Progress on the Pathway to Instigating a Revolution of Additive Innovation

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Progress on the Pathway to Instigating a Revolution of Additive Innovation

Introduction

The project described in this paper is part of a cohort of projects funded to revolutionize engineering and computer science departments (National Science Foundation RED initiative). The focus of our work is to take a systems-level perspective regarding how change can be facilitated within an organization. Our efforts aim to empower faculty to be agents of change and to cultivate a culture that recognizes and rewards risk-taking in the classroom. We approach our work by attending to the larger ecosystem of people and organizations within which change happens. Our evidence-based methods are intended to foster revolutionary advances within our engineering program. We are in the third year of our five-year project and have recognized that part of the revolution entails how our team adapts internally and externally through the different stages of the project. From an internal perspective, we have been intentional in reflecting on team process, team dynamics, and team structure so that we modify and adapt as necessary to maximize performance. From an external perspective, we are intentional to recognize and be responsive to changes that happen in the larger ecosystem, i.e., our institution and professional community, within which we are situated.

We are nearing completion of foundational aspects of the project and are transitioning during the pivotal year three to new focus areas and different phases of work. This paper provides a summary of our progress to date regarding meeting the project objectives, in addition to recent adjustments made to support our next steps. These adjustments are driven by our reflection of what, precisely, is our revolution, and how our project team is adapting to accelerate progress on the pathway to reach the revolution.

Where Have We Been?—Background on ASU RED project

Our focus is to empower faculty and students to become risk-takers and innovation leaders. By encouraging risk-taking, we create an environment that rewards experimentation and enables faculty and students to become passionate about their work. The project leverages an additive innovation mindset [1] by using 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 team initially organized into six working groups to provide structure to the project activities. These working groups focused on the key topic areas of the project: 1) capturing the culture, 2) characterizing the ecosystem, 3) coordinating a NEXUS (a term used to signify the intersection of project objectives) to realize risk taking and additive innovation mindsets, 4) studying how introducing making-related activities may enhance the mezzanine courses, 5) measuring pedagogical risk taking by the faculty, and 6) tracing impact beyond ASU. The working groups had been useful for the early and mid-stages of the project, but are now evolving as some groups have completed their work and are ready to transition to advance other aspects of the project. We provide a brief overview of each of the original working groups below. A more detailed description can be found in prior publications [2-6].

Capturing the Culture: Efforts to better understand the existing engineering program culture and dynamics were made to assess the catalysts and barriers to fostering a risk seeking culture. We used Schein's [7] organizational cultural framework as a theoretical framework and focused on the interplay of the experiences of individuals within the program and the larger sociocultural forces [8].

Characterizing the Ecosystem: Concepts from the business model canvas (BMC) [9-11] were used by this group to understand different customer segments and associated value propositions within the school ecosystem. The entrepreneurial approach taken by using the BMC aimed to identify administrative structures that have the potential for sustained change as well as creating faculty development activities that have value for faculty to achieve their goals. For example, we have launched the "RED poly faculty fellows program" (more details in the NEXUS section) which enables faculty to propose curricular innovations with support from the project and the school [4].

Coordinating a NEXUS to Realize a Risk Taking and Additive Innovation Mindset: The focus of "NEXUS" is to develop and implement ways to engage faculty (and indirectly, students) in realizing a mindset of additive innovation that promotes sharing, scaling, sustainability, and propagation of a risk-taking and innovation within our engineering program. The term NEXUS signifies the coordination or 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 courses offered between first-year and senior year, i.e., mezzanine. Early efforts to engage faculty led to the development of eight guiding principles for evaluating potential NEXUS interventions and three active working groups [4].

Studying Making in the Mezzanine Courses: The project explored introducing making-based activities and pedagogical techniques into engineering fundamental courses taught during the mezzanine years. Variations of making are already present in some aspects of the existing engineering curriculum (e.g., project courses offered in the curriculum project spine). We currently explore how aspects of making can extend further into the curriculum. Data have been collected and analysis is underway on three case studies of making-based pedagogy in our mezzanine-level mechanics, robotics, and statistics courses [12].

