PEDAGOGICAL RESULTS: JOINT ENTREPRENEURSHIP COURSE IN ENGINEERING AND BUSINESS SCHOOL

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ABSTRACT

This paper has the objective of testing the effectiveness of a joint course in entrepreneurship carried out by a teaching team from two very distinct schools in Brazil: one school of engineering and one school of business. The joint initiative came in the wake of an effort by both institutions to improve its pedagogical approaches and exactly when both schools were trying new methods of active learning. IME, the engineering school, was implementing CDIO. FGV EBAPE, the business school, was implementing PBL. This paper tests the effectiveness of the joint undertaking by evaluating the perception of the students at the end of the course according to four pedagogical principles, namely *development of attitudes and skills; revealing the students' knowledge in the classroom; striving for deeper understanding so that knowledge is usable; and taking a meta-cognitive approach to make students take control of their own learning*. The results from the survey of former students strongly suggest that the pedagogical methodology used in this joint entrepreneurship course fulfilled all principles and indicated its effectiveness in improving learning.

KEYWORDS

Active Learning, Problem Based Learning, Entrepreneurship Education, Standard 8.

INTRODUCTION

The new technological products and services enchant the youth worldwide. Several young men and women decide to study engineering and business to be part of this new world and contribute to solve an uncountable amount of problems. Beyond this, building a new business becomes an alternative to new graduates compared to the traditional quest for a good job in a well-established company. Hence, *entrepreneurship* becomes a mandatory subject within the curriculum of both engineering and business programs.

The implementation of successful technological business is not an easy task. Among several factors, the specialists highlight the *team building* as one of the most important critical

success factors in new companies (Tan & Frank Ng, 2006). In this context, not only the synergy between the company founders is important, but also having complementary abilities. Engineering students and professionals normally deal with technology and know very little about business methods. At the same time, business students and professionals have a lot of knowledge of business, but usually are not able to develop technological products or services to solve real problems. According to these premises, it is reasonable to think that a joint course that puts together students from these complementary courses, business and engineering, will contribute for the development of successful business ventures.

This article describes a joint implementation of an entrepreneurship course between two elite Brazilian schools: the Military Institute of Engineering (IME) and the Brazilian School of Public and Business Administration of Getúlio Vargas Foundation (FGV EBAPE). The main feature of this course is the intense use of active learning as the core pedagogical method. The review of the literature revealed that this work presents a different approach compared to previous articles. Nabi et al. (2017) developed an extensive survey about entrepreneurship in higher education and created an integrated teaching model framework to encompass the entrepreneurship education impact and the underpinning pedagogy. This framework considers three “archetypical” teaching models in higher education, as proposed in Béchard and Grégoire (2005): supply models (normally focused on lectures), demand models (student participation in terms of “exploration, discussion and experimentation” using, for example, library, interactive searches, and simulations), and competence models (based on active learning). The same framework also considers different types of impacts obtained from entrepreneurship education such as entrepreneurial intentions (Barba-Sánchez & Atienza-Sahuquillo, 2018), interest, knowledge, survival of startups and contribution to society. Nabi et al. (2017) suggest that competence model pedagogy is better suited for developing higher level impact and identifying a research gap to explain the reasons for the superior results of such competence models.

Differently from other approaches, this article focuses on the pedagogical results obtained from the application of active learning to address four pedagogical principles. The authors identified in the literature three key findings by the Committee on Developments in the Science of Learning of the National Research Council of the U.S. which have strong implications for the way teaching is done (National Research Council, 2000, p. 26-30). These findings were translated into three principles, namely *revealing the students’ knowledge in the classroom*, *striving for deeper understanding so that knowledge is usable*, and *taking a meta-cognitive approach to make students take control of their own learning*. The authors also selected the *development of skills and attitudes* as an additional factor because of its increasing importance in engineering and business education worldwide and its presence as a core motivation for the CDIO implementation (Crawley et al., 2012).

The authors contend that the joint entrepreneurship program developed by IME and FGV EBAPE was able to effectively cover these four pedagogical principles. This contention is tested through a survey applied to a sample of former students of the course. The authors also believe that this approach contributes to address the research gap identified in Nabi et al. (2017), mentioned in the previous paragraph.

