Course Development and Sequencing for Interdisciplinary Entrepreneurship Education
Cory Hixson, Marie Paretti, Jack Lesko, Lisa McNair
College of Engineering and Department of Engineering Education Virginia Tech

ABSTRACT
An increasing number of programs are being developed to promote entrepreneurship skills among undergraduates. Emphasis is often placed on the necessary content, and course sequences are often constructed to ensure that content is “covered” across the curriculum. But research on entrepreneurship and entrepreneurship education, as well as education in general, demonstrates that how teaching and learning occurs is as important as what is learned. In this paper, we explore the integration of a dominant framework for business model development (Lean LaunchPad) with frameworks for learning that emphasize the situated, social construction of knowledge; the role of mentors; and the need to work across disciplinary boundaries. By marrying business model development with intentional pedagogies grounded in Bruner’s spiral curriculum, Collins et al.’s framework for cognitive apprenticeship, and McNair et al.’s approach to interdisciplinarity in product development, we seek to enhance the development of technical innovation leaders.

Introduction
Efforts by the National Science Foundation to “develop and nurture a national innovation ecosystem that builds upon fundamental research” (National Science Foundation [NSF] 2012a, 383) to produce commercially viable products and processes have focused on the Lean LaunchPad curriculum (NSF 2012b). By focusing on a search process of customer discovery and product-market fit, Lean LaunchPad helps engineers and scientists, typically enamored with the elegance of the solution, to consider the customer needs in the context of value propositions and the viability of a specific implementation of the solution relative to a perceived opportunity (Blank and Dorf 2012). This opportunity assessment approach contrasts with more traditional models that emphasize the execution process found in business education, and seeks to train individuals in a perspective grounded in entrepreneurial expertise (Mitchell et al. 2007; Sarasvathy 2008). These skills and expert scripts (Mitchell 1996; Mitchell, Mitchell, and Mitchell 2009; Robinson 2008) are considered to be learned skills and attitudes, and not inherent or only innate qualities.

Given research stating that developing expertise requires 7,000 – 10,000 hours of practice at an activity, along with useful, constructive feedback on performance (Palmer et al. 2005; Berliner 2004), undergraduate curricula do not generally produce “experts.” However, they can provide a foundation for such expertise by leveraging both what is known about expertise in a given domain and what is known about learning. The Lean LaunchPad model rep-
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represents an expert model of the entrepreneurial process that incorporates many of the skills, characteristics, and approaches shown to be effective by researchers. It has been used successfully to help faculty across the nation move discoveries into viable business ventures through the NSF I-Corps Program (NSF 2012b). But questions remain about how best to integrate this model into the undergraduate curricula. Given the growing pressure in this century to move entrepreneurship education into higher education, an increasing number of researchers are exploring this integration (Heinonen and Poikkijoki 2006; Gibb 2002; Fiet 2000; Jones and English 2004; Corbet 2005; Hytti and O’Gorman 2004). A full review of this literature is beyond the scope of this paper, but even as these and other researchers propose a variety of educational models, the dominant orientation of these models focuses on situated, student-centered learning in which individuals learn by doing. Thus, rather than a traditional approach centered on the acquisition of business skills and content knowledge through lectures and case studies, current approaches have shifted to engaging students in authentic, mentored searches for viable business models focused on commercial opportunity identification and development.

Even with this shift, however, less attention has been given to the sequencing of courses within a curriculum and to how students develop over time. In addition, while much of the work noted above focuses on models of education that actively engage students in the process of creating entrepreneurial ventures, less work has been done on two critical components of these pedagogies: 1) the role of teachers and mentors, and 2) the role of interdisciplinary. To leverage the existing work on entrepreneurial education and provide opportunities to more fully explore student development over time, student-mentor interactions, and student engagement across disciplinary boundaries, we have drawn on three key strands of educational research to propose a curriculum sequence for entrepreneurship education: Bruner’s model of the spiral curriculum (Bruner 1960; Smith 2002), Collins’ et al. model of cognitive apprenticeship (Collins 2006; Collins, Brown, and Holm 1991; Collins, Brown, and Newman 1990), and McNair et al’s work on interdisciplinary self-forming teams (Kim, McNair, and Paretti 2009; McNair et al. 2011). The proposed four-course sequence marries these learning models with the framework for business model development offered by Lean LaunchPad, in conjunction with related work from the Kauffman Foundation-supported Ice House Entrepreneurship Program (The Entrepreneurial Learning Initiative 2012), to help students develop entrepreneurial thinking and skills based on concepts such as value, customer discovery, validating assumptions, and product-market fit analysis.

