

Teaching Entrepreneurship for Computer Science and Engineering Students Using Active Learning Pedagogical Strategies

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Abstract—Contribution: This innovative practice full paper presents a novel approach based on active learning pedagogical strategies and entrepreneurship programmes to teach entrepreneurship to computer science and engineering students. The proposed approach has been tailored for undergraduate classes in order to provide the students with the initial stages of developing a technological startup. **Background:** Within the computer science and engineering literature, there are some interesting works that deal with entrepreneurial education in different levels and concepts. However, there has not been a paper describing a hands-on approach that makes them experience the important initial stages of a startup. **Intended Outcomes:** By the end of the course the students will be able to: (1) Validate whether or not their idea can become a business; (2) Build a MVP (Minimum Viable Product) for their solution; (3) Elaborate a Business Model Canvas (BMC); (4) Present their solution and BMC to potential investors. **Application Design:** There are some very interesting approaches to teach entrepreneurship in programmes outside of the university, such as the startup weekend, which has created several successful startups. **Findings:** Before taking this module the majority of the students did not have any contact with any type of entrepreneurship education programme or startup related event such as hackathons. While taking the module, several students attended related events. Some of them got involved with other university entrepreneurship initiatives.

I. INTRODUCTION

Entrepreneurship Education is important across all disciplines and given the current economic trends it is particularly important for computer science and engineering students. For this reason previous work has approached this issue in different formats. In the work of Bellotti et al. [1] a series of serious games related to teaching entrepreneurship concepts were evaluated. In the work of Pech et al. [2] students are introduced to the four main phases of innovation by using case studies. In Wu et al. [3] the authors evaluated the impact of using a classroom response system to teach entrepreneurship concepts.

In Iborra et al. [4] the authors present an institutional engineering entrepreneurship education program that works in collaboration with the Internet of Things (IoT) industry. In the work of Newell & Varshney [5] a new Bachelor of Science degree in Innovation, Leadership and Engineering Entrepreneurship (ILEE) that was developed at the University of Illinois at Urbana-Champaign is presented. In the work of Chou [6] a method based on design thinking for social entrepreneurship projects is presented. According to Suzuki

[7] Design thinking has been used in Japanese Universities to teach entrepreneurship since 2008.

It should be noted that despite all these exciting and inspiring approaches, we did not find in the literature any approach that provided (and evaluated) a hands on approach tailored to be used specifically in a normal undergraduate module for the task. Therefore, the main contribution of this work is to present a novel methodology to be used in an undergraduate module that is based on strategies used outside of the universities in entrepreneurship events such as the Startup Weekend [8] and Lean Startup [9] with a mix of active learning pedagogical strategies. An additional goal of this paper is to describe the course and its results in sufficient detail to allow it to be easily replicated by colleagues at other colleges and universities. Furthermore, it should be noted that different offers of the course were used as opportunities to change particular aspects of the course in order to verify whether or not a given component makes a difference in the learning outcomes.

The remainder of this paper is organised as follows: Section II presents a brief overview of the active learning pedagogical strategies used in the proposed methodology presented in Section III. Section IV presents the evaluation of the proposed methodology in practice. Finally, Section V presents the final remarks of this work and future research directions.

II. ACTIVE LEARNING PEDAGOGICAL STRATEGIES

Felder and Brent [10] define active learning as “anything course-related that all students in a class session are called upon to do other than simply watching, listening and taking notes”. In the context of Computer Science and Engineering education there has been some very inspiring works that compare the efficiency of active learning against traditional learning. A comparison of several such works for undergraduate STEM courses is presented in Freeman et al. [11] where 225 studies that compared Traditional Learning Vs. Active Learning and that provided student performance data on examination score and/or failure rates were analysed. Their analysis shows an improvement by about 6% in active learning, and that students in classes with traditional lecturing were 1.5 times more likely to fail than students in classes with active learning.

