

# Teaching Entrepreneurship in Computer Science: Lessons Learned

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**Abstract**—Many Computer Science departments are offering courses in Entrepreneurship. Views vary widely on the purpose, appropriateness and value of this as a topic area for students majoring in Computer Science – hence the title of this paper. We begin by exploring the meaning of the term, and review representative examples of Entrepreneurship programs in different Computer Science departments, looking at their stated goals and outcomes. We then describe our own experience designing and teaching a new, two-part, yearlong course on "Software Entrepreneurship" at Brandeis University, we extensively explore important lessons learned from this experience. Our program includes two interlocking courses, one focused on the "discovery stage" and one focused on the "delivery stage". We briefly describe the structure, learning objectives and overall flow of the courses. We then examine, in turn, a series of common challenges and our solutions and innovations in each: a) forming well-functioning student teams; b) choosing the appropriate size of teams; c) catalyzing innovation in the student teams; d) encouraging positive team dynamics and dealing with crises; e) defining the final deliverable; and f) deploying outside experts and g) assessments at the end of the course. To get a handle on the effectiveness of our approach we present a selection of student written reflections on their experience, how they felt it impacted them, and to what extent they see entrepreneurship in their own future. We conclude by identifying two broad areas for future work and study.

**Keywords**—entrepreneurship, computer science education, software engineering, pedagogy, assessment

## I. INTRODUCTION

We have heard serious and successful entrepreneurs scoff at the notion of courses in Entrepreneurship: "Great entrepreneurs are born not taught", they say, and "You can't teach someone to be a great entrepreneur!".

And yet, it doesn't take much effort to find numerous University courses with "Entrepreneurship" in the title. For example, Katz reported that in 2003 there were over 2,200 entrepreneurship courses at 1,600 schools. [Katz, 2003] We can be certain that the number has increased since then. No doubt, this is partially marketing – after all, Entrepreneurship right now has a cool factor, and it is not beyond us to title our courses to appeal to the broadest audience.

One way out of the apparent contradiction is to observe that colloquially, "*a (great) entrepreneur*" refers to a particular entrepreneur who has had great success, making a lot of money and/or having a major impact on the world. In contrast, in our view the term "*Entrepreneurship*" refers to a set of beliefs, concepts and practices which are part of the entrepreneur's toolkit and tend to improve the chances of success. Hence, we can reasonably claim that we are effective in teaching entrepreneurship without believing that we are turning out "great entrepreneurs" one after the other.

In this paper we offer our definition of Entrepreneurship and what we base it on. After that we will describe the model of teaching Software Entrepreneurship implemented in the Brandeis Computer Science Department, go into detail on the pedagogy we've arrived at so far, including what worked and what didn't and what lessons one could derive from our experience. We consider how success in teaching Entrepreneurship can be measured, and describe our results so far.

## II. DEFINING ENTREPRENEURSHIP

Entrepreneurship is a famously hard word to define. A simple Google search will produce many differing results. We find ourselves aligned with the following definition by Hagel in the Harvard Business Review:

*"An Entrepreneur is someone who sees an opportunity to create value and is willing to take a risk to capitalize on that opportunity; some elements of this are opportunity spotting, risk taking, and value creation."*  
[Hagel, 2016]

Within this paper, we are looking specifically at Entrepreneurship curricula within Computer Science programs, where the focus is not on business per se, but on Entrepreneurship leading to computer based products and services.

We define Software Entrepreneurship as embodying a set of concepts, skills and practices that seem to be required to create real-world impact from computer-related but abstract "artifacts" such as ideas, concepts, inventions, designs or algorithms. (Note that we do not limit ourselves to commercial impact.) Those

concepts, skills and practices can be found in the learning objectives of our two courses which will be detailed below.

### III. CURRENT PRACTICES

#### A. Some relevant literature

We looked for examples of Computer Science Entrepreneurship programs both in the scholarly and business literature. The examples are in fact numerous and their objectives stated in different words and nuances, which makes describing current practices a challenge.

