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Competencies and skills for future Industrial Engineers defined in Spanish degrees

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Abstract:

Purpose: This paper has a double purpose. First, to analyze the competencies and skills proposed as ideals for an Industrial Engineering degree and identify them in the current study plans implemented in Spanish universities. Second, to check the fit between competencies and skills described in Spanish Industrial Engineering degrees and a real business environment.

Design/methodology/approach: We searched information from universities through the web www.universia.es and obtained the list of all Spanish Universities, which have been filtered one by one according to their studies about Industrial Engineering degree. In addition, to compare competencies with real business world we have used results provided from the web analysis and from a previous paper in which a qualitative methodology called grounded theory was used.

Findings: On one hand, we have analyzed and identified the competencies and skills proposed as ideals for an Industrial Engineering degree in the current study plans implemented in Spanish universities: competencies as multidisciplinariety and R&D are considered in all the universities, but commercial or environment are not so popular. On the other hand we have checked the fit between competencies and skills described in Spanish Industrial Engineering degrees and a real business environment. As a result, competencies as rotation, experience, company vision

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and corporative strategy are in all the analyzed study plans, but competencies as shared vision, free access to information and involvement of managers do not appear in new degrees, but they are required in real business.

Research limitations/implications: About the origin of information, we use official web sites belonging to Spanish public and some private universities, and corresponding schools. Some universities have not updated the information about degrees in Industrial Engineering, and they still have old plans information. Moreover, the comparison we can make between the competencies of degrees and the needs to develop the Industrial Engineering profession is theoretical because the introduction of new degrees has just started and there are no graduates.

Practical implications: The principal practical implication is to identify a professional profile of the engineer common to most Spanish universities and therefore facilitate the selection of one curricula or another for students. These can lead to check with the first graduates whether or not the competencies acquired in University fit in the business world. On the other hand, from a professional point of view, we open a future line of research by testing competencies acquired by graduates and competencies required in the professional field, as well as the study of these competencies in the professional field. In addition, current employees may decide to recycle their competencies or acquire new ones knowing the design of new degrees.

Originality/value: There are no comparative studies about competencies a Spanish Industrial Engineer has to acquire in University to develop his or her professional work. In consequence, there are not comparative studies about competencies acquired in University and profiles demanded by companies in real business world. This paper deals with both topics.

Keywords: competencies, skills, Industrial Engineering degree, Spanish universities

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1 Introduction

European universities are involved in an important transformation process, which aims at the convergence between different systems and the adequacy of their courses and degrees to professional demand. As it is well known, this interest was reflected by the members of the European Union in different declarations and conferences, starting with La Sorbonne (1998) and Bologna (1999).

In this context, it is necessary to change and transform the traditional teaching process to one based on competencies and skills because companies evaluate future employees according to their competencies. Universities have to base their teaching-learning processes in a model of competencies and skills associated with professional profiles (Sastre & Aguilar, 2003).

There are no comparative studies about competencies a Spanish Industrial Engineer has to acquire in University to develop his or her professional work. Due to the characteristics of the European convergence, each offered degree at each University has raised some general, specific and transversal skills, not necessarily coincident in all cases. However, we believe that the background of an Industrial Engineer has to have some essential common points independently of the University in which an individual has obtained the degree. Therefore, one objective of this study is to identify these commonalities and differences that may exist between the degrees of the Spanish universities. This can lead to a general engineer profile as a reference. Moreover, it can guide students to select one University or another according to the competencies and skills that are designed into each curriculum (number of skills and quality of specific skills).

Once we identify these competencies it is interesting to see if they adapt to the reality of business, because new titles are designed with the aim of providing competent and specialized workers. It's hard to make this comparison. First, because there are no studies of the competencies required by companies; instead, there are studies that evaluate workers for their skills. Secondly, because there is a lack of studies about competencies designed for degrees. Then, we use for comparison some of our previous works.

In this paper we present a review about Spanish universities that are implementing specific degrees in Industrial Engineering, in order to know the real professional

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profile of an Industrial Engineer and the similarities and disimilarities between it and with ideal models previously described. Then, we compare competencies and skills described in degrees and the ones existing in a real business environment. For this, we use a research developed by Canós and Santandreu (2010) that shows common characteristics for innovative companies, all of them associated with employees' competencies and skills.

