

# Educational Innovation Supported by ICT to Identify Entrepreneurial Skills in Students in Higher Education\*

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## ABSTRACT

It is indisputable that society is facing a time of great change and uncertainty toward the future. The situation around the world due to contingency has generated disruptions in all fields, and education is no exception. The digital transformation of educational institutions has increased vertiginously at all levels of instruction. The current reality leads organizations to worry about finding a way to train people with relevant skills that allow them to deal with the challenges that lie ahead. So, universities play an important role in the development of competencies that equip their graduates not only to enter the labor market but also to generate new employment options through entrepreneurship that contributes to the solution of major global problems. The purpose of this document is to present a doctoral thesis project that contributes to educational innovation based on technologies that identify entrepreneurial skills in university students. This study followed a design-based research methodology in which different quantitative and qualitative instruments were applied to collect data supportive of the objectives that had been set. It was found that this project contributes by analyzing the students' profiles to identify and understand better their entrepreneurial skills and interests and strengthening them transversally throughout their careers through connection with the university entrepreneurial ecosystem. The results show it is possible to develop an *e-learning* educational model that can be scaled to other contexts and contribute to the development of an entrepreneurial spirit, a competency that is difficult for students to achieve.

## CCS CONCEPTS

• Applied computing • Education • E-learning

## KEYWORDS

educational innovation, higher education, entrepreneurship education, entrepreneurial skills, challenge-based learning.

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mentoring, design-based research.

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## 1 Context and motivation that drives the dissertation research

The societal changes and concordant developments in technologies have transformed education at all levels. Especially, the penetration of the Internet and the use of network-connected devices and their impact on traditional teaching and learning methods have increased the use of technologies in education [1]. Therefore, new teaching materials and technological tools for knowledge transfer must be part of new educational models that consider the pedagogical and technological challenges that exist and lie ahead [2, 3]. Besides the changes in the way that students acquire knowledge, challenges arise in curricular content that must be relevant to the changing market and societal needs, and educational institutions must address these.

Along these lines, the current crossroads bring us to the challenging panorama of the formation of citizens. The European Commission states that it is necessary to develop transversal entrepreneurial skills that prepare for sustainable competitiveness and resilience [4]. Here, higher education institutions become relevant to meet these challenges because their graduates are expected to adapt to the labor market and develop new opportunities [5, 6]. So, competencies such as entrepreneurship, critical thinking, communication, innovation, and digital transformation must be developed to prepare the student [7].

In Mexico, Tecnológico de Monterrey, the university where this research took place, offers a complete entrepreneurial ecosystem. It includes incubators, business accelerators, technology parks, institutes for entrepreneurship, offices for technology transfer and support to entrepreneurs, and both curricular and extracurricular entrepreneurship programs [8]. Also, they have within their strategic plan the development of

the entrepreneurial spirit as a competency to be developed that must be strengthened in the students, so that its graduates can better adapt to the demands of the labor market [9, 10]. Therefore, this dissertation seeks to contribute to these institutional goals by presenting a proposal that supports the vision and strategic plan of the institution [11].

To bring knowledge about how to develop entrepreneurial skills in a university environment through educational innovation based on information and communication technologies (ICT), we sought through this doctoral dissertation to answer the following research question: How can the fundamental elements of an e-learning educational model focused on identifying entrepreneurship skills in professional-level university students within an entrepreneurial ecosystem be identified?

This paper is structured as follows. First, it presents context and motivation that drives the dissertation research. Second, the state of the art related to educational innovation, ICT applied to education and entrepreneurial skills. Third, the problem statement that the project aims to solve. Fourth, it lists the research objectives. Fifth, research approach and method explain how the study was conducted. Sixth, it presents the results to date obtained with the instruments and their validity. The following section describes the dissertation status. Finally, it develops the current and expected contributions and conclusions of the research.

## 2 State of the art

### 2.1 Educational innovation

The knowledge economy requires the emergence of initiatives that support the processes of the creation and development of new ideas [12]. In a globalized and increasingly competitive world, science, technology, and innovation become essential factors for the growth of countries, especially in times of uncertainty like the ones we now live [13, 14]. This globalization presents challenges that must be taken on in all fields, including education to improve the teaching-learning process [15, 16], so that innovative processes arise in the training institutions and inspire their members to generate innovative cultures.

