Real companies demand of competences in higher education study plans.

C. SANTANDREU-MASCARELL; L. CANÓS-DARÓS; C. PONS-MORERA
Department: Organización de Empresas
Universitat Politècnica de València. Escuela Politècnica Superior de Gandia
Paranimf, 1, 46730, Grau de Gandia, Valencia
SPAIN
crisannma@omp.upv.es; loucada@omp.upv.es; carponmo@upvnet.upv.es

Abstract: - In this paper we analyse competences and skills in Industrial Engineer degrees and in master's degrees related with this field. We have identified them in the current study plans implemented in Spanish universities. We check the fit between the different competences and skills described in Spanish degrees and master's degree. Then, we compare these specific competences with a real business environment. We base this comparison in a study developed by Canós and Santandreu (2010), in which innovative companies highlighted some competences. There are some competences in study plans that are not mentioned by managers in the considered companies. We think this can be a reflection for new degrees and master's degrees study plans designers in order to complement current curricula and better fit it to real companies' requirements.

Key-Words: - Competences; Skills; Degree, Master's Degree; Industrial Engineering.

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. 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 an educational context, it is necessary to change and transform the traditional teaching process to one based on competences and skills because companies evaluate future employees according to their competences.

Companies are organizational systems constantly changing and adapting to the environment to survive. Employees allow companies to modify its offer depending on requirements from demand needs. Some of these employees have higher education titles, as Industrial Engineering degree. They have to develop a continuous process of transformation and adaptation by enabling the new process of training (education and learning) proposed according to European convergence.

There are several papers that identify general competences in the European Higher Education Area, and other ones that focus in the specific case of an Engineer [2;3]. Likewise, some papers define ideal competences, generic competences and specific competences that an Industrial Engineer must have [4;5]. Moreover, some papers show results to concrete competences models in a subject, and provide feedback for general models [6;7;8;9]. In this context, Chad Holliday, former CEO and chairman of DuPont and Bank of America's current president, describes how companies and university training can help each other and can also collaborate to promote understanding and action in the field of sustainability. The interview presents some recommendations based on Mr. Holliday's knowledge, gained through diverse leadership roles and the building of relationships with over 50 universities worldwide [10].

2 Comparison of competences in Industrial Engineering and real demand of employees.

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 [11]. In particular, the Industrial Technologies Engineering degree 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 [12;13].

Basic competences and skills required for an Industrial Engineer are regulated by an Spanish Ministerial Order CIN/351/2009 of 9th of February, 2009: 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. The abilities to manage activities involved in the engineering projects described in the previous section are: knowledge, understanding and ability to implement the necessary legislation in the exercise of the Industrial Engineer profession, knowledge of basic materials and technology to learn new methods and theories, giving them the versatility to adapt to new situations, knowledge for doing measurements, calculations, assessments, appraisals, surveys, studies, reports, work plans, and similar work, ability to deal with specifications, regulations and mandatory standards, ability to work in a multilingual and multidisciplinary environment, ability to apply principles and methods of quality, 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, ability to analyze and evaluate social and environmental impact of technical solutions, and finally, ability to organize and plan in any company, and other institutions and organizations [13].

Following this list, Spanish universities have adapted new curricula to new needs. We have revised competences in degrees to establish if they follow these criteria or we can find some differences. The universities mentioned below take into account the competences presented in the Ministerial Order.

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

There are 15 universities throughout all the Spanish universities offering the degree we are studying: Antonio de Nebrija, Cádiz, Cantabria, A Coruña, Deusto, Gerona, Jaime I, Oviedo, País Vasco, Polytechnic of Cartagena, Polytechnic of Cataluña, Polytechnic of Madrid, Polytechnic of Valencia, National Spanish University on Distance Learning (U.N.E.D.) and Zaragoza.

From information obtained from universities and relating it to different papers discussed above [5;9;11;12] we present the following definitions of competences.

Multidisciplinary	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 general skills about science, technology and business. All universities under study include this competence.
R&D	We consider it exists if training about manage innovation is offered. Notice that this is a general competence. All universities under study include it.
Management	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 competences 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 [4;5;11] because is not according to a professional profile for an Industrial Engineer.
Teamwork	It is about teamwork techniques, roles, cooperation, status, coordination, etc. This general competence appears in the study plans of twelve listed universities. The new proposals of change of educational methodologies in the university tend to the incorporation of the participation of the student and the work in group through active methodologies [12].

