Pellicer Armiñana, E.; Yepes Piqueras, V.; Ortega Llarena, AJ.; Carrión García, A. (2017). Market demands on construction management: A view from graduate students. JOURNAL OF PROFESSIONAL ISSUES IN ENGINEERING EDUCATION AND PRACTICE. 143(4):1-11. doi:10.1061/(ASCE)EI.1943-5541.0000334

MARKET DEMANDS ON CONSTRUCTION MANAGEMENT: A VIEW FROM GRADUATE STUDENTS

Eugenio Pellicer[1], Víctor Yepes[2], Alejandro J. Ortega[3], Andrés Carrión[4]

ABSTRACT

The construction industry demands managerial skills for professionals working within it, especially from those having an undergraduate civil engineering degree, which is generally pursued through graduate programs (M.Sc. degrees) in the construction management field. This paper checks how graduate students' views are relevant in order to assess and improve these M.Sc. programs. The research is performed through a survey based on a sample of 534 graduate students from several American and European universities. Using confirmatory factor analysis with the survey data, it has been corroborated that the construction management field can be mapped according to two dimensions: the infrastructure life-cycle and the organizational breakdown. Furthermore, by means of an exploratory factor analysis, six components or approaches for a graduate program in the construction management field are highlighted as important by the respondents: leadership, built environment stakeholders, innovation and quality, economics, business management, and project management. The organizational point of view is clearly identified by the students: its four variables are highlighted as principal components. However, regarding the infrastructure life-cycle, certain important facets, such as feasibility

[1] Associate Professor, School of Civil Engineering, Universitat Politècnica de València, Camino de Vera s/n, 46022 Valencia, Spain. Corresponding Author: Phone +34963879562; Fax: +34963877569; E-mail: pellicer@upv.es.

[2] Associate Professor, ICITECH, Universitat Politècnica de València, Camino de Vera s/n, 46022 Valencia, Spain. E-mail: vyepesp@upv.es.

[3] Graduate Student, School of Civil Engineering, Universitat Politècnica de València, Camino de Vera s/n, 46022 Valencia, Spain. E-mail: alejandro.ortegallarena@gmail.com.

[4] Associate Professor, Department of Statistics, Universitat Politècnica de València, Camino de Vera s/n, 46022 Valencia, Spain. E-mail: acarrion@eio.upv.es.

analysis and operation and maintenance of infrastructures, are considered by graduate students less important than the classical design and construction. The findings of this research can help improving the curricula of graduate programs in the construction management field.

KEYWORDS: Curricula, Construction Management, Graduate Students, Market Demand, Survey

INTRODUCTION

The 19th century witnessed the birth of construction-related university degrees in Europe and America, basically civil engineering and architecture (Ledbetter 1985; Schexnayder and Anderson 2011; Navascués 1996; Allaback 2008). These degrees were focused on the design of heavy civil works and buildings, respectively. In civil engineering degrees, the curriculum had a strong base of mathematics, physics and strength of materials, whereas in architecture the curriculum had a strong base regarding drawing and art topics (Navascués 1996). Graduates from these degrees basically worked for owners and design organizations (Oglesby 1982 and 1990; Chinowsky 2002). On the other hand, contractors employed craft persons trained on the job to perform managerial tasks (Oglesby 1982 and 1990; Ledbetter 1985; Arditi and Polat 2010).

After the second half of the 20th century, civil infrastructure and building projects became more numerous and complex (Gann 2000). Contractors started hiring university graduates (Oglesby 1982), mainly civil engineers (Harris 1992). This trend continued through the years; therefore, universities were forced to take into consideration the demands from construction companies, requiring professionals with some knowledge of construction costs, scheduling and methods (Oglesby 1982; Chinowsky and Diekmann 2004; Schexnayder and

Anderson 2011). Civil engineering university degrees incorporated these subjects in different ways (Oglesby 1982 and 1990; Goodman and Chinowsky 1997; Chinowsky 2002; Arditi and Polat 2010): as mandatory or elective courses at the undergraduate level, or even as a specialization in construction engineering on its own. Moreover, other degrees were created or demanded a more prominent role in the construction field: quantity surveyor in the United Kingdom and other Commonwealth countries (Lowe 1991), technical architecture in Spain (Pellicer and Victory 2006), or architectural engineering (Fritchen and Tredway 1997; Baur et al. 2010) and construction engineering (Oglesby 1982; Tatum 1987; Hauck 1998) in the United States.

Currently, managers lead projects and organizations in the construction industry aiming to improve productivity and competitiveness (Goodman and Chinowsky 1997; Abbudayyeh et al. 2000; Chinowsky 2002; Hegazi et al. 2013; Lee et al. 2013). Employers (i.e. owners, design companies or contractors) require from professionals the combination of technical and managerial competencies in order to improve decision-making (Tatum 1987; Fondahl 1991; Goodman and Chinowsky 1997; Chinowsky 2002; Wilkinson and Scofield 2002; Milosevic et al. 2007). However, their education is still mainly focused on technical subjects: the “engineers’ paradigm” as named by Pries and Janszen (1995). Hence, there is a growing demand from the industry to increase “soft” or managerial skills for construction professionals, especially from those having an undergraduate civil engineering degree (Berger 1996; Wilkinson and Scofield 2002; Chinowski 2002; Russell et al. 2007; Yepes et al. 2012); leadership and communications skills are the most required demands (Oberlender and Hughes 1987; Fondahl 1991; Harris 1992; Berger 1996; Walesh 1997; Russell et al. 2007; Riley et al. 2008; Hegazi et al. 2013). Very often this has been pursued through graduate programs (M.Sc. degrees) in construction management

(Oberlender and Hughes 1987; Tatum 1987; Oglesby 1990; Lowe 1991; Walesh 1997; Chinowski 2002; Lee et al. 2013; Pellicer et al. 2013).

Thus, many universities have adapted their programs in order to fulfill the growing demand for construction professionals to be better prepared in managerial skills, either through an improvement of an existing undergraduate degree, or the creation of a new degree (undergraduate or graduate program). Some contributors (Atalah and Muchemedzi 2006; Salman et al. 2011) have analyzed the procedure that a specific university followed in order to comply not only with the accreditation body, but also with the needs of each particular market. Previous work by the authors (Yepes et al. 2012; Pellicer et al. 2013) introduced a model (named MAC2), as well as a set of indicators, to compare and design programs in construction management aiming to meet market demands. Using a survey of the Spanish construction industry (CICCP 2008), as well as a set of 21 graduate M.Sc. degrees related to construction management offered by leading universities in engineering and technology around the world (Yepes et al. 2012), the authors computed the adequacy of each of these programs to this particular market demand according to the MAC2 model (Pellicer et al. 2013). Following this research line, this paper takes a further step putting forward the following research question: What are the courses most demanded in the construction management field according to graduate students? The path to answer this question has two basic steps to pursue (each one is a partial goal of this research): (1) confirm the two dimensions of the theoretical model (MAC2) that maps the field of management applied to the construction industry considering the infrastructure life-cycle and the organizational breakdown; and (2) analyze the topics more demanded by graduate students. The data used to perform this research is based on a survey of 534 graduate students from several American and European universities.

This paper is organized in the following way. First, the theoretical model (MAC2) is introduced to the readers. Then, the research method used in this study is explained in-depth: the research questions, the sample, the questionnaire survey, and an overview of the statistical analysis. The next section displays the results of the analysis, considering the characterization of the sample, the confirmation of the MAC2 model and, finally, the identification of the most important courses on construction management (according to the respondents).

