ACQUISITION OF COMPETENCES IN A MASTER DEGREE IN CONSTRUCTION MANAGEMENT

Víctor Yepes, Saray Segado, Eugenio Pellicer, Cristina Torres-Machí

Grupo Excelcon - Universitat Politècnica de València (SPAIN)

Abstract

Competences are specific statements that describe what students are expected to know and know how upon completion of the program. These competences are related to skills, knowledge and abilities that students acquire as they progress in their studies. Their importance is crucial because most of the current accreditation models are based on the assessment of competences. In this line, the Master of Science in Planning and Management in Civil Engineering at the Universitat Politècnica de València needed to evaluate the competences of their graduates in order to comply with an accreditation by an external body (Spanish ANECA). For this purpose, the Academic Head of the Master Degree developed a survey among its graduates using a five point Likert scale. Twenty six questionnaires (out of a population of 72) were returned and analyzed. According to the respondents, the basic competences were reached (4.4 average out of 5.0), the specific competences got values between 3.7 and 4.5 average (out of 5.0), and the general competences obtained a 4.3 average (out of 5.0). The paper describes the characteristics of the respondents, the sample, the questions and scale used, and analyzes the results in the context of the Master Degree. Some recommendations for future improvement are also drawn.

Keywords: Assessment, Competences, Construction Management, Master Degree, Survey.

1 INTRODUCTION

Current university programs are not so focused on contents as they used to be. These contents have to be taught anyway, but changing the way they are transmitted to students and enhancing strategies to carry them out effectively and efficiently. In this context, the importance of competence acquisition is a key factor; therefore, universities should carry out those strategies needed to acquire them considering the teaching and learning process [1].

Competences are the set of cognitive, procedural and attitudinal skills that can and should be achieved in higher education; they are essential to ensure: personal, professional and social self-confidence; responsiveness to the needs of the life context; and effective exercise of the rights and duties of the citizens. These competences go beyond the professional skills, typical of the traditional model of university education [2]. Regulations and society demand broader degrees; hence, the educational model has to be changed in order to achieve the competences requested [3]. Thus, the current university model corresponds to a constructivist model in which the student is the center, building their own learning. Active methodologies are used, which implies that actions come from the students, with the commitment and support of teachers [4].

Competences are composed by a set of personal attributes such as knowledge (propositional and tacit), cognitive skills (related to the learning process), practical skills, motivation, values, attitudes y perception frameworks. Furthermore, they have to refer to the criteria that define a proper and effective professional activity. Competences are the ability to implement in an integrated way those acquired knowledge and personality traits to solve different situations. According to the Tuning Project there are three types of competences [5]: basic, generic and specific. Basic competences are those that should be available to all parties involved, i.e. all college students. This type includes theoretical knowledge, practical knowledge and skills, and personal attitudes or commitments. They constitute the ability of functional use of knowledge and skills in different contexts and they represent a minimum where the faculty and the institutions should focus their efforts. Generic competences are behaviors common to various professional activities; they are also called general, intermediate or transversal. The specific competences characterize the professional profile of each Bachelor / Master Degree; they vary from one profession to another. The curricula of the different degrees are the basis for the effective and efficient development of knowledge, attitudes and interests in the professional field of each degree.

This approach to learning by competences has been already implemented in the construction management field [6]. The competency-based approach has a greater adaptability to change, affecting the convergence between education and employment, and between universities and the labor market. It also allows an emphasis on the value of human resources for economic and social development, by linking the labor market to society. In this respect, it is interesting to see how one of the barriers to the employability of future graduates is related to learning of generic competences [7]. In addition, new competences related to aspects such as quality, environment and innovation management in construction companies are increasingly necessary [8,9]. In a previous work, Pellicer et al. [10] proposed a method to design a master program in construction management, based on previous results of Yepes et al. [11], which proposed in this respect a benchmark indicator to establish this type of competences for a Master degree.

Therefore, this paper aims to explore the opinion of graduates from the Master Degree in Planning and Management in Civil Engineering at the School of Civil Engineering (Universitat Politècnica de València) regarding the degree of acquisition of competences is that program. This allows the establishment of strategic lines of improvement in order to increase the degree of acquisition of those competences. As a result of this process of continuous improvement, the use of the portfolio has been implemented in order to improve the assessment of the course and competences. A very important part of this new method is the release of students' guides that show them the pace to solve the problems derived from the main case study that involves each subject of the syllabus.

