Using Challenge Based Learning to Create an Engaging Classroom Environment to Teach Software Startups

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ABSTRACT

Teaching entrepreneurship to computer science or software engineering students is challenging. Lecturers must find ways to effectively present the importance of focusing on the customers' problems and needs and work backwards to the technology. Additionally, the experience in the classroom has to be engaging and students must feel motivated to work on their given solution. We conducted a study describing the path of 30 software engineering students through an undergraduate software startup entrepreneurship course that applied Challenge Based Learning methodology to guide students' projects. Data was collected from both students and the lecturer through a semi-structured questionnaire applied at the end of each deliverable. Our preliminary results indicate that Challenge Based Learning methodology can strengthen students' collaboration and engagement in addition to helping in the process of learning how to develop a startup.

CCS CONCEPTS

• **Applied computing → Collaborative learning**.

KEYWORDS

Challenge Based Learning, Startup Development, Entrepreneurship, Engagement

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1 INTRODUCTION

The advances in technology in the past decades have enabled software development companies and even individuals to create products and services that can reach millions of people [9]. These new technology endeavours are called *startups* [2].

The majority of the startups follow the *lean startup* methodology [14]. This methodology combines short software development cycles with constant interaction with potential users and customers. This process intends to minimize risks, since it focuses on constant learning [4]. In a startup context, the most important metrics are not related to schedule or budget; what matters is how the project delivers value by meeting users' expectations and needs [5].

From an education standpoint, technology-related undergraduate programs are adapting themselves in order to fit startup content into their curriculum [6]. The challenge usually lies in providing a realistic setting for students to work on. When dealing with real users, students need to be creative in order to solve the problems that may arise. In other words, students must not only develop software development skills, but also many soft skills, such as critical thinking, adaptability, problem solving, and teamwork. This combination enables students to be prepared to deliver software that is not only technically well-design, but that also delivers value to a group of people [13].

In addition, encouraging and working with rapid and iterative development cycles, along with constant feedback as well as self-evaluation is harder in an academic setting. This happens due to students' lack of experience [8]. However, in order to meet current market demands in term of software development skills, it is necessary to combine creativity and innovation along with technical knowledge [7].

Thus, it is crucial to implement an engaging and collaborative approach in order to help students understand what is takes to be a world class software developer. One of the methodologies that combines the educational process with interactive learning and applied to everyday challenges is the Challenge Based Learning (CBL) [12]. This methodology works well not only in real world projects, but also in educational settings [15, 16]. CBL encourages problem-solving through activities such as reflections, self and team evaluations and challenges carried out during the process [11].

A study carried out with a group of 110 students [1] that used CBL to develop software during a one year period verified that the

methodology helped students to understand relevant problems to be solved and their solution. The study showed that this active learning is effective for teaching mobile software application development.

This paper describes the track of 30 software engineering students through an undergraduate software startup entrepreneurship course that applied CBL methodology to guide students' projects. Our preliminary results show that CBL can specially strengthen students' collaboration and engagement in addition to helping in the process of learning how to create a startup.

2 CHALLENGE BASED LEARNING

Experiential learning is the source of several learning frameworks that are used all over the world, not only in an academic setting, but also in real-world projects. Problem Based Learning, Project Based Learning, Task Based Learning and Challenge Based Learning are just a few examples of these approaches.

Challenge Based Learning (CBL) [12] was developed by educators working with *Apple Inc.* [11] and has been implemented both in educational and corporate environments. It is a learning framework based on solving real world challenges and problems. From an education standpoint, students obtain knowledge by working on open-ended problems and challenges in collaborative and (when possible) heterogeneous teams.

During the CBL learning process, professors/lecturers, students and other stakeholders work together as active collaborators. Divergent thinking and creativity are stimulated throughout the whole process. Moreover, the goal is not only on the final deliverable (the challenge solution), but also on the learning process itself. Students and lecturers must reflect from time to time on their learning/teaching evolution.

The CBL framework is divided into three interconnected phases: *Engage*, *Investigate* and *Act*. Each phase includes a different set of activities (see Table 1).

Table 1: Phases of the CBL framework.

Engage	**Big Idea**: a broad concept that can be explored. It has to be a topic that is engaging for students.
	Essential Question: the question related to the *big idea* that students want to explore.
	Challenge: a call to action derived from the essential question. It should be actionable and exciting.
Investigate	**Guiding Questions**: questions related to the challenge. Includes everything that needs to be learned.
	Guiding Activities and Resources: list of activities and resources that can help students pursue the challenge.
	Analysis: sets the foundation to develop the solution to the challenge.
Act	**Solution Development**: based on the learnings from the previous steps, the solution is implemented.
	Evaluation: verifies if the solution has addressed the challenge or if it needs refinement.

