Transforming Ideas and Developing Entrepreneurship Skills in Computing Sciences and Informatics Engineering Courses

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ABSTRACT

This paper presents an approach on entrepreneurship education which helps to turn ideas into Minimum Viable Products (MVP) and to capacitate students to become entrepreneurs. In this approach, we integrate development and management project to different business models. Students acquire, in addition to technical competencies, skills on market knowledge and business modeling. This approach has been applied for several years in an informatics engineering course and suggests a set of activities on 18 weeks. Teachers' perceptions and students' opinions were collected through direct observations and using a questionnaire in order to evaluate the process behind this pedagogical project which goes beyond the walls of the university. Most of the students are satisfied with the process since they develop projects that have a good fit with the market needs and opportunities and some of them are close to creating a startup.

CCS CONCEPTS

• :; • **Applied Computing**; • **Education**;

KEYWORDS

Informatics Engineering, Business Modeling, Entrepreneurship Education, Minimum Viable Product, Startups

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1 INTRODUCTION

Recently, authors as [2] and [3] stated that educators around the world are better cognizant of the need to adapt their entrepreneurship education and training systems to prepare young people for a future global knowledge economy. Similarly, entrepreneurs bring an enormous contribution to a country's economic growth. Developing individual's interest into new venture creation represents an important asset, especially for less developed countries where entrepreneurial activities are fundamental in enhancing economic growth [4].

Recently, it was mentioned [5] that in China reexamined the objective of training professionals according to market demand and meeting the needs of society and, for this, they established a curricular system with a good relationship between companies and universities. In [6] emphasized the cooperation between education entities and enterprises since this process not only provides guidance for the students' innovation and entrepreneurship, but also help to strengthen the close relationship between the development of higher education and local economic.

In [7] examined the evolution of scientific research in Entrepreneurship Education among 1987 and 2017, based on publications in the Web of Science database. The performance analysis results showed that students, rather than teachers, have become the main agents of the educational process. Furthermore, in [8] asked whether entrepreneurship could be taught to students in engineering, science and technology majors via the use of dedicated teaching models. Based on their review, it appears that the choice of pedagogy (i.e., experiential, active and cooperative learning) seems to be the most efficient way to design curriculum for technology entrepreneurship. In [9] authors proposed a course model for STEE (Science and Technology Entrepreneurship Education) that has been designed to enable academic researchers to play a more active and informed role in the commercialization of their discovery. They conclude that participants made significant gains in their confidence associated with both technology-development and the business-related tasks pertinent to STEE.

In [10] found that engineering graduates assessed that their university education helped them to develop significantly better problem-solving skills, critical thinking, self-evaluation skills, ability to develop new ideas and solutions, leadership skills and obtained significantly less entrepreneurial and financial knowledge during their studies. In [11] authors presented a methodology for

the development of startups, which enables a procedure for the integrated development of the product as well of the business model. As stated by [12] the entrepreneur spirit can be taught and the applied methodologies can improve through active participation.

In [13] was mentioned that the majority of the university programs use only Business Model Canvas (BMC) as a tool for the business modeling, and [14] showed that BMC appears as one of the most used tools for the development or documentation of new or existing business models. Thus, one of the biggest advantages of using business model, such as BMC, is that it gives to the entrepreneur a holistic view of his business. On the other side, the Value Proposition Canvas (VPC) is a tool that helps to align the value proposition of the offering with what the customer values and needs, in order to make it a better fit for the market.

Thus, in this paper, mainly motivated by the need to teach business modeling to engineering students, we present and discuss an integrated approach for teaching entrepreneurship in an informatics engineering course that addresses several business models (such as BMC, VPC, SWOT, Value chain, Competitor analysis, Porter´s five forces, financial and economic indexes), all of them aligned with the technological requirements. This education approach has been used in a 10-year period. We show the perspective from students and teachers and we present some lessons learned.

This paper is organized into six sections. Section 2 describes the main tools used in business modeling and section 3 presents our education approach. Section 4 introduces the materials and methods and discusses the main findings after 10 years using this experience, and finally, section 6 presents the conclusions.