Another important topic in this article is the description of non-intended results obtained from the relationship between IME and FGV EBAPE at this course. FGV EBAPE teachers had the opportunity to learn about the CDIO implementation at IME and could foresee the possibility

of transferring engineering education best practices to the business education environment and vice-versa.

Considering the main features described above, the article is structured as follows: a) Explanation of the partnership between IME and Getúlio Vargas Foundation (FGV); b) Description of the course itself highlighting the PBL classes; and c) Evaluation of the pedagogical results of this course through a survey applied to 40 students. At the end, the article briefly discusses the non-intended results mentioned above and closes with concluding remarks.

PARTNERSHIP BETWEEN IME AND FGV

The Memorandum of Understanding (MoU) between FGV and IME was established in August 2014. Since that moment, several activities have been running with fruitful results. IME students attend graduate and undergraduate courses at FGV and there is also faculty exchange. The Brazilian School of Public and Business Administration (EBAPE) is one of several schools that belong to FGV. Hence, the MoU also comprises activities that have been carried out with other schools. FGV also provided valuable support in IME's strategic planning in 2015, and e-learning support for IME students who were abroad participating at international internships. Regarding specifically the Entrepreneurship course, its joint implementation met FGV and IME needs, but was particularly driven by the Brazilian Army (BA) Commander's view that entrepreneurship could help modernize the Army.

IME and FGV have been discussing further joint activities. After the success of the entrepreneurship joint course, representatives of both organizations have been planning other collaborative efforts in research and the creation of a joint graduate and undergraduate programs.

COURSE DESCRIPTION

The Entrepreneurship course, taught by teachers from both institutions, was divided into two main parts. In the first half of the course, several entrepreneurship concepts were presented for discussion among the students, focused on the *lean startup* method (Blank and Dorf, 2014). This part also included the study of topics about business model canvas, strategy and marketing, in addition to lectures and discussion with angel investors. In the second half, the students were tasked to develop their own startup in groups of four or five, using the methods learnt in the first half.

The main goal of the first part (half) was to promote real-life case discussions and demonstrate their correlation with the main theories in this field. This part aimed at familiarizing the students with developing tools, analyzing customer feedback and developing the product or service. Thus, the students should be able to understand the importance of a real-world learning system to develop the competence of testing recursively, in a trial and error process, which would help them to fine tune the product based on market expectations. The course meetings in the first part were held once a week and were conducted using the Problem Based Learning (PBL) method. For the retention of the main concepts, the teachers applied, beyond the PBL, other active learning methods, such as group discussions, extra-class activities and lectures with practitioners and experts such as funding agency officials and real investors.

In the second part of the course, the students organized themselves into groups evenly comprised by students from IME and FGV EBAPE. The groups were challenged to create a startup and make, at the end of a seven-week period, a pitch for real investors from the local entrepreneurial ecosystem. During this time, the groups were advised by the teachers and encouraged to “get out of the building” to test their solutions against the needs of real customers.

At the end of the course, the students should have enough knowledge to develop the process of creating a startup on their own. Actually, the first cohort had one group which successfully launched the startup at the pitch presentation class, and after one year already expanded its activities from Rio de Janeiro to São Paulo. The second cohort taught last semester had one startup sold to a large company for a significant sum of money.

Class using PBL

As previously mentioned, the first half of the course was conducted on weekly meetings. A workbook, with the underlying problems, was developed to prepare and guide the students for the classes in PBL format. The problems had to stimulate students’ curiosity and engagement and represented a reference to raise a set of questions that would guide the self-study. In view of that, four problems were developed for debate, incorporating the entrepreneurship topics selected by the teaching team. The students were advised to prepare for debate covering the bibliographic material provided, as well as other materials considered important by the students themselves.

