protocol begins with informed consent, a
description of the purpose of the interview, and an explanation that a narrative interview is
interested in the interviewee’s story. The interview follows a semi-structured protocol\textsuperscript{2,3} in which
the interviewer provides follow up questions to specific critical incidents that may be mentioned
and encourages the interviewee to elaborate more on these incidents. Table 1 provides the RED
project’s research questions and maps them to the interview questions; the primary interview
questions are numbered 1-4, and follow-up questions are delineated and asked in the case where
an interviewee does not address those aspects naturally in his/her response.

In developing codes, a ‘lean coding’ approach\textsuperscript{4} was used initially, which began with a short list
of tentative codes. This coding structure was aligned to our specific research questions\textsuperscript{4,5} (see
Table 2). For example, to explore the first research question, To what degree has institutional
change influenced faculty members’ willingness to take risks?, a critical event narrative analysis
approach\textsuperscript{6} that involves identifying common critical events across the interviews and
constructing a set of narratives that represent different perspectives on a common event was
used. This enables the project to document how institutional change may have impacted faculty
members’ willingness to take risks\textsuperscript{7-9}.

The team completed the pilot stage of the interview protocols and data analysis, and is currently
conducting interviews with approximately eight more faculty. The initial target is faculty who
teach mezzanine courses, which include faculty associates, lecturers, and tenure/tenure-track
faculty at all ranks. The interviews will be transcribed, checked for accuracy, and initial codes
will be applied to the transcripts as interviews are conducted.
<table>
<thead>
<tr>
<th>RED Research Questions</th>
<th>Narrative Interview Questions</th>
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</table>
| 1. To what degree has institutional change influenced faculty members’ willingness to take risks? | 1. Tell me about your experiences as a faculty member at Poly since you first joined. Begin with what drew you to join the Poly faculty.  
   a. How do you see your role as a faculty member? Has this changed over time?  
   b. How has the leadership (dean, director) influenced you as a faculty member?  
   c. What are major shifts that have happened during your time at Poly? Could you elaborate on how those changes have influenced your teaching, research or service?  
2. How have you/might you approach risk-taking/innovation in your teaching and research that might challenge the status quo?  
   a. Has the ASU environment encouraged or discouraged you to challenge the way that academia has always done things? |                                                                                                                                                                                                                               |
| 2. What are the teaching practices, beliefs, and values of engineering faculty at Poly?  
2a. What are catalysts & barriers faculty identify to help/hinder changes to teaching practices? | 3. Let’s talk about your current teaching experiences. What is your teaching approach now? Tell me about a particular experience recently that would help me understand how you approach teaching now.  
   a. Describe any influences to your teaching, be it positive or negative, that in any way impact the strategies you adopt in the classroom. In what ways, if any, do you share your teaching ideas with other faculty? In what ways, if any, do you get or borrow new ideas for teaching?  
   b. Compared to your teaching peers, would you classify your teaching approaches as novel, common/standard or more traditional? How would other faculty or students describe your teaching? Can you think of times when you wanted to make changes in your teaching but didn’t and tell me about that? |                                                                                                                                                                                                                               |
| 2b. What influence do faculty development programs and administrative changes (e.g. P&T process) have on the teaching practices, attitudes, values, and beliefs of engineering faculty? | 4. How would you like to further develop as a faculty member? How do you think you’ll go about doing that?  
   a. Over the years, what or who has helped you make changes to your teaching?  
   b. How have/would opportunities to further develop as a teacher or researcher impact you as an engineering faculty?  
   c. What kind of institutional level support do you need to help make course innovations? |                                                                                                                                                                                                                               |
Table 2. Codes for faculty interviews