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 on-going 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.
Products and services design	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.
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.

Table 1. Competences in Industrial Engineering degrees study plans.

On the other hand, based about the competences in the Industrial Technologies Engineering degree, and considering that the degree is a previous requirement to access the master's degree, a deep research throughout all the Spanish universities has been made. For this, we looked for a master's degree in Industrial Engineering, which together with the corresponding degree would be equivalent to the traditional Industrial Engineering higher degree. Nevertheless, we found that each university denominates its masters freely; so therefore, the "master's degree in Industrial Engineering" (literally) does not exist.

It should be noted that we have only considered official master's degrees, not own titles of each university neither the master's degrees still not homologated at the moment. The sources of all data are the main websites of Spanish universities [http://universidades.universia.es/universidades-de-pais/datos-basicos/, consulted on May 27th, 2011]. Once excluded the universities that do not offer the previous master's degree, we visited the websites of the engineering schools in each university and identified the competences appearing in their curricula. With this first screening approach, Table 2 is prepared.

University	Master's Degree
University of Cantabria	Master's Degree in Industrial Engineering Research
University of Coruña	Master's Degree in Industrial Engineering and Technology
University of Extremadura	Master's Degree in Engineering and Architecture Research
Polytechnic University of Catalunya	Master's Degree in Industrial Organization Engineering
Polytechnic University of Madrid	Master's Degree in Industrial Organization Engineering
Rovira i Virgili University	Master's Degree in Industrial Organization
University of Sevilla	Master's Degree in Industrial Organization and Management
University of Vigo	Master's Degree in Industrial Innovation and Process Optimization

Table.2: Industrial Engineering master's degree in Spanish universities.

Sometimes we worked from brief descriptions of the master's degree, since there are universities that do not offer a list of competences in their websites. As examples, competences are listed in the websites of the Polytechnic University of Valencia and the University of Cantabria. In this case, information extraction was simple, since it was very detailed. In other cases, competences have been deduced, since

available information was very limited. In universities that offer a list of competences information extraction has been simple, since it was very detailed.

When studying in detail competences in master's degrees study plans we see they are similar, coinciding even in their description (see Table 3). Therefore, the competence described by University of Cantabria "Students must be able to integrate knowledge and handle the complexity of formulating judgments from information that, being incomplete or limited, include thoughts on social and ethical responsibilities linked to the application of their knowledge and judgments", too much resembles the one from University of Extremadura: "Ability to integrate knowledge and handle the complexity of formulating judgments from information that, being incomplete or limited, include thoughts on social and ethical responsibilities linked to the application of their knowledge and judgments". As it happens in this case, it is not surprising that almost all the competences coincide.

Five out of the ten competences exposed in the Industrial Technologies Engineering degree are repeated, but not by chance. They are also highlighted in the competences of the master's degrees' study plans with the exception of the competence "management", which only appears in the degrees with an organizational profile.

Multidisciplinary	Train versatile and general-purpose technicians for industry. Provide a solid scientific training and a wide range of expertise in diverse technologies in order to become multidisciplinary professionals. This competition coincides with the one shown in the previous study of degrees and has been highlighted, since it is repeated in all the universities under study.
R&D	Information about managing innovation is always offered. This competence coincides with the one shown in the previous study of degrees and has been highlighted, since it is repeated in all the analysed universities.
Management	It is about organizing and planning in the field of business and other institutions and organizations. Five universities in our study outstand this competence, the ones that offer masters based on Industrial Organization, not the most technological ones.
Lecturer-researcher training	This competence is oriented to the beginning of a PhD, after studying a master, as well as to the realization of scientific articles. It coincides with the one shown in the previous study of degrees but more focused on research than into teaching and has been highlighted, as is repeated in all the universities under study.
Teamwork	Techniques, roles, cooperation, status, coordination, etc. An example about teamwork related with communication can be seen in [14]. This competence coincides with the one shown in the previous study of degrees and has been highlighted, since it is repeated in all the analysed universities.
Communication	Based on the domain of oral, written, interpersonal and nonverbal communication. Also communication in different languages and communication as the capacity of the transmitting knowledge, whether through teaching as well as through scientific articles and publications. The competence is mentioned in all the universities under study.
Resources management	Resources like materials, human capital or time management, effectively and efficiently managed. The competence is mentioned in all the universities under study.
ICT	Knowing and using the Information and Communications Technologies in professional and personal lives. The competence is mentioned in all the universities under study.
Critical thinking	Presented in the competences as problems solving, creative thinking or logical thinking. The competence is mentioned in all the universities under study.
Ethic	Or ethical sense. The graduate must be able to make reflections on social and ethical responsibilities linked to the application of their knowledge and judgements. The competence is mentioned in all the universities under study.