The teaching team applied the PBL method in seven steps, as proposed by Moust et al. (2013, p. 22):

Step 1: Clarify unclear terms and concepts in the problem text
Step 2: Define the problem: What exactly needs explaining?
Step 3: Problem analysis: Produce as many ideas as possible
Step 4: Problem analysis: Arrange the ideas systematically and analyse them in-depth
Step 5: Formulate learning goals
Step 6: Seek information from learning resources
Step 7: Synthesise and apply the new information

The students received one problem every week. The students tackled the problem through three phases each week: phase 1) Pre-discussion, which comprised steps 1 to 5 and took place during the second half of class time; phase 2) self-study, which was represented by step 6 and took place outside the classroom; and phase 3) Post-discussion, which was represented by step 7 and took place during the first half of class one week after the pre-discussion class.

Because the PBL method requires intense interactions, the class size is small. Therefore, the class was divided into four subclasses, with about 15 students each. The class is usually run by one teacher, but thanks to a large number of teachers volunteering to participate in the innovative undertaking, the subclasses could afford to have two teachers each.

The mix of students in each subclass changed every week. The students were assigned to subclasses by an algorithm which ensured that each student would meet all 60 students through the four sessions of the first half of the course. This procedure promoted greater integration and ensured that, by the end of the four sessions, all 60 students had met each

other in a subclass. The system enabled constant exchange between students and teachers, offering them the opportunity to be in contact with all people involved in the learning process. Each session is conducted by a leader and a secretary, and both are chosen by the students themselves on a rotating basis. The leader's role is to conduct the discussion and connect the content studied in the bibliography with the real life problem. The leader should strive to produce a lively and balanced level of participation by all students. The secretary is responsible for taking notes and synthesizing ideas discussed in the meeting.

It must be emphasized that all the students were required to be prepared for the discussions by reading the indicated bibliography and were evaluated by the teachers at the end of each class. Teachers are responsible for concluding the discussion, reporting on the strengths of the group, pointing out the improvement (when applicable) and the academic performance of each student.

In each class, a participation grade was assigned, ranging from 0 to 1, which had a multiplicative effect on their mid-term evaluation. Although the grade was given only in the post-discussion, it took into account the student's performance in the pre and post-discussion for each "problem". Students who did not attend the class would be given 0 (zero) on that meeting. Nevertheless, students were required to attend a minimum percentage of classes.

Preparation, presentation, and participation were the bases for the grades in each class.

Application: building startups

The startup construction took place in the second half of the course aiming at applying the content studied in the PBL classes. At the beginning of this phase, the students presented a seven-minute pitch with the outline of their proposed business model for the startup. The teachers collectively validated the proposals, suggesting the necessary adjustments and defining the next steps for the development of the startup according to the lean startup method (Blank & Dorf, 2012). The advisory sessions started after this validation.

Each group of students, formed by a maximum of five and comprised by at least two students from each institution, was advised by two teachers, who assumed the role of tutors from that moment on. Throughout this process, the students carried out the following activities for the project development: market analysis (including customer discovery); business hypotheses and validations; pivoting; customer development and validation; supplier study; marketing plan; operational plan; and financial plan. In addition, students held meetings with potential clients and partners, carried out consumer research, and talked to investors who assisted them with market experience and knowledge of different scenarios that could affect the success of a new business.

At the end of this stage, the groups presented their pitches in an event open to the general public and special guests. The startup projects were evaluated by a panel of investors who evaluated the projects for future investments.

PEDAGOGICAL RESULTS

As mentioned in the Introduction, the pedagogical results presented in this article are related to four pedagogical principles proposed by the authors on the basis of studies carried out by Crawley et al. (2012) and the Committee on Developments in the Science of Learning of the U.S. National Research Council (National Research Council, 2000).

The four pedagogical principles can therefore be described as the following: a) development of attitudes and skills; b) revealing the students' knowledge in the classroom; c) striving for deeper understanding so that knowledge is usable; and d) taking a meta-cognitive approach to make students take control of their own learning. This section describes how the pedagogical principles are related to the application of the PBL method and other active-learning practices held during the course.

Development of attitudes and skills

The PBL section is a formal meeting conducted and reported by students but supervised by a teacher. During these sections all the students can express their ideas about the subject they learned during the previous week. Additionally, the students must listen carefully to the speech of their colleagues to make suitable comments about the questions that must be answered. Hence, it is possible to say that the PBL sections contribute to the development of oral speech, active listening and team working.