Daimi and Rayess [2008] have an excellent survey of practices from multiple “Technical Entrepreneurship” curricula. They identify as key practices: collaboration, computational thinking, and establishing communities of practice (we would say “networking”).

There were several examples of programs that emphasized the Lean Launchpad “process”, described in many places, e.g. [Blank, 2013]. The Lean Launchpad process is a very specific approach to the discovery or search phase of entrepreneurship.

While our course at Brandeis does not specifically use the Lean Launchpad process, we do follow the principles fairly closely (see below.)

Kusmaul [2000], describe the objectives of their course at Moravian College “A Team Project Course Emphasizing Software Entrepreneurship” as follows: 1) providing the experience of designing, implementing, and testing a significant piece of software; 2) giving students the experience of addressing issues and techniques associated with real projects; and 3) exposure to the range of non-technical issues that may affect them in the future, including team and project management, marketing, and intellectual property.

Miller [2017] comes at Entrepreneurship from the perspective of Engineering. He includes “Entrepreneurial Mindset” and “Teamwork and Consensus Building” among the key skills that should be taught to today’s engineers.

Finally, a general comment: just about every paper or article we looked at emphasized the importance of the softer, human skills in successful entrepreneurship. Just as one example, Miller [2017] states: “All of these skills focus on the human dimension of engineering—working with others to create solutions, but also embracing a wider perspective from which to define problems and approach solutions”, a sentiment that we agree with wholeheartedly.

### IV. LEAN STARTUP PROCESS

“The Lean Startup” framework, described in the current form in the book “The Lean Startup” [Ries, 2011], has heavily influenced many in the technology startup community [Blank, 2013]. It is closely related to the “Lean Launchpad” process alluded to above.

We have concluded that this particular set of concepts, processes and nomenclature is particularly relevant and useful to the Software Entrepreneur and have made it a core part of our curriculum (see below.)

The Lean Startup framework approaches entrepreneurship, and in particular Software Entrepreneurship, by “favoring experimentation over elaborate planning, and iterative design over traditional ‘big design up front’” [Blank, 2013].

The Lean Startup methodology applies a quasi-scientific method approach to discerning product-market fit. Eiserman, Ries and Dillard describe it as follows: “*A hypothesis-driven approach to entrepreneurship maximizes, per unit of resources expended, the amount of information gained for resolving such uncertainty. When following this approach, an entrepreneur translates her vision into falsifiable business model hypotheses, and then tests those hypotheses using a series of minimum viable products (MVPs). Each MVP represents the smallest set of activities needed to disprove a hypothesis.*” [Eiserman Ries and Dillard, 2011]

It is striking to note the similarity between Lean Startup and Design Based Research [Berab et al, 2005, 2006]: “*Design-based research, as conceived by Ann Brown (1992), was introduced with the expectation that researchers would systemically adjust various aspects of the designed context so that each adjustment served as a type of experimentation that allowed the researchers to test and generate theory in naturalistic contexts.*”

It’s hard to know whether Eric Ries or Steve Blank, the innovators behind the Lean Startup were in any way aware of Ann Brown’s work. This is likely an interesting example of thought leaders in academia and business coming to similar processes via what appear to be independent paths.

### V. BRANDEIS UNIVERSITY’S SOFTWARE ENTREPRENEURSHIP PROGRAM

#### A. Basics of the program

The Brandeis University Computer Science program includes a two course Software Entrepreneurship Program open to undergraduate and graduate students. Note that not all students take both courses, and in one particular year, the cohorts taking each course are usually different.

**“CS165: Software Entrepreneurship”** In this course, students work in teams, using the “Lean Startup” framework to validate a product idea of their own conception. Going beyond that methodology, they will conceive and test a growth model, a pricing model and basic marketing strategy.

The course culminates in a “showcase” event at the end of the semester where their business plans are assessed by a panel of experts drawn from outside the University.