2 TOOLS USED IN BUSINESS MODELING

According to [15] the majority of companies use the BMC - Business Model Canvas (100%), SWOT (78.6%), followed by the Blue Ocean Strategy 41.6%), Five Forces (39%) and Lean Startup (36.5%). In addition, other tools are used, like Balanced scorecard (36.25%), Value Chains (35.3%), Customer development (29.6%), strategy maps tools (26.9%). The canvas popularity is increasing and entrepreneurs are more aware of the benefits of using them. Not only entrepreneurs and startups started using it, but also universities, research institutions and big corporations. The Customer Development tool from Steve Blank and the Lean Startup method from Eric Rise are also directly linked to the BMC, due to many similarities of these models.

Another tool widely used is the VPC (Value Proposition Canvas). This tool acts as a framework to ensure that the offering is actually desired by the market and is capable of satisfying the customers' needs. This reduces the chances of the product failing in the market to a large extent. The VPC can be used both for refining an existing product/service and for launching an entirely new one in the market. Whatever the case, it is an essential tool to visualize, design, and test how can be created value for customers.

The VPC is an extension of the BMC with a focus on customer profile and value map. It requires the entrepreneur to observe what the customer actually wants and then design a value proposition that overcomes the customer's problem. It includes two elements: **(1) customer profile**, to observe the target market, and **(2) value proposition map**, to design the value proposition of the offering. The customer profile section includes important details about the needs, wants, pains, and gains of the target market. It is further divided into three parts (customer jobs, pains and gains).

These two very well-known tools (i.e., BMC and VPC) can be complemented with other ones. Namely, the Strategic Analysis Canvas (SAC) allows one to quickly see areas where a startup's strategy diverges from the competitors. As concluded by [16], SAC can be developed by associating concepts of strategic planning, strategic thinking and design thinking, which can be integrated with the BMC. The SAC model also helps to discover opportunities for innovation, and competitive differentiation. Similarly, to BMC, it has nine components: mission, competitors' analysis, PESTLE (analyzes the general environment in terms of Political, Economic, Socio-Cultural, Technological, Legal and Environmental), industry, competitive advantages, strategy, value chain, and SWOT (Strengths, Weaknesses, Opportunities, and Threats). In strategic analysis efforts should be made to introduce ways of taking advantage of opportunities in the strategy, taking advantage of strengths as well as minimizing weaknesses and threats.

Finally, students must perform an economic analysis, in addition to the development of the different types of canvas model. In order to validate the product, we propose each team to conduct a financial forecast. In this phase, we request the following information: (i) source of income, (ii) predicted sales forecast – focusing in a 5 year period, (iii) expected annual expenses in supplies and external services, (iv) staff expenses, (v) Investments: Throughout the years, it is also planned to make some necessary investments, so we also request: (vi) financing – since that an initial financing is crucial for the success of many projects and usually a company, in its early stages, does not have the financial stability to support its expenses; (vii) cash flow forecast, considering a 5-year period, (viii) break-even forecast, and finally, (ix) information about evaluation.

The evaluation of a project can vary widely, depending on several factors. So, for this last step, in terms of economic and financial evaluation, we recommend the use of the following three indicators: (1) **Internal Rate of Return (IRR)** indicates the return of a project; if this rate is higher than the rate of capital cost, it can be said that the project is viable; (2) **Playback Period** tells the time needed for the amount invested to be returned; (3) **Net Present Value (NPV)** indicates the sum of all inflows and outflows of money during the life of a project.

3 BUSINESS MODELS IN ENGINEERING COURSES

This approach has been used in the course 'project of informatics engineering' (PIE), which was launched in the academic year of 2009/10. It is part of the last year of the Informatics Engineering master's degree, promoted by the School of Engineering at the University of Minho (Portugal). It is a total effort of 420 hours for each student and requires a period of 18-weeks [17].

This approach seeks to internalize in students the need to reconcile the technical knowledge with a focus on business and entrepreneurship that most of them never addressed in their previous educational contexts. The main idea of this course is to enable students to acquire a core set of competencies related to a team-driven development of a software product, and the analysis of the business potential of that product.

This approach can be used in undergraduate or graduate courses, with the aim of transforming an idea into a specific product or service. The main objective of the course is to enable students to acquire a set of skills related to (1) the development of a software product (requirements, analysis, design, implementation, testing and management), working as a team and (2) the analysis of the business potential of that product.

Students are organized into medium-size teams (7/9 members) to carry out the project within a limited time frame (around four months). The students are evaluated during the execution of the project based on the deliverables and presentations that they produce jointly.