Table 2 illustrates some examples of the *Engage* phase. As it can be observed, *Essential Questions* are always formulated as questions, whereas *Challenges* are statements.

Johnson and Adams [10] have showed that the use of active learning methodologies improves students' learning when compared to traditional methods. Additionally, the engagement and the soft skills acquired during the process is also perceived as a big advantage not only for students, but also for other stakeholders involved.

Table 2: Engage phase.

Big Idea	Essential Question	Challenge
Tourism	What people look for when going abroad?	Deliver a great experience for people visiting Brazil
Charity	What makes people engage in charity events?	Make donation easier
Finance	How does the use of cash impact the life of students?	Make payments easier
Health	How does people buy organic food?	Make organic food affordable
Entertainment	What people look for when going out?	Deliver the best venue option according to your taste

As any teaching methodology, CBL also presents advantages as well as limitations. Even though CBL fosters students' engagement, some students may not grasp the concepts due to immaturity. For instance, they might not be comfortable working in groups, discussion ideas or receiving feedback. From a teaching perspective, the professor has to be familiarize with active learning methodologies. If the professor is only used to traditional teaching methodologies, he/she needs to prepare to adjust the teaching habits. Moreover, the assessment process is time-consuming. It is much easier to just grade exams than to assess students during a whole teaching cycle.

3 PROPOSED TEACHING METHOD

The methodology was applied in an undergraduate software startup entrepreneurship course with 30 students. Meetings were held twice a week for one hour and 40 minutes for a period of four months. Table 3 summarizes the course schedule.

Figure 1 presents a graphical representation of the CBL methodology drawn by one of the students in the class. It is important to point out that we have chosen CBL instead of other active learning methodology because CBL focus on the real-world problems that are connected to students. This is the context in which a startup is developed.

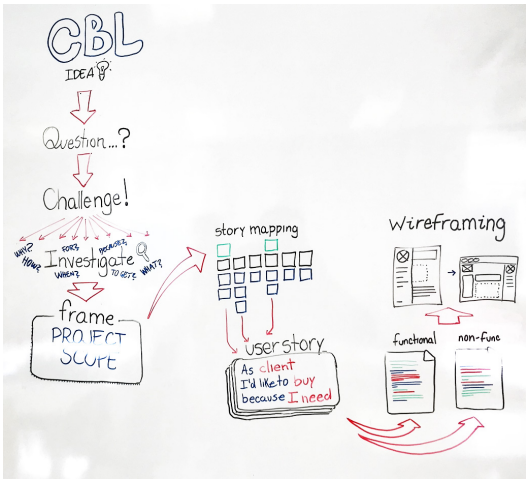

Figure 1: CBL Framework.

Table 3: Course Schedule.

Phase	Class	Topic	Goal
Engage	1, 2	Course introduction	Present the course format, objetives and goals
	3, 4	Introduction to the CBL methodology	Understand the purpose of the CBL and explore its phases (Engage, Investigate, and Act)
	5, 6	Definition of Big Ideas and Essential Questions	Brainstorm on Big Ideas; team formation; Big Idea and Essential Questions definition
	7, 8	Initial research	Challenge definition. Teams begin to organize their research process. Guiding Questions, Activities, and Resources definition
Investigate	9, 10	Market research	Teams should begin their field research according to the guiding questions raised
	11, 12	Field research analysis	Data analysis; teams should evaluate their preliminary results
	13, 14	Planning and prototyping	Finalize investigation; define solution; begin working on requirements for the given solution
Act	15, 16	Solution development I	Prototype construction and development
	17, 18	Solution development II	Prototype construction and development
	19, 20	Investments	Understand the resources needed to develop the solution
	21, 22	Solution evaluation	Validate solution with potencial users and customers
	23, 24	Pitch	Understand the process of delivering an effective pitch presentation
	25, 26	Fundraising and Partnerships	Understand the process of raising capital for a startup
	27, 28	Project Presentation	Present the project to a group of investors

3.1 Step 1: Engage

In the first month, students defined the *Big Idea* and completed the engagement stage. During this period, through lectures and activities, the CBL methodology was presented and students began the Engage phase. The identification and definition of the *Big Ideas* started by students bringing several themes of interest to the classroom. In this way, they could find common interests and formed teams according to those ideas. The result of this process was the formation of five teams. Once *Big Ideas* and teams were defined and formed, students explored their *Essential Question* in order to get to a *Challenge* to be solved. At the end of this stage, students not only delivered their results, but they also carried out the first reflection on their learning process.