Below is a summary of the learning goals for CS165:

- *Lean Startup*: Become conversant in the key concepts and practices of the methodology
- *Teams*: Working and being effective in teams, including planning, contributing, dealing with conflict, resolving issues.
- *Build-Measure-Learn*: How to find and evaluate ideas, build rapid prototypes, find and test hypotheses

- *Revenue and Growth*: Different types of pricing models, identifying and measuring engines of growth, cohort analysis.
- *Entrepreneurship*: Basic financial analysis, role of cash, venture financing, starting a company.

**“CS166: Capstone in Software Entrepreneurship”**. We believe that Software Engineering is an essential aspect of Software Entrepreneurship. The premise is that the first course is about “what and why” the product or service should be, and this course is about “how” it should be designed and constructed.

Again working in teams (but new ones) students will create, and implement SaaS [e.g. Rhyman, 2017] products or services as they learn the concepts and principles that go into this.

Below is a summary of learning goals for CS166:

- *Full Stack of Internet Technologies*: Understand at a high level how the internet “works”: the protocols, formats, and processes.
- *Architecture*: What is the structure of a software product or service? What are key protocols, formats, patterns that are useful? How is the database designed, how do we use a framework like Ruby on Rails to construct it?
- *Software Engineering*: Introduction to Agile Methodology, writing stories, the backlog, pair programming. Test Driven Development, refactoring automated deployment and other related concepts.
- *Teams*: Learn and demonstrate effectiveness in working in a team to design, implement, test and deploy a brand new product. Show facility in collaborating, dividing up work, setting priorities, managing your time.

## VI. METHODOLOGY

During each instance of each course we collected: a) an initial student self-assessment of her/his leadership, teamwork, business, and marketing ability, and plans to start a business; b) a self- and peer- assessment of teamwork and team contribution; and c) a self reflection on the impact the course experience has had on the student.

The insights that follow flow significantly from the teaching staff’s own observation and discussions, supplemented by more objective data collected along through surveys and student reflections.

## VII. CHALLENGES AND INNOVATIONS

The two courses we describe here have been taught for three years, and have evolved along the way. We are describing their current form with the understanding that they likely will continue evolving.

We have encountered similar challenges as others have reported when implementing entrepreneurship curricula. In this section, we describe and explain how we have addressed them, and why in each of 7 major areas: Team formation, Team size, Catalyzing Entrepreneurship, Team dynamics and crises, Defining Deliverables, Deploying outside experts and Assessments.

### A. Team Formation

Before engaging directly in the team formation work, we orchestrate a half hour social period with a prompt that students do a “deep bump” [Ferrazzi and Raz, 2005, page 129] with several of their peers. The students are prompted to introduce themselves, saying one thing about themselves that most people don’t know. We find that this lowers the stakes and eases the way to the next phase: the actual team formation exercises.

Here are the ways we’ve experimented with team formation:

- *Self-organize*: this sounds appealing because of the freedom it gives the students. It fails because friends team up with friends, and very strong students with other strong students. The result is highly imbalanced teams and often individual students that aren’t invited to any team.
- *Partial democracy*: Form up teams of 3 students with the understanding that a fourth member will be appointed by the teaching staff. While this sounds appealing, we found strong resistance from students. Once they had a taste of self-selection it was hard for them to accept that their choice of a ‘perfect’ fourth member would not be allowed to join.
- *Dictatorship*: After explaining the challenges of each approach to team formation, persuade them that the best approach is to have the teams formed by the teaching staff. Many will have seen (but not liked) this approach in other classes. The challenge with this approach when we tried it was, on what basis do you create the teams?
- *Team Catalysts*: Our most recent innovation, which has been tried twice, is to select or nominate students as “team catalysts” and charge them with the mission of recruiting three other team members. Team Catalysts are self-nominated and agree to take on a neutral role with the objective of bringing together a team that will work well together. The reason we like the team catalyst approach is that it brings together elements of each of self-organization and partial democracy.

We have found that the Team Catalyst model of team formation was the most successful.

### B. Team Size

Team based work is a core feature of both courses, and as we have seen, a key component of Entrepreneurship educational goals as well as fundamental to Entrepreneurship.