2 Methodology

The followed methodology has two parts. Then, we have to differentiate between the methodology used to find the competencies described in Industrial Engineering degrees in Spanish universities and the one used to determine competencies that are valued in business and its comparison with academic data. In any case, the authors have acted as experts in dealing with information, given their experience in the field of new curricula in the European Higher Education Area.

To search information from universities, we have used the web www.universia.es. Universia is the website of Spanish and Latin American universities and provides all information about university studies and services (http://universidades.universia.es/universidades-de-pais/datos-basicos/datos-basicos-universidades-espanolas.html).

Through this web, we obtained the list of all Spanish universities, which have been filtered one by one according to their studies about Industrial Engineering degree (if they exist or not). With this first approach we constructed the table that can be seen in Annex I.

According to our purpose, we excluded those universities that do not have the Industrial Engineer Degree, we analyzed the webs of the engineering schools at each university, drawing from available information about the studies plan and the competencies a future graduate has to achieve.

After reading, review, analyze and filter information, we observed that most universities emphasize on similar competencies, so we extracted the common competencies as items to consider. This can be seen in Table 1. Competencies and skills in Spanish Industrial Engineering degrees.

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To compare competencies with the real world, first we have to explain briefly the methodology used in the paper Canós and Santandreu (2010). By following the qualitative methodology called grounded theory, we are able to understand different contents that lead to an event. The point is to select the cases to be studied in a progressive way. When we gather information on the basis of some cases, only then, we know new cases that should also be considered to maximize differences. It is also important in the process of obtaining information, to be conscious about the extent to which the qualitative method constantly works, to take into account various ways in which the questions are understood by respondents (Marin-Garcia, García-Sabater, Perello-Marin, & Canós-Darós, 2009; Marin-Garcia, García-Sabater, & Canós-Darós, 2010).

With our results, we can identify some competencies required by companies as a conclusion from the application of grounded theory. In this paper, we compare our previous results with the ones obtained from universities, in order to know the most valued competencies in the industry. This can be seen in Table 2. Required competencies in real business and Industrial Engineering degrees.

3 Industrial Engineering degree in Spanish universities: competencies and skills

In an educational context, competencies and skills are defined by different international agencies and researchers. We use the concept defined by Bunk (1994): a person has professional competencies if he or she has the required knowledge, skills and attitudes to practice a profession, can solve problems in an autonomous and flexible way and is able to cooperate in the professional environment and work organization. In consequence, we define generic competencies as those forming an essential part of the professional and educational profile of all or most of the degrees. They are associated with higher education and include all cognitive and metacognitive skills, knowledge and instrumental attitudes considered valuable in the knowledge society. In addition, specific competencies belong to a concrete profile or are shared by few profiles. They are expressed through discipline-related knowledge or skills of the more common professional practice in the defined profile (Yániz & Villardón, 2006).

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There are several papers that identify general skills in the European Higher Education Area, and other ones that focus in the specific case of an engineer (Marzo, Pedrajas, & Rivera, 2006; Oliveros, 2006). Likewise, some papers define ideal competencies, generic competencies and specific competencies that an Industrial Engineer has to have, as Marin-Garcia et al. (2009) or Marin-Garcia, García-Sabater, Miralles and Rodríguez (2008). Moreover, some papers show results to concrete competencies models in a subject, and provide feedback for general models (Rodríguez, 2005; Centeno & Serafin, 2006; Mesa, Álvarez, Villanueva, & de Cos, 2008).

In Spain, guidelines exposed by Ministry through an official agency about degrees in Industrial Engineering state that engineers are able to analyze, model, design, implement and improve complex systems composed of people, materials, money, information, machinery, technology and energy (ANECA, 2005). In particular, the degree in Industrial Technologies Engineering has more to do with drafting, signing and the development of projects of construction, assembly or installation of structures, industrial plants or mechanical, electrical or energy equipment (Marin-Garcia et al., 2009; Marin-Garcia et al., 2010).