Revealing the students' knowledge in the classroom

The teacher must listen carefully to the student conclusions about the subject of the featured problem. In this moment the preconceptions and misconceptions are revealed and the teacher can intervene and make comments. Comparing the PBL section with the traditional lecture, the PBL section provides many more opportunities to express his opinion about the subject and to actively use the theoretical knowledge acquired during the self-study time outside the classroom.

Striving for deeper understanding so that knowledge is usable

The choice of building a limited curriculum with a deeper approach is normally hard for the teachers. However, research reveals that this approach contributes to the construction of a well-structured knowledge schemata. Additionally, this principle emerges from the research that compares the performance of experts and novices in learning and transfer of knowledge. This principle was used in the syllabus preparation. Several topics (lean startup, business model canvas, design thinking and blue ocean strategy) and books were initially selected. However, the teachers decided to focus on the lean startup method (which uses the business model canvas) to increase the students understanding about this topic and simplify the knowledge transfer for different situations.

Taking a meta-cognitive approach to make students take control of their own learning

The word meta-cognition is reflexive: thinking about your own thinking. In this context, it is related to development of the critical thinking about what each student learned individually. Once the PBL sections create an opportunity for the students to express their ideas and to listen to the other colleagues' knowledge about the featured problem, each student can make a self-criticism and look for additional learning, if necessary.

Questionnaire and its objectives

The questionnaire intended to evaluate the pedagogical results of the Entrepreneurship course according to the principles described above. The course was offered twice so far, and

approximately 90 students attended the course in total> A sample of 40 former students responded the questionnaires. Table 1 presents the questions and the answers.

Table 1. Questionnaire results

Question #1: Do you believe that the application of PBL method in the entrepreneurship course ***contributed*** for the development of your interpersonal skills:	
Yes – 90%	No – 10%
Question #2: Which interpersonal skills were developed during the PBL classes (more than one option may be selected):	
Team Working – 55%	Oral speech – 87.5%
Active Listening – 72.5%	None – 2.5%
Question #3: Do you believe that the PBL classes provided you the opportunity to expose your knowledge about the featured topics?	
Yes – 90%	No – 10%
Question #4: Do you feel able to put into practice the things you learned in the Entrepreneurship course?	
Yes, certainly – 42.5%	No, I cannot remember anything – 5%
Yes, but only if I could review the subjects – 52.5%	No, it is not possible to apply this subject – 0%

Questions #1 and #2 have to do with the first principle: *development of attitudes and skills*. It is clear that most of the students believe that the PBL sections contributed to the development of their skills. Moreover, it is important to highlight that all the students had another chance to practice *team working* and *oral speech* in the second part of the course, when they needed to build a startup and present their work for investors in a pitch section.

Question #3 is related to the second principle: *reveal the students' knowledge in the classroom*. It is clear that most of the students believe that they had the chance to reveal what they knew about the topic. Hence, there is evidence that the PBL method contributes to improve the learning process. It is important to notice that the methodology tasks teachers to correct substantive mistakes when the teacher sees a lack of time for the students themselves to correct a mistake during a specific class.

Question #4 is related to the third and fourth principles: striving for deeper understanding so that knowledge is usable, and t*aking a meta-cognitive approach to make students take control of their own learning.* The question itself measures the student's confidence to transfer the acquired knowledge to practical situations, and results from the entire course and not only from the PBL classes. The answers show three levels of learning/confidence: a) extremely confident, b) confident and c) not confident. These are outstanding results for the

teacher group (95% of the students feel confident to apply the knowledge acquired in the course) and show high usability of their knowledge after the end of the course.

ASSESSMENT OF LEARNING

The PBL method, with the pre-discussion class and the post-discussion class on the same topic, allowed the teachers and students to clearly view the progress between two sessions. We specifically monitored the students and the results were the following.

Problem 1: It is the actual description of two girls who decide to start a business in their last year of a management undergraduate program. In PBL, the description is purposefully incomplete, terms regarding solar energy and solar panel production are used as if addressing an audience of experts. Therefore, most students have scant idea of the terms and the issue and they start in the pre-discussion class by asking as many questions as there are doubts. Then, they are given one week to do research and to spend time in groups for developing the answers. One week later they discuss which are the best answers in the post-discussion.