Our finding based on trying different size teams is that teams of four students work best. Teams smaller than four are a challenge when dealing with inevitable situation of a student having to drop the course or otherwise needing to leaving the team. Teams larger than four students increase the likelihood of “free riding” on the other team members. After trying teams of 2,3,4,5 and 6 students, we have come to the conclusion that teams of four achieve the best balance.

### C. Catalyzing Entrepreneurship

As mentioned, in each of the two courses, students are challenged to work in teams on a product of their devising. For

the first course, the work has to do with product discovery and validation, leading up to a business plan. For the second course, the work will involve the actual design, implementation and deployment of the course.

(Note that the courses are not necessarily sequential, with the same student cohort, so the products chosen are different every time for each course.)

We have found that defining their own original products is one of the keys to student commitment. However, the challenge to guide students towards a product that is appropriate for the learning goals, the time available, and the likely obstacles they will hit.

*Idea Generation:* Our experience is that it will take several open discussions with some time between them to get to a set of solid ideas. In order to stimulate students there are several approaches that we have used successfully:

- Providing a list of all the projects undertaken in previous years
- Providing a list of ideas that we have come up with which have never been pursued.
- Providing links to web sites where new ideas are often discussed or promoted, e.g. Product Hunt (<http://www.producthunt.com>)

Notwithstanding all this, it is not surprising that most of the ideas that students propose are very directly related to their personal lives as students: how to find the best restaurant, how to plan a date, how to manage time better, etc.

One challenge is to make sure students are invested emotionally in the product they propose, as they will be working on it intensively for most of the semester. As the product “invention” happens early in the term, we have to take care that students understand the impact of the choice.

Another way to stimulate new idea generation is to motivate students to look at the challenge in a certain way: “Everyone has a million product ideas: you, your friends, your family. What in the world have you shaken your fist at, saying ‘I can’t believe I still have to do this by hand!’”

We have found that story telling about what the rest of the term will look like, and of cases where students didn’t think through the choice, work well to motivate the students to take the invention state appropriately seriously.

#### *D. Team dynamics and crises*

No matter how teams are formed, there is always the lurking potential of team conflict or non-conflict crises which will have a strong deleterious effect on their success.

It should be noted that the approaches and effective responses are exactly the same that any manager needs to confront. Libraries full of books have been written on this topic, so we will not try and cover them here.

However there are some unique challenges having to do with obvious factors:

- The team members are very young and inexperienced, possibly never having worked on a team before.
- The teams are very short lived (one semester) so certain approaches (training, management reviews, etc) just are not possible.

Still there are certain approaches and responses that we have found very effective in dealing with Student Team dynamics and conflict. Here are our key tools:

*Expectation Setting:* Sometime in the first week or two we expose students to Tuckman's "Stages of Group Development" [Tuckman, 65] model of team dynamics. This model uses catchy phrases to describe four stages in the evolution of an effective team: Forming, Storming, Norming and Performing.

When this presentation is timed right (it can be given too early before the students are ready to absorb it) it can take the self-doubt and panic away from team members who are in the middle of some conflict.

*Framing:* Individual students can ruminate about other team members that they are not liking or getting along with. They may wrongly frame their relationship as a potentially long term friendship and become too personally invested in fixing things which is a distraction and usually not productive.

We have found that reminding students that this is an artificially formed and temporary arrangement, and not a lifetime relationship can be very helpful.

On the other hand, it is also useful to be reminded that “in the real world” typically you don’t get to pick your teammates, and one of the important skills we are practicing is that of learning a *modus vivendi* with whomever is on your team.

*Actual Conflict.* Occasionally one or another member of a team will come to the teachers with a crisis of some kind. This poses a conventional management challenge to the teachers: how much or how little to get involved.

Our advice is to generally draw a hard line on allowing students to “switch teams.” Reasons for this are that this will be perceived as unfair by others, and that it will have a domino effect. We have found that reminding the students of the points mentioned in the previous section, and asking them to go back and try to make things work, should be the first tack and is almost always sufficient.