2 SURVEY

The Master Degree in Planning and Management in Civil Engineering at the Universitat Politècnica de València [12,13] needed to evaluate the competences of their graduates in order to comply with an accreditation by an external body (Spanish ANECA). In order to know the perception of the graduates regarding the acquisition of competences, the Academic Head of the Master Degree designed a questionnaire to collect the data by the means of a survey. Aiming to get the needed information, the questionnaire was divided in two parts: characterization of the respondent (year of completion and sex), and his/her opinion regarding the acquisition of competences. The latter was measured through 27 questions according to a five-point Likert scale, considering if the competency had been acquired: (1) strongly disagree; (2) agree; (3) middle ground; (4) disagree; and (5) strongly disagree.

All the population was inquired (72 graduates that finished the Master degree from 2010 to 2013). The purpose of the survey was to know the opinion of this population regarding the acquisition of competences. The final sample was comprised by 26 questionnaires; using a level of confidence of 95% (p=q=0.5), the error of the sample is 15.3%. The characterization of the sample was as follows: regarding sex, 80.8% male and 19.2% female; regarding the year of finishing studies, 7.7% in 2010, 26.9% in 2011, 38.5% in 2012, and 26.9% in 2013. Data was analyzed using IBM SPSS version 21.

3 RESULTS

3.1 Descriptive statistics

A descriptive statistical analysis of the results, regarding the acquisition of competences by graduates, is shown in Figures 1, 2 and 3. These figures use a radar chart as means of communicate the results of the quantitative variables using axes starting from the center, being the angle constant between them. Table 1 displays the mean and standard deviation for each of the 27 questions of the survey. The mean values of the basic competences range between 4.15 and 4.42 (see Figure 1); they show that graduates agree, or strongly agree, with the acquisition of these competences. This means that the Master has reached the minimum commitments that faculty and students must achieve in the teaching-learning process.

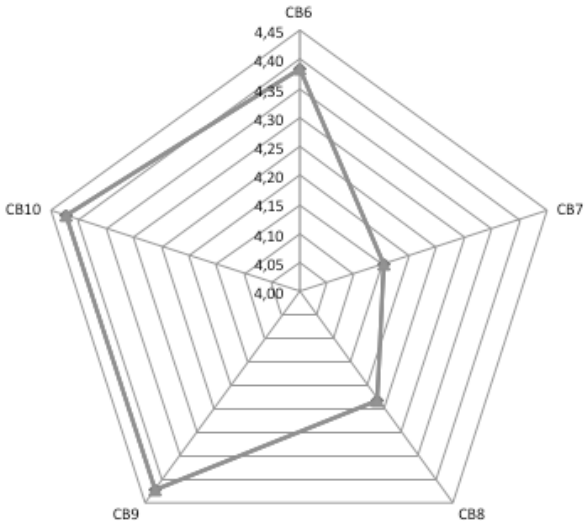

Figure 1. Radar chart of basic competences.

The mean values of the degree of achievement of specific competences (see Figure 2) vary between 3.73 and 4.50; they show that graduates believe that they have achieved such competences satisfactorily. The lower value is the CE131 competency on “meeting the environmental effects of infrastructure and ensure its sustainability”. This shows that the program does not give enough importance to environmental sustainability, maybe because it is mainly focused on construction management.

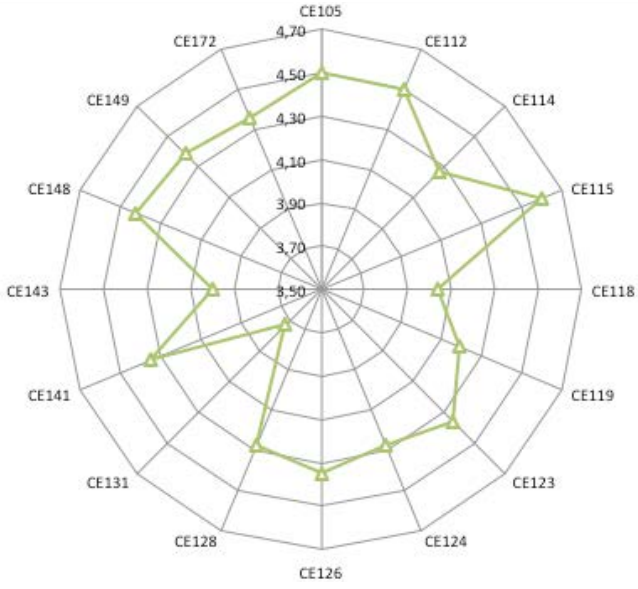

Figure 2. Radar chart of specific competences.

