

Engineering Students' Perceptions of Innovation and Entrepreneurship Competences

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Abstract – In this paper we present the results of exploring students' ideas about innovation and entrepreneurship concepts and the way that they perceive that innovation and entrepreneurship competences are developed or improved by engineering education. Comparisons are made between two samples (N= 119 students) at the School of Design Engineering (Polytechnic University of Valencia) by using a questionnaire-based methodology. The results show that the majority of students reported not receiving enough training in innovation and entrepreneurship competences. Thus a greater attention is to be paid to embed innovation and entrepreneurship competences into the current curricular reform in engineering education in Spain having in mind that an innovative and enterprise culture are vital to promote growth and development, increase productivity, create jobs and reinforce the knowledge based economy in Europe.

Index Terms – Students' perceptions, competences, innovation, entrepreneurship, engineering education.

INTRODUCTION

Today's Knowledge Economies are seeing the emergence of new paradigms for innovation and the advancement of knowledge in relation to economic activities. In several European countries, governments claim that building an innovative and enterprise culture are vital to reinforce the "Knowledge Europe". There is no doubt that entrepreneurship and innovation are central to the creative process in the economy and to promoting growth, increasing productivity and creating jobs. Flexibility, creativity, negotiation, among other competences had become necessary and engineering education therefore has an obligation to meet students' expectations with regard to preparation for the economy in which they will operate.

Young people face many challenges in their lives –the challenge of rapid technological advances, of multiple career and lifestyle changes and of taking greater personal responsibility for achieving "success" in their personal and work lives. Young people need an educational foundation that gives them the qualities, skills and understanding to take these challenges in their stride [1].

In the *Green Book Entrepreneurship in Europe* the European Commission points out that "to appreciate entrepreneurship, society must value and celebrate

successful entrepreneurs and tolerate failure. Positive attitudes towards entrepreneurship are particularly important among those on whom today's and future entrepreneurs depend, such as schools, universities, investors, local communities, regions, business organizations, business advisers and the media" [2, p. 21]. Education in entrepreneurship increases the chances of start-ups and self-employment and enhances individuals' economic reward and satisfaction [3]-[4]. An *Entrepreneurship Action Plan* was adopted by the Commission in February 2004, suggesting horizontal measures for the Commission and the Member States to create a supportive framework for entrepreneurship policy [5]. More recently, the *Declaration on the European Year of Creativity and Innovation* (2009) aims to raise awareness of the importance of creativity and innovation for personal, social and economic development; to disseminate good practices; to stimulate education and research, and to promote policy debate on related issues [6].

In this context, there has been an increasing emphasis in Higher Education on the development of students' transferable or generic competences, particularly in relation to employability and the development of a wider understanding of the innovation process and a more entrepreneurial attitude as prerequisites to empower an entrepreneurial culture [6]. Regarding universities and technical institutes, the European Commission recommended that these should integrate entrepreneurship as an important part of the curriculum. The *Dearing Report* in 1997 recommended that entrepreneurship should be encouraged through curriculum development [7]. The *Davies Review* report published in United Kingdom in 2002 called for greater attention to be paid to the development of pupils' knowledge, skills and experience of business and enterprise. But the same document revealed that less than 30% of young people gain "enterprise" experience at any point in their school career. Moreover, few gain the necessary awareness of finance and economic issues, vital skills for any would-be entrepreneurs [6]-[8].

In Spain, there is a wide range of initiatives but there is little evidence to suggest how innovation and entrepreneur education (and their corresponding competences) will be transferred across different subjects, and locations within the engineering programs. Employers affirm that some competences in certain non-technical areas such as communication ability, economics, leadership, teamwork and management are not practically being considered in the graduates' education [9]-[10].

In this paper we present the results of exploring students' ideas about innovation and entrepreneurship concepts and of whether they perceive that innovation and entrepreneurship competences are developed or improved by engineering education. In this study we compares two samples (N= 119 students) at the School of Design Engineering (Polytechnic University of Valencia) using a questionnaire-based methodology. In the first part the meaning of entrepreneurship education is discussed from an integrated perspective. In the second part the samples and methodology applied are explained and, finally, we show the results obtained.