The term "innovation" is related to something new, changes in the way's things are done, changes to behaviors, processes, knowledge, and methods of administration and production [17]. The concept of innovation also involves modifying what has already been done, improving it, and implementing the new ideas in pre-determined time frames [18]. Therefore, innovating is not only having good ideas but applying them in processes that require improvement to generate value. On the other hand, in order for the adoption of the innovation to be effective in different contexts, it is necessary to develop plans that support its implementation [19]. Because the transformation that produces innovation creates an imbalance, for it to survive in the long term, the communication and comprehension of all those involved are necessary [20]. This is especially important in the case of educational innovation that seeks to impact student learning.

The ICTs contribute to the processes of change in the different sectors of society. Education is one of the fields in which new technologies have modified the way teaching and learning occur as well as communicating [21, 22]. These new scenarios require the incorporation of flexible environments, in which research and innovation are the main axes for achieving a more inclusive development [23].

The literature review shows that for educational innovation to exist, it is not only necessary to introduce new technological tools but also the pedagogy that supports them [2]. There must also be an implementation planned that transitions the traditional model to one that incorporates change and at the same time has quality [24]. One of these pedagogies is Challenge-Based Learning (CBL). It actively engages the students in their learning while developing competencies such as collaboration, multidisciplinary teamwork, decision-making, leadership, and communication [25-28]. CBL leverages the students' interest by providing a practical application to education.

### 2.2 ICT applied to education

With the incorporation of technologies into education, various educational modalities emerged that have different pedagogical and technological characteristics that are necessary to know for their correct implementation. One of the modalities is e-learning, which refers to using technology to provide educational content and facilitate learning to multiple segments of the population [29, 30]. This modality is used for its flexibility and the possibility of accommodating it to daily work and family responsibilities, so it becomes a tool that enables education to be delivered remotely and at different times, thanks to the possibility of being carried out synchronously or asynchronously [31]. It has different components that must be considered during its application.

The elements that should comprise an e-learning proposal are a) the teacher guides the students to achieve the educational objectives, b) there is a comprehensive approach to align the skills with the interests of the student, and c) the e-learning integrates other disciplines, planning different methodologies that favor the publication of content by the student [32]. According to García Peñalvo and Seoane Pardo [33], the e-learning modality continuously evolves and keeps being a system that contributes to learning, supported by technologies. Its use has increased notably in recent times, where the development of e-learning products and their applications is one of the most rapidly expanding areas of education and training [34]. Now more than ever, we acknowledge the challenges to its proper implementation so that student learning is promoted.

This literature review analyzed empirical studies that applied ICTs in education. The studies showed the objectives that need to be achieved in educational settings. They recommend providing training on the tools to teachers and students beforehand. Also, because these researches achieved great results in knowledge acquisition in primary education, there were recommendations to scale the methodologies toward higher cognitive processes [35]. Another aspect in which the authors

agreed is that to make the most of these tools, it is necessary to have a pedagogical theory that supports their implementation. It is necessary to propose new models oriented to the students and the achievements they can have in their educational development, supported by ICTs [31]. According to this review, the existing models still need to be explored and adjusted to different contexts. Therefore, it is necessary to continue developing methodologies, theories, and practices to understand better how the technologies will be applied and to follow up after applying these models to know if the students retain the learning throughout their lives.

### 2.3 Entrepreneurial skills

In recent years, the topic of entrepreneurship has awakened interest. It is considered a means for economic growth, a way to energize the innovative process, and to generate new jobs [36, 37]. Also, markets must adapt to new conditions. People must be trained in entrepreneurial skills, which will reduce the negative impact of changes and help develop a society with better opportunities for all [38]. This training must have certain characteristics that develop citizens who are more active, autonomous, and action-oriented and must be based on models that sustain on-going training [39]. Hence, education is expected to promote the development of entrepreneurial skills [40, 41]. Therefore, the role of higher education institutions becomes especially relevant to the strengthening of these skills. Educational innovation becomes crucial to the design and presentation of programs that promote skills for the 21st century.