The mean values of the transversal competences achieved by graduates is comprised between 4.04 and 4.54 (see Figure 3); this means that graduates agree or strongly agree with the acquisition of transversal competences. The value obtained in competency CG07 highlights the high level of acquisition of abilities related to the critical analysis of planning and management processes.

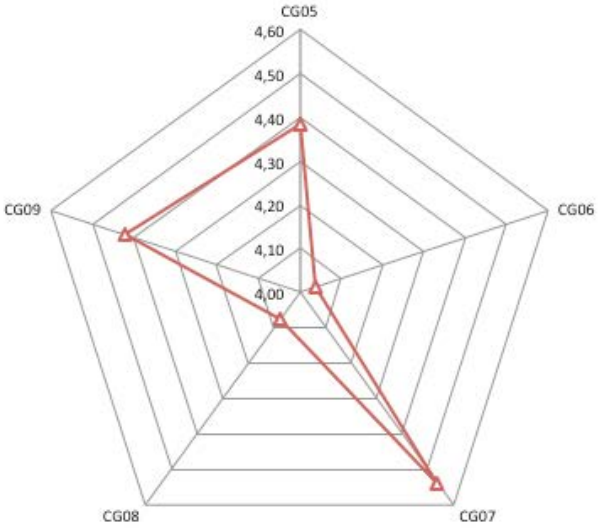

Figure 3. Radar chart of transversal competences.

Table 1 shows that respondents agree more on having acquired the following competences: (1) to know and understand the concepts of research development, and innovation within the legal framework and the social responsibility of civil engineering; (2) to analyze critically planning and management processes; and (3) to know how to manage consulting engineering firms, construction companies and developers, principally on issues related to planning, organizing, leading, controlling and marketing within the legal framework and the social responsibility of civil engineering. This specific competence is one of the best valued and has lower standard deviation (more consensus). On the other hand, the competency that shows higher standard deviation is to understand and take responsibility for ethical and professional civil engineering activities.

The less acquired competences are (in order): to meet the environmental effects of infrastructure and ensure its sustainability, to learn the basics of the evaluation and selection of investments within the legal framework and the social responsibility of civil engineering. It is also true that the answers to the acquisition of these competences are the ones with less consensus.

Table 1. Mean and standard deviation of competences' acquisition.

Code	COMPETENCY	N	Mean	SD
CB6	To understand knowledge that provides a basis to be original and to apply ideas, often in a research scenario.	26	4.38	0.571
CB7	To apply the acquired knowledge to problem-solving in new or little-known scenarios related to their field of study.	26	4.15	0.881
CB8	To integrate knowledge and face the complexity of making judgements based on incomplete or limited information, including thoughts on social and ethical responsibilities linked to the application of knowledge.	26	4.23	0.710
CB9	To communicate conclusions, and the reasons that support them, to specialized audience, in a clear and straightforward way.	26	4.42	0.809
CB10	To have the ability of learning in a self-directed or autonomous way.	26	4.42	0.643
CG05	To understand and use the appropriate language focused on planning and management in the construction industry, in general, and in civil engineering, in particular.	26	4.38	0.697
CG06	To understand and assume the ethical and professional responsibility of the civil engineering activities.	26	4.04	1.280
CG07	To analyze critically the planning and management processes.	26	4.54	0.647