Table 2. Analysis for Problem 1

Listing and Discussion of unknown topics Aug 11th 2017 (Pre-discussion)	**Answers developed by students in Aug 25th 2017** (Post-discussion; summarized)	**Observed objective learning** (Teachers meet right after class to evaluate the learning by the students as a whole)
Q1) What is a startup?	A1) Firms with an innovative business, scalable, and generally with a base in technology.	O1) Starting from mostly no idea, in one week students understood the concept and presented several examples discussed in groups. O2) Had no idea. In a week they were using “unicorns” to describe potential startups. O3) From not knowing much about solar energy in Brazil, in 1 week they understood the merits of clean energy and the relative advantage vis-à-vis other countries. O4) They also understood the existence of many related areas to be exploited as business. O5) From a general idea of what means to be sustainable, the students
Q2) What are unicorns?	A2) Unicorns are startups with Market value upwards to a billion dollar. Examples are Facebook, Uber, Airbnb, Spotify, among others. Because solar panels represent clean and sustainable energy, relatively low cost and plentiful in Brazil.	
Q3) Why produce solar panels?	A3) Main opportunities: photovoltaic system integrators, various consulting and advisory services (environmental, legal, tax, land, financial, solar resource evaluation, technical / engineering, training and qualification), certification services, etc.	
Q4) What business opportunities are there in this area?	It is the development of actions that allow man to meet his current needs without compromising the future of the next generations.	
Q5) What is sustainability?	As mentioned in the Brundtland Report, Our Common Future: "Essentially, sustainable development is a process in which resource exploration, investment direction, the path of	

	technological development and institutional change are in harmony and improve men's ability to have their needs and aspirations met both now and in the future."	were able to pinpoint the origins and precise meaning of the term.
Q6) What is the canvas method?	Business Model Canvas is a tool developed by Alex Osterwalder that helps the entrepreneur map and model his business, helping him in the process of creation, differentiation and innovation. It provides an integrated view of the business being proposed. The Business Model Canvas is divided into 9 areas: Client; Relationship; Channels; Value Proposition; Activities; Resources; Partners; and Sources of revenue.	O6) From not knowing anything, they discovered that it was a very useful way of understanding a business model through nine dimensions, with the value proposition at the center, how to enchant the customer, how to build an essential infrastructure, and how to make it produce income.

Problem 2: This problem uses the same underlying story about the girls planning the launch of a startup for production solar panels with social inclusion. The problem mentions some business tools that may be used to analyze the conditions to implement the new venture and guide the students to raise questions, including the main topic of this problem: the Customer Discovery stage in the development of a startup.

Table 3. Analysis for Problem 2

Listing and Discussion of unknown topics Aug 25th 2017 (Pre-discussion)	**Answers developed by students Sep 01st 2017** (Post-discussion; summarized)	**Observed objective learning** (Teachers meet right after class to evaluate the learning by the students as a whole)
Q1) What is Porter's Five Competitive Forces method?	A1) This method helps the companies to analyze the market and the competitors. The five forces are: Rivalry among existing competitors; Threat of new entrants; Bargaining Power of Buyers; Threat of Substitute Products or Services; and Bargaining Power of Suppliers.	O1) From a general idea of this concept, students could relate Porter's Five Forces concepts with the founding of new ventures. O2) Starting from mostly no idea, the students could contextualize the concept of *market in perfect competition* within the entrepreneurial environment. O3) The market estimation techniques were unknown for IME students. FGV EBAPE students could compare the technique proposed in the textbook with their previous marketing course.
Q2) What is a market in perfect competition?	A2) It is a theoretical kind of market that has a great number of companies and buyers and, for this reason, neither companies nor buyers can influence the equilibrium price.	
Q3) How can we estimate the market size?	A3) One possible approach is to define the total market, the addressable market and the accessible market for the startup products and services. To be successful in the estimation you should follow the rules: a) be generic first and specify your	

	market afterwards, b) be realistic, c) use reliable data, d) consider possible future changes.	O4) The Lean Startup's Customer Discovery was unknown for the students. The post-discussion was rich to put together previous and new knowledge in the entrepreneurial setting.
Q4) How can we discover potential customers?	A4) Searching and interviewing people that are possibly interested in the product or service.	
Q5) What is the *downstream* of the production chain?	A5) It is the part of the logistic chain that takes the product to the final customer.	