TABLE I: Entrepreneurship Course Overview

Week	Pre-class	In-class
1	-	Class presentation
2	60 seconds Elevator Pitch Preparation	Elevator Pitch Presentation; Best Pitch Voting; Team Building.
3	-	Problem Validation Questionnaire
4	Apply the Questionnaire and Elaborate a presentation	Presentation of the Problem Validation Questionnaire Results. Immediate feedback from the teacher about the research and the presentation.
5	(Optional) Re-Apply the Questionnaire and update the presentation	Re-presentation of the problem validation.
6	-	Explanation about MVP. Research about related MVPs.
7	Research about related MVP	Presentation on related MVP.
8	-	Students work in class to create their MVP proposal.
9	Prepare a presentation about the MVP proposal	Presentation. Teacher gives immediate feedback.
10	Development of the MVP	Teacher act as a consultant for the students on their MVPs.
11	Validation of the MVP with potential customers	Teacher act as a consultant for the students on their MVPs.
12	Validation of the MVP with potential customers	Teacher act as a consultant for the students on their MVPs.
13	Validation of the MVP with potential customers. Prepare a presentation about the MVP.	Presentation about the MVP and its validation.
14	Read teacher selected material about BMC	Students start developing the BMC for their solution.
15	Development of the BMC	Law Lecture with external real-world lawyers.
16	Development of the BMC. Prepare a presentation about BMC.	Presentation of the BMC.
17	Prepare the final pitch for potential investors	Pitch presentation for the teacher and class for feedback.
18	Improve the final pitch for potential investors	Pitch presentation for potential investors.

The challenge for the educators is therefore to select and adapt one or more of the existing active learning pedagogical strategies in order to make the teaching and learning process more interesting to the students. For this reason, in the remainder of this section, we will briefly review the main points of the active learning strategies that are used in our proposed methodology (which will be presented in Section III) for teaching entrepreneurship.

A. Flipped classroom

According to Lage et al. [12], “inverting the classroom means that events that have traditionally taken place inside the classroom now take place outside the classroom and vice versa”. Therefore, in the Flipped Classroom, the traditional lecture that takes place in person, is replaced by the students previously studying the related class material. There are several formats which can be provided for the students to study the class material before class, such as a pre-recorded video lecture or pre-selected mandatory readings. When the students meet the instructor in the class, the instructor will begin the class by asking whether or not there are any questions regarding the class material. In the case there are no questions, it is assumed that the students fully understood the class material [12].

B. Team-based learning

According to Michaelsen and Sweet [13] the primarily learning objective of team-based learning is “to go beyond simply covering content and focus on ensuring that students have the opportunity to practice using course concepts to solve problems.”

Team-Based Learning has four essential elements [13]:

- Groups: Groups must be properly formed and managed.
- Accountability: Students must be accountable for the quality of their individual and group work.

- Feedback: Students must receive frequent and timely feedback.
- Assignment design: Group assignments must promote both learning and team development.

Considering the groups, they are formed on the first day of class and it is going to stay the same for the remainder of the module. Also it is important that the group has diverse and complementary backgrounds and skill sets. When it comes to accountability it is important that the students have individual as well as group tasks. Ideally the individual task is done outside of the class while the group task is done during the class. Also it is imperative that the students understand that their individual task is important for the group task, therefore doing it properly before the class.

III. PROPOSED METHODOLOGY

The module called “Innovation for computer science and engineering” is offered every semester for students in their final two-years before completing their respective degrees (3 years for technological degrees, such as digital games developments; 4 years for B.Sc. degrees, such as computer science; and 5 years for engineering degrees). The students that enroll into the course are normally from computer science, computer engineering, information systems and digital games development. Although some students from other engineering degrees also enroll in this module. This module has been taught by the author since the second semester of 2016. The remainder of this section describes the learning outcomes, course format and the reason behind the choice of the pedagogical strategies.

A. Learning Outcomes

The methodology presented in this work has the objective of having the students experience some important stages during the development of a technological startup. This

methodology is based on the methodology used in the entrepreneurship programs used around the globe, such as the Startup Weekend [8] and Lean Startup [9]. It was designed with the following learning outcomes in mind, i.e. by the of the module the students will be able to:

- Validate whether or not their idea can become a business.
- Build a MVP (Minimum Viable Product) for their solution.
- Elaborate a Business Model Canvas (BMC).
- Present their solution and BMC to potential investors.

B. Course Format

Table I presents an overview of the Entrepreneurship course.

Week 1

In the first week of the module, as expected the students do not have any activities to do before class. During the first class, the instructor presents the course overview, grading system and ground rules to the students. It is also during this first class, that the instructor asks the students to present themselves. During this presentation the students must at least answer their name, course, current year of study, if they have any previous experience with startups, hackathons (or similar events), if they have any work experience and their current employment. This information will be used in the following class to build the different teams.

After the students' self presentations, the instructor asks whether or not the students are familiar with the concept of the elevator pitch and proceeds with the explanation about it. As most students are normally not familiar with the concept of the elevator pitch, one interesting example for them to use is the Founder Institute One-sentence Pitch Format (presented in Figure 1). The most interesting part about the Founder Institute pitch format is the "secret sauce" where the students have to already start thinking about how their solution is going to be different from the existing technologies. Another important information is that the students are made aware that all the pitches will be voted and the most voted pitches will be selected to be developed though the class.