#### *E. Defining final deliverable*

We employ many tools to create momentum in the teams towards delivering their best work. An important component of this is how we frame the final deliverables for each course. Briefly, they are:

- 8 minute presentation (slides + actual presentation). *Purpose: designing and delivering a compelling presentation is core to entrepreneurship.*
- 10-15 page report, detailing the product and the processes used to create it. *Purpose: Demonstrate the depth of work that went into the final product.*
- Code (if appropriate) in a github repository. *Purpose: Allow evaluation of the quality of actual software*

*engineering work. Drive students' sense of pride in their work.*

- A beautiful “portfolio” page, with a brief summary of the project. *Purpose: Students need portfolios to demonstrate their work to others. We give them help and a framework to create this essential artifact.*

It is critical to ensure the students really understand why these deliverables are selected, so they receive a clear set of instructions. However, our scaffolding never includes required outlines or templates, as that would be antithetical to an entrepreneurial mindset.

A final note on this section. For purposes of assessment (feedback to students and grading) all team members receive the same grade and feedback for this component of the grade. This is done for practical reasons. It also reinforces a sense of shared mission on the team

#### *F. Deploying outside experts*

We have found that students respond strongly to individuals from outside the university (i.e. people other than the teachers). From feedback, this is for several reasons in addition to simple variety:

- Students are hungry to learn how the “real world” does entrepreneurship. It validates what they are learning in their formal education, and also takes away some of the anxiety of what awaits them in the future.
- It allows us to organize things so that the students are asked to make commitments to the outside experts, perhaps from one meeting to the next, or by hearing what their expectations might be when they are “judging” a showcase.
- Finally, the astute students understand that meeting these outside experts is an opportunity for networking and making connections, and indeed, more than one student has gone on to work with someone they met in this context.

It is our opinion (and finding) that extensive use of outside individuals strengthens the effectiveness and impact of what we are doing in our program. Here are the roles we have for outside experts:

- *Guest Lecturer:* Topics vary from “Growth Hacking in Practice” to “Scaling Tripadvisor” to “How VC Works”. Each of these were topics covered by a guest lecturer in the recent past.
- *Product Reviewer:* In the Capstone course, where students are actually developing the product, the PR meets on four occasions during the semester with the whole team to challenge them, guide them, inspire them and make suggestions to them. It is structured as a mentoring/product management update meeting.
- *Product Showcase Judge:* At the end of each semester, student teams present their products to a panel of judges. The judges are given very clear guidance on what to look for. Even though the Showcase is structured as a fun competition, teams take great pride

in “winning”, as you can hear when they talk about the experience to others.

#### *G. Assessments*

As noted in the “Final Deliverables” section, all teams produce a series of deliverables. These are assessed against a detailed rubric based on the stated learning objectives. We look for careful testing of hypotheses, and whether they have been able to avoid personal biases by speaking to and listening to prospective customers.

All students prepare a set of self-reflections from which we extract information about the impact of the courses on the students own self-image, where we look for a changed perspective in their self-confidence and willingness to take risks.

As noted above, there are multiple opportunities for interaction and evaluations by practitioners and experts not connected to the University, another source of assessment insights, where we are listening for these experts’ informal comments

Near the end of the semester, all team members are asked to provide a self- and peer- review, confidentially and in writing. We see this as primarily a chance for reflection and not one for heavy feedback from us.

We are however on the lookout for near unanimous feedback that a particular team member was the clear leader and major contributor, or a particular member was just riding along, not showing up and not delivering.

### VIII. RESULTS

Assessment of the effectiveness of our program (and any Entrepreneurship program) is not a simple matter. We start by admitting that “Entrepreneurship” doesn’t have an agreed upon definition, and thus our assessments or the purposes of grading have to be tied to more conventional learning objectives.

Our own assessment looks at the following:

In class and out of class observations by the teachers and teaching assistants. Are students expressing a changed perspective on how to evaluate and test ideas? Are they showing increased confidence in being able to tackle creating a solution?

One of the other ways we assess the effectiveness of our efforts is by a student self reflection assignment which tries to focus the students’ attention on their personal growth and thinking, and does not ask for any assessment of the course itself. Here is the prompt we’ve used for the last 3 years.

