

An Entrepreneurship Education Co-Curricular Program to Stimulate Entrepreneurial Mindset in Engineering Students

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ABSTRACT

There is a need to expand the fundamental skills in science and engineering to include innovation & entrepreneurship (I&E) skills as core competencies. To better prepare the future Nanotechnology workforce, the University of Puerto Rico-Mayagüez Nanotechnology Center, broadened the educational content beyond traditional skills in science and engineering. The Center, offers a rich educational program for materials and nano scientists that aims to create the next generation of knowledgeable, experienced professionals, and successful entrepreneurs, who can develop value-added innovations that can spur economic growth and continue to impact the quality of life for society. Within the educational program an Entrepreneurship Education Co-Curricular Program (EEP) incorporates I&E training into the Materials Science, Nanotechnology, STEM (Science, Technology, Engineering, and Mathematics) faculty and student experiences. The EEP consists of a two-year series of workshops that seek to develop an entrepreneurial mindset, including five key topics: 1) Generation of Ideas, 2) Entrepreneurial Vision, 3) Early Assessment of Ideas, 4) Identification of Opportunities, and 5) Strategic Thinking. The EEP goals, target audience, and implementation strategy, is described with an evaluation tool to assess the program's success in developing an entrepreneurial mindset.

INTRODUCTION

Entrepreneurial mindset, is defined by Putta (2014; pag.71), as a specific state of mind which orientates human conduct towards entrepreneurial activities and outcomes; drawn to opportunities, innovation and new value creation [1]. Several studies show the relevance for individuals to have an entrepreneurial mindset to start an entrepreneurial journey [2,3]. An entrepreneurial mindset, implies an awareness of the importance of managing risk, experiencing failure, and ambiguity [4]. Therefore, an individual with an entrepreneurial mindset, should have the capacity to solve problems, provide creative and innovative solutions on an environment of risk and ambiguity, and the vision of new possibilities and opportunities to generate an uncommon new idea [5,6]. Entrepreneurial individuals, also need to have the innovative skills to assess early their ideas and act over it with strategic thinking [7,8].

The entrepreneurial mindset can be developed in individuals through formal courses, programs, competitions, and/or interventions where they can [9-11] broaden their understanding and implementation skills. Hence, students can be influenced by entrepreneurial learning experiences through curricular, co-curricular, and extra-curricular activities, where entrepreneurship is being taught as a set of practices, not as a process [2].

The challenge is to overcome the misconception that it is only about creating a business venture. Engineering students may have the entrepreneurial skills, but do not consider themselves as entrepreneurs [4]. For that reason, their self-perceptions about their capacity to identify opportunities, entrepreneurial concepts, and self-efficacy is a key starting point for any

intervention program [10]. Therefore, our program was designed based on the five steps described in the article: “Considerations to establish plans to foster entrepreneurial development: Lessons for the future” [12]. These steps include: 1) Understand your target group mindset; 2) Visualize where you need to take their mindset next; 3) Develop a plan that may help in moving the target; 4) Implement a strategic plan to reach your goal, and 5) Evaluate their progress.

In the following sections, we propose a two-year integrated model of five educational modules to develop and/or strengthen five entrepreneurial skills that are considered basic requirements for any person who wants to spark their entrepreneurial mindset [13]. To assess the impact of the integrated model, a questionnaire was developed as a pre-test/post-test for each intervention.

ENTREPRENEURSHIP EDUCATION PROGRAM (EEP)

In the fields of Materials Science and Nanotechnology, it is essential to develop human resources with a myriad of life-long skills, abilities, knowledge, and tools to face the continuous challenges of the future workforce [14]. In order to better prepare the future Nanotechnology workforce, in 2014, the UPRM Nanotechnology Center [15,16] broadened the educational content beyond traditional skills in science and engineering, to include topics such as intellectual property, scholarly communication, technology transfer, and I&E skills. The strategy aims to imbue I&E training into multiple aspects of the student experience and offer numerous outlets for student creativity; building entrepreneurs from the “ground up” by using the student's innate curiosity and ingenuity, while assisting them in becoming society's next innovators [17]. The strategy revolves around a practical co-curricular two-year cycle of multi-format activities; aimed towards Nanotechnology, Materials Science & Engineering, and STEM faculty, teachers, high school students, graduate, and undergraduate students, with a focus on Entrepreneurship Education. The Entrepreneurship Education Program (EEP) consists of structured workshops on five particular I&E subjects, and individual mentoring for students who show interest. The program (figure 1) aims to develop an entrepreneurial mindset in the all human resources, preparing UPRM students for successful insertion into the future Nanotechnology workforce, as an intrapreneur or entrepreneur, while complementing their laboratory experiences. The final goal of the EEP is to assist participants in the process of making a connection between their research in academia and the potential and innovative, real life applications of their scientific research.