ENTREPRENEURSHIP AND INNOVATION FOR ENGINEERS: AN INTEGRATED APPROACH

I. Entrepreneur education: Only for Business Schools?

Traditionally entrepreneurship has been considered to be a Business School topic and as such has been taught by people with a predominantly business background more than an engineering one.

This has brought an emphasis on business skills over innovation and product development. As a consequence we may face either a group of people who can manage a business but with no idea of how to develop a product or nurture innovation within their environment, or a group of people with a great engineering idea and not a clue on what to do with it.

Frequently the term entrepreneurship is associated exclusively with the practice of starting a new organization, particularly a new businesses involving the exploitation of opportunities that exist in a given market. However, entrepreneurship also occurs within existing organizations (*intrapreneurship*) that can even include the civil service.

Nowadays entrepreneurship is of vital importance not only to the employability of European youngsters but is considered an essential competence (or a set of competences) for personal development and self-fulfilment. With a narrow perspective, for some time entrepreneurship was considered un-teachable, but international experience demonstrates that elements of entrepreneurship can be taught and learned [11]-[12].

Entrepreneurs commonly use elements of creativity, innovation, problem-solving, risk-taking and pro-activity in the pursuit of their goals; these competences can generally be acquired and developed (as both specific or transferable competences). The European Commission defines entrepreneurship as *"the mindset and process to create and develop economic activity by blending risk-taking, creativity and/or innovation with sound management, within a new or an existing organization"* [3, p. 6].

In what concerns the profile of an entrepreneur, it is unlikely that entrepreneurship might be explained by a stable characteristic that differentiates some people from others in every situation but rather by a tendency of certain people to respond to opportunities.

Within the framework of key competences for European citizens, entrepreneurship neither is it seen as a distinct psychological characteristic, it is more in the line of an interaction of different skills, knowledge, affective factors and personal qualities [5].

II. What's the meaning of innovation?

Innovation has been studied in a variety of contexts, including in relation to technology, commerce, social systems, economic development, organizational change and policy construction. There are, therefore, naturally a wide range of approaches to conceptualizing innovation in the literature. The third edition of the *Oslo Manual* defines four types of innovation:

- **Product innovation:** the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics.
- **Process innovation:** the implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software.
- **Marketing innovation:** the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.
- **Organizational innovation:** the implementation of a new organizational method in the firm's business practices, workplace organization or external relations. [13]-[14].

A convenient definition of innovation from an organizational perspective is given by Luecke and Katz (2003), who wrote: *"Innovation . . . is generally understood as the successful introduction of a new thing or method . . . Innovation is the embodiment, combination, or synthesis of knowledge in original, relevant, valued new products, processes, or services"*[15].

Innovation typically involves creativity, but is not identical to it: innovation involves acting on the creative ideas to make some specific and tangible difference in the domain in which the innovation occurs. Any innovation begins with a creative idea and innovation means the successful implementation of creative ideas within an organization.

From this point of view, creativity by individuals and teams is a starting point for innovation. This definition encompasses the idea that it is somewhat intangible, and suggests that innovation is more than simple creativity. Innovation creates a valuable outcome: a new product, a new service, a new business model, a new initiative, or a new program.

Innovation is related to research and invention but they are not synonymous either. Invention is the creation of new forms, compositions of matter (devices) or processes. An improvement on an existing form, product or process might be an invention, an innovation, both or none of them if it is not substantial enough.

It can be difficult to differentiate change from innovation. According to business literature, an idea, a change or an improvement is only an innovation when it is valuable (in the market) and effectively causes a social or commercial reorganization.

METHODOLOGY & SAMPLES

A questionnaire was applied to 119 students in the first course of engineering in the Polytechnic University of Valencia (17-18 years old).

TABLE I
SAMPLES

Polytechnic University of Valencia (Spain) School of Design Engineering	
Aeronautic Engineering N= 65	Design Engineering N= 54

We have considered these samples separately due the different characteristics of both programs. Design Engineering students normally work with active methodologies such as Problem Based Learning or Project Based Learning, while Aeronautic Engineering in Spain use more traditional methods. Our original hypothesis was that Design Engineering students should most likely have developed competences such as Team Work, Organizational and Management Skills and Creativity.

The principal questions in this exploratory study have been:

- What do students understand by “innovation”?
- What importance do students attribute to entrepreneurship?
- To what extent do students perceive that innovation and entrepreneurship competences are developed or improved by engineering education?