*“I would like you to think back about what you thought about yourself as an entrepreneur before you took this course and how your views might have evolved. Think about questions such as: How do you feel you’ve changed your views on entrepreneurship and what it takes to be one? Do you see a role for yourself as an entrepreneur in the future? How has your thinking and approach about starting something brand new changed? What have you learned about yourself as an entrepreneur? How have you grown? In what way do you feel better prepared now? In*

*what way have you clarified what you want to do when you graduate”*

Responses to a question like the one above are useful, but certainly not conclusive assessments. A caveat is that while we feel that the exercise of thinking and writing is very valuable to the students’ own self-awareness, there’s no doubt that the actual essay submitted is colored by a desire to please and not offend the instructors. So they are taken with a grain of salt.

A second caveat is that we have not yet done a proper coding of all the submissions to develop a more quantitative view of the result of these reflections. Here are some common themes we saw.

**Theme:** Being an entrepreneur is hard work and requires much commitment and dedication.

*“Being an entrepreneur is not easy but it's fun. One needs to have passion and work really hard to be successful as an entrepreneur. There is nothing such as “overnight success” for entrepreneurs.”*

*“I feel like I learned just how much work is required to be an entrepreneur.”*

**Theme:** The idea is just the first step. There is a method and a process to getting to Product Market Fit

*“Through this course, I learned [instead] that entrepreneurship is a highly methodical process by which one attempts to chart the unknown and change course based in data rather than simply leaping into the unknown and steering blindly.*

*I see now that the biggest ingredient to success in a startup is execution and commitment, and passion in the idea and the startup are required in order to do what it takes.*

**Theme:** I’ve learned the importance of team work.

*“This class has showed me how important it is to have a good team, especially when starting out, the smaller it is, the more crafted it has to be in terms of equal level of passion, and skills that complement each other.*

*I learned that a startup needs a team of hard working people, but more than that it is largely dependent on the combination of diverse skills each member brings.*

**Theme:** Based on what I’ve learned, I don’t see myself yet as an entrepreneur:

*“I do still hope to be an entrepreneur one day, but I know that it will take far more time, effort, and flexibility that I had imagined.”*

*“This course has clarified for me that I don’t want to go right into entrepreneurship right after I graduate. I*

*need to be 110% in love with the idea otherwise I will not be successful.*

**Theme:** Based on what I’ve learned, I feel more strongly that I want to pursue entrepreneurship

*“Before this class I didn’t see myself as an entrepreneur. I never head the dream of creating the next big thing. After this experience, entrepreneurship seems more exciting to me now, and something I could end up seeing myself doing.*

## IX. FUTURE WORK

As Computer Science students show more interest in Entrepreneurship, it is important to improve our understanding of the effectiveness of these programs. Here are some of the further questions that we have identified as needing further work.

**Effectiveness:** What is the objective of teaching Entrepreneurship? Are we just responding to the trendiness of the term, or is this a valid Computer Science focus? Is the concept of “Entrepreneurship” too vague and ill defined (as we described earlier) to sustain deeper study? Is there any hope or purpose to trying for a standardized definition of Entrepreneurship?

**Measuring longer term results:** Given a particular definition desired outcomes, how can we best track our students’ progress one or more years after graduation against those? How could we reasonably define a control group? Is a before and after survey or reflection a useful way to measure the effectiveness of an Entrepreneurship program? What is the best way to do this?

## X. CONCLUSION

We began this paper with a question posed to us as a challenge by our peers in the startup world who say: “Entrepreneurs are born not built!”

First, we agree that we cannot take credit in the unlikely event that we have the next Steve Jobs or Jeff Bezos in our classroom. They were indeed born with some native instinct, ability, charisma or whatever other super power.

But just as it appears that we can teach empathy when training psychiatrists, and we can teach artistry when training actors, and we can even teach spirituality when training clergy, then it is our belief that certainly we can teach Entrepreneurship.

## XI. ACKNOWLEDGMENT

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