Problem 3: Following the same idea of the previous problem, the Problem 3 continues telling the same underlying story about the solar panels entrepreneurs. The story evolves showing their difficulty to meet the customer needs and guide the students to search for deeper understanding about the Lean Startup and the Customer Validation stage.

Table 4. Analysis for Problem 3

Listing and Discussion of unknown topics Sep 15th 2017 (Pre-discussion)	**Answers developed by students Sep 29th 2017** (Post-discussion; summarized)	**Observed objective learning** (Teachers meet right after class to evaluate the learning by the students as a whole)
Q1) What means business model pivoting?	A1) Pivoting means the implementation of changes in the business model. It normally happens when some problem is observed during the contact with customers.	O1) Starting from mostly no idea, in one week students understood the Lean Startup method and how it uses other important business concepts. O2) The students learned a lot in the post-discussion comparing Porter's Generic Strategies with the Blue Ocean Strategy. O3) The concept of MVP was unknown for most of the students and they could understand the importance of this initial version of the product for the *customer validation* stage.
Q2) What is customer validation?	A2) It means testing the proposals obtained from the prospective customers. The second step of the Lean Startup's C*ustomer Development.*	
Q3) What is the relationship between the customer validation and the MVP?	A3) It is very important to obtain an MVP that satisfies the customer needs. The MVP will be offered as an initial product to the customers, during the *Customer Development*. Its acceptance is an indication that the improved product will be also successful.	
Q4) What is the relationship between the Blue Ocean Strategy and the Porter's Generic Strategies?	A4) Porter says that it is not possible to have both product differentiation and low cost. The Blue Ocean Strategy suggest that it is possible and must be chased by the companies.	
Q5) When is relevant the change of product design?	A5) a) to improve product delivery, b) to enhance the market share, c) to reduce production costs, d) to follow the needs of most customers.	

The group of teachers analyzed the knowledge achievements in each session. This tool was important to catalog the learning results, and monitor the quality of the PBL problems proposed. This step was important to prepare the students for the startup construction.

NON-INTENDED RESULTS

As experienced by the Olin College of Engineering and Babson College that purposefully built the campus adjacent to each other, just proximity is not enough for a desired and expected synergy to occur. As the Provost of Olin College explained to one of the authors who visited them this year, the differences in culture between Olin and Babson were significant and they had not anticipated that. Curiously, the results attained by this joint entrepreneurship course had great success not only among the students, as shown by the survey results, but also among the faculty involved. The initial objective of the joint course was to respond to the request made by the Brazilian Army Commander to instil some entrepreneurial thinking on to rule abiding but less entrepreneurial military personnel. Surprisingly, in quick succession, one successful business startup in the first cohort was followed by an even more successful business startup in the second cohort.

CONCLUSION

The pedagogical results achieved by this joint initiative through an entrepreneurship course present an interesting evidence that this undertaking was a clear success according to the four principles considered: a) development of attitudes and skills; b) revealing the students' knowledge in the classroom; c) striving for deeper understanding so that knowledge is usable; and d) taking a meta-cognitive approach to make students take control of their own learning.

In other words, it suggests that there are significant gains to be obtained by joint partnerships between business and engineering schools if carefully designed along the pedagogical principles tested in this article. Further studies with larger samples are needed to confirm this initial finding.

As described in this article, most students have the first formal contact with the subject in this course. Additionally, although the course is only two years old, the authors are proud to have two successful former-student startups in operation, and one is being traded to be bought by a larger company. Its founders will become millionaires before graduating.

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BIOGRAPHICAL INFORMATION

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Waldemar Barroso Magno Neto was IME provost between 2014 and 2017, when started the CDIO implementation. In this same period, the joint course of entrepreneurship was initiated and had him as part of the teaching team. Currently, he is member of the implementation council of the new engineering program in blended learning format and teacher of entrepreneurship, both at the University Center UniCesumar.

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