Code	COMPETENCY	N	Mean	SD
CG08	To lead and command in an entrepreneurial and multidisciplinary context.	26	4.08	0.977
CG09	To direct and coordinate team-works, proposing work methods and tools.	26	4.42	0.578
CE105	To know in depth the management of consulting engineering firms, construction companies, and developers, basically regarding planning, organization, leading, control, and marketing within the legal framework and the social responsibility of civil engineering.	26	4.50	0.510
CE112	To know, from a theoretical and practical point of view, the four basic functions of management (planning, organizing, leading and controlling), and apply them to design and construction within the legal framework and the social responsibility of civil engineering.	26	4.50	0.583
CE114	To know integrated project management.	26	4.27	0.778
CE115	To know and comprehend the concepts of research, and innovation, technological watch within the legal framework and the social responsibility of civil engineering.	25	4.60	0.645
CE118	To analyze novel construction methods that help optimizing the performance of the construction project.	26	4.04	1.113
CE119	To comprehend the relationship between construction management and business management.	26	4.19	0.849
CE123	To acquire a positive attitude towards occupational risk prevention in construction, at the same level as production or quality.	25	4.36	0.700
CE124	To identify and value the most important risks in civil engineering, as well as the right preventive measures for their elimination or within the legal framework and the social responsibility of civil engineering.	25	4.28	0.843
CE126	To strengthen knowledge on production, planning and control of the construction site, deepening five fundamentals facets: changes, quality, time, safety and environment.	26	4.35	0.846
CE128	To know and analyze tools, techniques and methods that help the engineer to optimize the organization, planning, leading and control of the construction site.	25	4.28	0.737
CE131	To know the environmental effects produced by infrastructures and ensure their sustainability.	26	3.73	1.251
CE141	To know in-depth the methods of multicriteria and cost-benefit analysis, financial and economic within the legal framework and the social responsibility of civil engineering.	26	4.35	0.689
CE143	To understand the basics of evaluation and selection of investments within the legal framework and the social responsibility of civil engineering.	26	4.00	0.894
CE148	To analyze research documents related to planning and management in civil engineering.	26	4.42	0.809
CE149	To write research documents and doctoral thesis in the context of planning and management in civil engineering.	26	4.38	0.752
CE172	To understand the differences between the different concepts of quality, analyzing the ISO 9000 standards in the business context of the construction industry.	25	4.36	0.700
CE180	To know and analyze information and communication technologies in the construction industry.	25	4.04	0.790

After a correlation analysis between the different variables, the highest Pearson correlation (0.836, with bilateral significance at the 0.01 level) corresponds to CB7 and CB8, both having to do with the application of the knowledge acquired in new environments or with incomplete or limited information. CB7 and CE124 are also highly correlated (Pearson correlation of 0.819, with bilateral significance at the 0.01 level), as well as CE128 and CG06 (Pearson correlation of 0.810, with bilateral significance at the 0.01 level). In the two latter cases, there is no apparent reason for this correlation.

3.2 Principal component analysis

Factor analysis is performed using the method of principal components to identify underlying variables or factors that explain the pattern of correlations within the set of observed variables. Summarizing, the aim is to find out the "constructs" or underlying variables that explain most of the observed variance. The principal component analysis examines the interdependence between variables to reduce the size of an original set of variables to a new subset consisting of unobservable variables. Factors are a linear combination of the original variables and also independent of each other. The first major component is chosen in order to explain most of the possible variance of the original variables, and so on. This technique does not imply dependence between the variables a priori and, therefore, is applied before starting a multiple regression [14].

To prevent that the unit of measurement affects the results, the correlation matrix has been used instead of the covariance. Thus, the average value of the main components is 0 and standard deviation is 1. Moreover, the criterion for determining the number of principal components establishes that the eigenvalue of each factor has to exceed 1. Also, to facilitate interpretation, the Varimax method is used, which is an orthogonal rotation that minimizes the number of variables that have high loadings on each factor [15].

Before performing the extraction of the main components, each of the variables is explained 100% by itself. However, once the principal components are extracted, they do not explain all the variability of each variable; therefore, some information is lost. Table 2 shows the standard deviation reflected after the extraction, i.e. commonalities, which measure the amount of information after this extraction. The better explanation is given by the specific competence CE118, concerning the analysis of novel construction methods that optimize work performance. The one with less explanation is the specific competence CE105, regarding in-depth knowledge on management of consulting firms, construction companies and developers, mainly in aspects related to planning, organizing, directing, controlling and marketing within the legal framework and the social responsibility of civil engineering.

Table 2. Communalities.