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical Events</td>
<td>These are incidents that have an impact on the storyteller and the interviewer identifies after the event as being critical to their personal trajectory. “Critical events are ‘critical’ because of their impact and profound effect on whomever experiences such an event. They often bring about radical change in the person. These events are unplanned, unanticipated and uncontrolled” 6, p. 77. Critical events can be: 1) ‘Extrinsic,’ produced by events external to the faculty member, such as the merger of Poly with Fulton, 2) ‘Intrinsic,’ events that occur within the individual and happen in the natural progression of a faculty member’s career, such as working towards tenure or a mid-career move, and 3) ‘Personal,’ events that happen in an individual’s personal life, such as having a baby or an illness.</td>
<td>Examples of critical events may include changes in leadership, mergers within ASU, or a change to an active learning approach in a class.</td>
</tr>
<tr>
<td>Teaching Practices</td>
<td>Discussion of teaching practices in the classroom. Also include influences in how they became the teacher they are today. Classification may include: novel, common/ standard, traditional, non-traditional according to them and perceptions of they think their colleagues perceive them</td>
<td>Examples may include lecturing, sample problems, flipping the classroom, project-based courses.</td>
</tr>
<tr>
<td>Beliefs and Values</td>
<td>Interviewees’ perspectives or philosophy about teaching or their role as a teacher. These are more abstract goals about their teaching, their students, and how learning happens. These may inform their practice.</td>
<td>Examples may include personal motivations or goals, personal beliefs about teaching or learning, and values related to teaching.</td>
</tr>
<tr>
<td>Catalysts</td>
<td>Interviewee identifies influencers that motivate them to make changes to their teaching practices.</td>
<td>Examples may include faculty development programs, workshops, communities of practice, co-teaching, perception of promotion &amp; tenure process</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
<td>Example</td>
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<tr>
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<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Barriers</td>
<td>Interviewee identifies influencers that de-motivate them from engaging in new or innovative teaching practices</td>
<td>Examples may include changes in administration/organizational changes, perception of promotion and tenure process, perception of FSE’s goals</td>
</tr>
<tr>
<td>Additive Innovation</td>
<td>Interviewee shares instances of sharing and/or borrowing teaching approaches.</td>
<td>Examples may include finding ideas for lessons online, sharing course materials to others informally, or publishing proceedings related to teaching practices.</td>
</tr>
<tr>
<td>Continuous Development</td>
<td>Interviewee shares instances of continuous development and/or ideas or opportunities for improvement.</td>
<td>Examples may include sabbaticals in industry to improve impact of research and teaching or brown bag lunches to develop community around teaching.</td>
</tr>
</tbody>
</table>

**Characterizing the Ecosystem**

To characterize an ecosystem, in this case an educational ecosystem, a systems and entrepreneurial approach to better understand the variables, inputs, outputs, influencers, and other factors is required. The project employs the Lean LaunchPad business model canvas methodology to develop an understanding of the value propositions for all stakeholders in the system in order to implement innovations quickly, test the effectiveness of those innovations, and iterate using an agile approach. Encouraging a risk-taker identity helps create an environment that rewards an entrepreneurial mindset such that faculty and students become agents of change to realize their potential to make a difference.

The engineering program in TPS, which enrolled its first class as part of a different academic unit in 2005, could be considered a start-up. Taking the approach of a start-up, and using the tools for creating a sustainable business model, we utilize materials developed as part of the National Science Foundation’s I-Corps for Learning (I-Corps™ L) program, which is designed to urge funded investigators to define a successful model for enabling scalability and sustainability of their educational innovations. The program uses the business model canvas (BMC), customer development process, and agile engineering based on the Lean LaunchPad approach.
The business model canvas is shown in Figure 1. It consists of nine boxes that represent key aspects of what is necessary to maximize the potential for scale and sustainability. Core to the BMC is defining specific, measurable value propositions (VP) that align to specific customer segments\textsuperscript{13}. By using this approach, we use an entrepreneurial mindset to clearly articulate what is of value to key stakeholders in our system (i.e., faculty). Determining the value propositions for different faculty segments (pre-tenure, tenured, lecturers, etc.) will then allow us to determine policies, structures, or other motivators needed to engage individuals in risk-taking and additive innovation; effectively realizing the overall goals of our RED project. The Business Model Canvas also helps to identify other aspects of the ecosystem, such as partners, costs, resources, and revenue streams necessary to sustain the activity.

![Figure 1. Graphic of the business model canvas.](image_url)

The team used the BMC as a framework to guide one of our first NEXUS activities at the fall semester all-school faculty retreat. The goals of the retreat were inclusive of a variety of operational and strategic issues related to the start of the academic year, but also included a segment focused on characterizing the TPS ecosystem using elements of the BMC. We used the nine boxes to structure a set of reflective group activities to begin to understand our customer segments, what they value, and what they might need for success\textsuperscript{14}.