THEORETICAL MODEL

The construction management field can be mapped from two perspectives or dimensions (Yepes et al. 2012): infrastructure life-cycle and organizational breakdown (see Fig. 1). The life-cycle of the infrastructure is one of the dimensions of the model, measured in time. It is summarized in four main phases (Stuckenbruck 1981; Pellicer et al. 2014): feasibility, design, construction, and operation. The dismantlement, or deconstruction phase, is not taken into consideration because of its uncommonness and similarity in many ways to the construction phase: documents in advance describing the works to be performed, permits, and a contractor are needed too.

The organizational breakdown is the other dimension, measured according to the degree of fragmentation from an organizational point of view. Four facets are considered (see Fig. 1): the whole construction industry, the company, the team, and the individual. For the first facet, the construction sector as a whole represents the stakeholders' relationships and the built environment framework (Stuckenbruck 1981; Pellicer et al. 2014); it considers the entire life-cycle of a facility. This level takes into consideration topics such as regulations, ethics, project delivery methods, stakeholders' needs, etc. Innovative approaches such as integrated project delivery or public-private partnerships, as well as topics as internationalization and globalization, should also be considered because of their current importance in the construction industry.

The second level is focused on the company and it deals with business management. Gaining experience throughout the years, engineers and architects can rise to intermediate positions as managers in their organizations (Russell and Yao 1996; Milosevic et al. 2007). Business management in the construction sector comprises topics such as operational and strategic planning, financial management, total quality management, control, marketing, knowledge management, etc. (Castro et al. 2012; Yepes et al. 2012). This level involves different types of organizations, for instance, public agencies and developers (feasibility phase), consulting engineering and architectural firms (design phase), contractors and specialty subcontractors (construction phase), and maintenance contractors, service operators, and concessionaires (operation phase).

<FIGURE 1 HERE>

Organizations in the construction industry work and manage by projects using teams to develop the tasks (Gann and Salter 2000; Winch 2006). Therefore, the team level focus on project management (Cleland and King 1968; Russell and Yao 1996). The Project Management Body of Knowledge (PMI 2013) provides a general set of procedures and good practices to be implemented in most of the projects, most of the time, even in construction. From the life-cycle perspective, projects can adopt several labels: feasibility assessment (feasibility phase), design project (design phase), construction project (construction phase), and infrastructure or facility management (operation phase).

Finally, leadership (Farr et al. 1997; Bowman and Farr 2000; Riley et al. 2008) and human resources management (Edum-Fotwe and McCaffer 2000) are key factors from the individual viewpoint. The project manager can mainly take the role of the designer (design phase) or the site manager (construction phase). This level can take into consideration topics such as negotiation processes, conflict management, and team building (Yepes et al. 2012).

RESEARCH METHOD

Research Question and Goals

As stated in the Introduction, the research question is: What are the courses most demanded in the construction management field according to graduate students? In order to answer this question, two consecutive goals have to be achieved. First, as explained in the previous section, the MAC2 model has been already proposed and used in previous work of the authors. However, no statistical test has been performed yet in order to check if these two dimensions of the model (life-cycle and organization) are able to classify the construction management field. Therefore, this is going to be a previous step in order to meet the second goal of the paper. For this second goal, the topics more demanded by graduate students have to be found out and analyzed. To comply with both goals, the survey is chosen as the research tool because of its suitability for gathering beliefs from a large number of people (Cohen et al. 2011). The perception of the students in relation to each of the questions will provide the information for the later analysis.

Sample

The population consists of graduate students enrolled in M.Sc. programs related to construction engineering and management around the world. The sample was comprised by students from 17 universities which participated in the survey, as displayed in the Appendix. This is a convenience sample, not probabilistic, due to the difficulties of accessing a random worldwide sample

(Onwuegbuzie and Collins 2007), which may not yield a sensible response rate (Abowitz and Toole 2010); therefore, this sample comprises only those programs that the authors were able to reach through direct contact plus some snowball effect. The questionnaires were distributed to all students enrolled in mandatory courses offered by the degrees under analysis (93% of them overall: everyone who attended class that day). This way, the research team obtained 534 valid responses from graduate students. Incomplete and anomalous questionnaires were discarded. Assuming that these responses are representative of an infinite population, the sample error is 4.2% for a level of confidence of 95% and a standard deviation of 0.5.

Questionnaire Survey

The questionnaire was administered by hand in Spanish or English language, depending on the origin of the participants. It had three different parts: (1) characterization of the respondent; (2) subjects that shape a successful M.Sc. degree in construction management; and (3) topics that are most important for a M.Sc. degree in construction management. The first part includes questions on professional degree, gender, nationality, current working status, age, and professional experience. The subjects considered for the questions in the second part are focused on the four rows (construction industry, company, team and individual) and the four columns (feasibility, design, construction and operation) of the MAC2 model; these questions are used to test the validity of the MAC2 model (first goal of this research). The 27 topics considered in the third part of the questionnaire are developed from experience and previous work from the authors (Pellicer et al. 2013); the purpose is to find out the most demanded courses (second goal of this research).

In the second part of the questionnaire, the students were asked to grade the importance of each statement according to this question: “The success of a Master Degree in Construction Management is due to courses related to [subject]” (see the eight subjects in Table 1). In the third part of the questionnaire the students had to do the same with the following question: “A Master Degree in Construction Management should consider [topic]” (see the 27 topics in Table 3). For both parts of the questionnaire, a 5-point Likert scale was used to quantify the responses, being 1 not important and 5 very important. Using an odd scale of, at least five choices, responses to these questions could be analyzed statistically by calculating their mean and standard deviation (Cohen et al. 2011).

Statistical Analysis

Data were analyzed using IBM SPSS Statistics (version 16.0) as well as EQS (version 6.1). For each of the two research goals a different analysis is performed; they are outlined next. First, to check the soundness of the MAC2 model, a confirmatory factor analysis (CFA) of the eight variables included in the second part of the questionnaire is developed. The objective of this CFA is to check if the observed variables fit the underlying latent MAC2 model.

Once the dimensions of the model are confirmed, the other goal of the research is to find out the courses that are most important for a M.Sc. degree in construction management. This goal is achieved performing a descriptive analysis of the variables contained in the third part of the questionnaire, computing and comparing the mean and standard deviation for each one of them. Later on, a principal component analysis (PCA) is performed to condense the original 27 variables into a reduced set of factors that explain as much variance as possible.

RESULTS AND DISCUSSION

Statistical Characterization

According to the questionnaire responses, more than half of the respondents are American (56.2%), being 34.4% European and the remaining 9.4% from other continents. They can be profiled in the following way: younger than 26 years of age (52.1%), male (60.0%), and with no more than three years of professional experience (66.7%) having worked previously for a contractor (52.3%); regarding the academic background, 53.7% of them were civil engineers, 24.6% were architects, and the rest were architectural engineers or similar. These are typical characteristics of graduate students in construction programs (Torres-Machí et al. 2013), apart from the nationality.

Confirmation of the MAC2 Model

This step aims to meet two targets: (a) to highlight the importance of the subjects (cells) of the model for the respondents; and (b) to check the dimensions that define the proposed MAC2 model. To facilitate the data analysis, the eight variables representing the subjects in the MAC2 model were coded (see Table 1). This table displays the statistical description (mean and standard deviation) of the variables included in the second part of the questionnaire.