Recent studies propose different methodologies that can be used to promote entrepreneurship and develop the various skills that favor it. These studies focus primarily on providing students with the tools that allow them to develop new ideas and skills and respond to the challenges of society [42]. Among these methodologies are experiential learning based on the Kolb model [43] in which the student is presented real entrepreneurship experiences [44]. Another is active learning, which contributes to developing various skills, attitudes, and values [45]. Collaborative learning involves different internal and external actors, such as entrepreneurs, students, managers, and others [46]. Mentoring is another methodology [47]. It promotes motivation and supports educational understanding thanks to the experiences of the mentor [48].

The literature review highlighted that education programs in entrepreneurship require still more research. One finding is that it is necessary to determine what should be taught and how to do it because the study contents cannot always be found nor the pedagogical models suitable for their teaching [49-52]. It is also necessary to identify how to evaluate the entrepreneurial skills that lead people to contribute to the knowledge society. The latter presents more and more challenges in the development of science and technology. Thus, educational innovation plays an important role in the development of educational and pedagogical activities that strengthen the vision of education required for the knowledge society [53-54]. This literature

review defined aspects relevant approach the problem and the research proposal.

### 3 Problem statement

Education in entrepreneurship can be delivered transversally in different professional programs, not just in business administration curricula [55]. So, universities are expected to develop in the students the entrepreneurial spirit that enables them not only to create new companies but also to integrate themselves into the labor market more successfully [56]. However, entrepreneurial spirit is found to be difficult for students to develop, so it is necessary to create programs that strengthen this.

To take action on this need, we propose the development of an ICT-based, educational-innovation model that promotes the identification of entrepreneurship skills in professional students in a university context; it was the intention of this project. This proposal is to improve the teaching-learning process of the student, who will come to have transversal skills, such as entrepreneurship, through didactic activities offered in an online training environment. According to the studies consulted in the review, there is a need to determine what should be taught in training programs for entrepreneurship, as well as identifying the most appropriate methodologies to do so [47]. Innovative strategies were developed in this study for students to identify entrepreneurial skills, which are not only important for the creation of enterprises but also will serve them in their daily lives in the personal, social, and work spheres.

### 4 Research objectives

The objectives of the research are:

1. To implement an extracurricular training strategy in an online workshop course that combines pedagogical innovations and technological tools in teaching activities focusing on the identification of entrepreneurial skills in professional-level students.
2. To validate the instructional design of the workshop course and the teaching activities that aim to identify entrepreneurial skills in professional-level students with a group of experts.
3. To evaluate the quality of the design and the delivery of the workshop course through a set of indicators based on pedagogical, functional, technological, and temporal factors.
4. To analyze the evaluation criteria of the workshop course to identify areas of opportunity for improving the application of the educational innovation.
5. To apply tools that help identify the student profile and the entrepreneurial skills of the participating students.
6. To determine the main elements of an e-learning educational model that identifies entrepreneurial skills in university students at a professional level within an entrepreneurial ecosystem.

### 5 Research Approach and Method

This research followed a design-based methodology, which is used in innovative educational projects to facilitate the transfer of educational research into practice and increase its impact [57]. This methodology includes descriptive and explanatory methods, as well as qualitative and quantitative instruments, so it follows a holistic and pragmatic paradigm [58]. For the analysis of data, a case study was followed that involved an exhaustive study, in-depth and detailed, of a limited number of objects, individuals, and environments to achieve the stated objectives [59].

## 5.1 Sample

The selection of the sample was intentional and was comprised of 20 university students enrolled in different professional careers at Tecnológico de Monterrey plus five entrepreneurs who had graduated with a master's degree in Science and Technology Marketing from the University of Texas at Austin and who served as mentors of the course.

