

# Investigating the Gap Between Engineering Graduates and Practicing Project Managers\*

LUIS BALLESTEROS-SÁNCHEZ<sup>1</sup>, ISABEL ORTIZ-MARCOS<sup>1</sup> and ROCÍO RODRÍGUEZ-RIVERO<sup>1</sup>

<sup>1</sup> Universidad Politécnica de Madrid. Organization Engineering, Business Administration and Statistics. c/ José Gutiérrez Abascal, 2. E-28006 Madrid-Spain. E-mail: luisignacio.ballesteros@upm.es

The trend of the projectification of organizations to achieve their business objectives is currently a reality. In this context, a growing number of engineers are having their working roles redefined as project workers and managers. This study examined what is the main gap existing between engineering graduates and project management profiles in terms of personal competencies needed to successfully lead projects. Through the participation of 183 individuals (88 engineering master's students and 95 current project managers), using personal interviews and a survey, it was possible to assess eight competencies (emotional management; self-belief; commitment; communication; conflict management; resource management; team leadership, and; professionalism), and determine major differences between both groups. All personal competencies mean scores have shown to be higher for project managers than for engineering graduates. Five competencies are found to differ significantly for project managers than for engineering graduates: conflict management, team leadership, communication, emotional management, and professionalism. As a conclusion derived from this study, it is recommended to foster development of certain competencies from the early stages of engineers' education and project managers' careers. Special emphasis should be placed on strengthening conflict resolution, leadership and communication.

**Keywords:** leadership; project manager; competence; project management; engineering

## 1. Introduction

Projects are more frequently viewed as a mechanism to implement business strategies [1], allowing companies to grow and be sustainable. Projects are and will continue to be omnipresent in all parts of business, society and life [2, 3]. Practitioners and scholarly communities have recognized that project managers will remain key agents in the development of the business, growth and capabilities of organizations [4–6]. Experts have also highlighted that “*An idea will only ever remain an idea without project management to bring the idea to fruition*” [7].

Becoming a project manager is an important decision faced by individuals and helps meet organizations' needs for project management. This role has a set of unique challenges and problems that differ from other management duties ([8, 9], requiring both technical and personal competencies to develop teams that can work dynamically and creatively towards objectives in changing environments across organizational and functional lines [6]. Within project management competencies, personal competencies have been shown to be increasingly reliable predictors of successful project managers [10–15]. Personal competencies are those behaviors, attitudes, and core personality characteristics that contribute to a person's ability to manage projects [4].

Companies are developing learning experiences

to strengthen the project managers' personal competencies since it has been already proven that today projects don't fail because of technical problems but due to behavioral issues (ethical shortcomings, no employee engagement, low productivity and weak relationships) [16]. Organizations operating in the fields of engineering and other technical domains are especially likely to operate a projectified structure and therefore to rely, explicitly or implicitly, on a cadre of professional project managers, largely drawn from among the ranks of technical specialists, often on the assumption that a level of technical expertise is essential for the effective oversight of the technical aspects of the work process [17]. Although scholars have studied managerial competencies extensively [18–20] the topic in the context of project management still requires further research [12, 21–29].

Issues that have already been highlighted and explored are the importance of soft skills for the workplace success of engineers [30], as well as how to assess the achievement of these competencies [31]. In the knowledge of the importance of developing student professional competencies, engineering schools have redoubled their efforts in this field. Firstly, active learning methodologies to help students acquire both the technical and personal skills required to become competent engineers have been widely deployed. Secondly, the introduction of accreditation schemes has provided the opportu-

nity to define systems to effectively identify and measure the specific competencies that engineers should learn during their training [32].

ABET, Inc., formerly the Accreditation Board for Engineering and Technology, is a non-profit organization that accredits postsecondary degree programs in applied science, computing, engineering, and technology. Accreditation is intended to certify the quality of accredited programs [33]. Apart from the technical competencies required by engineers, this competency model includes other skills that successful engineers also need today, like “an ability to function in multidisciplinary teams” or “an ability to communicate effectively”.