<TABLE 1 HERE>

All of the subjects get a high mean (around four out of five). However, it is noticeable that the subject with lowest mean be “Operation and Maintenance”; it looks as if students do not appreciate the importance of this phase in the facility life-cycle. Other two variables displaying the life-cycle (“Feasibility Analysis” and “Design Project”) also scored less than 4.00. Most of the current programs are oriented towards the construction phase, leaving aspects related to feasibility, design, and operation and maintenance as secondary (Yepes et al. 2012; Pellicer et al.

2013). Literature, however, highlights the growing importance of the operation phase, specifically focused on maintenance and rehabilitation, aiming to uphold and lengthen the long-term facility life-cycle (Schraven et al. 2011), not only in transportation (Cooksey et al. 2011), but also in other fields such as wastewater (Ugarelli et al. 2010) and buildings (Grussing 2014). On the other hand, the variables in the organizational dimension are better balanced (see Table 1).

The next step is to perform a CFA to check if the observed variables fit the MAC2 model. CFA is a technique oriented to test the adequacy of an ‘a priori’ proposed model to the data. This model describes a structure in the data, specifying some underlying factors and defining which original variables are related with each of them. Different indicators of goodness of fit can be used, but the most frequent are the Comparative Fit Index (CFI), the Joreskog Goodness of Fit Index (GFI), the Root Mean Square Error of Approximation (RMSEA) and the Standardized Root Mean Square Residual (SRMR) (Hu and Bentler 1999; Jackson et al. 2009). Usually numeric results are complemented with a graphic representation of the model.

The two-factor model MAC2 was specified and tested. The results provide a moderately acceptable fit to the data, lending support to the original hypothesized structure of the questionnaire, with GFI = 0.889, AGFI = 0.791, RMSEA = 0.162, 90% CI RMSEA = 0.145 to 0.179, MFI = 0.779, and CFI = 0.728. Cronbach's Alfa was 0.681 and Reliability Rho was 0.722. Usually it is considered that GFI and CFI should be greater than 0.9, but in this case these values are not reached; nevertheless, values are high enough to confirm the model. The standardized model equations are shown in Table 2.

<TABLE 2 HERE>

For a better understanding of how the MAC2 model fits to the data, each of the two model components was tested separately. CFA confirms the structure of the first component (life-cycle) linked with variables LC1 to LC4 (CFI=0.964, RMSEA=0.095, 90% Confidence Interval for RMSEA=0.047-0.152, and SRMR=0.032). The second component (organizational breakdown) seems to be structured in two subcomponents, with an important correlation among them (R=0.48) and good fitting indicators (CFI=0.979, RMSEA=0.155, 90% Confidence Interval for RMSEA=0.089-0.234, SRMR=0.024).

The correlation between constructs was 0.144. Finally, the model can be represented as in Figure 2. The first goal of this research is achieved: the MAC2 model is composed of two factors which are rational and logical (see the structural model in Figure 2). These two dimensions agree with the initial proposal. Therefore, the goodness of the model has been successfully checked.

<FIGURE 2 HERE>

Most Important Courses on Construction Management

After confirming that the two dimensions of the MAC2 model (life-cycle and organization) are able to classify the construction management field, the other goal can be targeted. The research aims to find out the courses more demanded by graduate students in the construction management field.

In a previous work, the authors selected an exploratory sample of 21 M.Sc. Degrees in Construction Management at leading universities available online (Yepes et al. 2012). Later on, the authors analyzed the curricula of each one of these programs, grouping its courses (more than 300) into 27 “standard” topics (Pellicer et al. 2013). Based on that previous work, the authors have developed the survey presented in this paper; these “standard” topics (just “topics” from now on) are the ones considered in the third part of the questionnaire (displayed in Table 3). The respondents of the survey were asked to assess (through a 5-point Likert scale) the importance of each topic in a M.Sc. degree in construction management, in line with the main goal stated previously.

These topics are displayed in Table 3 and codified to facilitate the data analysis. Table 3 also displays a statistical description (mean and standard deviation) of the responses obtained in the third part of the questionnaire. Three topics have a higher mean: construction management, management of construction companies, and innovation management. These three topics are also the ones that get less standard deviation. The first two are linked to the construction phase of the facility life-cycle; they concur with the general tendency discovered in most of the graduate programs to focus on the construction phase of the infrastructure (Yepes et al. 2012; Pellicer et al. 2013). Furthermore, it appears that graduate students consider innovation an important part of the management of the organization (Yepes et al. 2016), even if it is focused on the construction phase (Pellicer et al. 2014). On the other hand, the three topics less popular are: professional engineering and architectural bodies, contractors' associations, and infrastructure users; their standard deviation are higher as it seems logical. All three of them are related to the global framework of the construction industry; perhaps these topics are not appreciated because they are not properly introduced, or its importance for the industry as a whole is not explained, during the undergraduate education.

<TABLE 3 HERE>

Once the responses are analyzed from a statistical descriptive point of view, the research aims to find out the latent approaches for a graduate program in the construction management field. Principal Component Analysis (PCA) aims to transform a set of highly correlated variables in another abridged and not correlated set of variables, named principal components; this way, the dimensionality of the data space is condensed using latent or underlying variables (Field 2013). The PCA computes a smaller number of variables (called factors or principal components) that are a linear combination of the original variables as well as independent among them; their average is 0 and their standard deviation is 1. The goal of the PCA is that the new factors retain as much information as possible from the original scenario based on the relationships among variables, but simplifying the structure of the information (Hair et al. 2009). The adequacy of the data set for a PCA is checked by Bartlett's spherical test ($p < 0.001$) and by the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (KMO = 0.828); for this test an output higher than 0.800 can be considered good (Field 2013). Furthermore, the determinant is bigger than 10^{-5}; thus, there is no multicollinearity problem either (Field 2013).

For each variable, there is a proportion of variance, or communality, which is shared with other variables. Communality measures the proportion of variance explained by the factors or principal components (Field 2013). For this case, Table 4 shows the communalities obtained after performing the analysis.

<TABLE 4 HERE>

The two courses with communality less than 0.500 (see Table 4) are eliminated from the subsequent analysis: legal concepts, and foreign languages. They are not going to explain the model after the extraction. The next step is to compute the principal components; due to the fact that normalized data are used (correlations instead of covariances), the number of eigenvalues is the same as the number of variables (25). Only six components are considered because, as it can be seen in Table 5, the point of inflection of slopes is the sixth eigenvalue (cut-off point); furthermore, the seventh and eighth eigenvalues are very close to 1 (Field 2013). These six eigenvalues explain 57.3% of the information; even though, the first one explains 26.1% (see Table 5). After applying a Varimax rotation, Table 6 shows the rotated component matrix and the grouping of courses within the six principal components.

<TABLE 5 HERE>

<TABLE 6 HERE>

As it can be seen in Table 6, three topics do not contribute to any of the six principal components: maintenance and operations management (C12), feasibility assessment (C09), and advanced technical concepts (C19). Therefore, a new PCA is going to be developed without considering these three variables. The PCA is performed using only 22 variables. It complies with the Bartlett's spherical test ($p < 0.001$), the Kaiser-Meyer-Olkin measure of sampling adequacy (KMO = 0.822); for this test an output higher than 0.800 can be considered good (Field 2013). The determinant is higher than 10^{-5}. Tables 7, 8 and 9 show the communalities, the principal component analysis and the rotated component matrix, respectively. The new six principal components obtained explain 60.5% of the total variance, while the first one explains 27.0% by itself. This total value is higher than the one obtained with 25 variables.