Code	COMPETENCY	Extraction
CB6	To understand knowledge that provides a basis to be original and to apply ideas, often in a research scenario.	0.747
CB7	To apply the acquired knowledge to problem-solving in new or little-known scenarios related to their field of study.	0.971
CB8	To integrate knowledge and face the complexity of making judgements based on incomplete or limited information, including thoughts on social and ethical responsibilities linked to the application of knowledge.	0.883
CB9	To communicate conclusions, and the reasons that support them, to specialized audience, in a clear an straightforward way.	0.877
CB10	To have the ability of learning in a self-directed or autonomous way.	0.638
CG05	To understand and use the appropriate language focused on planning and management in the construction industry, in general, and in civil engineering, in particular.	0.926
CG06	To understand and assume the ethical and professional responsibility of the civil engineering activities.	0.861
CG07	To analyze critically the planning and management processes.	0.734
CG08	To lead and command in an entrepreneurial and multidisciplinary context.	0.896

Code	COMPETENCY	Extraction
CG09	To direct and coordinate team-works, proposing work methods and tools.	0.653
CE105	To know in depth the management of consulting engineering firms, construction companies, and developers, basically regarding planning, organization, leading, control, and marketing within the legal framework and the social responsibility of civil engineering.	0.561
CE112	To know, from a theoretical and practical point of view, the four basic functions of management (planning, organizing, leading and controlling), and apply them to design and construction within the legal framework and the social responsibility of civil engineering.	0.634
CE114	To know integrated project management.	0.715
CE115	To know and comprehend the concepts of research, and innovation, technological watch within the legal framework and the social responsibility of civil engineering.	0.881
CE118	To analyze novel construction methods that help optimizing the performance of the construction project.	0.977
CE119	To comprehend the relationship between construction management and business management.	0.777
CE123	To acquire a positive attitude towards occupational risk prevention in construction, at the same level as production or quality.	0.935
CE124	To identify and value the most important risks in civil engineering, as well as the right preventive measures for their elimination or within the legal framework and the social responsibility of civil engineering.	0.902
CE126	To strengthen knowledge on production, planning and control of the construction site, deepening five fundamentals facets: changes, quality, time, safety and environment.	0.811
CE128	To know and analyze tools, techniques and methods that help the engineer to optimize the organization, planning, leading and control of the construction site.	0.872
CE131	To know the environmental effects produced by infrastructures and ensure their sustainability.	0.925
CE141	To know in-depth the methods of multicriteria and cost-benefit analysis, financial and economic within the legal framework and the social responsibility of civil engineering.	0.716
CE143	To understand the basics of evaluation and selection of investments within the legal framework and the social responsibility of civil engineering.	0.837
CE148	To analyze research documents related to planning and management in civil engineering.	0.871
CE149	To write research documents and doctoral thesis in the context of planning and management in civil engineering.	0.821
CE172	To understand the differences between the different concepts of quality, analyzing the ISO 9000 standards in the business context of the construction industry.	0.768
CE180	To know and analyze information and communication technologies in the construction industry.	0.793

These criteria underlie six main components that are able to explain 81.41% of the variance of the questions in the survey (see Table 3). The components are related to the following underlying issues:

- Component 1: Ability to solve unforeseen risks.
- Component 2: Knowledge of documents and standards.
- Component 3: Critical thinking.
- Component 4: Business management.
- Component 5: Communication and ethics.
- Component 6: Constructive and environmental procedures.

Table 3. Total variance explained.

Component	Total	% Variance	% Accumulated
1	12.990	48.112	48.112
2	2.638	9.770	57.882
3	2.017	7.472	65.354
4	1.826	6.764	72.118
5	1.329	4.922	77.041
6	1.179	4.367	81.408

Table 4 shows the factorial matrix of the rotated components, indicating the correlation between each of the main components and the original variables. It displays the weights of each variable in the linear relation of each principal component to the different variables. Rotation has converged in 18 iterations; values less than 0.600 has been eliminated.

Table 4. Factorial matrix of the rotated components.