Measuring Pedagogical Risk Taking by the Faculty: An instrument has been developed to measure faculty attitudes and behaviors toward taking risks in their teaching practices. This effort is in support of the project objectives to 1) establish an understanding of the engineering program culture and dynamics, and 2) assess the catalysts and barriers to establishing a culture that is risk seeking. We intend to disseminate the instrument for broad use within the engineering education community. The initial instrument was designed using a newly created framework informed by Expectancy Value Theory (EVT) [13]. The instrument is near completion with a plan to use it to establish a baseline measurement of risk-taking and innovation among our faculty and to evaluate the success of faculty interventions designed to encourage our faculty members to become more innovative.

Tracing Impact: Our tracing impact work has explored the impact of our project beyond the local context. We have received nearly twenty requests from other institutions to share our successful RED proposal. Each requestor was provided with the following response: "As a project team we

have agreed to share our proposal as a way to continue to advance the revolution." This set of activities is consistent with the notion of additive innovation that is woven throughout our project. We invited all who received our proposal to be interviewed to garner insights surrounding the landscape of challenges within their programs and to understand what, if any, influence our approach may have in helping frame their approach. We have interviewed eleven participants and are currently analyzing the results.

Where Are We Now?—Overview of current activity

We break down and provide details about relevant and substantive activities that span across the project. These efforts are all currently underway and do not necessarily fall within the scope of a specific working group.

NEXUS Affinity Groups

There are currently three affinity groups organized around topics that faculty have identified as pain points to be addressed in the curriculum: 1) project spine affinity group, 2) revolutionizing math-intensive courses affinity group, and 3) revolutionizing content heavy courses through flipping. We will expand two of the groups in the following subsections.

Project Spine Affinity Group: This group is an assembly of faculty who regularly teach the project-based courses required each semester throughout the engineering and manufacturing engineering programs, i.e., project spine. The primary goal is to share aspects of each course to better align and scaffold content. Meetings are regularly attended by eight faculty that span all four years of the project spine. Varying degrees of change have occurred within each course based on the knowledge provided by each participant regarding courses they primarily teach. The primary resource developed by the group is a spreadsheet that maps efforts in a variety of areas (e.g., computer aided design, programming, project management, etc.) across each course.

Revolutionizing Math-intensive courses Affinity Group: This group includes faculty that teach engineering courses that heavily rely on mathematics, namely Engineering Statistics, Model-based Design, Robotic Systems, Systems Modeling, and Complex Systems. The aim of this group is to support students in transferring relevant mathematics concepts to the respective engineering course when they need to be used in support of learning a new concept or skill. The group meets once per month and began by focusing on a common problem. The next phase included interviewing other faculty members in the program to understand the extent to which the problem permeated the curriculum and what ideas faculty had to address the problem. The group used this data to better understand and compare options for addressing the problem. The group has recently identifying the first strategy to be used to address the challenge associated with transfer. The following four-point strategy was operationalized and is currently (Spring 2018) being implemented:

1. Identify a short list of the key mathematical concepts with which students must be proficient in order to succeed in the class, along with a general time in the semester at which proficiency with the concept will be required
2. Write a test or quiz consisting of example questions to test the students' proficiency with each mathematical concept identified in step 1

3. Assemble a list of resources that students can use to self-study each of the mathematical concepts; map the resources to the questions from step 2
4. At the beginning of the semester, provide students with the test/quiz along with the resource links; require students to take the test (potentially outside of class)

This group plans to continue to meet to discuss the following: variations in ways to implement the action plan, challenges to implementations and strategies for overcoming them, and ways to study the effectiveness of this action plan after the semester ends.

Advisory Board Engagement

Our project has a diverse external advisory board comprised of individuals with long-term interest in the professional formation of students. These individuals come from industry, higher education, and non-profit organizations, and bring relevant expertise in making and innovation, industry needs, faculty development, and undergraduate engineering education. Our approach has been to enable each advisory board member to lend their unique perspective to the project in a very interactive and substantive way.