<TABLE 7 HERE>

<TABLE 8 HERE>

<TABLE 9 HERE>

Anyway, each topic is assigned to only one component; the one that has more loading. The new components group these topics as follows:

- Leadership (PC1): contains the four topics related to leadership skills as a designer (C15), site manager (C14), feasibility manager (C13), and operation manager (C16). They are the four cells of the leadership variable in Figure 1. This principal component corresponds to the individual facet of the organizational breakdown (OB4). The first two (C15 and C14) have a higher load factor, contributing more to this component; as highlighted along the text, they belong to the two main phases of the life-cycle: design and construction.

- Built Environment Stakeholders (PC2): encompasses the four topics related to the different stakeholders' associations in the construction industry from different viewpoints (designers, C02, contractors, C03, final users, C04, and civil service, C01). This component corresponds exactly with the four cells of the stakeholders' relationship and built environment framework of the MAC2 model. It shows the corporate facet of the profession and its relationship with the society (OB1).
- Innovation and Quality (PC3): comprises topics related to quality in a broader sense (including not only the quality per se, C22, but also the environment –C22– and health and safety –C25–) as well as innovation (including not only innovation per se, C24, but also research –C27– and information and communication technologies –C26–). Health and safety (C25) contributes more to the load factor, recognizing the importance of preserving human life; innovation (C24) and information and communication technologies (C26) are also important, maybe because of their attractiveness.
- Economics (PC4): contains the three topics related to economy and financial concepts (C20), accounting (C21), and marketing (C23). In this case, the first two (C20 y C21) support most of the load factor.
- Business Management (PC5): includes three topics on management of companies related to concessionaires (C06), consulting firms (C07) and developers and public agencies (C08); it has some participation of management of contractors (C05) too. The

management of consulting firms (C07) is the variable that contributes more to the load factor. These four topics comprises the business management variable in the MAC2 model (OB2).

- Project Management (PC6): contains two topics related to construction (C11) and design management of the infrastructure (C10), as well as management of construction companies (C05). Only construction management (C11) contributes fully to this component. Even though this one is not as clear as the other three, it somehow represents the project management variable (OB3) of the MAC2 model.

As displayed in Table 9, the four variables of the organizational breakdown of the MAC2 model are recognized by the students in a latent way; the university programs are conveying quite successfully the organizational facets in construction to their students. Nevertheless, the PCA scatters completely the importance of the infrastructure life-cycle. Even though the facets related to design and construction are included in the PCA, facets related to feasibility and operation of the infrastructure are not so well highlighted according to the students' opinion. This result disagrees with the current issues related to the inefficient decision-making during the feasibility phase (Kabir et al. 2014; Sierra et al. 2016), as well as the growing importance of maintenance and operation in developed economies (Ugarelli et al. 2010; Schraven et al. 2011; Grussing 2014). Since graduate programs in construction management are not conveying properly the importance of the feasibility and operation phases of the infrastructure life-cycle, additional efforts should be made by universities, offering courses and improving current syllabi.

CONCLUSIONS

This paper analyzes how graduate students' views are relevant in order to check the two dimensions of the MAC2 model and its relationships. The MAC2 model maps the construction management field aiming to assess and improve M.Sc. programs related to construction management. The results of a survey of more than 500 graduate students from American and European universities highlight that, according to the respondents and using a confirmatory factor analysis, the construction management field shows two latent dimensions: the infrastructure life-cycle and the organizational breakdown. This outcome implies that a graduate program in construction management must be able to plan a curriculum where all the stakeholders are considered in this double dimension: the facility life-cycle and the organizational structure.

Moreover, by means of an exploratory factor analysis, the survey has determined six components or courses for a graduate program in the construction management field: leadership, built environment stakeholders, innovation and quality, economics, business management, and project management. Four of these components comprise the organizational breakdown dimension of the MAC2 model. However, it is worth mentioning that, regarding the infrastructure life-cycle, important facets such as feasibility analysis and operation and maintenance of infrastructures, are considered by the graduate students less important than design and construction. This shows that, the construction programs where the questionnaire was applied are focused on the design and construction phases of the facility life-cycle; it also highlights that these programs are able to communicate properly the importance of the different approaches of the organizational breakdown to their students.

As any research, this one also has limitations. Even though the number of responses is high (more than 500) and that it can be considered statistically significant, the sample is not completely random; it only represents those programs that the authors were able to reach through direct contact plus some snowball effect. The MAC2 model, as well as the results from this survey, could be taken as the point of departure by other groups already working on this topic, such as the Associated Schools of Construction (http://www.ascweb.org/) or the Global Leadership Forum for Construction Engineering and Management Programs (http://rebar.ecn.purdue.edu/glf/) in order to get a randomly representative sample. Anyway, the authors are already working on the use of the MAC2 model for the design of new programs and the adjustment of existing ones to the current market demands.

ACKNOWLEDGMENTS

The authors are indebted to Professors Luis F. Alarcón, Salvador García, David Eaton, Pawel Nowak, Gloria I. Carvajal, Sheyla M.B. Serra, Carlos T. Formoso, M. Dolores Martinez-Aires, and José C. Teixeira for their collaboration throughout this study. The authors also want to thank all the participants in the study. The questionnaire survey was possible due to the partial support of the following agencies and projects: CYTED (project GESST-IC, network 309RT0375), European Commission (Life Long Learning Program, project MBAIC, grant 2013-1-PL1-LEO05-37822), and Spanish Ministry of Economy and Competitiveness (project BRIDLIFE, grant BIA2014-56574-R).

APPENDIX: UNIVERSITIES THAT PARTICIPATED IN THE RESEARCH

České Vysoké Učení Technické v Praze (Czech Republic)

Dublin Institute of Technology (Ireland)

Instituto Superior Tecnico de Lisboa (Portugal)

Instituto Tecnológico y de Estudios Superiores de Monterrey (México)

Politechnika Warszawska (Poland)

Pontificia Universidad Católica de Chile

Sakarya University (Turkey)

The University of Salford (United Kingdom)

Universidad Católica del Maule (Chile)

Universidad de Granada (Spain)

Universidad de Medellín (Colombia)

Universidad de San Carlos (Guatemala)

Universidade do Minho (Portugal)

Universidade Federal de São Carlos (Brazil)

Universidade Federal do Rio Grande do Sul (Brazil)

Universitat Politècnica de València (Spain)

University of the Incarnate Word (Texas)

REFERENCES

Abowitz, D.A., and Toole, T.M. (2010). “Mixed method research: Fundamental issues of design, validity, and reliability in construction research.” *Journal of Construction Engineering and Management*, 136(1), 108-116.

Abudayyeh, O., Russell, J., Johnston, D., and Rowings, J. (2000). “Construction engineering and management undergraduate education.” *Journal of Construction Engineering and Management*, 126(3), 169-175.

Allaback, S. (2008). *The first American women architects*. University of Illinois Press, Chicago (IL).

Arditi, D., and Polat, G. (2010) “Graduate education in construction management.” *Journal of Professional Issues in Engineering Education and Practice*, 136(3), 175-179.

Atalah, A., Muchemedzi, R. (2006) "Improving enrollment in the Master of Construction Management Program at Bowling Green State University." *Journal of Professional Issues in Engineering Education and Practice*, 132(4), 312-321.

Baur, S.W, Myers, J.J., and LaBoube, R.A. (2010). "Architectural engineering curriculum at Missouri University of Science and Technology". *Journal of Architectural Engineering*, 16(2), 74-79.