Frameworks for Learning
Before describing the proposed course sequence, we begin with a brief review of the salient learning models, all of which are shaped by the constructivist and situated frameworks.

Constructivism and Situated Learning
As noted above, theories of constructivism and situated learning support the learning models used to design the proposed curriculum. Constructivist approaches emphasize the learner’s active role in building new knowledge rather than passively receiving it whole from an expert (e.g., Duffy and Cunningham 2006), while situated learning stresses that knowledge is dependent
on the context in which it exists or is learned (e.g., Greeno, Collins, and Resnick 1996). Situated learning in particular emphasizes “the role of the environment on an individual's conception of knowing and how they learn” (Johri and Olds 2011, 155). Together these theories point toward the need to engage learners in authentic activities in which the acquisition of knowledge and the application of that knowledge in “real-world” contexts are intertwined.

**The Spiral Curriculum**

The concept of the spiral curriculum, proposed by Jerome Bruner in the 1960s, shifts education from a model in which content comes first and application second to one in which learners are engaged in authentic (“real-world”) applications of knowledge at ever-increasing levels of complexity across a curriculum (Bruner 1960; Smith 2002). Although not always explicitly stated, this framework underlies much of the recent work in engineering education. For example, it stresses design across the curriculum, in which design moves from being solely a capstone experience to one in which learners are “doing” design consistently across the curriculum even as they continually acquire new knowledge that allows them to design increasingly complex products or processes at more sophisticated levels.

**Cognitive Apprenticeship**

While the spiral curriculum approach focuses on what students are doing as they move through the curriculum, cognitive apprenticeship focuses on how they are interacting with instructors and mentors. Rather than positioning the teacher as the expert who pours knowledge into a raptly attentive student, cognitive apprenticeship emphasizes the teacher’s role as a guide and facilitator who supports student development (Collins, Brown, and Holum 1991). First, the model emphasizes that learners need to acquire four different types of knowledge: 1) content knowledge, which is generally the traditional focus of education; 2) tacit knowledge or heuristics for accomplishing common tasks and applying content knowledge in practice; 3) metacognitive knowledge involved in understanding how to carry out tasks, how to make decisions, and related monitoring; and 4) learning strategies for acquiring the other three as needed over the course of time (Collins 2006). In helping students develop these types of knowledge, the instructor or mentor typically employs four key practices, summarized in Table 1.

<table>
<thead>
<tr>
<th>Traditional Apprenticeship Expert Techniques</th>
<th>Definitions</th>
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<tbody>
<tr>
<td>Modeling</td>
<td>The apprentice observes the master demonstrating how to do different parts of the task. The master makes the target processes visible, often by explicitly showing the apprentice what to do.</td>
</tr>
<tr>
<td>Scaffolding</td>
<td>The support the master gives apprentices in carrying out a task. This can range from doing almost the entire task for them to giving occasional hints as to what to do next.</td>
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</tbody>
</table>
Fading | The notion of slowly removing the support, giving the apprentice more and more responsibility.
---|---
Coaching | The thread running through the entire apprenticeship experience. The master coaches the apprentice through a wide range of activities: choosing tasks, providing hints and scaffolding, evaluating the activities of apprentices and diagnosing the kinds of problems they are having, challenging them and offering encouragement, giving feedback, structuring the ways to do things, working on particular weaknesses.

Table 1. Traditional Apprenticeship Expert Techniques with Definitions (Collins, Brown, and Holum 1991)

Cognitive apprenticeship is critical to our curriculum development because it emphasizes that the educational models we create depend not only on what we have learners do (e.g., work on creating real business models) but also on how course instructors, entrepreneurial mentors, and others interact with the learners to support their development.

Pedagogies of Interdisciplinarity

Finally, frameworks for interdisciplinary teaching and learning are critical because, as scholars such as Johnson et al. note, entrepreneurial work crosses disciplinary boundaries (Johnson, Craig, and Hildebrand 2006). We focus here on interdisciplinarity as it is defined in the literature, distinct from multi-disciplinary approaches that promote a divide and conquer approach in which experts “own” their own knowledge domains. By interdisciplinarity, we mean approaches in which individuals from different domains collaborate “to identify, integrate, and value multiple perspectives and to learn from one another in ways that reshape their own understanding and practices. . . . [I]nterdisciplinary learning involves more than simply adding new content from other fields, but also understanding and integrating new values and approaches to problem definition and problem-solving” (Richter and Paretti 2009, 31). This definition aligns with Lattuca’s conception of synthetic interdisciplinarity, in which individuals may continue to act as experts in their own domain, but work to integrate knowledge across those boundaries, learn from one another, and forge dialogic connections across boundaries (Lattuca 2003, 2010).

