

Entrepreneurial Education Program for STEM teachers and students

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Abstract

The STEM workforce requires skills and competencies not covered in traditional education. Conventional teaching usually focuses on passive learning, whereas non-traditional topics such as entrepreneurship, needs more active learning approaches. The University of Puerto Rico- Mayagüez Campus (UPRM) Nanotechnology Center (CREST) designed a two-year cycle extra-curricular program to enhance the entrepreneurial skills and mindset in STEM teachers, high school students, and university students. This Entrepreneurship Education Program (EEP) consisted of a series of workshops that used an active learning approach to generate innovative solutions to real-life problems related to participant's areas of research. Through a pre-test, post-test questionnaire, a study was developed to assess the entrepreneurial mindset change in the EEP participants based on opportunity identification, individual self-efficacy, and entrepreneurial environment awareness factors. Results indicate that the EEP workshops had a positive impact on the perception of the individual's entrepreneurial opportunity identification, entrepreneurial environment awareness, and self-efficacy.

Keywords

Entrepreneurial Mindset, Opportunity Identification, Entrepreneurial Environment, Self-Efficacy, Entrepreneurial Education in STEM

Introduction

The entrepreneurial mindset is a state of mind or orientation which grants an individual with the ability to adapt to any given context to achieve innovation, value creation, and other entrepreneurial activities to resolve problems creatively.^{1,2,3} The requirement of this state of mind isn't limited only to entrepreneurs, since the skills and attitudes of an entrepreneurial mindset are compatible with some of the 21 century skills that all people have to possess as part of the workforce.⁴ Peterman and Kennedy⁵, Pihie and Sani⁶, and Romaguera⁷ suggest courses, programs, competitions, and specific interventions help develop the entrepreneurial mindset in individuals. Therefore, the entrepreneurial mindset is a teachable skill, but educators should go beyond traditional teaching methods integrating what students learn and do in the classroom with real-life applications in their research areas and future works.

Entrepreneurial education should combine diverse active-learning methods, such as lectures, workshops, case studies, special projects, internships, and even field trips to real-world businesses to develop the entrepreneurial mindset on individuals.^{3,6,8,9} These methods incite creation, discussion and reflection to build entrepreneurial knowledge and experience through an "experiential learning from doing".¹⁰ Therefore, topics such as the identification of opportunities, creativity, innovation, strategic thinking and other non-cognitive skills like socialization, motivation, self-esteem, self-control, and forward-thinking behavior are fundamental for a change in the student's attitude toward entrepreneurship and their mindset.^{3,9, 11, 12}

UPRM-CREST Entrepreneurship Education Program (EEP)

With National Science Foundation (NSF) support, the UPRM developed the Nanotechnology Center (named CREST) for Biomedical, Environmental, and Sustainability Applications. The Center's mission is to combine transformational research and education efforts in the area of nanoscaled materials.¹³ The UPRM-CREST broadened the educational content beyond traditional skills in science and engineering, to include entrepreneurship education through a program called Entrepreneurship Education Program (EPP) as part of the objective of developing human resources to face constant challenges in the future workforce of the Materials Science and Nanotechnology field¹⁴. The EEP consists of five (5) structured workshops, which focused on innovation and entrepreneurship subjects: generation of ideas, entrepreneurial vision, early assessment of ideas, identification of opportunities and strategic thinking. In a two-year cycle, for almost five years to now, the UPRM-CREST coordinated and offered the workshops to all the participants of the program. The participants are members of the UPRM-CREST program which included STEM faculty, teachers, high school students, graduate, and undergraduate students who participated voluntarily in the workshops.¹⁵ All the EEP's workshops have a duration of an hour and a half and were designed using an active learning approach through the practice-based entrepreneurial education model. The program provided basic concepts on innovation and entrepreneurship topics and hand-on activities with commonly used tools to foster the entrepreneurial mindset.