The goal of this study is to analyze the main gaps that currently exist between engineering and project management positions in terms of personal competencies required for success in a projectized context. Through participation of 183 individuals (88 engineering master's students and 95 current project managers) using personal interviews and a survey, it has been possible to assess eight competences (emotional management; self-belief; commitment; communication; conflict management; resource management; team leadership, and; professionalism), and determine major differences between both groups. This research helps to identify the key personal competencies required by project managers, as well as to grasp the developmental and educational needs of engineering students to prepare them for future practice.

The remainder of this paper is structured as follows. The next section provides an overview of the relevant literature concerning project management competencies, followed by a review of challenges faced by project managers who come from technical positions. In the fourth section, the research methodology is included. This is followed by a presentation of results in the fifth section, which describes the main gaps that exist between engineering graduates and project managers. In the sixth section, the limitations of the study are discussed. The article concludes in the last section with a summary of the main insights related to the goal of the research.

## 2. Literature Review

### 2.1 *Project Management Competencies*

In the past, there has been a recognition that the role of a project manager has not been very attractive for professionals [34], which may be due to the high level of responsibility and demanding conditions for this role combined with relatively low authority [9, 17, 35, 36], poor support, lack of recognition and fewer (or no) career paths or

opportunities for development [37, 38]. The project manager's role is still typically compromised by structural and cultural aspects of organizational and industrial contexts [39], the still fragile credibility of project management, and the lack of legitimacy, resourcing, and autonomy afforded to those taking up this role [17, 36].

The importance of providing project managers with attractive career models in order to motivate and provide them with an adequate professional identity has been emphasized [37], as has the need for an integrated incentive system and information about which competencies and know-how should be acquired, attracting talented project managers and preventing the loss of valuable know-how and expertise [9, 34, 40]. Clear career expectations for individuals in a flexible and dynamic context with adaptation to the requirements and needs of the project manager remain essential [13, 41]. In this effort, the importance of building and sustaining project management competencies has been emphasized [9, 34, 40].

Project management competencies can be defined as a cluster of knowledge, aptitudes, attitudes, and behaviors that are required to accomplish a piece of work [42]. Along these lines, Parry [43] defines competencies as a set of related knowledge, skills, and personal characteristics that have an influence on individual and group work in an organization, are related to job performance, and can be improved through training and professional development.

The importance attributed to the strategic role of a project manager in organizations in recent decades has led to the growing development of frameworks of international competencies and professional standards for project management [44]. Some of the main competency frameworks are the Project Manager Professional (PMP) certification by the Project Management Institute [5], the International Project Management Association certification [45], the competency framework of the Association for Project Management [46] and the professional standards that have been defined by the Australian Institute of Project Management [47]. These competency standards provide guidance to individuals and organizations for the definition, assessment and development of project manager competencies. Their use has been extended internationally.

Some researchers have found that the project management literature has not carefully considered the contribution of the project management competency to project success [48]. This focus on efficiency rather than on interpersonal factors has been emphasized historically [49]. Until now, competency frameworks have developed and mapped

both technical and personal competencies for project managers; however, the focus has been mainly on the assessment and development of knowledge and performance for the use of tools and techniques in project management rather than on personal competencies [29]. Nevertheless, the number of research studies and publications concerning personal competencies has grown recently [8, 12, 23–29, 50].