3.2 Step 2: Investigate

From the second month of the course, students carried out the research phase by defining *Guiding Questions, Activities and Resources*. During this period, students conducted a review of the literature on their topic in addition to working on a field research with potential users of the product or service. Moreover, students were encouraged to validate the relevance of their projects, as well as to make changes to their research project. Students could even go back to the Engage phase in order to modify their challenge. At the end of this stage, students delivered their research findings (as a report) and also their second reflection on the learning process.

3.3 Step 3: Act

After the research phase, students developed their solution for the proposed challenge based on their research findings. During this stage, students evaluated and validated their final project with potential users and customers in order to verify whether the solution meet their needs. At the end of the semester, students presented the process they went through as a pitch presentation. The deliverables of this stage were a report summarizing the whole CBL process - from ideation to the final solution. In addition, the final reflection was carried out in order to explore students' learnings and also to verify whether the CBL methodology was relevant to them.

4 DATA COLLECTION METHODOLOGY

Data was collected from the both students' deliverables (reports and presentations) and reflections. Reflections were conducted on the following prompt: "*what did you learn the most in this phase? What did you struggle with? Is there anything that could be done differently?*". Reflections were done individually and privately. This encouraged students to be more open to share their thoughts. In addition to this information, at the end of the course a questionnaire was applied so we could collect and explore more data regarding the development of the projects. The results of this process is explored in Section 5. Finally, we also collect a reflection from the professor, so we could understand his perception not only in regards to the CBL methodology, but also on students' involvement and engagement.

5 EVALUATION

We present in this section some research findings as well as the teacher and students' perception about the use of CBL in the classroom environment for startup development.

5.1 Students' Engagement

The first question we asked students was related to their engagement. The goal was to understand how connected they were with class activities, project and also with their peers. Figure 2 presents the results. As it can be observed, 25 out of the 30 students reported to be highly engaged. In our opinion this outcome is outstanding, since it is very rare to keep students excited throughout the whole process.

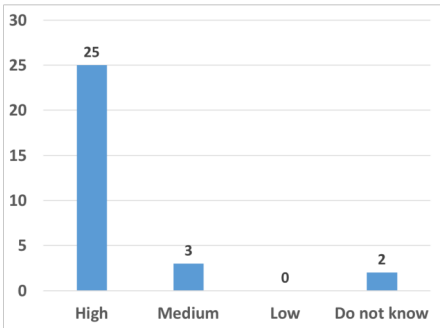

Figure 2: Students' Engagement.

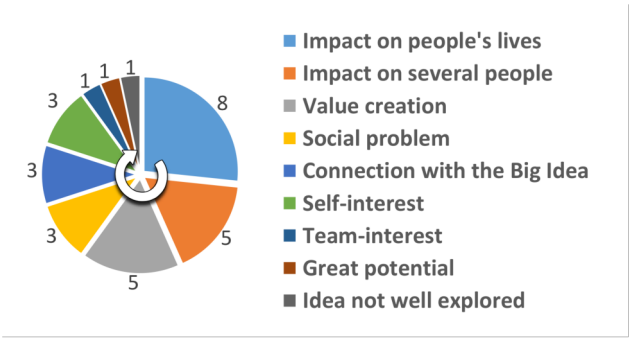

Figure 3: Reasons that engaged students in their project.

Table 4 presents the most important attributes that motivated students in regards to the whole course. This data was collected through an open-ended question. Students could say as many attributes as they wanted. In total, we had collected 44 attributes. It is important to point out that we grouped similar answers together according to their meanings and contexts. As we can see in table 4 , self-interest was the most cited reason for students' motivation. In addition, we can observe the importance of being connected to the Big Idea and to the team.

Table 4: Attributes that motivate students.

# times	Attribute
10	Self-interest
6	Connection with the Big Idea
6	High involvement with the team
5	Team motivation
4	Good communication with the peers
3	Impact generation
3	Learning experience
2	Solution for you or people close to you
1	High number of users
1	Confidence
1	Recognition by the team
1	Startup development
1	Working in teams

We also wanted to know the reason why students were engaged to their projects. Figure 3 presents outcomes. Making a difference in people's lives seems the be the most important factor for students to work on their projects. It is interesting that none of them pointed out the opportunity of making money. This seems to be a characteristic of the new generation; money will always be important, but being engaged and connected to a given project is more relevant.