Basic competencies and skills required for an Industrial Engineer are regulated by a Spanish Ministerial Order CIN/351/2009 of 9th of February, 2009:

1. Ability to draft, sign and develop projects in the field of Industrial Engineering aimed, according to the foreground as provided in paragraph 5 of this order, construction, alteration, repair, maintenance, demolition, manufacture, installation, assembly or operation: structures, mechanical equipment, energy facilities, electrical and electronic installations, facilities and industrial plants and manufacturing and automation processes.
2. Ability to manage activities involved in the engineering projects described in the previous section.
3. Knowledge, understanding and ability to implement the necessary legislation in the exercise of the Industrial Engineer profession.
4. Knowledge of basic materials and technology to learn new methods and theories, giving them the versatility to adapt to new situations.
5. Knowledge for doing measurements, calculations, assessments, appraisals, surveys, studies, reports, work plans, and similar work.

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6. Ability to deal with specifications, regulations and mandatory standards.
7. Ability to work in a multilingual and multidisciplinary environment.
8. Ability to apply principles and methods of quality.
9. Ability to solve problems with initiative, decision making, creativity, critical thinking and to communicate and transmit knowledge, skills and abilities in the field of Industrial Engineering.
10. Ability to analyze and evaluate social and environmental impact of technical solutions.
11. Ability to organize and plan in any company, and other institutions and organizations.

Following this list, Spanish universities have adapted new curricula to new needs. We have revised competencies and skills in offered degrees to establish if they follow these criteria or we can find some differences.

About the origin of information, we use official web sites belonging to Spanish public and some private universities, and corresponding schools. Some universities have not updated the information about degrees in Industrial Engineering, and they still have old plans information (in some cases, they are pending of approval). The available Industrial Engineering degrees are shown in Annex 1.

In Table 1 we can see competencies and skills that Spanish universities have implemented in their Industrial Engineering degree, including professional profiles.

From information obtained from universities and relating it to different papers discussed above (ANECA, 2005; Marin-Garcia et al., 2009; Marin-Garcia et al., 2008) we present the following ideas:

- Multidisciplinarity: It is about technical and multi-purpose training for industrial world. It consists in bringing a strong scientific background and a wide variety of expertise in various technologies. This competence covers various general skills about science, technology and business. All universities under study include this competence.

- R&D: We mark X if training about manage innovation is offered. Notice that this is a general competence. All universities under study include this competence.

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UNIVERSITY	Multidisciplinarity	R&D	Management training	Lecturer-researcher training	Team work	Project teams	Environment	Design of products and services	Quality management	Commercial
Antonio de Nebrija	X	X	X	X	X	X	X	X	X	
Cádiz	X	X	X	X	X	X	X	X	X	X
Cantabria	X	X	X	X	X	X	X	X	X	X
A Coruña	X	X	X	X		X		X	X	X
Deusto	X	X	X	X	X	X	X	X	X	X
Gerona	X	X				X		X		
Jaime I	X	X	X	X	X	X		X		X
Oviedo	X	X			X	X				
País Vasco	X	X		X				X	X	X
Politécnica de Cartagena	X	X	X	X	X	X	X	X	X	
Politécnica de Cataluña	X	X	X	X	X		X	X	X	
Politécnica de Madrid	X	X	X	X	X	X	X	X	X	
Politécnica de Valencia	X	X	X	X	X	X	X	X	X	X
U.N.E.D.	X	X		X	X			X		
Zaragoza	X	X		X	X			X	X	

Table 1. “Competencies and skills in Spanish Industrial Engineering degrees”.

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- Management training: It is about organizing and planning in the field of business and other institutions and organizations. Ten universities under study consider this competence, through general skills about basic business and the specific competences: strategy management, information management and design and planning.

- Lecturer-researcher training: Dedicated to learn about teaching in secondary schools or professional training modules. Thirteen universities under study consider that engineers should achieve this competence. Nowadays, this competence is not mentioned in ANECA (2005), Marin-Garcia et al. (2009) and Marin-Garcia et al. (2008) because is not according to a professional profile for an Industrial Engineer.

- Team work: It is about team work techniques, roles, cooperation, status, coordination, etc. This general competence appears in the study plans of twelve listed universities.

- Project teams: It is based in the interpretation of top managers' ideals. In companies, teams play a key role because they provide a shared context where people can interact and establish an ongoing dialogue that enables effective reflection. Through dialogue and discussion, team members create different views that are integrated into a collective perspective. This competence can be both general and specific. We can found it in eleven degrees under study.