The reality is that the demand for personal competencies is even more pronounced in project management than in other business environments, as relationships must be developed more quickly and there are frequently interpersonal interactions across organizational and professional cultures in a project environment [14]. The project manager must usually exhibit more engagement and commitment than regular employees in order to complete a project successfully [30]. Project managers are more likely to successfully cope with their tasks if they win the respect of their team members by displaying behaviors, such as being polite and reasonable [51]. People respond better to these approaches, carrying out the project manager's requests or instructions voluntarily and with greater enthusiasm. Effective project managers are people-oriented with strong leadership skills and excellent communication abilities. They are flexible, creative, imaginative, and adaptable, and can cope with a myriad of unexpected occurrences [52]. More than knowledge and technical skills, it is behavioral and personal competencies that are most critical to solve most of the "typical" (primarily human) problems in managing projects [12, 52]. To have enough adaptive capacity to handle the level of environmental complexity and change found in many projects today, project managers should demonstrate a high degree of self-reference, the ability to thrive on change, a solid foundation in traditional methods and techniques, and the ability to quickly adapt to change and develop new approaches [6].

### *2.2 Challenges Faced by Project Managers coming from Engineering Positions*

Engineering still constitutes the core of project management [36]. The tension between the technical specialist and technical manager roles is not a new issue in management or in research, and discussions on the work values of engineers and engineering managers have existed since the 1960s [17]. In most high-technology firms project managers evolve from technical enclaves, especially engineering. However, the skills needed to be a successful project manager differ significantly from those desired and rewarded in an engineering role [54].

When promoted to management, engineers face a new set of problems with which they are unfamiliar

[55]. They have to learn on the job, and they often pay a price in emotional currency. As an example, project leaders with a technical background may need to improve the way they motivate a team or galvanize the technical staff around a common problem, and good communication skills become essential for success [55–56]. The move from engineering positions to management involves a diversion and distraction from a strong technical vocation, reinforced by extended training and induction into their particular engineering culture [17]. Practitioners are seen as trained technicians who can rigidly follow learned methodologies on well-defined projects but are neither adaptable nor reflective enough for ill-defined project demands [57].

Engineers are frequently assigned responsibility on projects, expecting them to learn by doing, which can be risky for new project managers and for organizations in terms of cost overruns, missed deadlines, substandard project performance, unnecessary stress, lowered employee morale and lack of alignment between their project plans and the overarching strategy of an organization [54, 58]. This can impact project managers' career aspiration, confidence, and self-esteem.

Personal competencies are perhaps the most difficult area for engineers to improve as they move into project management positions. In this sense, a full understanding of the relationship between engineering and project management requires an analysis of both those factors driving and those impeding engineers from undergoing a career transition from engineering to management positions [17], characterized by the need to deploy human competencies. Team leaders with engineering backgrounds often focus on technical issues while giving management aspects little attention [58], since they generally prefer to concentrate on solving technical problems and find human relations a distraction that must be minimized [55].

## **3. Research Objective**

This paper concentrates on personal competencies of engineers and their careers as project managers, which requires further exploration and explanation [17, 27, 59]. Some evidence on the gap between engineering graduates and project management roles are explored. This is useful for identifying the key competencies required by future project managers, as well as for understanding the developmental and educational needs of engineering students to prepare them for future practice.

Considering the need for further research, this study proposes answering the following research question:

RQ. What is the main gap between engineering graduates and project management profiles in terms of the personal competencies needed to successfully lead projects?

#### 4. Method

The research was conducted through the following three stages:

*Stage 1: Identification of main project manager's personal competencies.* This stage had the aim of identifying a set of personal competencies to be measured for the purpose of the research, allowing for quantitative analysis of the main gaps between engineering graduates and those of project managers. First, a review of the relevant literature in the field of project management and engineering made it possible to collect and better understand the main personal competencies required for competent project management work in this field. Semi-structured personal interviews were then conducted with 12 project managers with a technical/engineering background, allowing previous competencies and indicators to be filtered and new ones they considered relevant for being successful at their work to be identified. These 12 project managers were selected from a Spanish professional network on the basis of independence, representativeness and heterogeneous principles, giving them the opportunity to voluntarily participate in the study. The participants were all project managers with a science/engineering degree and belonging to companies of different sectors: Transport, International Development, Energy, Defense, Construction, Agribusi-

ness, Fashion and Education. These interviews were conducted individually with all project managers following a list of themes and questions to be covered, giving the opportunity to propose new topics and/or change the order of questions depending on the flow of the conversation. Based on the literature review and these personal interviews with project managers (expert opinion), it was possible to propose 37 relevant performance indicators grouped in eight units of competency valid for analyzing personal competencies of project managers and engineering graduates (see Appendix). The units of competency were: (a) emotional management (five items); (b) self-belief; (four items) (c) commitment (four items); (d) communication (five items); (e) conflict management (four items); (f) resource management (five items); (g) team leadership (five items), and; (h) professionalism (five items). A unit of competence is a number of elements or performance indicators clustered required for a competent project manager [4].