Berger, L. (1996). "Emerging role of management in civil engineering." *Journal of Management in Engineering*, 12(4), 37-39.

Bowman, B., and Farr, J. (2000). "Embedding leadership in civil engineering education." *Journal of Professional Issues in Engineering Education and Practice*, 126(1), 16–20.

Castro, A.L., Yepes, V., Pellicer, E., Cuéllar, A.J. (2012). "Knowledge management in the construction industry: state of the art and trends in research." *Revista de la Construcción*, 11(2): 62-73.

Chinowsky, P. (2002). "Integrating management breadth in civil engineering education." *Journal of Professional Issues in Engineering Education and Practice*, 128(3), 138–143.

Chinowsky, P.S. and Diekmann, J.E. (2004). "Construction engineering management educators: history and deteriorating community." *Journal of Construction Engineering and Management*, 130(5), 751-758.

CICCP (2008) *Análisis estratégico del campo de actividad profesional del ingeniero de caminos, canales y puertos*. Colegio de Ingenieros de Caminos, Canales y Puertos, Madrid (in Spanish).

Cleland, D.I., and King, W.R. (1968). *System analysis and project management*. McGraw-Hill, New York.

Cohen, L., Manion, L., and Morrison, K. (2011). *Research methods in education* (7th Edition). Routledge, New York.

Cooksey, S.R., Seok, D.S., and Chae, M.J. (2011). Asset management assessment model for state departments of transportation. *Journal of Management in Engineering*, 27(3), 159–169.

Edum-Fotwe, F. T., and McCaffer, R. (2000). "Developing project management competency: perspectives from the construction industry." *International Journal of Project Management*, 18(2), 111–124.

Farr, J. (1997). "Leadership development for engineering managers." *Journal of Management in Engineering*, 13(4), 38–41.

Field, A. (2013). *Discovering statistics using SPSS* (4th Edition). Sage, London.

Fondahl, J.W. (1991). "The development of the construction engineer: past progress and future problems". *Journal of Construction Engineering and Management*, 117(3), 380-392.

Fritchen, D.R., and Tredway, T.C. (1998). "Kansas State University architectural engineering". *Journal of Architectural Engineering*, 4(1), 34-39.

Gann, D.M. (2000). *Building innovation. Complex constructs in a changing world*. Thomas Telford Publishing, London.

Gann, D.M., and Salter, A.J. (2000). "Innovation in project-based, service enhanced firms: The construction of complex products and systems." *Research Policy*, 29(7–8), 955–972.

Goodman, R.E., and Chinowski, P.S. (1997). "Preparing construction professionals for executive decision making". *Journal of Management in Engineering*, 13(6), 55-61.

Grussing, M.N. (2014) "Life cycle assessment management methodologies for buildings". *Journal of Infrastructure Systems*, 20, 04013007-1/8.

Hair, J.F., Black, W.C., Babin, B.J., Anderson, R.E. (2009). *Multivariate data analysis* (7th Edition). Pearson - Prentice Hall, Englewood Cliffs, NJ.

Harris, R.B. (1992). “A challenge for research.” *Journal of Construction Engineering and Management*, 118(3), 422-434.

Hauck, A.J. (1998). “Construction management curriculum reform and integration with a broader discipline: a case study”. *Journal of Construction Education*, 3(2), 118-130.

Hegazy, T., Abdel-Monem, M., Saad, D.A., and Rashedi, R. (2013). “Hands-on exercise for enhancing students’ construction management skills”. *Journal of Construction Engineering and Management*, 139(9), 1135-1143.

Hu, L.T., and Bentler, P.M. (1999). “Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives”. *Structural Equation Modeling*, 6, 1-55.

Jackson, D.L., Gillaspy, J.A., and Purc-Stephenson, R. (2009). “Reporting practices in confirmatory factor analysis: An overview and some recommendations”. *Psychological Methods*, 14(1), 6-23.

Kabir, G., Sadiq, R., and Tesfamariam, S. (2014). “A review of multi-criteria decision-making methods for infrastructure management.” *Structure and Infrastructure Engineering*, 10(9), 1176-1210.

Ledbetter, B.S. (1985). “Pioneering construction engineering education.” *Journal of Construction Engineering and Management*, 111(1), 41-51.

Lee, S., Esmaeilzadeh, A., and Lee, D.E. (2013). “Graduate construction management programs in the U.S.: lessons learned from leading institutions.” *KSCE Journal of Civil Engineering*, 17(7), 1664-1671.

Lowe, J. (1991). “Interdisciplinary postgraduate education for construction managers.” *Journal of Professional Issues in Engineering Education and Practice*, 117(2), 168–175.

Milosevic, D.Z., Martinelli, R.J., and Waddell, J.M. (2007) *Program management for improved business results*. John Wiley & Sons, Hoboken (NJ).

Navascués, P. (1996). “La creación de la Escuela de Arquitectura de Madrid.” In: *Madrid y sus Arquitectos: 150 Años de la Escuela de Arquitectura*. Comunidad de Madrid, Dirección General de Patrimonio Cultural, Madrid (in Spanish).

Oberlender, G.D., and Hughes, R.K. (1987). “Graduate construction programs in the United States.“ *Journal of Construction Engineering and Management*, 113(1), 17-26.

Oglesby, C.H. (1982). “Construction education: past, present, and future.” *Journal of Construction Division*, 108(4), 605-616.

Onwuegbuzie, A.J., and K.M.T. Collins (2007). “A typology of mixed methods sampling designs in social science research.” *The Qualitative Report* 12(2), 281-316.

Oglesby, C.H. (1990). "Dilemmas facing construction education and research in 1990s." *Journal of Construction Engineering and Management*, 116(1), 4-17.

Pellicer, E., and Victory, R. (2006). “Implementation of project management principles in Spanish residential developments.” *International Journal of Strategic Property Management*, 10, 233-248.

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

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

PMI (2013). *A guide to the project management body of knowledge* (5th Ed.). Project Management Institute, Newtown Square (PA).

Pries, F., and Janszen, F. (1995). “Innovation in the construction industry: the dominant role of the environment”. *Construction Management and Economics*, 13, 43-51.

Riley, D., Horman, M., and Messner, J. (2008). “Embedding leadership development in construction engineering and management education.” *Journal of Professional Issues in Engineering Education and Practice*, 134(2), 143–150.

Russell, J., and Yao, J.T.P. (1996) “Consensus! Students need more management education.” *Journal of Management in Engineering*, 12(6), 17-29.

Russell, J., Hanna, A., Bank, L., and Shapira, A. (2007). “Education in construction engineering and management built on tradition: blueprint for tomorrow.” *Journal of Construction Engineering and Management*, 133(9), 661-668.

Salman, A.F., Ibrahim, Y.E., El-Shami, M.M., Osman, S., and Hariri, A.S. (2011) “Developing of specifications and academic curriculum in construction engineering, a case study in University of Dammam, KSA.” *International Journal of Engineering Education*, 27(3), 670–678.

Schexnayder, C., and Anderson, S. (2011). “Construction engineering education: history and challenge”. *Journal of Construction Engineering and Management*, 137(10), 730-739.

Schraven, D., Hartmann, A., and Dewulf, G. (2011) “Effectiveness of infrastructure asset management: challenges for public agencies”. *Built Environment Project and Asset Management*, 1(1), 61-74.

Sierra, L.A., Pellicer, E., and Yepes, V. (2016) “Social sustainability in the life cycle of Chilean public infrastructure”. *Journal of Construction Engineering and Management*, 142(5), 05015020.

