# A CONCEPTUAL MODEL TO OVERCOME THE FACULTY CHALLENGES WHEN INTEGRATING ENTREPRENEURSHIP IN UNDERGRADUATE ENGINEERING PROGRAMS

*by Jahannie Torres-Rodríguez[1] and Moraima De Hoyos-Ruperto[2]*

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## 1. INTRODUCTION

With advances of the 21st century come new challenges that cannot be solved by a single discipline. If engineering educational programs are to meet these challenges, they must comprehend the nature of workplace problem solving in order to better prepare their students for real scenarios (Jonassen, Strobel, & Lee, 2006). However, other authors argue that the learning model of engineering education has been the same since the 1950's; where large classes and single-discipline, lecture-based delivery were the norm (Mills and Treagust, 2003).

On the other hand, entrepreneurial education promotes the problem solving and identification of it as a mainstream. Therefore, an interdisciplinary perspective of engineering with entrepreneurial education may help to accomplish the goal to develop the 21st century

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[1] Jahannie Torres-Rodríguez is an undergraduate student at the University of Puerto Rico-Mayagüez Campus (UPR). She is pursuing a bachelor's degree in Computer Engineering with a focus on Software and a minor in Entrepreneurship. She has participated in several projects developing educational videogames, providing professional development to educators and growing entrepreneurial ecosystems through the student movement. Since 2015, she serves as leader, organizer and/or mentor of: (1) E.P.I.C. Makerspace, (2) Student Organization Idea Platform, (3) University Innovation Fellows Program at Hasso Plattner Institute of Design (d.school), Stanford University, (4) Lean Startup Program for Student Entrepreneurs and (5) UPRM Start-Up Job Fair.

[2] Dr. Moraima De Hoyos-Ruperto is an Associate Professor at the College of Business Administration (CBA) at the University of Puerto Rico-Mayagüez Campus (UPRM) and Co-Director of the Business and Economic Development Center (BEDC). She is offering courses within the minor of Entrepreneurial Development at the UPRM-CBA. She has participated in studies about how to promote the commercialization at the university, and how to strengthen the entrepreneurial ecosystem within the university. Since 2014, she serves as PI, Co-PI and/or Senior Personnel, of: (1) College Innovation: an ecosystem approach to tech venture, (2) Promoting Commercialization of Research through the U.S. Engineering Program "Pathways to Innovation" an Interdisciplinary proposal, NSF grant and (3) CREST Phase II Interdisciplinary Education Group, with the Entrepreneurship Educational Program for CREST Phase II: Nanotechnology Center for Biomedical, Environmental and Sustainability, NSF grant, among others. Dr. De Hoyos is a Co-founder of the UPRM E-ship Network a collaborative movement of professors, students and external allies to promote the business venturing. Also, is a board member of several non-profit organizations.

skills on university students. This study proposes a conceptual model to integrate entrepreneurial education in engineering programs by overcoming traditional education challenges with online education benefits; for the purpose of developing the entrepreneurial mindset and skills in engineering students while in turn develop the 21st Century skills.

## 2. LITERATURE REVIEW

In the engineering field, it has been found that there is a consistent mismatch in what universities offer and employers seek. More specifically in the skills undergraduate engineering students possess (Pellicane, 2015). When learning to solve problems in engineering, students usually face academic problems through a linear process to be memorized, practiced, and habituated (Jonassen, Strobel, & Lee, 2006); rather than the identification of real problems. This traditional educational approach does not help students in the development of 21st Century skills. Table 1, Sections 1 and 2 present the major difference between academic and practical problems approach according to Sternberg et al., 1995.

One way to close the mentioned gap is by introducing the entrepreneurial perspective across the engineering education. Entrepreneurial education is centered on the identification of practical problems to perform the entrepreneurial practices such as discovering, evaluating and exploiting opportunities (Bosman & Fernhaber, 2018). Sections 2 and 3 of Table 1 illustrate a list of similarities between the education focus on practical problems and the entrepreneurial education perspective.

However, this practical approach can also cause challenges to the faculty when integrating entrepreneurship subjects in engineering courses because of its differences with traditional educational system approach towards evaluation techniques and structure. Some of the challenges are: assessment, quantifying outcomes to obtain funding, curriculum changes that comply with accreditation, student entrepreneurial background and professor background.