Week 2

Before this week's class, the students have to prepare and rehearse their elevator pitches. In the class each student is given exactly 60 seconds to present their pitch. If they run over the time everyone starts clapping. After the students' presentations are finished, voting takes place. Each student votes in three different pitches that they think were the best (they can vote on their own pitch as well). This approach based on using the pitches to start the teams is based on the Startup Weekend [8] entrepreneurship event and it was further enhanced with principles of team-based learning [13]. In order to build the teams that will work throughout the courses, the information that was gathered in the previous class is used to assign the students to each team. Ideally we

My company, _____, ,
 is developing _____
 to help _____
 _____ with

NAME OF COMPANY
 A DEFINED OFFERING
 A DEFINED AUDIENCE
 SOLVE A PROBLEM
 SECRET SAUCE

Fig. 1: The Founder Institute's One-Sentence Pitch Format (From: [14])

want to build teams with diverse backgrounds, skills, courses and work/startup experience.

Week 3

In the third week of the module, the students work in class to elaborate problem validation questionnaires. The idea is to verify whether or not other people in the "real world" relate with the problem identified by the group. Another important aspect here is to make the students clearly see the distinction between a problem and it's solution, as normally the students are very biased towards only seeing these two aspects together. Therefore, a worthy problem might have several possible solutions. In class the students are asked to work on problem validation questionnaires with between 5 and 7 questions, with at least one question being open-ended. It should be noted that the students are requested to interview at least 5 people per team member physically. This is important as when talking to people (rather than filling out an online form) the students might gather other information that they were unaware of.

Weeks 4 and 5

Before this week's class the students have to apply the questionnaires and summarize their findings in a three minute presentation about the problem validation. Also all students must be prepared to deliver the presentation, as the presenter will be chosen randomly in the class. The reason behind this idea (which is used within most of the presentations during the course) is that students normally split the presentation and only learn fractions of the content. In this way, unless they are really lucky, they will all prepare and learn the materials. During the class, each team delivers their presentation and feedback is given after each presentation. Depending on how the presentations and obtained results are, it may be necessary to re-work on the questionnaire, re-apply it and re-present.

Week 6

After the teams have validated the problem they will work on, we present the concepts of Minimum Viable Product

(MVP) [9] in class. In Lenarduzzi & Taibi [15] a systematic mapping on the definitions of MVP was performed. According to [15] the term MVP was first used by Frank Robinson in 2001 [16] and then disseminated by Eric Ries since 2009 [9].

In order for the students to understand how an MVP works, we present the example of a Brazilian successful startup called "EasyTaxi" [17]. In the EasyTaxi MVP in 2011, as the creator did not know how to program, he made a blog where the people had to fill in their name, e-mail, address and telephone and then click on the "call taxi" button. However, this button would send an e-mail to the creator instead of actually calling a taxi. As soon as the creator received an e-mail he would look up the person's address in google maps to check which taxi stations were close to the address, call one of them, make the arrangements with the taxi driver and then call the client informing which vehicle would pick them up.

After explaining the EasyTaxi MVP, the students are then asked to research MVPs that are as close as possible to the problem they are trying to solve, or that use similar technologies to the ones they are planning to use in their solution. Each member of a team is responsible for researching one related MVP and explaining it to their teammates. In the next class, all teams are required to present their related MVPs. In order to avoid that different teams present the same MVPs, each student has to post in a forum of the virtual learning environment the name of the MVP they are going to present.

Week 7

Before the class the students work on their presentations of the related MVPs. As with other presentations, the order in which students present which MVP will be selected randomly, in order for all students to be aware of all the relevant MVPs found by the members of their team. During class the students present their related MVPs, with immediate feedback from the instructor after each presentation.

Week 8

In this class the students start working on their MVP proposals. The instructor normally goes around the class discussing the preliminary ideas of the team's MVPs.

Week 9

Before this week's class, the students prepare a presentation about their MVP proposal. In class, each team presents their MVP proposal and receives immediate feedback from the teacher and from the other teams.

Weeks 10-13

During weeks 10-13, the students work on the development and validation of their MVP. During the classes from weeks 10-12 the students do progress report meetings with the teacher. Before the class in week 13 the students prepare a presentation about the development and validation of their MVP.

Week 14

Before this week's class, the students read the pre-selected material about the Business Model Canvas [18] in a flipped classroom style. During the class the students clarify their doubts and start working on the BMC for their project.

Week 15

Before the class, the students work on their BMC. During the class, we invite lawyers from the local startup ecosystem to give a lecture about important legal aspects of starting an actual startup.