Table 3. Competences in Industrial Engineering master's degree study plans.

Universities have to base their teaching-learning processes in a model of competences and skills associated with professional profiles [15;16]. Competences and skills are defined by different international agencies and researchers. We use the concept defined by [17]: a person has professional competences 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 competences as those forming an essential part of the professional and educational profile of all or most of the degrees. They are associated with high education and include all cognitive and metacognitive skills, knowledge and instrumental attitudes considered valuable in the knowledge society. In addition, specific competences 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 [18].

Based on the foregoing, we are aware of the competences offered by universities; we must now determine whether these competencies are the ones required by companies. In [1] a theoretical framework that justifies the relationship of the organizational structure of companies and the circuit through which information flows is presented. In this paper, a qualitative methodology called grounded theory is followed to understand different contents that lead to an event. The point is to select the cases to be studied in a progressive way and to be conscious about the extent to which the qualitative method constantly works, to take into account various ways in which respondents understand questions [4;13]. The results appearing in [1] are shown in Table 4.

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 [19;20].
Free access to information	Business knowledge becomes more fluid and easy to implement through transparency in reporting.
Teamwork	Teamwork techniques, roles, cooperation, status, coordination, etc. [21;22;23;24]
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 [19;24].
Communication channels	This issue is clearly related to information, assertiveness and information systems [25].
Experience	We consider this competence if a university offers the possibility of doing business practices or internship to students.
Company vision	It has its origin in managers, with responsibilities related with multidisciplinary, considering different views, openness, etc. [26].
Corporative strategy	It is considered if training about managing innovation is offered [24].
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 4. Competences that companies demand to Spanish universities.

3 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 competences for students.

After the analysis, study, determination and abstraction of competences we compare the information obtained both from universities and companies.

From the competences in the labour field, the ones implemented in the university field are: rotation, teamwork, project team, company vision and corporative strategy. The competences not found in degree and master's degree study plans are: shared vision, free access to information and involvement of managers.

Rotation and company vision lie within multidisciplinary competence. Teamwork and project team are shown exactly by universities. Corporate strategy is linked to R&D. Experience is not mentioned as a competence by universities but it is included in all of them since they all offer professional practices (internship) in companies; therefore, we should consider whether experience should be included as a competence even though it appears as a subject.

It is noted that the five out of the ten competences demanded by companies are clearly defined in the academic study plans. The other five are not identified, so it may be the case that universities do not provide that training to their students or that they are included within specific competences (it would be necessary to expand the study and check). But as far as we have extended our research, we conclude that the universities who want to provide their students the training required by companies must train them on: shared vision, free access to information, communication channels and involvement of managers, either as generic or specific competences.

On the other hand and according to the competences offered by universities we observe that management training, lecturer-researcher training, environment, products and services design, quality management and commercial are not demanded in the professional field. This should be studied more deeply as it can be considered that many companies see them as basic and necessary, for example: environment is highly regulated from the outside; products and services design is obvious because graduates must be able to perform these tasks; quality management becomes a competitive advantage and provides additional value to products and services; management training and commercial can be considered more specific capabilities and its demand may vary depending on the type of company; lecturer-research training is more focused on developing competences related to training and teaching, so it is logical that it is not demanded in the professional field.