The primary goal of the EEP¹⁶ is to develop an entrepreneurial mindset on the UPRM-CREST participants. To nourish them with the attitudes and skills for the future workforce, as intrapreneur or entrepreneur, in their respective work fields. The time distribution of the workshop started with an explanation of concepts and tools. The second step was the implementation, including the creation of a presentation. In the end, participants presented and shared a reflection of the process. Small groups worked all the activities and tools according to their areas of research in the CREST program. The professor who offered the workshop stayed as a facilitator during the whole process. SCAMPER, Opportunity Discovery Canvas and Business Model Canvas are tools commonly used in entrepreneurial education courses (Figure 1 showed all the tools used).

Topic	Generation of Ideas	Entrepreneurial Vision	Early Assessment of Ideas	Identification of Opportunities	Strategic Thinking
Objective	Understand the process & tools for the generation of innovative ideas with commercial potential.	Envision how to gear research towards specific problem or community need.	Understand what to do after having an innovative idea to start a new business.	Apply a systematic process to identify & evaluate innovative ideas based on customer needs.	Understand the customer needs before creating a startup.
Tool	SCAMPER	From Research to Entrepreneurship Workshop	Intellectual Property Office & UPRM Eship Network	Ice House Opportunity Discovery Canvas	Business Model Canvas

Figure 1. The Entrepreneurship Education Program (EEP) tools and objectives for STEM students and faculty

Measuring the Entrepreneurial Mindset

Shane's¹⁷, Shane and Venkataraman's¹⁸, Krueger and Brazeal's¹⁹, Guiso, Sapienza, and Zingales's²⁰, and Casson's²¹ work presented key factors that can be used to assess the entrepreneurial mindset on an individual. In this study, we evaluated three factors that may impact if individuals act more entrepreneurially or not: identification of entrepreneurial opportunities^{17,18}, individual's self-efficacy¹⁹, and the national mindset toward entrepreneurship^{20,21}. Identification of entrepreneurial opportunities means the willingness to discover and exploit existing possibilities to take entrepreneurial advantage.^{17,18} Self-efficacy is the willingness that could drive an individual's assessment of his ability to carry out an entrepreneurial task in a successful way.¹⁹ While the environment around the individuals including existing social and cultural accepted standards may encourage or discourage entrepreneurial actions.^{20,21} Figure 2 shows the conceptual framework of the Entrepreneurship Education Program created by the Nanotechnology Center of the University of Puerto Rico-Mayagüez Campus to develop the entrepreneurial mindset on their program's participant.