- Environment: It is about sustainable development, environmental responsibility and clean technologies. By achieving this competence students get the ability to valuate social and environmental impact of technical solutions. Eight of the listed universities consider this competence, whether as general, specific and even in others.

- Design of products and services: Design, develop, implement, manage and improve products, systems and processes in different industrial areas, by using appropriate analytical, computational or experimental techniques. Only one University does not consider this specific competence.

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- Quality management: Acquisition of the ability to apply principles and methods of quality to improve products and services. Eleven universities include this competence in their degrees.

- Commercial: Performing tasks related to the sale of facilities and equipment. Only seven universities in the case study above consider this specific competence in the design and planning process.

4 Comparison of competencies in Industrial Engineering degrees and real demand of employees

In Canós and Santandreu (2010) a theoretical framework which justifies the relationship of the organizational structure of companies and the circuit through which information flows is presented. In concrete, we focus in a region called La Safor, Gandia. It has a population of 81 950 inhabitants and is one of the main Spanish tourist destinations. Currently, the main base of local economies is trade and services small companies, being the commercial head of which orbit the populations of the region, 180 000 inhabitants.

The competences wanted by companies for their staff, according to Canós and Santandreu (2010) are:

- Shared vision: Degree of staff identification with corporate culture and level of socialization.

- Rotation: Understood as the change between jobs or tasks in the company. Rotation allows employees to know the company from multiple perspectives and develop not only one routine, but creative work. Rotation allows duplication, that is, the deliberate overlapping of information, operational and management responsibilities, to create knowledge (Nonaka, Toyama, & Nagata, 2000; Ortt & Smits, 2006).

- Free access to information: Business knowledge becomes more fluid and easy to implement through transparency in reporting.

- Team work: Team work techniques, roles, cooperation, status, coordination, etc. (Chiesa, Coughlan, & Voss, 1996; Rothwell, 1992; Souitaris, 2002; Quinn, Anderson, & Finkelstein 1996).

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- Project teams: It is based in the interpretation of top managers' ideals. Teams play a key role because they provide a shared context where people can interact and establish an ongoing dialogue that enables effective reflection. Through dialogue and discussion, team members create different views that are integrated into a collective perspective (Nonaka, Toyama, & Nagata, 2000; Quinn, Anderson, & Finkelstein, 1996).

- Communication channels: This issue is clearly related to information, assertiveness and information systems (Rogers & Shoemaker, 1971).

- Experience: We consider this competence if University offers the possibility of doing business practices or internship to students.

- Company vision: It has its origin in managers, with responsibilities related with multidisciplinarity, considering different views, openness, etc. (Choi & Lee, 2003).

- Corporative strategy (Innovation): It is considered if training about manage innovation is offered (Quinn, Anderson, & Finkelstein, 1996).

- Involvement of managers: Degree of management commitment in the implementation of strategies. No references have been found in any University.

Following the concept of competition both from the professional and academic point of view, we might say that the result of research gives us a view of the professional profile demanded by companies.

Table 2 shows the relationship between competencies considered by real companies, understood here as professional demands, and if skills are within the profile considered by universities in the definition of study plans.

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UNIVERSITY	Shared vision	Rotation	Free access to information	Team work	Project teams	Communication channels	Experience	Company vision	Corporative strategy (Innovation)	Involvement of managers
Antonio de Nebrija		X		X	X		X	X	X	
Cádiz		X		X	X		X	X	X	
Cantabria		X		X	X		X	X	X	
A Coruña		X			X		X	X	X	
Deusto		X		X	X		X	X	X	
País Vasco		X					X	X	X	
Gerona		X			X		X	X	X	
Jaime I		X		X	X		X	X	X	
Oviedo		X		X	X	X	X	X	X	
Politécnica de Cartagena		X		X	X		X	X	X	
Politécnica de Cataluña		X		X	X		X	X	X	
Politécnica de Madrid		X		X	X		X	X	X	
Politécnica de Valencia		X			X		X	X	X	
U.N.E.D.		X		X	X		X	X	X	
Zaragoza		X					X	X	X	

Table 2. “Required competencies in real business and Industrial Engineering degrees”.

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As we can see, shared vision, free access to information and involvement of managers are not considered in new degrees, but required in real business. On the other hand, rotation, experience, company vision and corporative strategy are in all the Industrial Engineering degree study plans. In addition, team work and project teams are present in almost all the Spanish degrees, meanwhile communication channels is only considered by one University.