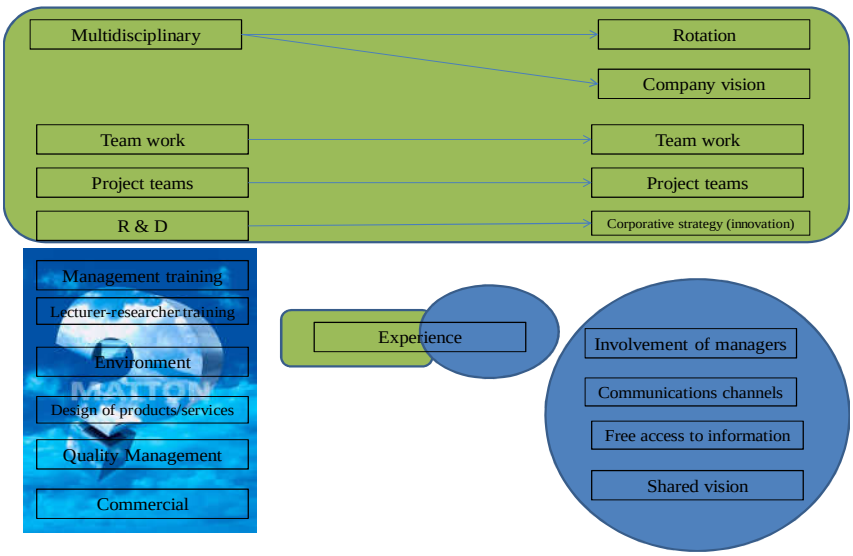

Figure 1. Relation between competences in higher education study plans and real demand.

As we can see in Figure 1, on the left hand, competences offered in higher education study plans are presented, whereas on the right hand, competences demanded by companies are listed. There is a coincidence between academic offer and real business world demand, colored on green on the top of the figure. There is not a fit in academic competences represented by with a question mark and employers' competences circled in blue. A special case is Experience that we consider as a part of study plans if internship exists according to our own criterion.

Limitations exist because the degrees are being implemented at the moment, there is very little information available about how universities are performing the process and the access to that information is rather difficult. It is also hard to contact and obtain information from the companies, since we cannot ask directly about the competences required for their employees because these vary from one to another and depending on the job, they must abstract from the way of working in each position and the relations between them.

Acknowledgements:
Partially supported by the projects PIME A14/11, PAID-05-11-2846 and CORSARI MAGIC DPI2010-18243.

References:

[1] Canós, L. and Santandreu, C., An integrated model of organizational structure and ideas, *INBAM Conference*, Valencia, 2010.

[2] Marzo, Navarro M.; Pedraja Iglesias, M. and Rivera Torres, P., Las competencias profesionales demandadas por las empresas: el caso de los ingenieros, *Revista de Educació*, Vol.341, 2006, pp 643-661.

[3] Oliveros Martín-Varés, L., Identificación de competencias: una estrategia para la formación en el Espacio Europeo de Educación Superior, *Revista Complutense de Educación*, Vol.17, No.1, 2006, pp 101-118.

[4] Marin-Garcia, J.A.; García- Sabater, J.P.; Perello-Marin, M.R. and Canós-Darós, L., Proposal of skills for the bachelor degree of Industrial Engineering in the context of the new curriculum, *Intangible Capital*, Vol.5, No.4, 2009, pp 387-406.

[5] Marín-García, J.A.; García- Sabater, J.P.; Miralles, C. and Rodríguez Villalobos, A., Profile and competence of Spanish industrial engineers in the European Higher Education Area (EHEA), *Journal of Industrial Engineering and Management*, Vol.01, No.02, 2008, pp 269-284.

[6] Rodríguez, L.M., Herramienta para medición de las competencias genéricas de los futuros ingenieros respecto de las relaciones interpersonales, *Revista de Informática Educativa y Medios Audiovisuales*, Vol.2, No.26, 2005, pp 7-16.

[7] Centeno, R. and Serafin, M, Modelo de competencias para el diseño de programas de formación de gerentes de proyectos, *Fourth LACCEI International Latin American and Caribbean Conference for Engineering and Technology (LACCEI'2006). "Breaking Frontiers and Barriers in Engineering: Education, Research and Practice"*, Mayagüez, Puerto Rico.