As a result, students acquire, apply and develop a set of skills that, in most cases, was not properly explored in the previous academic path and that the market valuates very positively. This set of skills includes technical knowledge and competencies (related to requirements engineering, documentation, design and testing) and business profiles (such as leadership, management, team organization, presentation, communication, marketing, business modelling, and entrepreneurship).

The validation process should be performed based on the feedback obtained from (potential) customers. In this way, validation cycles are performed until a valid value proposition is obtained. In order to bring external contributions, the teachers promote regular (on a weekly basis) contact of the teams with experts in the software business field. These sessions allow teams not only to obtain technical feedback about their products, including suggestions and recommendations related to the business model. In the same sense, whenever deemed appropriate, seminars on relevant topics are organized (e.g., development of business plans for software products, project management, and agile software development). The interaction with the outside world culminates and has its defining moment on the final pitch. Thus, this approach can be operationalized on a set of 11 activities, which are next detailed.

(1) Team composition: The number of students in each team varies depending on the number of students enrolled in the course. The choice of students with different technical backgrounds is suggested in order to have people in the team with different and complementary competencies and skills.

(2) Ideation and idea selection: Preferably, students should propose the ideas; thus, they get more motivated to develop them. However, it is possible to consider ideas from a third party. The idea that a group develops should be selected by its members as the result of a brainstorming.

(3) Double Diamond: This course is divided into two phases, known as double diamond, the first one where the focus is identifying and developing the business idea and the second one focused on developing the product.

(4) Seminars: This course requires various skills that, in most cases, students did not address in their academic experience. Thus, there is an opportunity to exploit them. Thus, short seminars are organized on topics that are repeatedly shown to be necessary and the teams understand as useful.

(5) Weekly meetings: The teams are mandatorily together one day a week. That period is also used for the team to meet with the teachers and invited tutors.

(6) Technologies and methodologies: No technology or software development process is imposed; similarly, students can choose the approach they prefer to build the business model.

(7) Contact with the market: The teachers promote regular visits of experts from industry and market.

(8) Pitches: pitches are made throughout the project development (3–5 minutes presentations) in three different moments: **(i) the first pitch** (initial) takes place in an early design phase (after 2 or 3 weeks), when the idea is not fully defined yet, thus seeking to obtain some feedback on the feasibility of the idea and how to continue with the project; **(ii) the second pitch** (academic) takes place when the project is near the end (4 weeks to the end) and it permits to evaluate the product and the business model proposed by each team, and **(iii) the third pitch** (business) takes place when the project is over (last week) and aims to present the product and its business model to a panel of experts from the software industry.

(9) Technical Reports: At the beginning of the semester, two dates for the deliveries related to the projects are established. **In the first delivery**, which occurs approximately in the middle of the project, each team shall provide a requirements document and a business plan (both in an intermediate version)**. The second delivery** should include the following elements: product vision; document requirements; project plan; project state of the document; installation documentation (if applicable); manual (or alternatively videos with explanations or help menus); and business plan.

(10) MVP (Minimum Viable Product): At the end of the course, each team must deliver a software system working properly. A plan, a simple vision of the system, or a prototype are not acceptable. The teams should also submit the source code, the tests performed, and related documentation. The product should be developed in a professional manner and function as expected with no obvious defects. The product is validated from both a user point of view and a technical one, in order to check how it is built and structured.

(11) Assessment: There are several ways to calculate the final grade of the curricular module. For example: (i) evaluate only the final MVP; (ii) consider the final work with its MVP, technical report and pitch; (iii) evaluate only the technical reports and respective pitches); (iv) evaluate only the pitches; (v) consider only the technical reports; (vi) consider proposal 2 adding aspects related to the business model and the quality of the programming and code used in the MVP presented; (vii) evaluate the grade of each team which can be calculated based on the following four elements: material of the first delivery (20%), contacts outside the university (20%), material of the second delivery (50%), and the academic pitch (10%), and others.