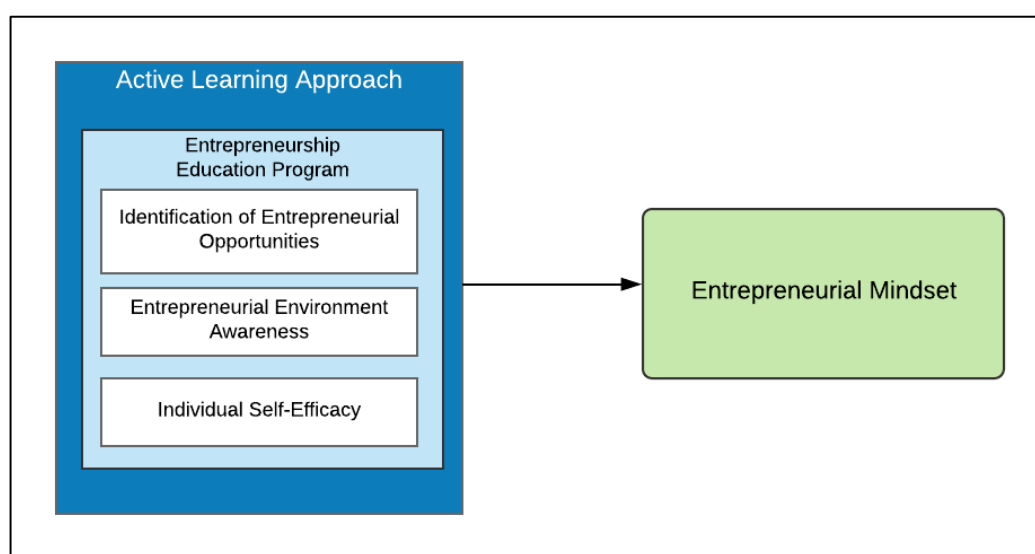


Figure 2. The entrepreneurship education program conceptual framework

Methodology and sample

The purpose of this research study was to evaluate if there was any change in the participant's entrepreneurial mindset based on their gender, self-reported a desire to be an entrepreneur and a business idea. Each participant answered the same questionnaire at the beginning as a pre-test, and the end as a post-test to measure the impact of the workshop in the participant's mindset. The questionnaire included three groups of questions: four demographic questions, four general questions, and eleven entrepreneurial mindset questions that targeted one of three components studied: opportunity identification (C1: OPPO), entrepreneurial environment (C2: ENVI) and self-efficacy (C3: SELF).²² The entrepreneurial mindset questions included three OPPO items, four ENVI items, and four SELF items. OPPO and ENVI questions are adaptations from Reynolds, Bosma, Autio, Hunt, De Bono, Servais, López-García and Chin²³, and SELF questions are adaptations from Chen, Gully, and Eden²⁴. The entrepreneurial mindset questions used a 5-point Likert scale (1 "completely disagree" to 5 "completely agree"). Example of the questions are:

- Do you want to be an entrepreneur? (General)
- Do you have a business idea / product / service or technology that you would like to develop? (General)
- In my view, there are good opportunities to create new products/service/technologies. (C1: OPPO)
- I was encouraged by the CREST project to take entrepreneurial risks. (C2: ENVI)
- I am confident that I can perform effectively on many different tasks compared to other people. (C3: SELF)

The sample includes one hundred and twenty-nine (129) students or teachers that participated in eight workshops during the last four years of the CREST project. Five participants attended three different workshops, while 17 participated in two different workshops of the series. A total of 94 participants answered 121 surveys (total includes multiple workshop participants). After inspection of the responses, due to incomplete data in the questionnaire responses, the final dataset had 79 unique participants and a total of 100 questionnaire response sets. Overall, 43% of the 79 unique respondents were male, and 57 % were female. Most participants were graduate students (N=23), followed by high school students (N=20) and teachers (N=20), and 15 undergraduate students. The largest age group were participants of more than 25 years of age (44%), followed by 17% between the ages of 23-25 years, 16% between 14-16 years, 13% between 17-19 years, and 10% between 20-22 years of age. The respondent's characteristics show the outreach diversity of the CREST program.

This study analyzes the reliability of each construct using Cronbach's Alpha coefficient. Cronbach's Alpha test showed a high level of consistency (Pre-test = .81, Post-test = .91) between the three factors that compose the entrepreneurial mindset construct. Comparative analyses were done using Paired-T test and Chi-squared. Paired T-test was conducted to examine if there was any difference between the pre-test and post-test scores of the participants. Chi-square test was performed to identify if there was any difference by gender on the desire to be an entrepreneur or on having a business idea. Other descriptive statistics were used to analyze the demographic data.

Results

Results for overall mean score differences amongst pre-test and post-test analysis for each entrepreneurial mindset factor indicate that the EEP workshops had a positive impact on the perception of the individual's entrepreneurial opportunity identification, entrepreneurial environment awareness, and self-efficacy as shown in Figure 3. On the other hand, even though more than 65% of participants wanted to become entrepreneurs (N=51), the majority did not have a clear idea of a product or service they could create. Besides, this study did not find any association between participant gender and their desire to be an entrepreneur or on having a business idea.

The nature of this research, a case study based on a single program, makes it difficult to generalize the results. However, these findings contribute to the entrepreneurial education and entrepreneurial mindset field examining not previously considered STEM populations.