[8] Mesa, J.M.; Álvarez, J.V.; Villanueva, J.M. and de Cos, F., Actualización de métodos de Enseñanza-Aprendizaje en Asignaturas de Dirección de Proyectos de Ingeniería, *Formación Universitaria*, Vol.1, No.4, 2008, pp 23-28.

[9] Santandreu-Mascarell, C.; Canós-Darós, L. and Pons-Morera, C., Competencies and skills for future Industrial Engineers defined in Spanish degrees, *Journal of industrial Engineering and Management*, Vol.4, No.1, 2011, pp 13-30.

[10] Holliday, S., An Interview With Chad Holliday, (Former) CEO & Chairman, DuPont The Relationship between Sustainability Education and Business, *Academy of Management Learning & Education*, Vol.9, No.3, 2010, pp 532–541.

[11] ANECA, Libro blanco de titulaciones de grado de ingeniería, 2005.

[12] Marin-Garcia, J.A.; Martínez Gómez, M. and Lloret, J., Enhancing motivation and satisfaction of students: analysis of quantitative data in three subjects of Industrial Engineering, *WSEAS Transactions on Advances in Engineering Education*, Vol.6, No.1, 2009, pp 11-21.

[13] Marin-Garcia, J.A.; García- Sabater, J.P. and Canós-Darós, L., Industrial Engineering and the design of new European degrees, *Dirección y Organización*, Vol.40, 2010, pp 35-43.

[14] Siti Rozaimah, S.A.; Mohd Sobri, T.; Abu Bakar, M.; Noorisham, T.K.; Manal, I. and Masturah, M., Integrated project: Comparative analysis of lecturers' and students assessment of program outcomes, *WSEAS Transactions on Advances in Engineering Education*, Vol.8, No.2, 2011, pp 31-52.

[15] Azami Zaharim, M.; Zaidi, O.; Hassan, B.; Norhamidi, M. and Farah Liza, M.I., A gap study between employers' perception and expectation of engineering graduates in Malaysia, *WSEAS Transactions on Advances in Engineering Education*, Vol.6, No.11, 2009, pp 409-419.
[16] Sastre, M A. and Aguilar, E. M., *Dirección de recursos humanos. Un enfoque estratégico*, Madrid, McGraw Hill, 2003.
[17] Bunk,G.P., Teaching competence in initial and continuing vocational training in the Federal Republic of Germany, *Vocational Training European Journal*, Vol.1, 1994, pp 8-14.
[18] Yániz, C. and Villardón, L., *Planificar desde competencias para promover el aprendizaje*, Bilbao, Mensajero, 2006.
[19] Nonaka, I., Toyama, R. and Nagata, A, A firm as a knowledge-creating entity: a new perspective on the theory of the firm, *Industrial and Corporate Change*, Vol.9, No.1, 2000, pp 1-20.
[20] Ortt, J. R. and Smits, R., Innovation management: different approaches to cope with the same trends", *International Journal of Technology Management*, Vol.34, No.3/4, 2006, pp 296-318.
[21] Chiesa, V., Coughlan, P., and Voss, C.A., Development of a Technical Innovation Audit, *Journal of Product Innovation Management*, Vol.13, 1996, pp 105-135.
[22] Rothwell, R., Successful Industrial Innovation: Critical Factors for the 1990s, *R&D Management*, Vol.22, 1992, pp 221-239.
[23] Souitaris, V., Technological Trajectories as Moderators of Firm-level Determinants of Innovation. *Research Policy*, Vol.3, No.6, 2002, pp 877-898.
[24] Quinn, J.B., Anderson, P. and Finkelstein, S., La gestión del intelecto profesional: Sacar el máximo de los mejores, *Harvard Deusto Business Review*, Vol.75, Noviembre-Diciembre, 1996, pp 4-17.
[25] Rogers, E.M. and Shoemaker, F.F., *Communication of Innovations: A Cross-Cultural Approach*, Free Press, New York, 1971.
[26] Choi, B. and Lee, H., "An Empirical Investigation of Knowledge Management Styles and Their Effect on Corporate Performance", *Information & Management*, Vol.40, 2003, pp 403-417.