5 Conclusions

The construction of the European Higher Education Area supposes the implementation of a new educational model that is forecasted to be a very good model because of new learning results. In consequence, new degrees for Industrial Engineering are designed by considering competencies for students.

In this paper, first we have analyzed the competencies and skills proposed as ideals for an Industrial Engineer degree. For this, we have used some Ministerial documents and other reference papers that describe an ideal degree. Then, we have identified them in the current study plans implemented in Spanish universities. Competencies as multidisciplinariety and R&D are considered in all the universities, but commercial or environment are not so popular.

Moreover, we have checked the fit between competencies and skills described in Spanish Industrial Engineering degrees and a real business environment. We base our comparison in a study developed by Canós and Santandreu (2010), in which some competencies were highlighted by innovative companies. In this case, rotation, experience, company vision and corporative strategy are in all the analyzed study plans. On the other hand, competencies as shared vision, free access to information and involvement of managers do not appear in new degrees, but they are required in real business. We think this can be a reflection for new Industrial Engineering degrees' designers in order to complement current curricula and better fit to real companies requirements.

Currently, the only comparison we can make between the competencies of degrees and the needs to develop the Industrial Engineering profession is theoretical because the introduction of new degrees has just started and there are no graduates. Therefore, a future line of research would be to check with the first graduates whether or not the competencies acquired in University fit in the

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business world. We are also interested to know the competencies of masters, which are considered as a specialization, and see if they provide some added value to degree studies.

From this paper we can reflect about two contributions: one academic and one professional. The academic one involves identifying a professional profile of the engineer common to most Spanish universities and therefore facilitates the selection of one curricula or another for students, who can choose their studies according to the differences that may exist between different degrees in different universities. The professional contribution open a future line of research by testing competencies acquired by graduates and competencies required in the professional field, as well as the study of these competencies in the professional field. In addition, current employees may decide to recycle their competencies or acquire new ones knowing the design of new degrees.

Moreover, we do not have to forget that studies taught in Universities and real business world have to fit constantly to optimize the performance of graduates in their professional development. This adaptation is possible by considering studies as the one described in this paper.

Annex 1

UNIVERSITY	Industrial Engineering degree
Abat Oliba CEU	no
Alacant	no
Alcalá	no
Alfonso X El Sabio	no
Almeria	no
Antonio de Nebrija	yes
Autónoma de Barcelona	no
Autónoma de Madrid	no
Barcelona	no
Burgos	no
Cádiz	yes
Camilo José Cela	no
Cantabria	yes
Cardena Herrera CEU	no
Carlos III de Madrid	yes (not available data)
Castilla La Mancha	no
Católica de Ávila	no
Católica San Antonio de Murcia	no
Católica de Valencia San Vicente Mártir	no
Complutense de Madrid	no
Córdoba	no
A Coruña	yes
Deusto	yes

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Europea de Madrid	no
Europea Miguel de Cervantes	no
Extremadura	no
Francisco de Vitoria	no
Girona	yes
Granada	no
Huelva	no
Illes Balears	no
Internacional de Andalucía	no
Internacional de Catalunya	no
Internacional Menéndez Pelayo	no
Jaén	no
Jaume I	yes
La Laguna	no
La Rioja	no
Las Palmas de Gran Canaria	no
León	no
Lleida	no
Málaga	yes (not available data)
Miguel Hernández d'Elx	no
Mondragon Unibertsitatea	no
Murcia	no
Navarra	no
Oberta de Catalunya	no
Oviedo	yes
Pablo de Olavide	no
País Vasco	yes
Politécnica de Cartagena	yes
Politécnica de Catalunya	yes
Politécnica de Madrid	yes
Politécnica de Valencia	yes
Pompeu Fabra	no
Pontificia de Comillas	no
Pontificia de Salamanca	no
Navarra	no (pending of approval)
Ramón Llull	no
Rey Juan Carlos	no
Rovira i Virgili	no
IE University	no
Salamanca	no (pending of approval)
San Jorge	no
San Pablo CEU	no
Santiago de Compostela	no
Sevilla	yes (not available data)
UNED	yes
Valencia	no
Valladolid	no
Vic	no
Vigo	no
Zaragoza	yes

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