Work by Richter and Paretti identified “disciplinary egocentrism” as a significant barrier, particularly for engineering students, to such interdisciplinary work (2009). This type of egocentrism includes both failing to value (and thus engage with) the contributions of other disciplines and failing to see how one’s own domain contributes to an interdisciplinary problem. These barriers limit students’ capacity for dialogic exchange and synthetic learning.

To address these barriers and to support students’ development of interdisciplinary identities, particularly in innovative product development environments, McNair et al. have developed a pedagogical framework that relies on self-forming teams, engagement across disciplinary boundaries (particularly early in the project), role-modeling by the instructors, and student-led (rather than instructor) dissemination of disciplinary knowledge in which students teach each other relevant concepts and skills from their respective domains (Kim, McNair, and Paretti 2009; Martin et al. 2011; Martin et al. 2011b; McNair et al. 2011; Paretti and McNair 2012).
Course Development

The frameworks described in the previous section provided the basis for designing a course sequence for entrepreneurial education at Virginia Tech. The content for this sequence, as noted above, derives primarily from the Lean LaunchPad approach developed by Blank and colleagues (Blank 2008; Blank and Dorf 2012). Notably, Blank’s work and the current implementation of Lean LaunchPad tacitly rely on several of the key principles articulated here. Moreover, as noted earlier, the core situated learning framework upon which all of these approaches depend is fast becoming the dominant model for entrepreneurial education. The curriculum described in this section explicitly and intentionally integrates all of these elements to help students not simply “acquire” the knowledge needed to execute a business plan but to develop the identity of an entrepreneur and to lay the foundation for further expertise development.

The proposed sequence consists of four courses, shown in Figure 1:

The Spiral Approach

Consistent with the spiral curriculum model, the approach shown in Figure 1 engages students in entrepreneurial activity in each course, actively doing the work embodied in the Lean LaunchPad process, even as the learning objectives and the nature of the project work grow increasingly complex and sophisticated.

- Innovation and the Technology Leader’s Mindset (ITLM), a one-credit course intended for first-year students, utilizes the Ice House Entrepreneurship Program to introduce students to entrepreneurial characteristics. Additionally, it helps students explore concepts such as divergent thinking; dealing with uncertainty, confusion, and risk; validating assumptions; teamwork; and communication in the context of a project in which they identify, validate, and innovate a solution pertaining to a pain point for a specific customer base (e.g., students at Virginia Tech). Students get experience business model canvas (Osterwalder and Pigneur 2010) with
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interviewing customers, reporting and analyzing their findings, and then using those results to help shape product conception.

- The Startup Class (funded initially by NCIIA) is a three-credit course that takes students through the process of developing a viable business model suitable for submission to an entrepreneurial competition. The emphasis shifts from developing an entrepreneurial mindset to developing the skills needed to create a minimum viable product using fully implemented Lean LaunchPad practices (customer discovery and product-market fit). Ultimately, this course prepares students for participation in business competitions, supports collaboration with experts, and builds relationships with incubators and business accelerators for support beyond the class.

- The Washington Entrepreneurs’ Summer Semester or WESS program moves students from the campus environment to the corporate one for an intensive twelve-week summer program in which they pursue entrepreneurial start-up projects with support not only from mentors, but from business incubators and accelerators in Northern Virginia and the Washington, DC region. WESS provides the opportunity for students to further focus on the search process in the heart of the Washington, DC metro area and seeks to move students beyond preparing for business competitions and align them more closely with startup realization.

- The eXperience Entrepreneurship Capstone (XEC) course is a year-long capstone course that allows students to fully integrate the development of the business model with the development of fully functional technologies. The course thus marries technical and entrepreneurial skill development, with access to all of the laboratory and research facilities afforded by an R1 university to support sophisticated product development that leverages students’ disciplinary expertise. Where earlier courses in the sequence focus on moving students away from “solution fixation” to focus on customer and market development, XEC brings technical development of that solution back into sharp focus to produce a fully viable (in technical and market terms) product.

At each stage, students are able to repeat practices and approaches learned in earlier courses, bringing increased disciplinary expertise and facing an increasingly complex and demanding deliverable. Each course thus supports learning in context with tangible, authentic project outcomes appropriate to students’ developmental stage (product concept, business plan for competition, a business idea of their own, a fully viable product).