Teamwork was also a point of interest to us. Hence, we asked students about team engagement. Twenty one students reported that all participants were equally involved into their project activities and that they all collaborated to better find the solution to the proposed challenge. Seven students understood that their teams were not as excited as they should be, and only two students mentioned that teamwork was below expectation. It is interesting to notice the different perceptions among students. Even though the majority of them were comfortable with their peers, a few students felt that they could have done better than they did.

Another important aspect that we were interested in was how students were open to new ideas and thoughts. Since CBL fosters and stimulates engagement, we wanted to know how this process worked and how students felt about it. Almost all students (25 of them) stated that their ideas and thoughts were heard and accepted by their peers. Four students reported that their ideas were partially accepted by others, and only one student had the perception that his ideas were never taken into account throughout the process.

In order to verify whether the three CBL phases (Engage, Investigate, and Act) were important to students, we asked students if the framework helped them going further into the process of creating their startups. All students agreed that CBL was important specially because of the Engage phase. Defining an essential question and a challenge helped teams understand their goals. Once the goal is clear, it is much easier to investigate on it.

5.2 Students' Difficulties

We also asked students about their difficulties and problems throughout the process specially in regards to the development of a startup. We divided our question into two moments. The first one was related to the Investigate phase (Figure 4) and the second one to the Act phase (Figure 5).

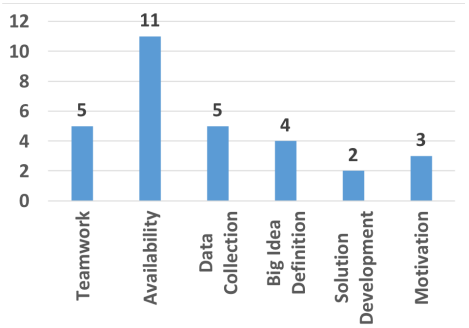

Figure 4: Difficulties during the Investigate phase.

It is clear that availability was a key problem during the investigation phase. We have a few hypothesis that could be further analyzed.

Since this is a software engineering undergraduate course, maybe students are not very comfortable with doing actual research (specially field research, when they have to talk to real users). This is not a common activity for a software engineering student. Another possibility is that students were not able to organize themselves to work on this activity.

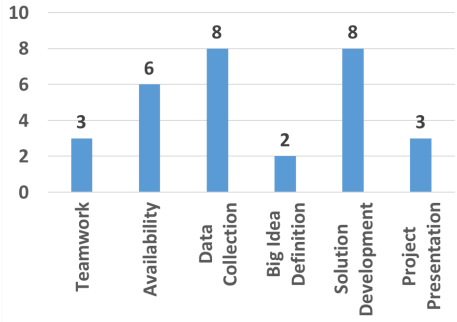

Figure 5: Difficulties during the Act phase.

In regard to the difficulties during the Act phase, the solution development was a critical point. We further found out that students felts that they did not have enough time during the semester to work on their solution. Some students even suggested that this class should be two-semester long. In this way, they would have more time to develop their solutions. Regardless of this perception, the professor stated that the students' solutions were appropriate for the scope of the course.

Finally, we wanted to understand how students dealt with when they needed to pivot their idea. In the CBL context, a pivot means that the current step must the revisited, or it is necessary to go back and redesign their previous step. For example, if a team is on the investigation phase and they find out that the challenge is not worth solving, they need to return to the Engage phase in order to adjust it according to their findings.

Figure 6 shows that only nine students understood the need to modify one or more aspects of the project during the investigation phase. This means that they either had to adapt their strategy during investigation or they had to go back to the Engage phase to adjust their challenge.

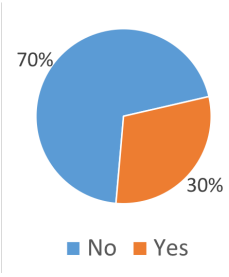

Figure 6: Percentage of students who pivoted during the investigate phase.

During the Act phase, however, more students felt the need to adjust part of the process (see Figure 7). This happened probably due to the fact that when teams begin working on their solutions, it becomes clearer whether or not they are closer to solve the challenge. Therefore, more adjustments might be needed in order to nail on the solution.

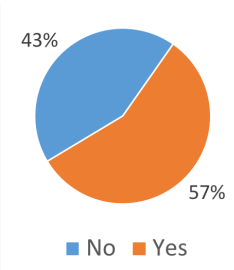

Figure 7: Percentage of students who pivoted during the act phase.

