Innovation Corps for Learning: Evidence-based Entrepreneurship™ to Improve (STEM) Education

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***Abstract*— The Innovation Corps for Learning (I-Corps-L) is a pilot initiative from the National Science Foundation (NSF) and the American Society for Engineering Education (ASEE) to study whether the NSF I-Corps model can help to propagate and scale educational innovations. The NSF I-Corps guides teams based on established strategies for business start-ups, using Blank's Lean LaunchPad and Osterwalder's Business Model Canvas and associated tools, to build entrepreneurial skills that will encourage mainstream application of their emerging technologies. The overriding goal is improving student learning and success rates in key STEM courses by helping to accelerate the process of bringing effective educational innovations to scale. The project goal of I-Corps-L is to investigate the potential of the I-Corps model for fostering an entrepreneurial mindset within the education community to impact the way innovations are designed and implemented. This Work in Progress describes the features of the I-Corps-L pilot and provides preliminary indications of its applicability for propagating, scaling and sustaining education innovations. Addressing the persistent challenge in STEM education to adopt evidence-based instructional practices is an urgent need as many approaches have been tried yet the rate and extent of adoption are very low.**

Keywords—I-Corps, innovation, scalability, sustainability

I. INTRODUCTION

I-Corps-L is a two-year pilot project focused on addressing the longstanding challenge of enacting educational transformation by taking an entrepreneurial approach. The overarching goal of I-Corps-L is to foster an entrepreneurial mindset within the education community to impact the way innovations are designed and implemented. The program provides participants a model approach to assess the potential of educational innovations for sustainable scalability and to develop a transition plan to move innovations forward. Thus, the expected outcomes of this pilot project are two-fold: (1) enabling participants to promote and gain broad acceptance of their innovative products and approaches, and (2) enabling the project team to determine the applicability of the I-Corps model to propagating and scaling educational innovations. An overriding goal is improving student learning and success rates in key STEM courses by helping to accelerate the process of bringing effective educational innovations to scale.

II. RESEARCH TO IMPLEMENTATION

A. Challenges

Governmental, corporate and non-profit organizations have been calling for transformational change in science, technology, engineering and mathematics (STEM) education in the U.S. for many years [1-9]. As a result, a number of Federal agencies as well as corporate foundations have invested significant resources in an effort to improve teaching and learning in STEM disciplines [10].

The continuing calls for STEM transformation suggest several assumptions: 1) previous investments have not resulted in the desired level of change, 2) educators in the STEM community share the same level of agreement that change is necessary, 3) educators in the STEM community share a common vision for what needs to be changed, and 4)

mechanisms for educational transformation are well-known and readily implementable. Several recent reports have addressed these assumptions and raised questions about how transformation might effectively occur within an education system [11-15].

In addition, numerous recent studies have documented the challenges translating ideas from educational and socio-behavioral research into instructional practice [16-19]. As highlighted in the Discipline-Based Education Research (DBER) report we know a great deal about evidence-based instructional practices that could make a difference in student learning; however, STEM faculty by and large do not engage in these practices. This proposed project is focused on addressing the longstanding challenge of enacting educational transformation and the translation of research into practice.

Research by Discipline-Based Education Research (DBER) scholars has generated insights with the potential to improve undergraduate education in science and engineering [20]. For example, many research studies and syntheses report that evidence-based approaches to teaching that actively engage students in their own learning are more effective than traditional lecturing. Yet evidence that these educational approaches (and others) are effective has not yet prompted widespread changes in teaching practice. There is no magic solution for moving from the evidence to implementing effective teaching practices. The Lean Start-Up approach has the potential to change the rate and extent of enacting educational transformation by taking an entrepreneurial approach [21].

B. Lean Start-Up

Traditionally, launching a new business or implementing an instructional innovation has been done in a very formal way – business plan, pitch to investigators or adopters, assemble a team, introduce a product, and start selling [21]. Unfortunately, the approach rarely works. Recently, an alternative approach has emerged, the "lean start-up," that favors experimentation over elaborate planning, customer feedback over intuition, and iterative design over "big design up front" development. This approach is at the heart of the NSF I-Corps program and was embraced in this NSF I-Corps-L pilot program. Aspects of this approach, such as "agile development" are beginning to appear in resources for first-year engineering students [22].

A key feature of the lean start-up approach is listening to customers (adopters, users, etc.) to search for a business model that works. The developers translate ideas into business model hypotheses, test assumptions about customer needs, and then create a "minimal viable product" to try out their proposed solution [21]. This process continues as other hypotheses are tested to validate customer needs. If no alignment between the innovator's value proposition and customer needs, then a change of direction (called a "pivot") is called for.