The process of search instilled within the customer discovery and product-market fit analysis of the Lean LaunchPad approach naturally promotes the active construction and refinement of entrepreneurial expert scripts that improve the information processing abilities of the student. Expert scripts are mental maps or knowledge structures that impact our ability to act or make decisions (Robinson 2008). These scripts are created from both succeeding (getting the right answer) and from failing. Failure or the determination of the wrong direction or the invalidation of an assumption is celebrated and reinforced as a key learning moment. The spiral nature of the curriculum, returning consistently to core concepts, facilitates that learning as students are encouraged to reflect on these scripts, concepts, and techniques; share their experiences, thoughts, and way of thinking; and develop models or schemas
that explain what and how they are learning as they move through the sequence.

It is also important to note that the courses focus primarily on developing students’ “search” skills and intentionally forego the necessary and relevant “execution” skills of entrepreneurship education (Blank and Dorf 2012, 22-24). By using the term “search,” we echo Blank’s thoughts that we are not teaching students the business skills needed to properly execute a company; instead we are coming alongside students as they develop the skills to “search” for facts that will reduce their chances of startup failure. The customer discovery process requires that the students get “out of the building” and into real-world settings to learn about customer pains and test value propositions (Blank and Dorf 2012).

Models of Business Development

Through the use of Lean LaunchPad practices (customer discovery and product-market fit), participation in business competitions, and collaboration with experts, the courses also provide a path to launch promising startups. This can be seen in The Startup Class as we draw on Shane and Venkataraman’s (2000) framework of opportunity discovery, evaluation, and exploitation (see Figure 2).

Elements – The Startup Class

- Interdisciplinary Design Pedagogy
- Ideation, Product/Market Fit & Customer Development
- Entrepreneurial Identity
- Student Business Competition
- Integrated Incubator and Business Accelerator Support
- Mentoring and E-Team Creation

Combining these two frameworks, the courses move students through the process of identifying potential market opportunities, creating innovative conceptual designs, selecting one or more viable products with a minimum feature set (minimum viable product), and targeting market opportunities while profitably solving customer pain points. The pedagogy is intentionally designed to provide students with a substantial sense of ownership, while guiding their ability to make critical decisions based on a range of technical,
business, and market factors uncovered through extensive customer interviews. At the same time, students are developing core skills in communication, collaboration, conceptual design, and entrepreneurship and business perspectives as they come to see themselves as entrepreneurial leaders and innovators.

**Discovery**

To facilitate this learning, we bring together entrepreneurial mentors, faculty, and students from different disciplines to support student teams in discovering entrepreneurial opportunities. This self-direction is critical because for many students, their previous course experience has focused on solving narrowly defined problems in ways that are not conducive to entrepreneurship. To succeed as entrepreneurs, however, they need to define, not simply solve, problems – a process Schön calls problem setting (1983). These problem-setting skills involve fully understanding the problem, as well as identifying the relevant parameters and constraints. Successful entrepreneurs are those who can both discover and exploit the opportunities presented by these problems.

**Evaluation: Customer Discovery and Product-Market Fit**

To help students move from concept generation to product, the courses draw on the theory of product-market fit, a key component of Customer Discovery and Agile Development, pioneered by Steven G. Blank and underpinning the Lean LaunchPad approach (2008). The instructional team will use this approach to support student teams’ preparation for business competitions, and Blank’s text was used in the course development. The methodology provides an effective approach to turning a “neat” technical idea into a viable value proposition.

**Evaluation and Exploitation: Student Business Competitions**

Discovery is followed by further evaluation and exploitation as students are provided a range of opportunities, dependent on the course and the specified deliverable, to move designs toward implementation. For example, students in ITLM will participate in internal competitions; students in The Startup Class will participate in national competitions; and students in WESS and XEC will work toward start-up launches.

**Exploitation: Incubator and Business Accelerator Support**

As described in more detail in the next sections, these courses also leverage the entrepreneurial resources of Virginia Tech’s campuses in both Blacksburg and the National Capital Region (NCR). Students will be introduced to contacts and resources through mentors and site visits designed to help hone their value propositions by validating their market and customer assumptions. In addition, students will have the opportunity to network with professionals who can help them launch businesses beyond the sequence presented here.

**Mentoring Though Cognitive Apprenticeship**

As noted earlier, the content, learning outcomes, and deliverable expectations of the curriculum suggested by the spiral approach are also integrated with an explicit attention to how instruction and mentoring happens across the sequence. Mentoring programs are common and a natural part of entrepreneurship programs, whether in incubators or tech transfer activities. Likewise, a central element of the Lean LaunchPad approach leverages the
instructors, who are typically entrepreneurs themselves, with a mentoring team. For example, the NSF I-Corps teams include a faculty member, an entrepreneurial lead, and a mentor who is typically a person with previous start-up and/or new venture financing experience (NSF 2012b). This is in addition to an instructor team with entrepreneurial expertise that executes the class.