Week 16

Before the class, the students prepare a presentation about their BMC. During the class the students make their presentations about the BMC.

Week 17

Before the class, the students prepare a 5 minute pitch about their project. During the class they present it and the teacher gives immediate feedback about how to improve the pitch to the investors in the following week. This presentation is one of the few that the students can choose their best presenters to make the pitch.

Week 18

Before the class, the students improve their 5 minute pitch about their project. During the class they present it to a jury with potential investors. In case investors are not available due to the limitations of time and place of the lectures, we always invite other people who are well connected within the local startup community. In case none of them are available, we invite internal staff related to the entrepreneurial activities of the university.

Parallel Entrepreneurial Activities

One aspect that is worth mentioning, is that all students that are enrolled in the module are encouraged (getting extra marks) to attend related entrepreneurial activities in the university and/or outside the university and share their experience with their colleagues.

IV. EVALUATION OF THE PROPOSED METHODOLOGY

In this section we report the teachers perceptions as well as the students perceptions about the proposed methodology. This module was offered to one class in the first semester of 2017 with 21 students, three classes in the second semester of 2017 with 23, 17 and 9 students, one class in the first semester of 2018 with 21 students and two classes in the second semester of 2018 with 30 and 34 students. In all offerings of the module, the students had to fill in a self evaluation questionnaire.

A. Team Composition Strategy

The idea of using the most voted pitches to select the leader of each team, allied with the teacher analysis of the students' presentation in the first class, was successful to create teams with a different set of skills. Some of the students who would usually work together, ended up being split into different teams, as their pitches were among the most voted ones.

B. Team Sizes

Given the different number of students in each class, we were able to experiment with different team sizes. In 2017 most teams normally had between 3 and 4 members. In the first semester of 2018 the teams had between 5 and 6 members. In the second semester of 2018 the teams had between 4 and 5 members. Considering the students feedback, it seems that for the proposed methodology smaller teams work better for them than larger teams.

C. Random Presenter Strategy

The random presenter strategy, i.e. at each group presentation selecting one of the students at random to present, successfully enforced that most team members were familiar with the presentation topic. One of the students who attended the classes, has told us that the dynamics used in this module were essential for him to perform well in a highly competitive employee selection dynamic, securing the job.

D. Problem Validation Questionnaires

All students that applied the problem validation questionnaires in person, had different insights, stories and even related solutions they were unaware of to share. This reinforces our earlier insight that when they are interacting with people they are able to gather more information than simply using the online forms.

E. MVP Development

As mentioned in Section III after validating that they have an interesting real-world problem to work with they develop and validate an MVP. It should be noted that in all classes, regardless of the class size there has always been at least one team that was able to successfully create an MVP that delivered the core of their business to the clients. For the teams that did not reach this stage, some of the highlighted lessons learned were "we should pay closer attention to the input we get from the users" and "getting users to join our site was more challenging than we thought".

F. The Impact of the Law Firm Lecture

One of the highlights mentioned by all students at the end of the course, is that the lecture with the lawyers was really important. For the majority of the students that was the first time that they had contact with professional lawyers and with the many important legal issues that should be addressed when opening a startup, such as: the importance of choosing the right strategies when bringing new partners in the business (i.e. vesting contracts); the importance of some

actionable contract clauses, such as drag-along clauses (in case another company decides to buy the business); the importance and how to register intellectual property (when applicable).

G. The Impact of the final pitch to real entrepreneurs

Another aspect that is highlighted by the students is the importance of the final pitch about their projects at the end of the term to an evaluation committee formed by entrepreneurs from the local ecosystem. All teams took this presentation very seriously, as they understand that it is a good opportunity for them to get external feedback about their ideas as well as making new connections and eventually some potential funding or mentorship.

H. The Impact of Parallel Entrepreneurial Activities

Every class, there was at least (but usually more than) one student that got involved in extracurricular entrepreneurship activities within the university programs or with external events such as hackathons. However, all students are now familiar with the university entrepreneurship programmes and activities and know where to go in case they need help to pursue an idea of their own.

V. FINAL REMARKS

In this paper we have presented a new methodology that is based on a mix of strategies inspired by some of the most engaging industrial entrepreneurship programs and active learning pedagogical strategies to fit a 18 week undergraduate course. The evaluation of the students' learning outcomes have shown that all of them have grasped the main concepts related to creating a startup in a very practical way. Furthermore, this methodology can be used to encourage the students to further develop their projects in other institutional or external entrepreneurship programmes. In future research we plan to investigate how well the proposed methodology works in entrepreneurship classes with students from very different courses of the university.

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