## 5.2 Instruments

Different techniques and instruments taking qualitative and quantitative approaches can be applied in design-based research studies, including questionnaires, surveys, case studies, observation of the participants, structured or semi-structured interviews, instrument designs, and expert panels, among others [60]. The following instruments and tools were used in this research:

- An e-learning online workshop course developed on the Moodle platform for the identification of entrepreneurial skills. It consisted of four modules aimed to enable students to identify entrepreneurial skills through activities that would allow them to resolve a challenge collaboratively with the support of a mentor and to strengthen their knowledge of entrepreneurship and innovation. The activities took advantage of the resources of the platform, such as forums, blogs, video conferences, task assignments sent online, and questionnaires, among others.
- Entrepreneurship workshop questionnaire consulted with experts: This instrument was used to validate that the activities and resources proposed in the workshop course promoted the achievement of students' learning objectives. A consultation questionnaire was given to experts. It consisted of 12 questions, six open questions about the profile of the expert, and six Likert-scale questions related to the objectives of the course.
- Entrepreneurial Skills Identification Test: This was used to determine the students' interests, attitudes, and entrepreneurial skills before and after the workshop course. It is an adaptation of the instrument, The Engineering Entrepreneurship Survey (EES), developed at Purdue University in the USA by Duval-Couetil et al. [61-62]. It consisted of 25 questions with a four-point Likert scale and with yes/no responses.
- Questionnaire to evaluate the quality of the workshop course: An adaptation of the Pedagogical Quality Indicators

instrument developed by Alemán de la Garza [63] was used. The instrument featured 50 items that measured pedagogical, functional, technological and time indicators on a Likert scale.

- Escala i: This instrument developed by Tecnológico de Monterrey is used to determine the impact of educational innovation on the teaching-learning and continuous-improvement processes [64]. It analyses five criteria: learning outcomes, educational innovation, institutional alignment, growth potential, and financial viability.

## 5.3 Procedure

This research was conducted in four stages. All stages are shown in Figure 1.

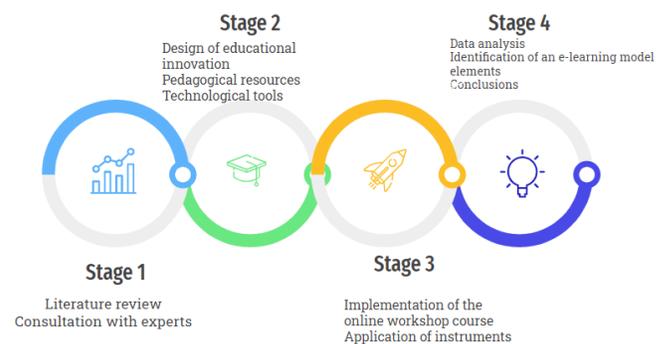


Figure 1: Research stages

Stage 1 involved a literature review of empirical studies related to educational innovation and entrepreneurial skills to identify what problem to analyze, to delve into the methodologies in the studies analyzed, and primarily to know what gaps existed in their results. Subsequently, a consultation was conducted with experts involved in the topic of entrepreneurship, done in collaboration with the Global Center for Innovation and Entrepreneurship (CGIE) at the University of Texas in Austin to validate the findings found in the literature [65].

In stage 2, the research focused on the design of educational innovation. This involved exploring innovative educational tools to present training activities, elaborating the instructional design of the module contents for the training program in the workshop course, defining the aspects to include in the mentoring, designing the educative technological resources, putting the workshop course on the online platform, reviewing the course with expert teachers, forming the group of participating students, and contacting the mentors who participated in the study. In stage 3, the workshop course was implemented, and the instruments were applied to determine the results in student learning and measure the changes that resulted. Finally, in stage 4, the data were analyzed, and the elements of an e-learning model for the formation of entrepreneurship skills were identified.

### 5.4 Analysis of the data

In this research, the objectives of the study guided the analysis strategy to provide answers to the research questions posed. So, three axes of analysis were established: educational innovation, information and communication technologies (ICT), and entrepreneurial skills. These were connected to the objectives and instruments, as shown in Table 1.