In the proposed sequence at Virginia Tech, mentoring figures strongly in all classes, both in terms of the role of the course instructor(s) and in the deployment of external industry mentors. All course instructors and mentors will receive training in the techniques and practices of cognitive apprenticeship, supplemented by research-based explorations of these practices in the context of problem-based learning (Hmelo-Silver and Barrows 2006 and 2008) and capstone design (Pembridge 2011). Paretti and McNair both have substantial expertise training instructors in mentoring practices in a variety of contexts, and the training materials developed for this sequence will also be made publicly available.

As noted, however, in addition to course instructors, the sequence will integrate mentors available both within the local Blacksburg community and through our connections to the Washington, DC metro area through our Virginia Tech Research Center in Arlington, VA. Moreover, the local technology councils have begun to work more closely with Virginia Tech to build the mentoring networks and familiarize them with the customer development and product-market fit curriculum approach. The Lean LaunchPad structure integrates mentoring within the day-to-day activities of the courses and enhances the elements of customer discovery and the critical assessment of the value propositions. The entrepreneurial expert scripts and experiences of the mentors are valuable in guiding the student development and validation of assumptions that create the business model. As with the course instructors, however, these mentors will also participate in ongoing professional development to support their work in role modeling, coaching, scaffolding, and ultimately fading as students develop expertise.

Pedagogies of Interdisciplinarity

Finally, the courses described in this sequence are designed not only to be open to students across all majors, but also to actively promote the integration and synthesis of knowledge across disciplinary boundaries and the development of flexible, interdisciplinary identities for learners. While not typically called out in the Lean LaunchPad and other entrepreneurial curricula, the exposure to and engagement with others outside the student’s immediate discipline is a natural consequence of the customer discovery and product-market fit process, and, as Johnson et al. point out, successful entrepreneurs require expertise that reaches beyond the traditional disciplinary boundaries (Johnson, Craig, and Hildebrand 2006).

Thus, following the empirically validated pedagogies developed by McNair et al. and successfully deployed in multiple product development contexts (Kim, McNair, and Paretti 2009; Martin et al. 2011; Martin et al. 2011b; McNair et al. 2011), the proposed courses will not only rely on teams comprised of students from diverse disciplines, but will actively integrate activities, role modeling, and learning opportunities to promote exchange of knowledge and values across boundaries. Detailed descriptions of these pedagogies have been reported elsewhere; in short, they emphasize engaging all students (not
just those with a particular expertise) across the whole project, particularly
in customer development phases; intentionally structuring opportunities for
students to teach one another core disciplinary concepts that inform and in-
fluence project development; and facilitating self-forming teams in which stu-
dents have a high degree of ownership and are empowered to act both within
and across disciplinary boundaries. Students lead activities from their own
field, acting as disciplinary experts and embracing their professional identi-
ties, and learn by practicing activities led by their peers in other disciplines,
gaining interdisciplinary competence.

These activities allow students to experience both leadership and adaptive
learning roles, increasing their understanding of how each discipline defines,
analyzes, and solves problems. This increased awareness contributes to suc-
cessful collaborations in terms of both creativity and implementation. Techni-
cal students begin to understand the social, economic, and aesthetic forces
essential to market success; business students begin to understand techni-
cal capabilities, constraints, and opportunities that support development; art
and design students become familiar with technical and economic issues that
inform opportunities, and so on. As these emerging entrepreneurs gain fa-
miliarity with the wide range of domains that contribute to any successful
venture, they gain the perspective needed to not only succeed as individuals,
but to build teams that can recognize--and ultimately exploit--entrepre-
neurial opportunities.

Conclusion
This paper extends work in the development of entrepreneurial curricula in
the US by exploring the intersection of learning theories (specifically spiral
curricula, cognitive apprenticeship, and interdisciplinarity) with proven mod-
els of entrepreneurial success (Lean LaunchPad, Discovery-Evaluation-Exploi-
tation) to create an integrated four-course sequence in entrepreneurship.
The course sequence focuses on:

• The entrepreneurial mindset fostered through student-centered, au-
thentic, and real-world learning environments.
• Mentoring and advising that provides not only access to experts, but in-
tentional cognitive apprenticeship.
• Lean LaunchPad practices.
• Learning both within and across disciplines to develop flexible, respon-
sive entrepreneurial identities.

While continual development and implementation will be required and re-
ported, this paper presents a multi-course entrepreneurship curricula that
will encourage continued conversations regarding the development of entre-
preneurship education offerings and the development of current and future
technology leaders.
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