This course has been taught since 2009. During these ten years, 92 groups have been organized, with approximately 650 students, and all delivering a final MVP. In the last two editions, 2018/2019 and 2019/2020, the number of groups were, respectively, 20 and 13. During these two last years, two types of projects were developed, either proposed by students or external customers. In order to stimulate entrepreneurial competencies, students must employ project management techniques and deliver a cost-effective solution. In this paper, we consider the analysis of the project management, since we want to assess the methodology applied since the brainstorming session within groups until the MVP is delivered. This process is

likely to stimulate the undergraduate students with the opportunity to promote their products as a seed for building start-up companies.

The process started with a general presentation of the teacher responsible for this course. In this first meeting, the other five teachers who collaborated and followed the whole process were presented. In this meeting the students are left with the responsibility of forming the groups, nominating a group leader, and thinking about possible ideas for the products. Afterwards, in the following two weeks, there are periodic meetings, and each group discusses with the teachers the different possibilities related with each idea.

So, the **first phase** ends with the presentation of the first pitch, where each group presents the selected idea, some brief information from the market, and a summary of the competitors.

In the second phase, the teachers monitoring the process with weekly meetings. At these meetings, business artifacts and tools are discussed and the groups were asked to improve the characteristics and the requirements of the product/service. It was also recommended that they help themselves with information from a mentor with experience and knowledge of the market in the area of each project. This second phase ended with the second pitch and the delivery of a first technical report of the project, which, in addition to the business plan, is expected to contain technical information about technologies and computational tools that should be used in the development phase. These second pitches are evaluated by experts from the market, who provided feedback about the value/usefulness of the product and its market fit.

In the third phase, the students develop deeper the technical parts of the product, and the teachers follow the whole process with weekly meetings. In these meetings, the technical part and the business part are aligned. This third phase ends with the third pitch and final report. In this presentation, a functional version of the product/service is presented, and more accurate information about the market, the competitors, and the economic and financial viability are discussed. This final presentation is open to the public, with guests from companies, the city hall, startups, and society.

4 4. EXPERIENCES USING THE INTEGRATED METHODOLOGY

4.1 4.1 Materials and Methods

The paper uses an exploratory research design based on a case study. It is one of the most used qualitative research methodologies in educational research. The case study is based on multiple lines of evidence, based on triangulated proposals, and uses the previous development of theoretical propositions to guide data collection and analysis. In this article, the case study is based on several sources of evidence, and the sources were: document analysis (technical reports, presentations, source code analysis of computer programs and applications, guest comments on project presentations), interviews, direct observations, participant observation and physical artifacts.

Our case study is the course PIE (Projects of Informatics Engineering). Some of the data were collected through a self-administrated online survey. A link to the survey and a short description of the research objectives was sent to all 109 participants of the 2019/20 edition of the course. A sample of 79 respondents was collected (resulting in a return rate of 72,5%). On the other hand, the sample was not segmented in subgroups since we are not interested in analyzing the effects of gender, age, background, or experience and the intention to launch one's own business, but as the students of the course get benefits using the methodology.

The questionnaire was made available using digital media, via Google forms. An email was sent to all students one week immediately after the presentation of the last pitch and the delivery of the final report. They were given a week to complete the questionnaire. A 38-question questionnaire was proposed, with all questions with five possible answers (using a Likert scale score). The students could select for each question only one answer, the one that in their view was closest to what was actually done in their respective projects.

4.2 What Lessons can be Learned

Following the approach described in section III of this article, and based on the results of our case study using questionnaires and multiple lines of evidence, we present some points that deserve to be highlighted:

- **Mentor**: Importance of having the figure of a specialist (MENTOR) with experience and market knowledge in the idea proposed by each group. It helps to get to know better and match the proposed solution to the problem the teams want to solve, as they can know the pains of customers in the market, as well as understand more quickly if the solution will bring gains. This is relevant as it helps to define the VPC and BMC models, which can facilitate the requirements gathering process, which in turn facilitates having a product view and an MVP with SMART characteristics (Specific, Measurable, Achievable, Realistic, and Time-bound). Therefore, it helps in MVP and facilitates market entry (SAC model) and possibly;
- **Leader**: All students agreed that each group should have one of its members carrying out the activities of a leader, since he will assist in the coordination of all tasks and activities involved in the process. Hence, it is important to decide well who to nominate as leader. For that, models could be used to help understand the entrepreneurial and leadership profile of each of the team members, so as to make a good choice;
- **Team size**: This methodology is supposed to be carried out by groups of students, as far as possible with varied training, skills and competences. Students agree that the ideal size can be between 3 and 5 or between 5 and 7. They did not recommend small groups (less than 3) or very large groups (over 7);
- **Business Models**: As expected, VPC and BMC models are highly recommended to better understand the process of transforming an idea into a business;
- **Market Information:** Here the recommendation is for each group, at the beginning of the process, to research and to add information and market statistics related to the project idea. This information is relevant to have parameters for choosing the initial idea, and then in the segmentation of customers (to better understand the needs and desires of the market), they help to match the product to the market, as well as to define which primary characteristics and functionality to be included in the first MVP;