**Assessment**

Since practical problems are unformulated and could have multiple accepted solutions, it can become difficult for the professor to measure the solution result for grading it. As Duval-Couetil (2013) highlights entrepreneurship education differentiate from other academic disciplines in manners that make assessing it particularly difficult.

**Quantify outcomes to obtain funding**

Funding opportunities usually ask for data driven reasons to invest in courses or programs. Financial support enables the university with hiring workforce, management, production of products, and mainly on the creation of infrastructure, services, training and education for innovation and entrepreneurship (Reyes, García, Medina, & De Hoyos, 2017).

**Curriculums changes that comply with accreditation**

In order to incorporate materials to develop an entrepreneurial mindset and skills in engineering courses, it is necessary to modify the curriculum. A process for curriculum changes in engineering education must include data collection and discussions to establish the proposal, the design and development process, as well the implementation plan (Walkington, 2002).

**Student entrepreneurial background**

When deciding to include entrepreneurial topics in an existing course, it needs to be taken into consideration that students may have different entrepreneurial backgrounds and experiences. This kind of diversity represented a challenge to the faculty in delivering a cohesive curriculum that could support each individual learner (Huang-Saad et al., 2015).

**Professor educational background**

Even in the case in which the professor has the knowledge or practical experience as an entrepreneur, the professor would need to design and prepare the material. This means that in order to include entrepreneurial topics in engineering programs, engineering professors would need to be trained on entrepreneurial subjects and resources available (ASEE, 2012).

Based on the literature review, we noticed that exists a challenge to the faculty that wants to overcome the gap between the academic and practical approach in engineering entrepreneurial education through the traditional educational system. At the same time, these challenges limit the development of the 21st Century skills, as well the entrepreneurial mindset and skills on students. This study proposes a model to overcome traditional instruction challenges of engineering entrepreneurial education with an online approach.

## 3. CONCEPTUAL MODEL

Current evolutionary changes in educational technology and pedagogy will be seen due to its benefits for students, the organizations, and to society (Hiltz & Turoff, 2005). Online education provides additional benefits to collect historical data, measure outcomes, integrate modules in already existing courses, allow students to navigate open content and co-teach with experts in the field. Diagram 1 shows our proposed model to address the traditional engineering entrepreneurial education challenges through online education as details as follow.

### Historical Data

Online education provides wide opportunities to teach and evaluate students. The platforms that are used to deliver courses in this modality include features for grading, measure student engagement and student participation. In fact, it seems that assignments and project that involve critical thinking, creativity, problem-solving and group interaction are more appropriate for online e-learning (Baporikar, 2014).

### Measure outcomes

The ASEE highlighted the importance of the measuring progress in implementing policies, practices, and infrastructure in support of scholarly and systematic innovation in engineering education (ASEE, 2012). Online education not only allows to measure historical data, but also to maximize resources, making the process of integrating entrepreneurial education in engineering programs more scalable without limitations of place and time.

**Integrate modules in already existing courses**

Flexibility is seen as the key to the development of higher education (Collis and Moonen,2001). This flexibility can help to create courses in a modular manner in which modules can be integrated into engineering established curriculums as part of a set of transversal competences.

**Open Content**

Other of the benefits that online education platforms have is to present open content adapted to everyone's needs (Romdhane, 2014). Therefore, students that are in different levels of entrepreneurial intent could use the material that they need when they need it.

**Prepared by Experts**

The Innovation with Impact Report (ASEE, 2012) recommends that to build a stronger foundation for engineering education, there should be more collaborations and partnerships between engineering programs and other disciplinary programs. Hence, engineering professors would not need to be trained or prepare material about entrepreneurship, instead those materials could be developed by experts and integrated in engineering courses.