*Stage 2: Data collection by survey administration.* Based on the previous stage, a survey was developed with the 37 performance indicators and additional demographic information (sex, age, work and management experience, etc.). To measure competencies, each indicator was defined by an extended Likert scale (from 1 to 7) for use in self-assessment of the frequency of each behavior. The survey aimed to cover a sample of both project managers with a technical background and engineering master's students (recently engineering graduates) in order to compare the results and detect the main differences and needs from an early stage. Project

#### RESEARCH STAGES

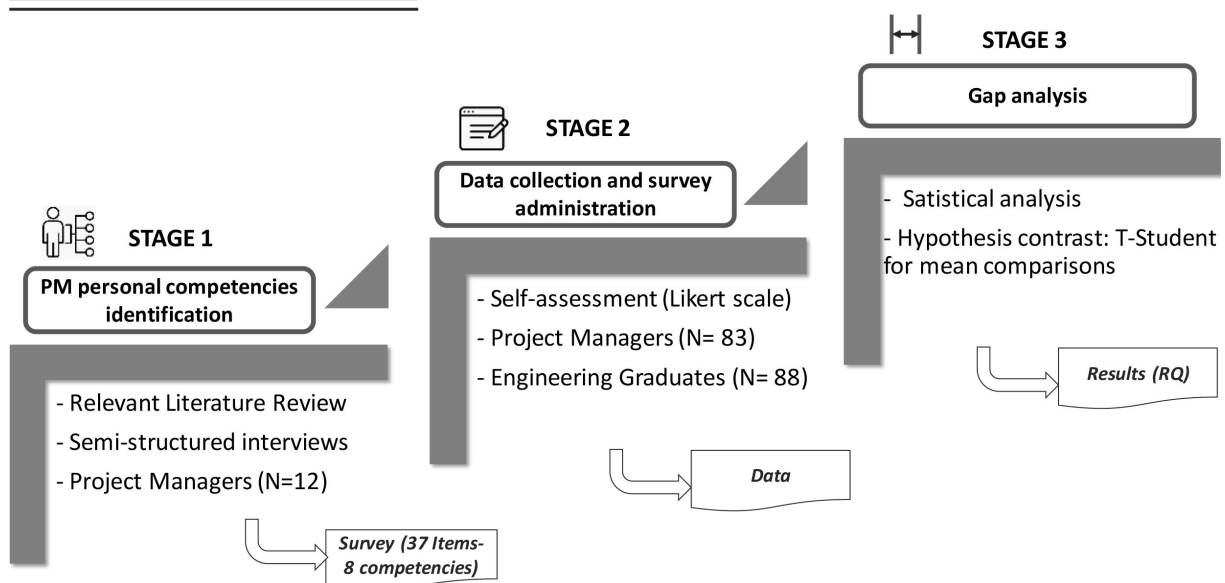


Fig. 1. Research method.