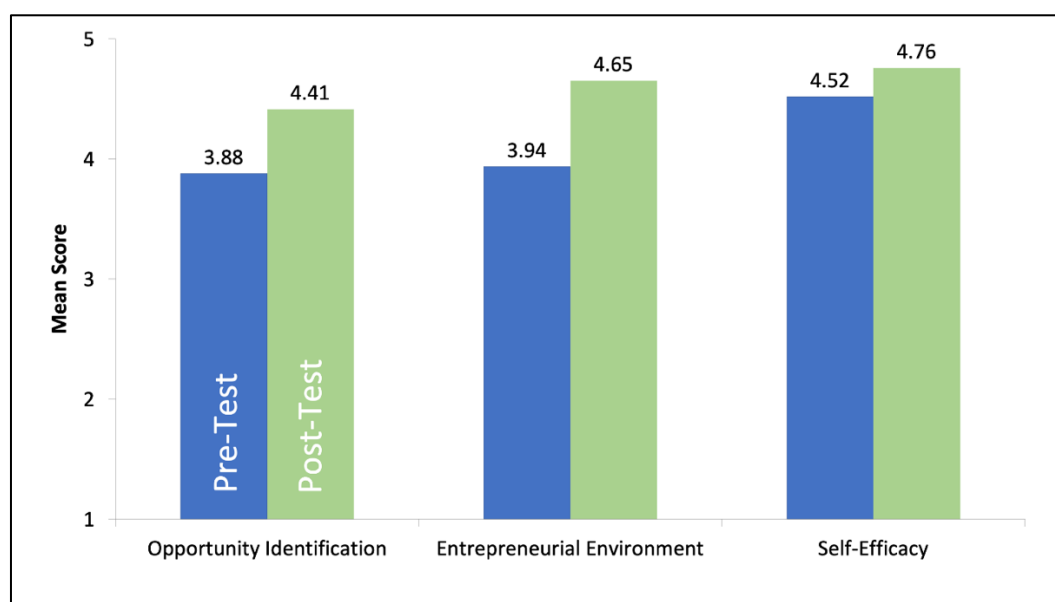


Figure 3. Pre-test and Post-test mean score chart.

Discussion

The Nanotechnology Center of the University of Puerto Rico- Mayagüez Campus goes beyond traditional STEM subjects and methods of education through a series of active learning workshops on innovation and entrepreneurship themes. The conceptual model of the Entrepreneurship Education Program encompasses a two-year series of workshops that integrate what participants learn and do with real-life applications of their research work. The program aims to develop an entrepreneurial mindset which implies a better formation of STEM human resources to successfully face future workforce challenges. In a period of four years, one hundred and twenty-nine individual among STEM teachers, high school students, and university students participated in the EEP workshops.

The results indicate that the entrepreneurial workshops had a positive impact on the perception of the individual's entrepreneurial environment, opportunity identification, and their self-efficacy. Therefore, this study restates the theory that we can teach entrepreneurship and entrepreneurial mindset. Moreover, it adds to the literature the possibility to stimulate a change of mindset through education. Additionally, results showed there is no association between gender and wanting to be an entrepreneur or on having a business idea, which may represent a dichotomy with previous studies. In a country with a long economic depression entrepreneurship could be considered as an option, however identify or create an advantage opportunity not necessarily is a straightforward process. Develop and strategic thinking to build a successful business model may represent a challenge that can be overcome through the exposition to the entrepreneurial education, real-life application research and practical experience.