**Coordinating a NEXUS: Realizing an additive innovation and risk taking mindset**

The focus of “NEXUS” is to develop and implement ways to engage faculty (and indirectly, students) in realizing a mindset of additive innovation to promote sharing, scaling, sustainability, and propagation of a risk-taking and innovative culture within our engineering program. The term NEXUS signifies the coordination/intersection of several goals of the project: advancing the additive innovation mindset, impacting the culture, creating new administrative structures, and propagating making-related activities in the mezzanine.
The phrase *Additive innovation* is a term used to describe collaboration in the Maker community\(^\text{15}\), and is a mode of collaboration where participants in a community are: (1) inspired by shared artifacts/ideas, (2) openly share (and learn about) the technology and process used to create these artifacts/ideas, (3) design and prototype their own modified version of the shared artifact/idea, and (4) share their modified artifact/idea back with the community. The ASU RED project leverages the notion of additive innovation to instill this type of mindset in faculty to encourage the sharing of teaching materials, in-class testing results, reflective practices, faculty testimonials, and other materials.

The team has led two NEXUS activities within the engineering program at ASU—the fall faculty retreat and an end of fall semester workshop. The overall goals of the retreat were to build social capital and cross-pollination among our faculty, develop a shared identity and discourse, create content and a framework for our school’s annual report, and identify values and strengths of our programs. The specific goals for advancing RED were to develop a business model canvas, as described earlier, with a focus on characterizing our school’s ecosystem based on faculty input and identifying value propositions for faculty, i.e., what faculty need and value so that the project team can work to change the culture in future interventions.

The second ASU NEXUS activity involved an end-of-semester workshop. The objective of the workshop was to develop an understanding of perceived barriers and catalysts of faculty to make changes to their teaching. Fifteen faculty attendees were grouped according to their titles—lecturers, assistant professors, associate professors, and full professors. The workshop began with providing fictionalized scenarios of a lecturer, an assistant professor, and a professor. Faculty read the scenario most closely aligned with their job function and were then asked a series of think, pair, share questions to elicit their perspectives on the catalysts and barriers experienced by the faculty members portrayed in the scenarios. Then faculty were asked to develop changes that the fictionalized faculty could implement into their classroom—one that would be easy to implement and one that would be more significant. The final step of this activity was to have faculty identify specific changes that they could make to their own teaching to improve student learning. The end of the workshop concluded with a discussion of the larger RED project and plans for future NEXUS workshops. Faculty notes taken during the activity were collected to capture the barriers and catalysts that faculty identified and ways that they would like to make changes to their classrooms.

In addition to the ASU-based NEXUS activities, two team members also delivered a three-hour workshop at the University of New Mexico (UNM). This workshop originated through contact by the chair of the UNM Chemical and Biological Engineering Department to the project team asking to collaborate on RED-related activities. The purpose of the workshop, developed in consultation with the UNM team, was to help faculty identify barriers and catalysts to changing engineering programs, to identify ways to make changes to their courses, to develop a “test
card”

(see Figure 2) that includes specific plans to implement and assess the impact of a particular change to teaching, and to discuss the RED project. This workshop consisted of: 1) discussing a set of character scenarios, 2) developing ideas to make changes through introduction to the test card concept, and 3) presenting the RED project to potentially inform how UNM might make revolutionary changes to their chemical engineering program. The ASU RED team was proactive in taking this opportunity to develop and implement this workshop in order to make connections to other universities, begin to scale and propagate our RED ideas, and to develop communities of practice around a shared goal of revolutionizing engineering programs.

![Test Card Example](image)

**Figure 2. Test Card Example**

Some immediate next steps include holding a spring semester NEXUS activity at ASU where faculty might develop as an example, test cards around a big idea (something that they have
always wanted to try in their teaching), develop a plan to implement this big idea in their classroom, and develop a way to assess how well the idea worked. Additional NEXUS activities will be held biannually every fall and spring semester, to provide opportunities for faculty in TPS to regularly reflect on and improve their teaching practices. Plans also include the creation of peer teams that consists of two faculty members and one RED team faculty member with expertise in engineering education. Each peer team will conduct peer observations when a test card activity/idea is implemented and will provide feedback to each other on what works well in their classroom, how the big idea worked and how it could be improved, and plans for future iterations. The overall goal is to develop a community of faculty risk takers who are engaged and interested in each other’s teaching; something uncommon in most university contexts.