In the taxonomy of innovation and entrepreneur competences it was considered the following:

- Teamwork
- Communication (oral & write, including oral presentations, for example)
- Organizing skills and task management
- Creativity
- Problem solving
- Team project management
- Leadership
- Negotiation/conflict management skills
- How to start up business (knowledge & abilities)

RESULTS

I. What do students understand by “innovation”?

In general, students’ ideas related to innovation were confused, vague and incomplete. The principal expressions were linked with “creativity”, “novelty”, “process to generate ideas”, etc.

They usually do not distinguish between creativity, invention, R&D (research and development), and innovation. In the following Table II it shows in decreasing order the expressions used by students in their definitions of innovation.

Examples:

“change, novelty, originality”

“to invent new things”

“development and improvement of a new knowledge area”

“the practice of new tasks and manners to act, to teach and to learn”

“something new and original, modern”

“change that implies the improvement of some product”

“development of new ideas or concepts about objects, activities, devices ...”

“to look for new solutions for the existing problems”

“to invent new things more useful”

“things that did not exist and somebody invents”

“something new and useful for society”

TABLE II
STUDENTS’ IDEAS ABOUT INNOVATION

	Aeronautic Engineering N= 65	Design Engineering N= 54
Generation of improved products & processes	17	12
Creativity, novelty, originality, new idea or concept	13	20
Creation of new product or process	12	13
Research/science development	9	3
Applied research	7	-
Utility/profits	7	4
Revolution/something	6	9
Market	4	1
Problem solving	2	3
Other (example: development of new techniques to improve learning)	7	2

The aspect mostly indicated was the creation of improved products and processes and nobody mentioned innovation in services. As expected Design Engineering students (20 out of 54) associate the innovation with creativity and novelty. Only 11 students of the total sample have considered the relation between innovation and utility

or profit and 5 students have mentioned the word “market” in their phrases.

II. Students’ interest in entrepreneurship

The students answered the following questions:

- Have you curiosity/interest to know how to start up a business/being an industrialist ...?
- Have you thought to start up a business/of being an industrialist?

In Table III we can appreciate that the interest is very high in all the cases.

TABLE III
STUDENTS’ CURIOSITY/INTEREST IN ENTREPRENEURSHIP

Sample	Curiosity/interest to knowledge on entrepreneurship (%)		Have you thought to start up a business/of being an industrialist? (%)	
	Yes	No/ I have never thought about it	Yes	No/ I have never thought about it
Design Engineering N= 54	92.6	7.4	86.1	13.9
Aeronautic Engineering N= 65	83,4	16,6	61,5	38,5

III. Students’ perception on the contribution of engineering education to acquire/development some innovation and entrepreneurship competences

The question asked to students was: Have you followed courses or received training about the following competences? The response scale was: M (much), S (a little bit), N (never).

The options presented to the students were: if they received training in a subject (or part of a subject) within their university (UC), in a complementary course supplied by the same university (CC), in a complementary course in another university (COU) or off the university system (OU).

Figure 1 shows the results for the competence “teamwork” comparing Design Engineering (N=54) and Aeronautic Engineering (N= 65). Figures 1 and 2 show the results obtained for first year students perception of the development of their teamwork competence by the curriculum

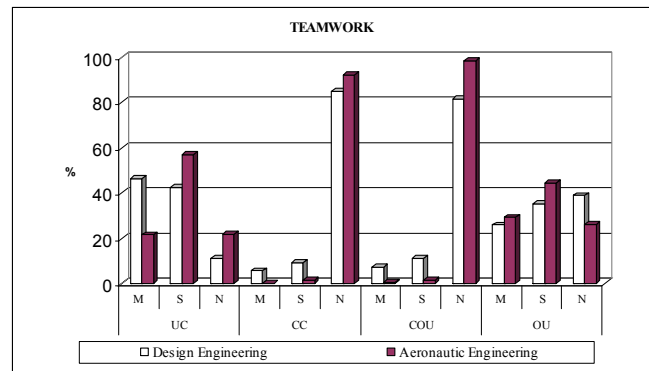


FIGURE 1
FIRST YEAR STUDENTS’ PERCEPTION ON THE CONTRIBUTION OF EDUCATION TO SOME INNOVATION AND ENTREPRENEURSHIP COMPETENCES. UC = IF THEY HAVE PARTICIPATED IN “UNIVERSITY COURSE” (A SUBJECT OR PART OF A SUBJECT), OU = “OFF THE UNIVERSITY”, CC = “COMPLEMENTARY COURSE IN THE SAME UNIVERSITY”, COU = “COURSE IN ANOTHER UNIVERSITY”