A primary tenant of the I-Corps program is that startups are not small versions of big companies, which implies, for example that a business plan is of little use. As Steve Blank notes, "no business plan survives first contact with customers." Therefore, the I-Corps program has teams develop a business model, which is a search process to find alignment between the researcher's innovation (value proposition) and customers (adopters, users, etc.) for whom the innovation solves a problem or relieves pain.

III. I-CORPS-L PILOT

We developed the I-Corps for Learning (I-Corps-L) model to provide a program for NSF-funded researchers and their teams to evaluate the sustainable scalability potential of their educational activities. Based on the Lean LaunchPad approach developed by Steve Blank at Stanford University [23, 24], the I-Corps-L team developed and delivered an eight-week course of study designed to teach I-Corps-L teams the business model design and customer development process.

During fall 2013, NSF awarded supplements to each of 9 grantees drawn from the Computer and Information Science and Engineering (CISE), Education and Human Resources (EHR), and Engineering (ENG) directorates. These supplement awards were provided to exemplary projects selected by program officers in the three directorates.

The I-Corps-L program goals are to work with these teams to accomplish the following:

1. Give the I-Corps-L team an experiential learning opportunity to help determine the readiness of their innovation for sustainable scalability. Sustainable scalability involves a self-supported entity that is sustainable and systematically promotes the adoption of the educational innovation and enables and facilitates its use.

2. Enable the team to develop a clear go/no go decision regarding sustainable scalability of the innovation.

3. Develop a transition plan and actionable tasks to move the innovation forward to sustainable scalability, if the team decides to do so.

The eight-week pilot program (January and February, 2014) was composed of an introductory 3-day workshop, five online sessions, and a closing 2-day workshop (Table I). Each of the nine teams participating in the pilot was comprised of three to four members, including a NSF-funded principal investigator, an entrepreneurial/innovation lead, and a mentor. The innovation areas of each of the nine teams that participated in the I-Corps-L pilot are shown in Table II.

Throughout the program participants engaged in customer discovery to understand the ecosystem associated with their projects, including potential adopters, collaborators, and users. Each team used Blank's Lean LaunchPad approach and was instructed to conduct at least 100 interviews to test hypotheses related to the nine elements of Osterwalder's business model canvas (Fig. 1): value propositions, customer segments, channels, relationships, revenue streams, key partners, activities, resources, and cost structure.

The I-Corps-L project is funded by the National Science Foundation under grants NSF DUE-1355391 and 1355431.

TABLE I. EIGHT-WEEK DEVELOPMENT COURSE

3-Day Kickoff Workshop	5-Week Online Sessions	2-Day Wrap-up Workshop

• Teams are introduced to the Lean Launchpad approach.
• Teams learn the business model development and customer development process.
• Teams meet with customers and present what they learned to the class.
	• Teams "get out of the building" and test their business model assumptions.
	• Each of the five online classes has two parts:
	  ○ 1.5 hours: Team presentations.
	  ○ 1 hour: Class discussion of the weekly lecture.
		• Teams present the lessons learned in their exploration of sustainable scalability.

TABLE II. PARTICIPATING TEAMS

Team	Project Description
Mobile Hands-On STEM Pedagogy	Innovative approaches to learning enabled by Mobile Hands-On STEM pedagogy.
Concept Warehouse	Platform that improves teaching effectiveness by speeding the propagation of evidence-based instructional practices among STEM faculty.
I-Tutor for Automation	Industrial automation tutor for instructors and learners.
Math Jam	Week-long school-sponsored boot camp for the Math Placement Test and/or upcoming math course.
ELeVATE	Holistic transition program that supports veterans interested in engineering and technology careers and educates faculty and staff on how to set veterans up for success in college and beyond.
Engineering Ambassador Network	Program to launch undergraduates into leaders.
Carpal Coding	Bridge the gap in algorithm development and syntax for novice makers to program microcontrollers.
Women in Computing	Institutionalizing successful project to benefit women and Universities nationwide.
Increase the Impact	Providing NSF and PIs ways to design educational development projects that are more likely to result in broader impacts.

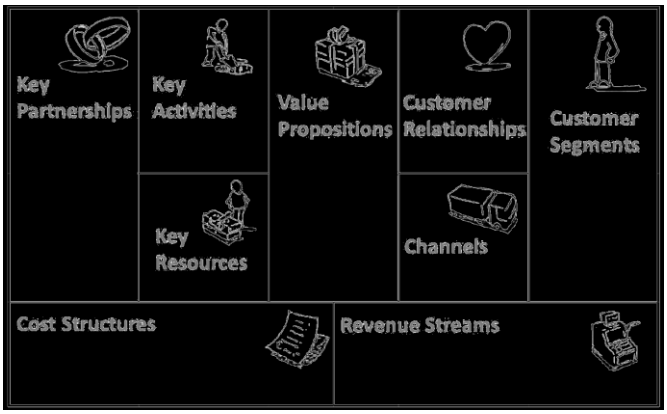

Fig. 1 Osterwalder's business model canvas (BMC)

IV. PRELIMINARY RESULTS

Eight of the nine teams completed 100 or more interviews and about half the teams significantly revised their value proposition and/or customer segments. An example of the development is the ELeVATE (Experiential Learning for Veterans in Assistive Technology and Engineering) team who conducted 102 interviews. Their development is reflected in the changes to their Business Model Canvas – Initial (Fig. 2) and Final (Fig. 3).