**Making in the Mezzanine**

The making aspect of the study seeks to explore and introduce making-based activities and pedagogical techniques into the engineering fundamentals classroom. Variations of making are already included into some aspects of the engineering curriculum, such as in the project courses that make up the design project spine. However, the project aims to explore how aspects of making can extend further into the curriculum, in particular within the mezzanine level engineering fundamentals courses. The aim is to provide examples of how faculty members are currently teaching engineering fundamentals, and delineate potential making-based techniques that may enhance student learning in these classes.

The making in the mezzanine study thread also contributes to the characterization and creation of an additive innovation mindset within our faculty. In the case of RED, the shared ideas will be making and engineering fundamentals-related pedagogical innovations to which faculty are exposed to in the NEXUS activities.

Characterizing our current engineering fundamentals courses through a lens of making in engineering will lead to both understanding the starting point for change and building a library of examples from TPS faculty that can be used to seed the culture of additive innovation. In order to seed a culture of additive innovation in faculty, examples (ideally from our TPS faculty) are helpful to inspire faculty to take the risk of trying something new. The team’s initial efforts have focused on better understanding making as it is currently implemented within our program.

**Measuring Risk Taking**

The group working to develop a measure of risk taking is developing an instrument for measuring faculty attitudes and behaviors around taking risks in their teaching practices. This effort is in support of the project objective to establish an understanding of the engineering program culture and dynamics to assess the catalysts and barriers to establishing a culture that is risk seeking, with the intent to disseminate the instrument for broad use within the community.
The team is following a rigorous instrument development process, in line with the processes taken by other recently published instrument development efforts\textsuperscript{16,17}. Below is a description of the phases associated with this work.

- Phase I consists of conducting a thorough literature review to identify factors that would serve as barriers (e.g., time constraints, lack of knowledge about new pedagogical approaches) or catalysts (e.g., promotion and tenure based incentives, course release for additional prep time) for faculty to take risks in their teaching practice and then to define risk taking as a construct in our particular context.
- Phase II focuses on developing items and evaluating face validity.
- Phase III includes conducting an exploratory factor analysis using a convenience sample of graduate teaching assistants at our home institution.
- Phase IV will consist of revising the instrument (based on findings from Phase III) prior to conducting a confirmatory factor analysis using a nationwide sample of faculty possibly recruited, for example, from ASEE. Using the same sample, we will evaluate the convergent and divergent validity of the instrument by comparing it to constructs known to be theoretically similar or different from ours.
- Phase V involves conducting a test-retest analysis to examine the stability of the factor structure.

The team is currently in Phase I and plans to complete all phases by the spring of 2017. Upon completion of the instrument development process, the team will use it to establish a baseline measure of risk taking attitudes and behaviors among the FSE faculty at ASU. In the later stages of the project, the instrument will be re-administered to evaluate the impact of changes that have been implemented through the course of the RED project to document changes in faculty risk taking attitudes and behaviors. It is anticipated that these combined efforts will result in a psychometric analysis of the instrument itself and detailed results of its application to the faculty at ASU.

**Tracing Impact**

The tracing impact working group is exploring the impact of the ASU RED project beyond the local context of ASU. These efforts are not only an extension of the explicitly stated project objectives, but also help advance the scholarship on the impact of federally funded STEM education research and development (R&D) projects—an area of literature that is slowly growing, but severely lacking.

Nearly twenty people from other institutions reached out to the RED team during the Fall 2015 semester, asking if the team would be willing to share the RED proposal with them. To each email request, the response was the same: “As a project team we have agreed to share our proposal as a way to continue to advance the revolution. By sharing our proposal, we are also advancing our approach of "additive innovation" which is about sharing ideas so that the community can continue to build on them to advance the field. Good luck with your proposal!”
The team realized with each request that this set of interactions presented a unique opportunity to begin to trace the impact of our RED project on engineering programs at other institutions. The team is leveraging this opportunity to help address one of the biggest challenges to studying the non-scientific impact of federally funded R&D projects: attribution\textsuperscript{18}.