## 4. CONCLUSIONS

This study starts with a discussion of the disconnection of engineering education with 21st century problems, causing students to not fulfill the necessary skills to identify and solve them. Having in mind that the skill of identifying and solving problems is a mainstream of the entrepreneurial education, an approach to integrate entrepreneurship in existing engineering courses was discussed. An overview of the main concerns of traditional educational approach was also presented. The main concerns exposed here are assessment, quantifying outcomes to obtain funding, curriculum changes that comply with accreditation, entrepreneurial intent stages and professor preparation. Therefore, a model to overcome these traditional education challenges with online education was proposed. This implies that administrators could benefit

from the features that online education provides to measure outcomes for funding requests or administrative processes. On top of that, they could also benefit of an innovation in education that do not affect the accreditation status. On the other hand, this model implies that students will have access to open content that adjusts to their need. Lastly, educators can benefit from a more detailed historical data of their student's behavior and engagement and can benefit from co-teaching with experts in entrepreneurial topics.

The future work of this study includes the development of questionnaires to measure both qualitative and quantitative data that demonstrate perceptions, expectations and concerns on the use of online education to develop entrepreneurial mindset and skills in engineering students in comparison with the traditional face to face approach.

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***Appendix A.***

*Table 1: Comparison between academic, practical problems and entrepreneurial practices*

| (1) Characteristics of academic problems approach | (2) Characteristics of practical problems approach | (3) Similarities between the education focus on practical problems and the entrepreneurial education perspective |
|---|---|---|
| (a) formulated by others | (a) unformulated or in need of reformulation | (a) Entrepreneurs may have an idea about the problem they're trying to solve, but it's not until they validate it through the customers discovery process that it's formulated or reformulated. This uncertainty not only relates to finding a way to build the solution (feasibility), but also uncertainty as to how the customer will react (desirability) or whether the solution is viable from a business sense (viability) (Bosman & Fernhaber, 2018). The goals and constraints are uncovered during the design thinking process. (Glen, Suciu, & Baughn, 2014). |
| (b) intrinsically uninteresting for the most part | (b) personally interesting | (b) Entrepreneurs undertake because of a personal interest or motivation, several researchers proposed that these could include the need for achievement, the need for independence and desire for wealth (Morales-Gualdrón, Gutiérrez-Gracia, & Dobón, 2009). |
| (c) self-contained, in that all needed information is available from the beginning | (c) lacking information necessary for solution | (c) In general, entrepreneurship researchers stated that entrepreneurship is associated with certain risk taking because entrepreneurial activities are associated with decision-making under uncertain conditions (Kusmintarti, Thoyib, Maskie, & Ashar, 2016). Entrepreneurs use different methodologies to seek information that is lacking in when creating a solution. |
| (d) disembedded from an individual's ordinary experience | (d) related to individual's everyday experience | (d) Entrepreneurs design solutions to relieve their customers pains and *provide them a better experience*. When taking this approach, entrepreneurs are designing with humans in mind. IDEO points out that human-centered design offers problem solvers a chance to design with communities, to deeply understand the people they're looking to serve, to dream up scores of ideas, and to create innovative new solutions rooted in people's actual needs (IDEO, 2015). |
| (e) well defined | (e) poorly defined | Sometimes when entrepreneurs are designing a solution, they first define a symptom and not the real |

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|---|---|---|
| | | problem. One deviation from the rational paradigm is that designers are often not able to completely define the problem prior to testing out solutions (Glen, Suciu, & Baughn, 2014). |
| (f) characterized by a 'correct' answer | (f) characterized by multiple correct or at least "acceptable" solutions, each with liabilities as well as assets | (f) A person who has the character of tolerance for ambiguity tends to seek as much information as possible first, and then manages the information as a basis for decision making (Kusmintarti, Thoyib, Maskie, & Ashar, 2016). Entrepreneurs may design different solutions for the same problem but for different customer segments. Unlike the solution to a scientific problem, which can be judged in terms of correct or incorrect or true or false, design solutions are assessed in terms of better or worse, which is highly dependent on the specific context of use (Glen, Suciu, & Baughn, 2014). |
| (g) characterized by a single method of obtaining the correct answer | (g) characterized by multiple methods for evaluating a problem solution | (g)The main aspect of proactiveness that belong to an entrepreneur is their effort in introducing new products to the market as well as their readiness to seek a variety of information about a lot of thing to prepare the next step (Noer, Idrus, Hadiwijoyo, & Wirjodirdjo, 2013). Entrepreneurs can get this variety of information by empathizing through *different methods* such as customer interviews, customer observations and prototyping testing. |

*Diagram 1: Online education model proposed to address traditional engineering entrepreneurial education challenges of faculty*