Stuckenbruck, L.C. (1981). *The implementation of project management*. Project Management Institute, Newton Square, PA.

Tatum, C.B. (1987). “Balancing engineering and management in construction education.” *Journal of Construction Engineering and Management,* 113(2), 264–272.

Torres-Machí, C., Carrión, A., Yepes, V., and Pellicer, E. (2013). “Employability of graduate students in construction management.” *Journal of Professional Issues in Engineering Education and Practice*, 139(2), 163-170 (DOI: 10.1061/(ASCE)EI.1943-5541.0000139.

Ugarelli, R., Venkatesh, G., Brattebo, H., di Federico, V., and Saegrov, S. (2010) “Asset management for urban wastewater pipeline networks”. *Journal of Infrastructure Systems*, 16(2), 112-121.

Walesh, S.G. (1997). ”More coaching-less osmosis: teaching soft skills to hard scientists.” *Journal of Management in Engineering*, 13(4), 3–4.

Wilkinson, S., and Scofield, R. (2002). ”Integrated management curriculum for civil engineers and architects.” *Journal of Professional Issues in Engineering Education and Practice*, 128(3), 125–130.

Winch, G.M. (2006). “Towards a theory of construction as production by projects.” *Building Research and Information,* 34(2), 164–174.

Yepes, V., Pellicer, E., Alarcón, L.F., and Correa, C.L. (2016). “Creative innovation in Spanish construction firms.” *Journal of Professional Issues in Engineering Education and Practice*, 142(1), 04015006.

Yepes, V., Pellicer, E., and Ortega, A. J. (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), 48–54.

CODE	SUBJECT (variable)	Mean	Standard Deviation
LC1	Feasibility Analysis	3.95	1.014
LC2	Design Project	3.77	1.048
LC3	Construction Works	4.03	0.961
LC4	Operation and Maintenance	3.58	0.983
OB1	Stakeholders’ Relationships and Built Environment Framework	4.17	0.928
OB2	Business Management	4.02	0.984
OB3	Team Building	4.01	1.020
OB4	Leadership and Human Resources	3.96	1.021

Table 1. Codes and Statistical Description of the Subjects (Cells) of the MAC2 Model

LC1 =	0.382 * F1	+ 0.924 * E1
LC2 =	0.667 * F1	+ 0.745 * E2
LC3 =	0.654 * F1	+ 0.757 * E3
LC4 =	0.524 * F1	+ 0.852 * E4
OB1 =	0.398 * F2	+ 0.917 * E5
OB2 =	0.540 * F2	+ 0.842 * E6
OB3 =	0.812 * F2	+ 0.583 * E7
OB4 =	0.749 * F2	+ 0.662 * E8

Table 2. Structural Equations

Code	Topicss	Mean	Standard Deviation
C01	Civil Service	3.39	1.068
C02	Professional Engineering and Architectural Bodies	2.86	1.070
C03	Contractors' Associations	3.11	1.050
C04	Infrastructure Users	3.12	1.073
C05	Management of Construction Companies (Contractors)	4.24	0.799
C06	Management of Companies working in the Operation Phase	3.51	0.962
C07	Management of Consulting Engineering and Architectural Firms	3.67	0.968
C08	Management of Real Estate Companies, Developers and Public Agencies	3.66	1.012
C09	Feasibility Assessment	3.94	0.960
C10	Design Management	3.95	1.036
C11	Construction Management	4.26	0.872
C12	Maintenance and Operations Management	3.60	0.971
C13	Leadership Skills as a Feasibility Manager	3.67	1.033
C14	Leadership Skills as a Site Manager	3.97	0.984
C15	Leadership Skills as a Designer	4.02	0.969
C16	Leadership Skills as a Maintenance and Operations Manager	3.56	1.010
C17	Legal Concepts	3.65	1.042
C18	Foreign Languages	3.37	1.255
C19	Advanced Technical Concepts	3.77	1.076
C20	Economy and Finance	3.87	0.966
C21	Accounting	3.47	1.073
C22	Quality and Environmental Management	3.95	0.978
C23	Marketing	3.49	1.142
C24	Innovation Management	4.13	0.932
C25	Safety and Health Management	3.83	0.988
C26	E-Business and Information Systems	3.57	1.005
C27	Research Methods	3.23	1.151

Table 3. Codes and Statistical Description of the Most Important Topics

Code	Variables	Initial	Extraction
C01	Civil Service	1.000	0.506
C02	Professional Engineering and Architectural Bodies	1.000	0.680
C03	Contractors' Associations	1.000	0.513
C04	Infrastructure Users	1.000	0.510
C05	Management of Construction Companies (Contractors)	1.000	0.529
C06	Management of Companies working in the Operation Phase	1.000	0.528
C07	Management of Consulting Engineering and Architectural Firms	1.000	0.630
C08	Management of Real Estate Companies, Developers and Public Agencies	1.000	0.569
C09	Feasibility Assessment	1.000	0.468
C10	Design Management	1.000	0.659
C11	Construction Management	1.000	0.746
C12	Maintenance and Operations Management	1.000	0.530
C13	Leadership Skills as a Feasibility Manager	1.000	0.621
C14	Leadership Skills as a Site Manager	1.000	0.743
C15	Leadership Skills as a Designer	1.000	0.732
C16	Leadership Skills as a Maintenance and Operations Manager	1.000	0.612
C19	Advanced Technical Concepts	1.000	0.470
C20	Economy and Finance	1.000	0.635
C21	Accounting	1.000	0.640
C22	Quality and Environmental Management	1.000	0.478
C23	Marketing	1.000	0.488
C24	Innovation Management	1.000	0.543
C25	Safety and Health Management	1.000	0.551
C26	E-Business and Information Systems	1.000	0.519
C27	Research Methods	1.000	0.422

Table 4. Communalities of the Most Important Topics (1st iteration)

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
PC	**Total**	**% Variance**	**% Cumulative Variance**	**Total**	**% Variance**	**% Cumulative Variance**	**Total**	**% Variance**	**% Cumulative Variance**
1	6.517	26.066	26.066	6.517	26.066	26.066	2.688	10.754	10.754
2	1.813	7.250	33.317	1.813	7.250	33.317	2.680	10.718	21.472
3	1.679	6.716	40.032	1.679	6.716	40.032	2.623	10.490	31.962
4	1.541	6.163	46.196	1.541	6.163	46.196	2.227	8.907	40.869
5	1.458	5.833	52.028	1.458	5.833	52.028	2.134	8.537	49.407
6	1.315	5.261	57.290	1.315	5.261	57.290	1.971	7.883	57.290
7	1.065	4.261	61.551						
8	1.042	4.167	65.718						
9	0.836	3.344	69.062						
10	0.803	3.210	72.272						
11	0.730	2.921	75.193						
12	0.675	2.701	77.893						
13	0.629	2.518	80.411						
14	0.603	2.410	82.821						
15	0.529	2.118	84.939						
16	0.513	2.052	86.990						
17	0.487	1.949	88.939						
18	0.459	1.835	90.774						
19	0.403	1.613	92.387						
20	0.376	1.505	93.892						
21	0.368	1.473	95.365						
22	0.341	1.364	96.729						
23	0.314	1.254	97.983						
24	0.269	1.076	99.059						
25	0.235	0.941	100.000						

Table 5. Principal Component Analysis of the Most Important Topics (1st iteration)