It is useful to mention that research impact includes two facets: scientific and societal impact. Scientific research impact refers to advances in reliable knowledge (i.e., theories, methodologies, models, and facts) that primarily influence academic communities\textsuperscript{19-22}. Alternatively, societal research impact is broadly defined as research that influences social, cultural, environmental, or economic capital of a nation\textsuperscript{19-21}. These two facets of research impact are widely accepted among research impact scholars, yet there are many unresolved issues with characterizing and studying the societal impact of R&D—supreme among these is the ability to connect the realized impact of a project with a particular research project and/or researcher(s)\textsuperscript{20}. Said differently, the attribution problem is the difficulty with attributing impact to particular research projects or other inputs; this problem is also referred to as impact accretion. The reasons it is so difficult to connect the realized impact of R&D with a particular research project or researcher(s) is because impact diffuses through time and space, and all research builds on earlier research. We hypothesize that tracing the impact of research gets easier with improved documentation of related activities and somewhat meticulous follow-up surrounding those activities—particularly the kinds of activities that seem tangentially related to the conduct of the research project itself.

The tracing impact working group will attempt to test this hypothesis by exploring the extent to which the ideas in our RED proposal influenced the activities of those with whom the proposal was shared. The team has invited those who sent emails requesting the proposal to participate in a 30-minute semi-structured interview\textsuperscript{23,24}. The interviews will be used to garner insights surrounding the landscape of challenges in the engineering education departments that teams seem to feel comfortable addressing, and more importantly, the influence of our approach to addressing challenges in our local context (as outlined in the proposal) on the ideas readers had for addressing challenges in their context. Table 3 includes the interview protocol associated with this research activity. Insights on ideas they decided to replicate and/or adapt to their institution will be most useful for tracing the impact of our work beyond ASU. This work is in the early stages, and is on track to have all of the interviews completed by Summer 2016. Thematic analysis of the interviews will begin soon after.
Table 3. Impact Tracing Interview Protocol

<table>
<thead>
<tr>
<th>Discussion Topic</th>
<th>Interview Questions</th>
</tr>
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<tbody>
<tr>
<td>Motivation to pursue RED funding</td>
<td>What prompted your interest in requesting our proposal? Was there something specific about our RED project that prompted you to ask us? Did you request all of the awarded RED proposals? (If so, did all RED teams share their proposals?)</td>
</tr>
<tr>
<td></td>
<td>What motivated your interest in submitting a RED proposal? What challenges/problems/issues are going on at your institution such that you wanted to instigate change/incite a “revolution”? Did you ultimately submit a RED proposal?</td>
</tr>
<tr>
<td>Compelling aspects of ASU’s RED proposal</td>
<td>As you read through our proposal, what stood out to you and why? Did you decide to submit a RED proposal in response to the most recent RFP? Did our proposal dis/encourage you to submit a proposal? If not, what influenced this decision? If so, was there anything that was helpful to you as you developed your proposal?</td>
</tr>
</tbody>
</table>
| Tracing impact of our RED project beyond ASU      | While all RED projects focused on enacting systemic change in engineering education with an explicit focus on the mezzanine courses, we believe that there were four aspects of our proposal that were unique from the others that were awarded. Since I do not expect you to be an expert on our proposal, I’ll briefly remind you of them, then ask a follow-up question. They are:  
  a. The use of the Business Model Canvas to characterize our ecosystem and get input on how to incite a revolution that aligns with faculty values.  
  b. The emphasis on Additive Innovation, which is an understanding that innovations are most impactful when they are shared and built on to fit a new context.  
  c. ASU prides itself on being an innovative and progressive institution, and with this characterize comes a culture of change. In our project, we are studying how this culture has influenced people’s willingness to take risks (in their teaching or otherwise).  
  d. We made an explicit choice not to engage in curriculum development, but instead to focus on faculty development and culture. |
| Wrap up questions                                  | Would you be willing to share your proposal after RED funding decisions are made? Is there anything else you would like to share? |
Summary

During our first semester of the project the ASU RED team has established a coordinated structure that provides the necessary cohesion to manage the multi level and multi method nature of our investigation. The structure of the six working groups serves as an important framework that allows each of the subgroups to make advances in their particular area, but also helps facilitate the interaction between the groups. We recognize that revolutionizing engineering education is a systems-level endeavor with interdependencies, much like the systems level approach illustrated by our interconnected working groups.

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Bibliography