Figure 1 presents the EEP integrated model, linking five specific I&E topics and tools, across the cycle to develop an entrepreneurial mindset. This two-year cycle includes workshops during the summer to integrate participants from the Materials Science & Engineering High School Student Summer Camp and the Research Experience for Teachers Program [18]. In particular, the EEP targets five (5) primary topics for the development of an entrepreneurial mindset, according to the level of the audience addressed. Although we know there are several skills that are important in this process, we have selected these topics to accomplish our goal: 1) Generation of Ideas, 2) Entrepreneurial Vision, 3) Early Assessment of Ideas, 4) Identification of Opportunities, and 5) Strategic Thinking.

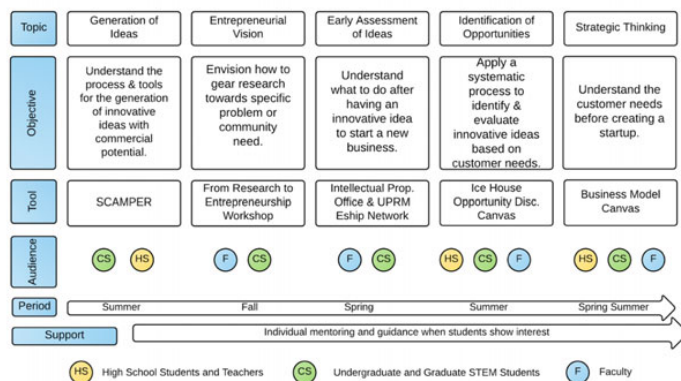


Figure 1. Integrated model for the Entrepreneurship Education Program (EEP).

Entrepreneurial Vision implies the ability to see beyond what exists right now. As such, the program tries to engage participants that may empathize with a specific problem as a way to gear their research towards meeting those needs. Opportunities exist; however, the key is to be able to identify them. Hence, participants are urged to reflect about the different possible solutions to one problem. To accomplish that, a systematic process to identify and evaluate innovative ideas based on customer needs is used. Being creative and innovative are essential skills for the entrepreneurial path, but individuals also need to be able to assess those ideas strategically and early on in the process. Therefore, the EEP integrate educational practices such as creation, experimentation, and play focus on customer needs. All workshops were designed and developed using an active learning approach through the practice-based entrepreneurial education model to develop students who can act more entrepreneurially [2], better known as actionable theory. To ensure the engagement of participants, each workshop follows the educational learning process shown in figure 2. Consequently, the assessment tool evaluates the impact of the EEP workshops on participant's mindset and, at the same time, provides them a tool about their awareness, attitudes, and self-efficacy perception. The questionnaire was developed to address three specific mindset related criteria based on the participant perception: Criteria 1 (C1): the ability to discover and the willingness to exploit and identify existing entrepreneurial opportunities [19,20], Criteria 2 (C2): the UPRM Nanotechnology Center impact towards their mindset and support of individual actions that may lead to a new venture [21,22], and Criteria 3 (C3): an individual's assessment of his/her ability to carry out a task in a successful way [23-25] or Self-Efficacy.

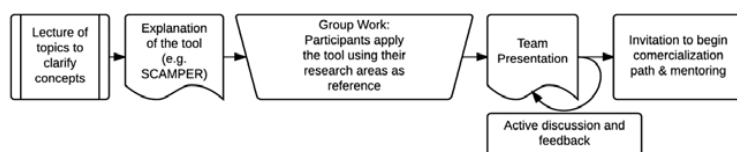


Figure 2. Educational learning process for the Entrepreneurship Education Program (EEP).

METHODOLOGY

In order to evaluate the impact of the EEP on entrepreneurial mindset, participants were provided a unique identifier at the beginning of the program in order to track their progress through the program. At the beginning of the workshop, participants complete the pre-test, which include all three parts of the questionnaire and at the end of the workshop, participants complete a post-test, which includes only the general and mindset questions.