Regarding assessment, this course had no written exam. Students were evaluated throughout the whole process by presenting their evolution on a weekly basis. This accounted for 60% of their grades. The remaining 40% was related to the final pitch presentation. It is important to point out this assessment configuration has nothing to do with the CBL process. The goal of this approach is to focus on the journey and not only at the end result.

5.3 Students' and Teachers' Perceptions

In addition to the questionnaire, the perceptions of students and faculty were also collected (reflections). The purpose of this analysis was to identify positive and negative aspects as well as improvement points in regards to the CBL methodology.

From faculty stand point the application of this methodology was very interesting, because it brought to the classroom the construction of a business project based on a real opportunity. According to the professor, the methodology allowed students to work on a solution based on a consistent research process. Since students were connected to the challenge they were trying to solve, the level of engagement grew as teams learned more about the context their were working on. Even though teamwork is not a trivial process, by focusing on users' needs, team members were able to solve conflicts more easily, since they were excited about delivering value to people they care about. A negative aspect would be the lack of time to work on the Act phase. When students got the work on their solutions, the semester was almost over. The professor suggested breaking down this course into two semesters, so students could investigate in the first semester, and focus an entire semester to work on their solutions.

In regards to the students' perceptions on the CBL methodology, what called our attention was the lack of engagement in the beginning of the semester. Most students admitted that their focus was on passing the course. They were not concern about what they would be learning. However, the Engage phase was key to change this perception. Since students were working on something they cared about, engagement went up. One student said: "*I never like when teachers ask us to research on a given topic. However, when it is something that I have an interest on, the game changes; it becomes more fun. I did not even realized I was actually studying.*"

One interesting aspect about the Investigate phase is that some students felt frustrated about their findings, since they could not validate their hypothesis and had to restructure their challenge. However, this was a big learning point: the process of developing a business is cyclical. There is a need to iterate with customers and users in order to understand exactly what they want. The professor helped students dealing with this frustration by explaining that it would be way worse if they had build a whole solution that would be useless to users. In fact, these students saved time.

Students also agreed that there was not too much time to work on the solution. One team mentioned that they would continue working on the project after the course was over. However, this was an important take away from this course: one semester might not be enough to fully experience a software business creation.

6 DISCUSSION

The use of CBL as a learning methodology for startups development have provided many positive dimensions to students, including the possibility of collaborative work, the reflection process for their learning process, the active searching for technical knowledge, as well as the personal involvement to solve a real problem.

Unlike other learning methodologies e.g.: *Problem or Project Based Learning*, the CBL foundations are characterized by the active and experiential learning, where students can actively acquire knowledge through work on open-ended problems. The possibility and flexibility of allowing students to choose their own projects and problems to be solved are great differential that increase students' engagement throughout the learning process.

During one semester students needed to define which problem and customer would be tested in order to run a set of experiments and to validate whether their problem was relevant for possible customers, collect customers' feedback, and to develop a solution for the problem, and test whether the business could gain traction. This process in a short period time was one of the big challenges faced for those who want to create a startup, specially for undergraduate students with no experience in dealing with real users.

Collecting information from real users is always a challenging and difficult task. Many students have reported that interaction with users, as well as the constant discovery of new requirements in the searching for the solution of the problem have created some barriers to develop an efficient solution of the problem. One possible solution for this situation could be the application of lean startup strategies into the methodology, where customer interaction must occur in short cycles of time during the solution development, maximizing the learning process and minimizing the risks of a useless solution.

7 CONCLUSION

In this study we presented the use of the Challenge Based Learning (CBL) methodology in the educational context of an undergraduate software startup entrepreneurship course. CBL is a powerful methodology that allows students to keep focused on the development of a solution for a real world problem. Our results showed that the usage of CBL have fostered students' engagement during the startup development process. Moreover, students have reported that the methodology was crucial to keep them motivated to develop a solution which really does the difference in people's lives.

As we can observe in many learning methodologies, CBL also has a set of steps that must be followed in order to reach the proposed final goal. In this sense, our results have also demonstrated that an issue faced by was the short period time (one semester) to follow all steps in order to develop a real startup. Since it is crucial to have constant interaction with potential users and customers, lecturers must find creative ways to minimize this problem. It is worth mentioning that teaching software startups is not an easy task. As already presented in another study [3], it is hard to mimic a real world scenario in a classroom environment. Instructors must be creative in connecting students to real problems and real users.

As future work, we are planning to update the CBL methodology framework in order to introduce some lean startup and customer development concepts during the investigation, solution and validation phases. Therefore, we can have a more thorough method that allows students not only to obtain the technical skills needed to develop a startup, also students could connect themselves with potential customers in order to get real world experience.

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