Table 1. Axes of analysis, objectives, and instruments

Axis of analysis	Objectives	Instruments
Educational innovation	To implement an extracurricular training strategy based on an online workshop course that integrates pedagogical innovations and technological tools through teaching activities focused on the identification of entrepreneurial skills in professional-level students.	Online workshop course for identifying entrepreneurship skills.
	To validate with a group of experts the instructional design of the workshop course and the teaching activities that aim to identify entrepreneurial skills in students at a professional level.	Consultation Questionnaire to the experts.
ICT	To evaluate the quality of the design and the delivery of the workshop course through a set of indicators based on pedagogical, functional, technological, and temporal factors.	Questionnaire to evaluate the quality of the workshop course, Escala i
Entrepreneurial skills	To analyze participant feedback to identify areas of opportunity for improving the application of the educational innovation. To apply the instruments to identify the profile and the entrepreneurial skills of participating students.	Initial and Final Entrepreneurial Skills Identification Tests

The Yin [66] case studies suggest the use of qualitative and quantitative data to strengthen the analysis. This analysis strategy allows comparing the results, and it facilitates triangulation by having different sources of information. Data triangulation addresses the validity of the construct because multiple sources of evidence provide various measures of the same phenomenon [58].

For the questionnaire responses, frequency and percentage distributions were used, as well as descriptive statistics such as the mean, the standard deviation, the minimum and maximum in the case of Likert questions to know the most common answers among the participants, the data dispersion, and measurements to determine whether the results supported the achievement of the objectives that were sought [67].

Cronbach's Alpha was used to determine the reliability of the instrument, and the results were compared with the original instrument. To compare student profile results, we conducted a

Fisher's Exact Test to find out if there were significant differences among the participants' results [62].

For the students' responses to forums, blogs, mentor interactions, and open questionnaire, a content analysis was conducted to identify categories that emerged from the student responses. Passages were identified within the data and were categorized to determine the intentions of the participants within the context of the study [68]. Once the categories were defined, an inductive analysis was used to segment the texts and compile evidence for each category by comparing them to the participants' responses [27, 69].

### 6 Results to date and their validity

To date, the results found with the application of each instrument are the following:

- Online workshop course for the identification of entrepreneurship skills: this workshop course followed CBL methodologies and mentoring; twenty students and five mentors participated. Six teams were formed to solve a challenge related to sustainable development problems and had a terminal efficiency of 60%. From the content analysis of the forums, it could be seen that the students were deeply concerned about social and environmental problems. Mostly, they expressed interest in finding solutions by developing enterprises connected with their careers of study. However, they stated that they do not know if they have the skills to develop them or know how to arrive at proposals for solutions. Hence, they hoped to be able to learn it in the course.
- Of the six teams, five presented a final pitch of the proposals to solve the challenge posed to them. These projects were evaluated under a rubric where it was found that 84% of the teams investigated topics related to the problem and the solution proposal, and 84% identified the benefits of their proposal and provided interesting information for the users. The work in teams received a grade of 72% because some of the teams had difficulties organizing themselves during the process. The presentation of statistics for the problem received a grade of 60%, as well as the communication of the pitch idea. The items that had the lowest scores were the validation of the idea with potential users and the presentation of the number of users that would be impacted by the solution. (48% of the teams presented this in their proposals.
- Questionnaire to the expert consultants about the workshop course on entrepreneurship: The course was validated by seven experts from the areas of educational innovation, entrepreneurship, and education following the method of individual aggregates [67]. The results showed that the online workshop-course was appropriate for the fulfillment of the objectives. The course objective that the student would learn the concepts that enabled him or her to identify entrepreneurial skills attained the highest mean (3.89). The second highest, that the students could identify their

entrepreneurial skills when starting their training and communicate their ideas with a final pitch, had an average of 3.67. The objective concerning whether students could propose innovative solutions with the help of a mentor received an average of 3.44, and the goal of whether they would be able to identify the change in their skills achieved the lowest score (3.33). All scores were between 3 and 4 had a dispersion of less than 1, with 4 being the highest possible score, so it was concluded that the instrument was validated [70].