**Table 1.** Sample features

Res. stage	Objective	Participants	Method	N	Sex	Age (years)		Professional exp. (years)		Management exp. (years)	
						Mean	S.D.	Mean	S.D.	Mean	S.D.
Stage 1 Personal	competencies identification	Project Managers	Semi-structured interviews	12	Male: 7 (58.3%) Female: 5 (41.7%)	35.6	4.4	12.6	3.8	8.4	1.75
Stage 2	Data collection	Project Managers	Survey	83	Male: 70 (84.3%) Female: 13 (15.7%)	42.7	7.9	19.0	7.9	13.0	8.0
		Engineering graduates (master's students)	Survey	88	Male: 62 (70.5%) Female: 26 (29.5%)	22.9	2.3	0.7	2.0	–	–
			TOTAL	183							

managers were contacted through several project management associations as well as professional networks (i.e.: linked-inn). Engineering graduates were Master's Degree students at a technical university of Spain, and coming from schools of engineering. The survey was initially completed by a total of 171 participants (83 project managers and 88 engineering graduates). The features of the sample are shown in the Table 1.

*Stage 3: Gap analysis.* To answer the research question (RQ), means and standard deviations for the performance criteria and competency units were calculated in order to assess the results and compare different groups (project managers and engineering graduates). Mean comparisons using t-student for hypothesis contrasts were used for unpaired samples so that the significance of competency gaps could be determined. To validate the survey, the data obtained were analyzed for scale reliability via SPSS 23.0 to check for internal consistency. The resulting Cronbach's alpha coefficient value of 0.944 was above 0.7; accordingly, the scale was considered reliable for the purposes of this study [60].

## 5. Results and Discussion

### 5.1 Main Gaps

To answer research question (RQ – What is the main gap between engineering graduates and project management profiles in terms of the personal competencies needed to successfully lead projects?), the competency unit gaps comparing project managers and engineering graduates were determined; the main results appear in Table 2 and Fig. 2.

All competency units mean scores are higher for project managers than for engineering graduates. From the eight units of competency, five are found to differ significantly for project managers than for engineering graduates. These five competency units are in descending order: *Conflict management* (9.6% difference), *Team leadership* (8.7%), *Communication* (7.9%), *Emotional management* (6.6%), and *Professionalism* (5.2%). On the other hand, three competency units do not show significant differences, namely: *Commitment* (3.6%); *Resource management* (4.0%), and *Self-belief* (4.2%). These results emphasize what other authors have already concluded, especially concerning the importance of

**Table 2.** Personal competency unit means for project managers and engineering graduates

Competency Unit	Project Managers (n = 83)		Engineering graduates (n = 88)		t-Test (Means) <sup>1</sup>	
	Mean	Std. Dev.	Mean	Std. Dev.	Dif (%)	p-value
Overall Mean (Personal Competencies)	5.43	0.77	5.11	0.57	6.3%	0.03**
A. Emotional management	5.31	0.94	4.98	0.73	6.6%	0.011**
B. Self-belief	5.40	1.08	5.18	0.98	4.2%	0.165
C. Commitment	5.79	0.90	5.59	0.81	3.6%	0.122
D. Communication	5.18	1.06	4.80	0.86	7.9%	0.011**
E. Conflict management	5.23	0.93	4.77	0.92	9.6%	0.001***
F. Resource management	4.96	1.01	4.77	0.89	4.0%	0.187
G. Team leadership	5.47	0.97	5.03	0.92	8.7%	0.002***
H. Professionalism	6.08	0.73	5.78	0.86	5.2%	0.017**

<sup>1</sup> T-student hypothesis test for unpaired samples. \*\* p < 0.05. \*\*\* p < 0.01.