The Entrepreneurship Mindset Questionnaire includes three sets of questions: (1) demographic questions (i.e. gender, age, program of study/group, member ID), (2) general questions, and (3) entrepreneurship mindset questions. The questionnaire was created in both English and Spanish, with questions adapted from different questionnaires identified in the literature [26,27]. The English version of the questionnaire is presented below.

General Questions

1. Do you want to be an entrepreneur?
☐ Yes ☐ No
2. Do you have a business idea / product / service or technology that you would like to develop?
☐ Yes, but not clear
☐ Yes, and it is very clear
☐ No, but I would like it
☐ No, and I don't care
3. What do you think **you need** to start to develop your business idea/ product/service or technology?
4. What do you think **you have** that will help you develop a business idea/ product/service or technology?

Entrepreneurial Mindset Questions

These questions relate to the level of understanding, motivation, and desire towards entrepreneurship and is aligned with each specific mindset criteria (Entrepreneur's perception of opportunities (C1); National Mindset toward Entrepreneurship (C2); Entrepreneur's Self-Efficacy (C3)). The questions relating National Mindset towards Entrepreneurship have been adapted to focus on the Nanotechnology Center (CREST) impact towards Entrepreneurship. In this section, participants need to indicate the level of agreement with each statement using a 5 point Likert Scale (5=Completely Agree; 4=Agree; 3=Neither Agree nor Disagree; 2= Disagree; 1=Completely Disagree).

1. In my view, there are good opportunities to create new products/service/technologies. (C1) [26]
2. In my view, there are more entrepreneurial opportunities than people that are able to take advantage of them. (C1) [26]
3. I could easily pursue entrepreneurial opportunities. (C1) [26]
4. I was encouraged by the CREST project to be individually successful through its promotion of autonomy and personal initiative. (C2) [26]
5. I was encouraged by the CREST project to take entrepreneurial risks. (C2) [26]
6. The CREST project stimulates creativity and innovativeness. (C2) [26]
7. I was encouraged by the CREST project to take charge of my own life. (C2) [26]
8. I am able to achieve most of the CREST project's goals that I have set by myself. (C3) [27]
9. I am confident that I can accomplish any difficult task. (C3) [27]
10. I am confident that I can perform effectively on many different tasks compared to other people. (C3) [27]
11. I can perform quite well in spite of adversities. (C3) [27]

CONCLUSIONS AND FUTURE WORK

In an approach to encourage life-long learning, the goals of this effort include generating highly skilled, productive, motivated, and creative scientists and engineers. Recognizing the need for commercialization of research, this program creates a bridge to fill the gap between fundamental and applied research in materials science and engineering, and commercialization of that research, taking into account business considerations and intellectual property.

The integrated model for the Entrepreneurship Education Program (EEP) goes beyond traditional skills in science and engineering, following a holistic approach to human development. The EEP workshops presents a two-year intervention program that consists of five structured workshops on the innovation and entrepreneurship arena and individual mentoring, to develop an entrepreneurial mindset in all the program human resources.

As anecdotal result, we have started to see the impact of the EEP on undergraduates, graduates, and faculty members of the Nanotechnology Center that have participated on the first cohort of workshops. Also, the Innovative and Entrepreneurship movement developed during the last two years at the UPRM named "UPRM E-ship Network" has enabled the connection between all the stakeholders related to the entrepreneurial ecosystem in and out the UPRM to leverage the opportunities of entrepreneurial experience and commercialization.

As a preliminary impact, four undergraduates and two graduate students, and one faculty member of the Nanotechnology Center program have taken advantage of the EEP mentoring to start their process of market considerations, intellectual properties and/or the development and design of an innovative technology for commercialization. For that, the EEP interdisciplinary faculty provide, in addition to the workshops, a one-on-one mentoring and insertion into the Puerto Rico entrepreneurial ecosystem allied in some way or another with the UPRM.

In conclusion, the integrated model of Entrepreneurial Educational Program developed by the Educational Program for Innovative and Entrepreneurial Materials and Nano Scientists of the UPRM Nanotechnology Center seems to be a fundamental resource in the process to close the gap between the scientific research community and the commercialization path. Our experience has started to demonstrate it. Based on that experience, we have developed a structured educational program and an assessment tool to measure the change in mindset on the

participants. In the future, we expect to analyze the results from the pre-test and post-test on the EEP workshop and assess the impact of the program in the Center's human resources.

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