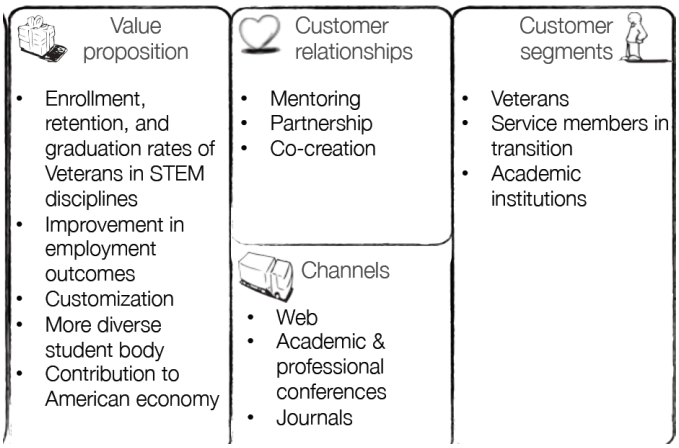

Fig. 2 ELeVATE Initial Business Model Canvas (focus on value propositions and customer segments)

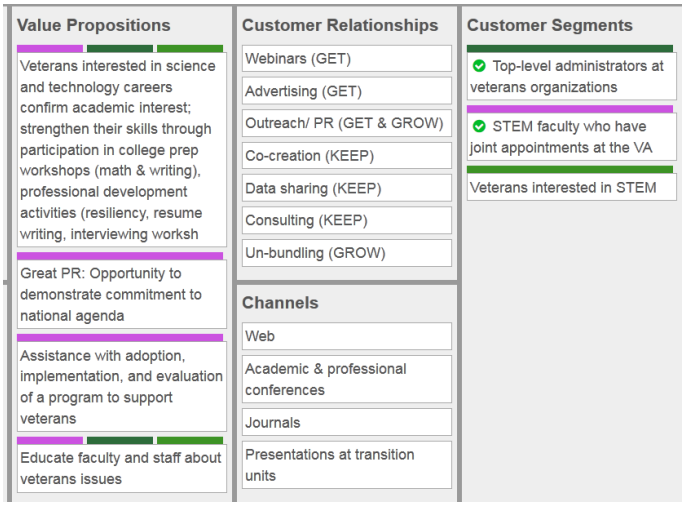

Fig. 3 ELeVATE Final Business Model Canvas (focus on value propositions and customer segments)

The ELeVATE team's key insights and "lessons learned" were:

- Veterans services organizations were the ones with the most interest in the program
- Academic institutions were not always excited about replicating ELeVATE; the reasons given were:
  - lack of funds to support a veterans program
  - lack of infrastructure needed to accommodate veterans with disabilities (e.g., access to rehabilitation counselors)
  - lack of knowledge of student veterans' needs
  - school prioritizes in favor of other underrepresented groups (e.g., if a school's focus is on expanding opportunities for URM's, they are not likely to shift focus to veterans with disabilities, even though students with disabilities are underrepresented in STEM)
  - schools that are serving veterans in some way might not be interested in trying out ELeVATE
- ELeVATE needs to work more closely with local vet services organizations and academic institutions
- The ELeVATE model is relevant outside of STEM
- Institutional support (at the higher administration level) is essential to the successful implementation/ scaling up of ELeVATE
- Community organizations are interested in contributing to a veterans program; an ELeVATE site can benefit from partnering with organizations for services ranging from catering (for food donations for program events) to professional development training activities (resume writing workshops, mock interview workshops, etc.)

Quality Evaluation Designs (QED) is conducting a comprehensive evaluation focused on three facets of the I-Corps-L program:

1. Program delivery, including the 3-day initial workshop, 5 webinars, and 2-day final workshop;
2. Impact of I-Corps-L program delivery on I-Corps-L teams
3. Program effectiveness in fostering innovative, effective, and scalable learning strategies.

Results from the pilot implementation will be shared when available.

ACKNOWLEDGMENT

We extend our deepest appreciation to the nine I-Corps-L teams who participated in the pilot program and thoughtfully and generously provided essential feedback for deciding on the next steps. We thank team ELeVATE, particularly Maria Milleville, for their contributions to this document. Lastly, we would like to acknowledge the generous support of the Intel Foundation provided to the nine I-Corps-L pilot teams.

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