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References

- 1 Haynie, J. M., Shepherd, D., Mosakowski, E., and Earley, P. C., "A situated metacognitive model of the entrepreneurial mindset," *Journal of Business Venturing*, Vol 25, No. 2, 2010, 217-229.
- 2 Putta, S. S., "Entrepreneurial Mindset Crises in Enterprises," *Journal of Commerce & Management Thought*, Vol 5, No. 1, 2014, 70-75.
- 3 Täks, M., Tynjälä, P., Toding M., Kukemelk H., and Venesaar, U., "Engineering Students' Experiences of Entrepreneurship Education A qualitative approach," Institute of Education, Faculty of Social Sciences and Education, University of Tartu, Estonia.
- 4 World Economic Forum, "New Vision for Education Unlocking the Potential of Technology," Geneva, Switzerland, World Economic Forum, 2015.
- 5 Peterman, N. E., and Kennedy, J., "Enterprise Education: Influencing Students' Perceptions of Entrepreneurship," *Entrepreneurship Theory & Practice*, Vol 28, No. 2, 2003, 129-144.
- 6 Pihie, Z.A.L., and Sani A.S.A, "Exploring the Entrepreneurial Mindset of Students: Implication for Improvement of Entrepreneurial Learning at University," *The Journal of International Social Research*, Vol 2, No. 8, 2009, 340-345.
- 7 Romaguera, J.M., "Chispa Empresarial: Reconociendo y haciendo realidad las oportunidades empresariales," International Entrepreneurship Institute, 2010.
- 8 Merenda, M. J., Li, J., and Dutta, D., "Does Entrepreneurship Education Matter?" *Proceedings of the Northeast Business & Economics Association*, 2010, 531-535.
- 9 Ali, A., Reimer, D.M., and Gehart, A.L., "Relationship Between Student Capstone Design Project and Entrepreneurial Mindset," ASEE Annual Conference and Exposition, 2012.
- 10 Krueger, N. F., "What Lies Beneath? The Experiential Essence of Entrepreneurial Thinking," *Entrepreneurship Theory and Practice*, Vol 31, No. 1, 2007, 123-138.
- 11 Cunha, F., and Heckman, J., "Investing in Our Young People," Cambridge University Press, 2010, 381-414.
- 12 Gundry, L. K., Ofstein, L. F., and Kickul, J. R., "Seeing around corners: How creativity skills in entrepreneurship education influence innovation in business," *International Journal of Management Education*, Vol 12, No. 3, 2014, 529-538.
- 13 Suárez, O., Padovani, A., Torres, M. Hernández, A., and Peralez, O., "CREST Phase II: Nanotechnology Center for Biomedical, Environmental and Sustainability Applications" Centers For Research Excellence in Science and Technology, 2014.
- 14 National Academy of Engineering, "The Engineer of 2020: Visions of Engineering in the New Century," The National academy Press, 2004.
- 15 De Hoyos-Ruperto, M., Pomales-García, C., Padovani, A., and Suárez, O., "An Entrepreneurship Education Co-Curricular Program to Stimulate Entrepreneurial Mindset in Engineering Students," *MRS Advances*, Vol 2, No. 31-32, 2017, 1673-1679.
- 16 Keefe, J, and Wintermantel T., "Unleashing Pharma form the R&D Value Chain," A.T. Kearney, Inc., 2013.
- 17 Shane, S., "A General Theory of Entrepreneurship: The Individual-opportunity Nexus," Edward Elgar Publishing, 2003.
- 18 Shane, S., and Venkataraman, S., "The Promise of Entrepreneurship as a Field of Research," *The Academy of Management Review*, Vol 25, No. 1, 2000, 217-226.
- 19 Krueger, N., and Brazeal, D., "Entrepreneurial Potential and Potential Entrepreneurs," *Entrepreneurship Theory and Practice*, Vol 24, 1994, 91-104.
- 20 Guiso, L., Sapienza, P., & Zingales, L., "Does Culture Affect Economic Outcomes?," *Journal of Economic Perspectives*, Vol 20, No. 2, 2006, 23-48.
- 21 Casson M., "Entrepreneurship, business culture and the theory of the firm," *Handbook of Entrepreneurship Research*, Kluwer Academic Publishers, 2003.
- 22 O'loughlin, M., "Rethinking Science Education: Beyond Piagetian Constructivism Toward a Sociocultural Model of Teaching and Learning," *Journal of Research in Science*, Vol 29, No. 8, 1992, 791-820.
- 23 Reynolds, P., Bosma, N., Autio, E., Hunt, S., De Bono, N., Servais, I., Lopez-Garcia, P., & Chin, N., "Global Entrepreneurship Monitor: Data Collection Design and Implementation 1998–2003," *Small Business Economics*, Vol 24, 2005, 205-231.
- 24 Chen, G., Gully, S., and Eden, D., "Validation of a New General Self-Efficacy Scale," *Organizational Research Methods*, Vol 4, No. 1, 2001, 62-83.

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