Code	Variable	PC1	PC2	PC3	PC4	PC5	PC6
C02	Professional Engineering and Architectural Bodies	0.751					
C03	Contractors' Associations	0.665					
C04	Infrastructure Users	0.626					
C01	Civil Service	0.504					
C15	Leadership Skills as a Designer		0.823				
C14	Leadership Skills as a Site Manager		0.816				
C13	Leadership Skills as a Feasibility Manager		0.701				
C16	Leadership Skills as a Maintenance and Operations Manager		0.631				
C25	Safety and Health Management			0.703			
C24	Innovation Management			0.675			
C26	E-Business and Information Systems			0.659			
C27	Research Methods			0.542			
C22	Quality and Environmental Management			0.505			
C23	Marketing			0.446		(0.411)	
C07	Management of Consulting Engineering and Architectural Firms				0.768		
C08	Management of Real Estate Companies0. Developers and Public Agencies				0.713		
C06	Management of Companies working in the Operation Phase				0.549		
C05	Management of Construction Companies (Contractors)				0.450		(0.430)
C12	Maintenance and Operations Management						
C20	Economy and Finance					0.759	
C21	Accounting					0.728	
C11	Construction Management						0.825
C10	Design Management						0.703
C09	Feasibility Assessment						
C19	Advanced Technical Concepts						

Table 6. Rotated Component Matrix of the Most Important Topics (1st iteration)

Code	Variables	Initial	Extraction
C01	Civil Service	1.000	0.509
C02	Professional Engineering and Architectural Bodies	1.000	0.715
C03	Contractors' Associations	1.000	0.569
C04	Infrastructure Users	1.000	0.527
C05	Management of Construction Companies (Contractors)	1.000	0.633
C06	Management of Companies working in the Operation Phase	1.000	0.395
C07	Management of Consulting Engineering and Architectural Firms	1.000	0.700
C08	Management of Real Estate Companies. Developers and Public Agencies	1.000	0.620
C10	Design Management	1.000	0.587
C11	Construction Management	1.000	0.754
C13	Leadership skills as a Feasibility Manager	1.000	0.627
C14	Leadership skills as a Site Manager	1.000	0.751
C15	Leadership skills as a Designer	1.000	0.736
C16	Leadership skills as a Maintenance and Operations Manager	1.000	0.627
C20	Economy and Finance	1.000	0.714
C21	Accounting	1.000	0.711
C22	Quality and Environmental Management	1.000	0.506
C23	Marketing	1.000	0.502
C24	Innovation Management	1.000	0.545
C25	Safety and Health Management	1.000	0.550
C26	E-Business and Information Systems	1.000	0.537
C27	Research Methods	1.000	0.487

Table 7. Communalities of the Most Important Topics (2nd iteration)

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
PC	**Total**	**% Variance**	**% Cumulative Variance**	**Total**	**% Variance**	**% Cumulative Variance**	**Total**	**% Variance**	**% Cumulative Variance**
1	5.939	26.997	26.997	5.939	26.997	26.997	2.612	11.871	11.871
2	1.730	7.866	34.862	1.730	7.866	34.862	2.537	11.531	23.402
3	1.542	7.007	41.870	1.542	7.007	41.870	2.460	11.181	34.583
4	1.477	6.712	48.582	1.477	6.712	48.582	2.037	9.260	43.843
5	1.348	6.128	54.710	1.348	6.128	54.710	1.973	8.967	52.810
6	1.266	5.755	60.466	1.266	5.755	60.466	1.684	7.656	60.466
7	0.968	4.400	64.866						
8	0.808	3.673	68.539						
9	0.788	3.582	72.121						
10	0.748	3.400	75.521						
11	0.709	3.223	78.744						
12	0.622	2.829	81.573						
13	0.569	2.588	84.161						
14	0.520	2.365	86.526						
15	0.485	2.205	88.731						
16	0.465	2.115	90.846						
17	0.405	1.842	92.687						
18	0.378	1.720	94.407						
19	0.356	1.617	96.024						
20	0.347	1.577	97.601						
21	0.274	1.247	98.848						
22	0.253	1.152	100.000						

Table 8. Principal Component Analysis of the Most Important Topics (2nd iteration)

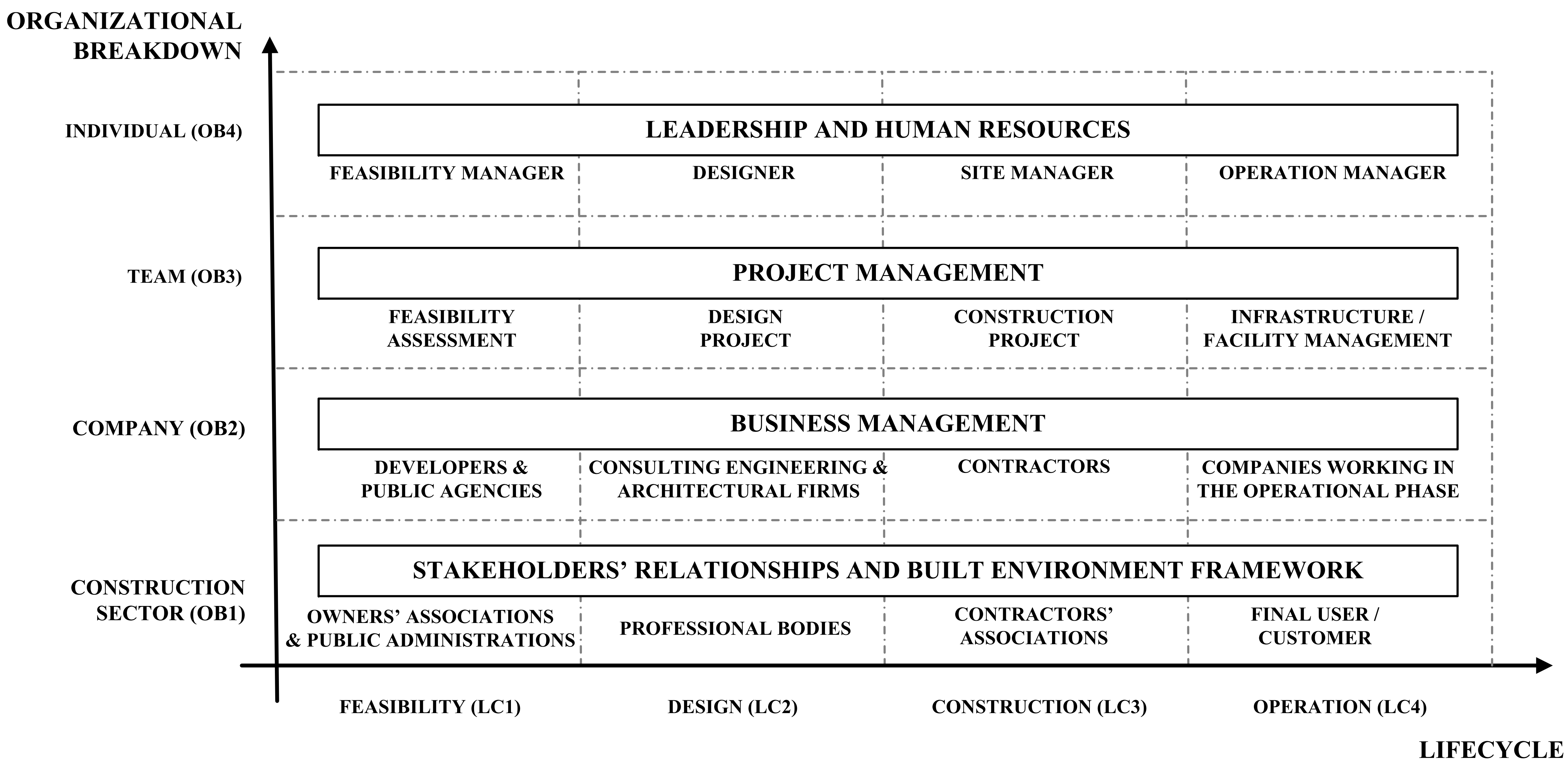
Code	Variable	PC1	PC2	PC3	PC4	PC5	PC6
C15	Leadership skills as a Designer	0.819					
C14	Leadership skills as a Site Manager	0.816					
C13	Leadership skills as a Feasibility Manager	0.715					
C16	Leadership skills as a Maintenance and Operations Manager	0.673					
C02	Professional Engineering and Architectural Bodies		0.780				
C03	Contractors' Associations		0.713				
C04	Infrastructure Users		0.652				
C01	Civil Service		0.540				
C25	Safety and Health Management			0.698			
C26	E-Business and Information Systems			0.678			
C24	Innovation Management			0.667			
C27	Research Methods			0.591			
C22	Quality and Environmental Management			0.460	(0.421)		
C20	Economy and Finance				0.818		
C21	Accounting				0.793		
C23	Marketing			(0.402)	0.493		
C07	Management of Consulting Engineering and Architectural Firms					0.813	
C08	Management of Real Estate Companies, Developers and Public Agencies					0.755	
C06	Management of Companies working in the Operation Phase					0.487	
C11	Construction Management						0.835
C10	Design Management		(0.456)				0.603
C05	Management of Construction Companies (Contractors)					(0.509)	0.552