	Component					
	1	2	3	4	5	6
CE124	0.806					
CE126	0.739					
CE123	0.727					
CE112	0.715					
CB07	0.709					
CE114						
CG08						
CE172		0.810				
CE149		0.731				
CE115		0.709				
CE141						
CE119						
CG07			0.794			
CE143			0.661			
CB06			0.659			
CE148		0.610	0.641			
CE128						
CG09				0.711		
CE105				0.706		
CE180				0.646		

CB9	0.841	
CG06	0.630	
CB8	0.622	
CG05	0.621	
CE131		0.773
CE118		0.617
CB10		

4 CONCLUSION

Graduate studies related to construction management cannot be oblivious to the approach of learning competences for accessing the labor market. This approach has a greater adaptability to change, considering the value of human resources for economic and social development, by linking the labor market and society. A statistical study of graduates during the past four years from the Master Degree in Planning and Management of Civil Engineering indicates that competences development was achieved almost entirely. However, it points out that expertise related to sustainability and awareness of the environmental effects of infrastructure is the competence showing the lowest level of achievement. There is thus room for improvement in this facet, considering the global framework of construction management. Moreover, all competences tested can be explained to a large extent (over 80%) with six underlying constructs that correspond to the ability to solve unforeseen risks, knowledge of documents and standards, critical thinking, business management, communication and ethics, and construction and sustainable procedures. As a future line of research, the results should be checked with a larger sample of graduates in the forthcoming years.

ACKNOWLEDGMENTS

The authors are grateful to the alumni of the Master Degree in Planning and Management in Civil Engineering for their cooperation. This work was supported by the School of Civil Engineering at the Universitat Politècnica de València through the Education Improvement and Innovation Project PIME 2013 and the EICE 2012 program (EXCELCON group).

REFERENCES

[1] R. Vaatstra, R.D. Vries, The Effect of the Learning Environment on Competences and Training for the Workplace according to Graduates, Higher Education, 53 (2007), 335–357. doi:10.1007/s10734-005-2413-4.

[2] S. Adam, Competences, Learning Outcomes and Convergence. In: Higher Education for Modern Societies: Competences and Values, Council of Europe Publishing, Strasbourg, France, 2010.

[3] D. Pepper, Assessing Key Competences across the Curriculum — and Europe, European Journal of Education, 46 (2011), 335–353, doi:10.1111/j.1465-3435.2011.01484.x.

[4] E. Pellicer, L.A. Sierra, V. Yepes, Appraisal of infrastructure sustainability by graduate students using an active-learning method, Journal of Cleaner Production, in press (2016), doi:10.1016/j.jclepro.2015.11.010.

[5] J. Gonzalez, R. Wagenaar, Tuning Educational Structures in Europe, Universidad de Deusto, Bilbao, Spain, 2003.

[6] Pellicer, E., Yepes, V., Teixeira, J.C., Moura, H.P., Catalá, J. (2014). Construction Management, Wiley, New York.

[7] Torres-Machí, C., Carrión, A., Yepes, V., Pellicer, E. (2013). Employability of graduate students in construction management, Journal of Professional Issues in Engineering Education and Practice, 139(2), pp. 163-170.

[8] Pellicer, E., Correa, C.L., Yepes, V., Alarcón, L.F. (2012). Organizacional improvement through standardization of the innovation process in construction firms. Engineering Management Journal, 24(2), pp. 40-53.

[9] Pellicer, E., Yepes, V., Correa, C.L., Alarcón, L.F. (2014). Model for systematic innovation in construction companies. Journal of Construction Engineering and Management, 140(4), B4014001.

[10] Pellicer, E., Yepes, V., Ortega, A.J. (2013). Method for planning a graduate program in construction management. Journal of Professional Issues in Engineering Education and Practice, 139(1), pp. 33-41.

[11] Yepes, V., Pellicer, E., Ortega, J.A. (2012). Designing a benchmark indicator for managerial competences in construction at the graduate level. Journal of Professional Issues in Engineering Education and Practice, 138(1), pp. 48-54.

[12] Jiménez, J., Pellicer, E., Yepes, V. (2011) Teaching and learning using a case study: application to a master degree in construction management. Procedia - Social and Behavioral Sciences, 15, pp. 696-702.

[13] Jiménez, J., Yepes, V., Picornell, Pellicer, E. (2012). Strategic analysis applied to a Master degree in construction management: a view from the faculty. International Technology, Education and Development Conference INTED 2012, pp. 5607-5615, Valencia (Spain).

[14] Shaw, P.J.A. (2003). Multivariate Statistics for the Environmental Science, Hoddeer-Arnold, London.

[15] Kaiser, H.F. (1958). The Varimax criterion for analytic rotation in factor analysis. In: Psychometrika, 23(3), pp. 187-200.