- **SWOT**: We recommend the use of the SWOT model, as it helps to better understand the strengths and weaknesses of the proposal, as well as understanding the market, in order to think about opportunities and challenges;
- **Competitor Analysis:** Similar to SWOT, it is one of the most used and recommended tools by students and teachers. The competitor analysis helps to better understand what is or will be the real difference of the proposed product compared to what already exists in the market. This helps to refine the use of VPC, BMC, and throughout the development of the project, it helps in obtaining a successful MVP;
- **Five Forces Model and Value Chain** – These two components of the strategic analysis (SAC) were not widely used by the students. They are more theoretical and formalized in business and administration courses, and this may be the reason why they tend to be optional in engineering projects. The relatively small duration of the project (18 weeks) can also have here an impact;
- **Economic Indexes**: Students must complete an Excel spreadsheet with economic information, such as the main costs of the project as a whole, possible money inflows with estimated product sales, costs associates, among others. Therefore, they learn to perform the economic and financial part. In this methodology, we recommend that students should deliver the following project indexes: IRR (Internal Rate of Return), PBP (Playback Period), and NPV (Net Present Value). With these indicators, students analyze probabilities of financial success with this product. In this phase, the spreadsheet is helpful, since it needs information such as Source of Income, Predicted Sales Forecast cost, among others, and it automatically get key outputs and economical indexes;
- **The final projects have better technical quality and market orientation.** This evidence improvement is also a consequence of the contacts made with different business stakeholders, which promoted a better adjustment between the product and the market;
- **Students are highly motivated with this methodology:** We have observed that the students end the course highly motivated, and their skills and competences improved while developing the project. This is a consequence of the methodology used, which integrates technical knowledge, business models, economic and financial aspects, and work in groups, in order to overcome real problems, to design solutions, and to present a good MVP;
- **More time dedicated to the technical part than to the business model**: We observed that informatics engineering students spent more time in technical and scientific activities. Despite of realizing the importance of having relevant information to refine business models, this part needs to be further improved. This part is relevant to have a good idea/solution that fits to the market. In others words, it is relevant to have a solid business, but students tend to be more focused on the technical part of the project;
- **Select and use a tool for project management**. In the PIE course, Redmine were used and students were satisfied with the use of this tool;
- **MVP** (Minimum Value Product) satisfactory. All groups came up with a partial solution of the planned product, that one can call an MVP. In some groups, the mentor has shown interest to become the first customer;
- Stimulating Entrepreneurship. Most students were satisfied with the entire process of this course (technical integration and business modeling), and wish to continue with the entrepreneurship process, and some of them indicated that launching a startup is among their career choices.

5 CONCLUSIONS

In this paper we present the teaching experiences in the course PIE (Project of Informatics Engineering) at University of Minho (Portugal). This course has been taught since 2009 and has been improved every year.

The objective of the course is to start with ideas and problems, and end up with a product or service, presenting a prototype with MVP characteristics. For this, students must integrate the technical knowledge of various subjects of the course with knowledge of the business world. The approach here discussed uses a sequence of eleven activities and completing the entire process in an 18-week period. This integrated approach was divided into two phases, known as double diamond. In the first one, the focus is to identify and develop the business idea and the in second one the product development is the main target.

In the business part, the use of different business models is recommended. For this, the students must (i) present a product, (ii) know and have information about the market, (iii) present a business model, and (iv) present strategies to introduce that product into the market. For this, the use of different business models, such as VPC (Value Product Canvas), BMC (Business Model Canvas), Strategy Analysis Canvas and economic and financial indicators, is recommended. Thus, over 70% of the students confirm that the use of these different validation models helps to have good requirements and allows them to devise an MVP more adjusted to the needs of the customers.

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