Table 9. Rotated Component Matrix of the Most Important Topics (2nd iteration)

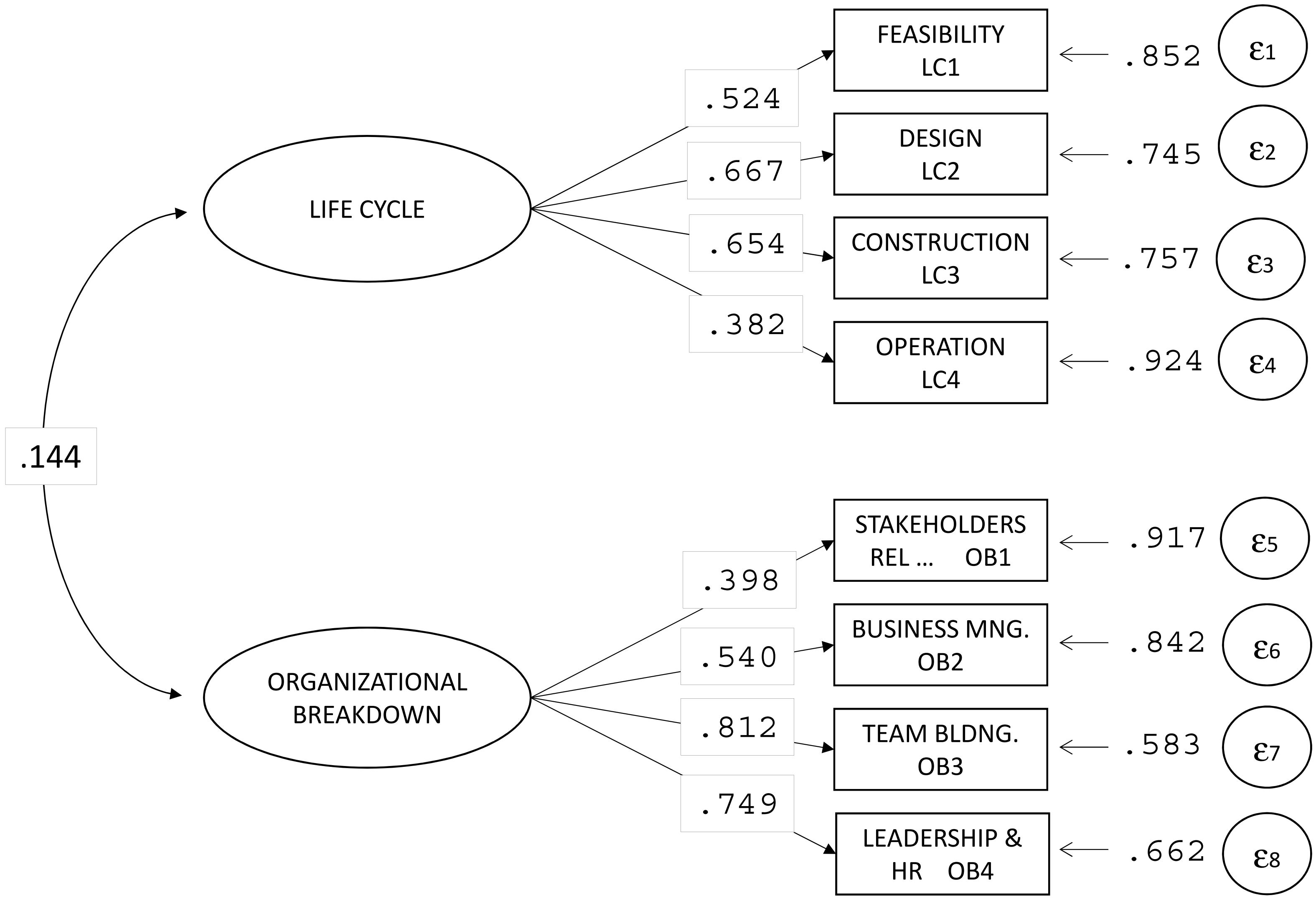
Figure Captions List

Figure 1. MAC2 Model (Yepes et al. 2012)

Figure 2. Structural Equation Model



ORGANIZATIONAL BREAKDOWN
INDIVIDUAL (OB4)
TEAM (OB3)
COMPANY (OB2)
CONSTRUCTION SECTOR (OB1)
LEADERSHIP AND HUMAN RESOURCES
FEASIBILITY MANAGER
DESIGNER
SITE MANAGER
OPERATION MANAGER
PROJECT MANAGEMENT
FEASIBILITY ASSESSMENT
DESIGN PROJECT
CONSTRUCTION PROJECT
INFRASTRUCTURE / FACILITY MANAGEMENT
BUSINESS MANAGEMENT
DEVELOPERS & PUBLIC AGENCIES
CONSULTING ENGINEERING & ARCHITECTURAL FIRMS
CONTRACTORS
COMPANIES WORKING IN THE OPERATIONAL PHASE
STAKEHOLDERS’ RELATIONSHIPS AND BUILT ENVIRONMENT FRAMEWORK
OWNERS’ ASSOCIATIONS & PUBLIC ADMINISTRATIONS
PROFESSIONAL BODIES
CONTRACTORS’ ASSOCIATIONS
FINAL USER / CUSTOMER
FEASIBILITY (LC1)
DESIGN (LC2)
CONSTRUCTION (LC3)
OPERATION (LC4)
LIFECYCLE


LIFE CYCLE
ORGANIZATIONAL BREAKDOWN
.144
.524
.667
.654
.382
FEASIBILITY LC1
DESIGN LC2
CONSTRUCTION LC3
OPERATION LC4
.852
.745
.757
.924
ε1
ε2
ε3
ε4
.398
.540
.812
.749
STAKEHOLDERS REL ... OB1
BUSINESS MNG. OB2
TEAM BLDNG. OB3
LEADERSHIP & HR OB4
.917
.842
.583
.662
ε5
ε6
ε7
ε8