To date, we have hosted two advisory board members for intensive two-day visits to campus in an effort to enable deeper engagement and richer feedback than might be possible through a group visit, by phone conference, or by a virtual meeting venue. Each two-day advisory board visit begins with a meeting with project leadership to review progress. The advisory board member is also provided with the opportunity to meet with students, faculty, and administrators within both the unit's engineering program as well as with other programs across the college; to tour campus classrooms and facilities, including engineering design studios and research spaces; and to deliver a talk as part of the Engineering Education Systems and Design (EESD) Ph.D. seminar series. The trip culminates in a debrief with project leadership based on the advisory board member's observations of strengths (e.g., areas where the team is being particularly innovative) and opportunities for improvement (e.g., areas where the team could have even greater impact). Additional advisory board visits are planned in Years 3-5.

Engaging our Evaluation Team

The evaluation team has provided important services to the team, including helping with data collection and analysis, observing project activities and providing feedback, meeting the team to debrief on progress and needs, and preparing annual reports. These have been important and helpful activities. We recognize as we transition to the latter half of the project that we can engage the evaluation team to also help from a project management perspective. The focus of our evaluation team now is a close monitoring that we are on track to meet our short-term and long-term goals of the project's revolution. The evaluation team was invited to attend our Fall 2017 end-of-semester team debrief to observe the status of the project through the team's conversation. Three priorities emerged as dedicated focal points for the remainder of the project:

1. Establish, cultivate, and promote a culture of pedagogical risk-taking
2. Provide mechanisms to share, disseminate, collaborate, develop, etc. interesting and effective teaching approaches

3. Focus on the ecosystem, administrative structures and processes that support sustained change

The evaluation team visited the project team again at the beginning of the 2018 Spring semester to lead the team through a process of identifying desired outcomes associated with the priorities, specific inputs to the system, and planned outputs. This process resulted in the current logic model shown in Appendix A. The logic model is a work-in-progress, but serves as a starting point to keep the team focused on reaching project goals. It illustrates our identified short-term, medium-term, and long-term outcomes. Some of the short-term outcomes include specific and attainable activities, such as observing colleagues' classes for inspiration, and providing positive recognition for trying something new, even if it fails. Medium-term outcomes include establishing a strong community around trying new things in teaching, and documenting faculty pedagogical risk taking using our instrument. Long-term outcomes include an additive innovation cycle fully implemented and administrative policies that continue after the project ends. We also identified inputs to the system, which could be related to parts of the BMC, such as key resources, key partners, or revenue streams needed to meet project goals.

The discussion around outputs is helping to bring clarity around what we might claim as elements of our revolution. We have identified important details for what we need to do locally and will continue to refine the logic model in terms of what would be considered revolutionary beyond our program. We are conscious and working toward what might be a potentially lasting contribution of this project to the engineering education community. The logic model, along with more proactive engagement with the evaluation team, will serve as a guidepost to assess our progress towards meeting our project goals.

Where Are We Going?—Next steps to reach our revolution

We have identified a few areas that need more attention as we launch the next phase of the project. Two specific identified areas include a dedicated focus on articulating administrative policies and mapping research questions and implementation activities to the logic model.

Mapping Research Questions to the Logic Model

The most recent stage of the project has focused both on the development and support of faculty affinity groups as well as engagement with our advisory board and evaluation team. We intend to increase our focus on formally evaluating progress toward the three key priorities identified in the logic model during the final years of our project. This focus will allow us to formally evaluate the efficacy of both ongoing and upcoming change efforts that the project leads, in turn providing valuable evidence to the engineering education community about what worked (and what did not work).

We are currently developing research questions and accompanying research designs that address indicators of progress toward each of these broad goals. The full project team will work with the support of the evaluation team to generate and formalize research questions associated with an increased focus on research (vs. development). We anticipate that potential indicators of progress will include: positive changes in pedagogical risk taking among our faculty measured by the team designed instrument, evidence supporting greater sharing of and building upon faculty

teaching practices, and established norms and practices for supporting the sustainment of current and creation of new faculty affinity groups. Finally, project sub-teams will be created and charged with the task of developing associated research designs, to be enacted across the project team and in conjunction with faculty outside the project, where appropriate.