- **Entrepreneurial Skills Identification Test:** This questionnaire was answered by 20 students and led to know the profile of the participants of the workshop course. 60% of the students were women, all taking from the fifth to the ninth semester of their curricula; the careers studied the most were engineering. 70% had taken no previous entrepreneurship course or only one. 70% believed that in their scholastic career, there had been little or insufficient discussion about entrepreneurship. Most participants believed that students should learn more about the subject (80%) and that there was little or no assessment instrument for the entrepreneurial skills of the students (70%). Regarding the entrepreneurial skills identified, 60% indicated persistence, followed by orientation to change, entrepreneurial intent, and search for opportunities (55%). Forty percent indicated having low self-confidence, poor skills in communicating ideas (30%), and little networking (30%).
- **Questionnaire to evaluate the quality of the workshop course:** An analysis of the results revealed that the functional factor was the one that obtained the highest results with mean of 3.59, followed by the pedagogical factor (3.49), the technological factor (3.48), and the time factor (3.30). When comparing a face-to-face (presential) course with an online course, the participants indicated that the online course required less time to learn about a topic (3.73) and that its improved teaching and learning. They also felt that it facilitates performing different activities at the same time (3.64). The reliability of the instrument to measure the quality of the online course was considered adequate, having Cronbach Alpha values between 0.88 and 0.97, indicating that this instrument was a robust tool for this purpose.
- **Escala i:** According to the assessments in the five criteria, this innovation is considered to have growth potential and can contribute to the development of entrepreneurial spirit in students, but it requires further implementation and analysis of results with larger groups. The ethical aspects were addressed through a protocol to maintain the privacy, confidentiality, and integrity of the data, as well as the privacy and consent of the participants.

## 7 Dissertation status

At the time of this writing, the study is in its final stage. To date, the workshop-course was implemented with the participants, the

instruments were applied, and the data was collected. The data analysis was performed for the three axes and triangulated with the literature and the qualitative and quantitative data. The process of defining a model is underway. The first results have been published in indexed journals and congresses [6,8,27,65]. We expect to continue presenting the results of the research at congresses such as TEEM in Spain and CIIE in Mexico [71].

## 8 Current and expected contributions

This research seeks to contribute to knowledge both in the fields of educational innovation and education for entrepreneurship. For educational innovation, this project contributes to the challenge of developing e-learning products and presenting design principles that can be implemented in other contexts, as well as the implementation of active pedagogies that support the use of ICT in education, as well as CBL and mentoring.

Concerning CBL, the learning objectives, training activities, educational resources, forms of assessment, and the process to present the solution proposals were employed, which led to the generation of five entrepreneurial proposals to solve sustainability problems [27]. For mentoring, elements were identified related to the steps and activities to perform in an online course in entrepreneurship [8], contributing to the need for studies related to mentoring in online courses [48]. We also presented a strategy for solution proposals that can be used in other peer-mentoring courses or by teachers. This methodology was validated by the experts who participated in this study [72].

The contribution to entrepreneurial education lies in the design of this educational innovation project with learning objectives aimed at strengthening entrepreneurial talent and by the contributions made with publications that include scientific articles in indexed journals (Scopus and Web of Science).

Also, our presentations at national and international congresses (COMIE, International Conference on Research Approaches in Social Science, Business E-Commerce and Entrepreneurship, 2020 International Conference on Technology and Entrepreneurship) and a public policy related to the theme of young entrepreneurial talent [73] have been contributions. Others include a stay at the Center for Global Innovation and Entrepreneurship at the University of Texas, Austin, where two research projects were developed and a connection to make this doctoral proposal, and the launch of an experimental project in educational innovation on the topic of entrepreneurship selected by the NOVUS 2019 Found at Tecnológico de Monterrey.

Our expected contributions consist of the transfer of this educational innovation towards an entrepreneurship skills training program to be used in this and other contexts. To this aim, we are seeking support from the university and different civil society actors to advance the project continuity.

In conclusion, the results show it is possible to develop an e-learning educational model that can be scaled to other contexts. This project contributes to determining the students' profile to understand their interests and entrepreneurial skills, and to developing an entrepreneurial spirit. For future research, we recommend sharing the results of this project with the different

participants in the training of entrepreneurial competencies of the institution to be able to implement and scale it successfully in larger groups using the instruments developed in this study. Also, to continue inquiring about the impact of entrepreneurship courses in the development of entrepreneurial competence of university students.

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