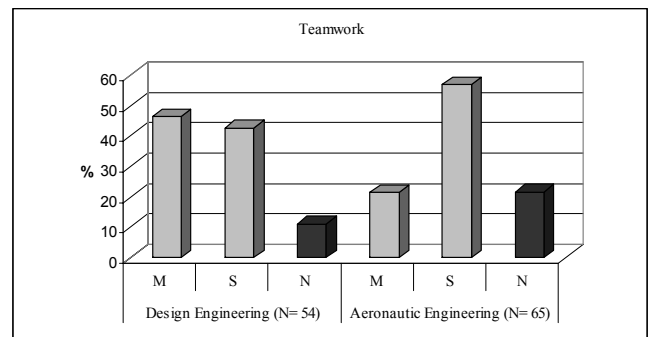


FIGURE 2
STUDENTS’ PERCEPTION ON THE CONTRIBUTION OF ENGINEERING EDUCATION IN THE ACQUISITION AND DEVELOPMENT OF THE “TEAMWORK” COMPETENCE

We can observe (Figure 1) that the training was mainly done within the course (subject or part of a subject) or off the university. In a minor extent, complementary courses in the same university or another university have contributed to the students’ learning of teamwork.

This constitutes a tendency, the training being more relevant in the same university or directly in other extra-university context. Figure 2 shows the perception of the students of their acquisition and development of the “Teamwork” competence.

Teamwork competence indeed plays an important role in students’ future career. The results show clearly that this competence is being considered in the case of Design Engineering. But for Aeronautic Engineering students the training in teamwork is considered in the scale “a little bit, S” (56.9%).

Table IV presents the results obtained in the category “University Course” (UC) for the set of pre-established competences.

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TABLE IV
STUDENTS' PERCEPTIONS ABOUT THEIR TRAINING IN INNOVATION AND
ENTREPRENEURSHIP COMPETENCES

Competence	Design Engineering (N= 54)			Aeronautic Engineering (N= 65)		
	M	S	N	M	S	N
Teamwork	46.3	42.6	11.1	21.5	56.9	21.6
Communication (oral & written)	9.2	55.6	35.2	3.1	44.6	52.3
Organizing skills and task management	25.9	35.2	38.8	13.8	38.5	47.6
Creativity	35.2	38.8	25.9	6.2	43.7	50.1
Problem solving	22.2	51.9	25.9	40.0	49.2	10.8
Team project management	33.3	44.4	22.2	16.9	56.9	26.1
Leadership	9.2	31.4	59.3	0.0	15.4	84.6
Negotiation/conflict management skills	3.7	31.4	64.8	4.6	12.3	83.0
How to start up a business	9.2	12.9	77.8	9.2	46.1	44.6

In general the percentages obtained are low and show a lack in the majority of innovation related competences. In no case 50% is achieved and team work is pointed out by 46.3% of Design Engineering students, and 40% of Aeronautic Engineering students believe to be prepared in problem solving. Leadership, negotiation, conflict management resolution, knowledge and abilities of how to begin a business (typical and necessary entrepreneurship competences) are practically inexistent.

CONCLUSIONS & COMMENTS

This paper has been an exploratory insight to be extended in a near future to a wider sample, covering more groups of students and including a gender study. We think that innovation culture is fundamental in order to promote growth and development, and with this aim Engineering Education should include innovation and entrepreneurship competences, such as the ones analyzed in this paper.

Let us point out that only the competence "teamwork" has been considered by almost half of the Design Engineering students while a key competence such as "oral and written communications" is considered by just 9.2% of Design Engineering students and 3.1% of Aeronautic Engineering students.

Despite the range and intensity of initiatives aimed at enhancing entrepreneurship education in engineering syllabus, the majority of them are extra-curricular and there is little evidence about their effectiveness.

On the other hand, students report difficulties in assimilating entrepreneurship competence into their core practice where its teaching is not explicit.

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