Administrative Policies

An important thread throughout our project work is to be explicit about documenting aspects of the ecosystem that work to influence, support, and enable sustained change. This intent has always been present, but has yet to be formalized in a systematic way because we did not have the information needed. We will devote specific attention in the next phase of the project to documenting parts of the ecosystem, in particular what might be considered administrative policies, that will contribute to sustaining a risk-taking culture beyond the life of the grant. We will take a more systematic approach to this by using the logic model to specify outputs and goals, and to develop indicators through associated research questions aligned with our priorities.

Summary

Similar to the other RED programs, the pathway to revolution involves a system level perspective to enact sustained, and meaningful change. We document our pathway to illustrate the dynamic nature of a multi-year project, and how this necessitated a need for adaptability among team members, as well as adaptability of activities and focus as the project evolved. The system perspective is inclusive of faculty, students, curriculum, culture, policies, and many other factors that influence the system. While these factors may have nuances by program and by institution, they are present nonetheless. Our work aims to shed insight on our approach to managing the project through different phases, while considering system level factors to account for how our project is progressing through its path to revolution.

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Appendix A: RED Program Logic Model

Situation

Priorities

-Establish, cultivate, promote a culture of pedagogical risk-taking

-Provide mechanisms to share, disseminate, collaborate, develop, etc. interesting and effective teaching approaches

-Focus on the ecosystem, administrative structures and processes that support sustained change

Inputs	Outputs		Outcomes – Impact		
	Activities		Short Term	Medium Term	Long
What we invest -Faculty (RED Team & College/ Department Faculty) -Money/Time -Graduate Students	What we do **Short-term/Near** -Finalize risk-taking instrument and obtain baseline data -Support new faculty affinity groups -Institutionalizing additive innovation (identify first) – constructs related to risk-taking: 1) Community part /support risk-taking; 2) Logistical part = sharing (via social media/Dropbox) -Create champions for key activities – include students -Have more interventions: -Expert talks about pedagogical risk-taking -Workshops, test cards -Classroom observations -Informal community building -Dissemination mechanisms for pedagogy -Central website to share teaching approaches -Social media (Facebook group, Instagram, Twitter) to share ideas - Identify activities & resources needed to continue to support the risk-taking culture **Longer Term** -Include non-tenure track faculty (and part time) – consider timing (FA, construct, tenure track) -Modify topics part of annual review process (can use guidance from local community) -Business Model Canvas update -Be more explicit about what is valued -Administrative policies	Who we reach -College/ Department Faculty -ENG Faculty in other universities -Students	-Non-RED faculty initiate change -Faculty (new and old) willing to try new things to help make their classes more engaging and effective -Make teaching more public -Faculty drop in and watch colleagues' classes for inspiration -Regular gatherings to share ideas and experiences from the classroom -Positive recognition for trying something new (even if it fails) -Risk-taking vision is reinforced in faculty retreats, meetings -Seed money for all to try new stuff in classes -Different types of "interventions" tried and evaluated to determine impact on pedagogical risk-taking and/or additive innovation	-Natural existence of affinity group -Strong community around trying new things in teaching -Faculty engaged in sharing teaching practices -Faculty evaluation (review) rewards pedagogical risk-taking & includes a place to document and get feedback on pedagogical changes (risks) the past year - Course evaluations capture risk-taking -A supportive team -Faculty buy-in to change -New faculty on-boarding -Documented change in faculty pedagogical risk-taking as measured by RED instrument -Building a unified team of risk-takers (in the classroom) -Changes in advice to junior faculty about the importance of good teaching in the pursuit of tenure (more valuing of teaching) -Safe space where all faculty (including adjunct and lecturers) feel comfortable trying new things	-Additive innovation cycle fully implemented -All classes look like project spine/PBL courses -EGR Studios well integrated with innovation hub and labs -Creating a culture of additive innovation and risk-taking - Accepted norm that teaching is a priority -NEXUS/Center for Teaching -National Academy of Engineering (NAE) Gordon Prize recognition -Administrative policies that continue after RED project ends -Students appreciate "weird" teaching approaches -Undergraduate enrollment increases -Pathways to "tenure" as professor of teaching (> 1 yr-contract)