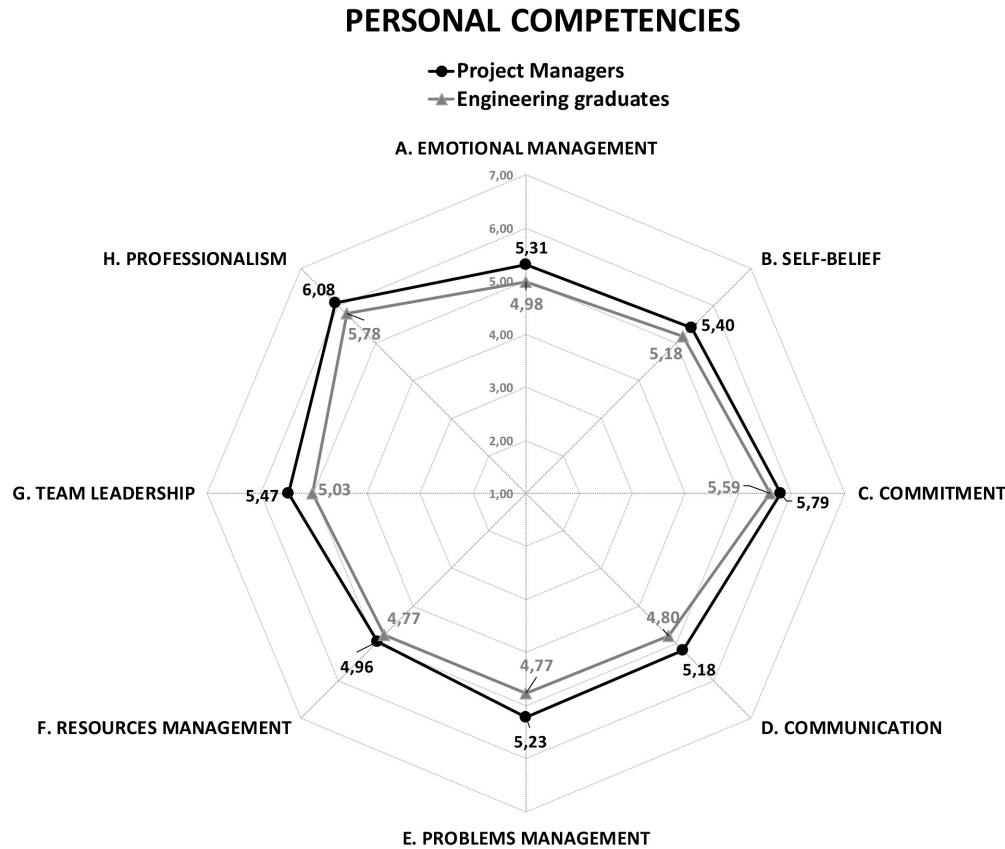


Fig. 2. Personal competency units: project managers and engineering graduates.

improving team leadership and communications skills for success [55–57, 61–63]. Particularly interesting is the highest gap, found for the *Conflicts management* competency, which reinforces the challenges of working on projects in the current context and the need to address the development of this competency in engineering profiles early on. The results are also in line with some researchers which attribute higher professional skills development within realistic, complex, and contextualized experiences [64]. Further research is recommended to better address this issue.

For project managers and engineering graduates, several common features of the results can be observed. In both groups, the highest mean scores are for the *Professionalism* unit with 6.08 and 5.78, respectively, followed by *Commitment* with 5.79 and 5.59. Additionally, the lowest scores are for *Communication* and *Resource management* with 4.80 and 4.77, respectively (in the latter case there was a tie with the *Conflict management* unit). From these results it can be derived that both project managers and engineering graduates tend to be especially responsible and committed profiles, but nevertheless have difficulties in managing their personal resources such as time, which can be a main source of stress, overload, and lower employee

morale. This is in line with previous research [34, 54, 58].

In the light of these results we suggest increasing activities during Master's Degree and project management courses for engineers with lower results to strengthen these competences (*Resource and Conflict management* as well as *Communication* skills) or these with bigger differences (*Problems and Conflict management*, *Team Leadership* together with *Communication*) to better prepare engineers for the challenges they will have to face during their professional life. This was already highlighted by other authors [65–66]. Researchers specifically affirm that engineering graduates are required to work in multicultural environments [67]. This is a reality that companies face where *communication* skills take on an important role since communication styles are different depending on the cultural approach. Focusing on *conflict management* or *resource management* (or any other competence) the same reflection could be made since cultural indicators [68] reveal how different and important these issues can be when carrying out projects in intercultural environments.

By focusing on the gaps of specific items (performance indicators) belonging to each competency unit, it is possible to identify those behaviors with

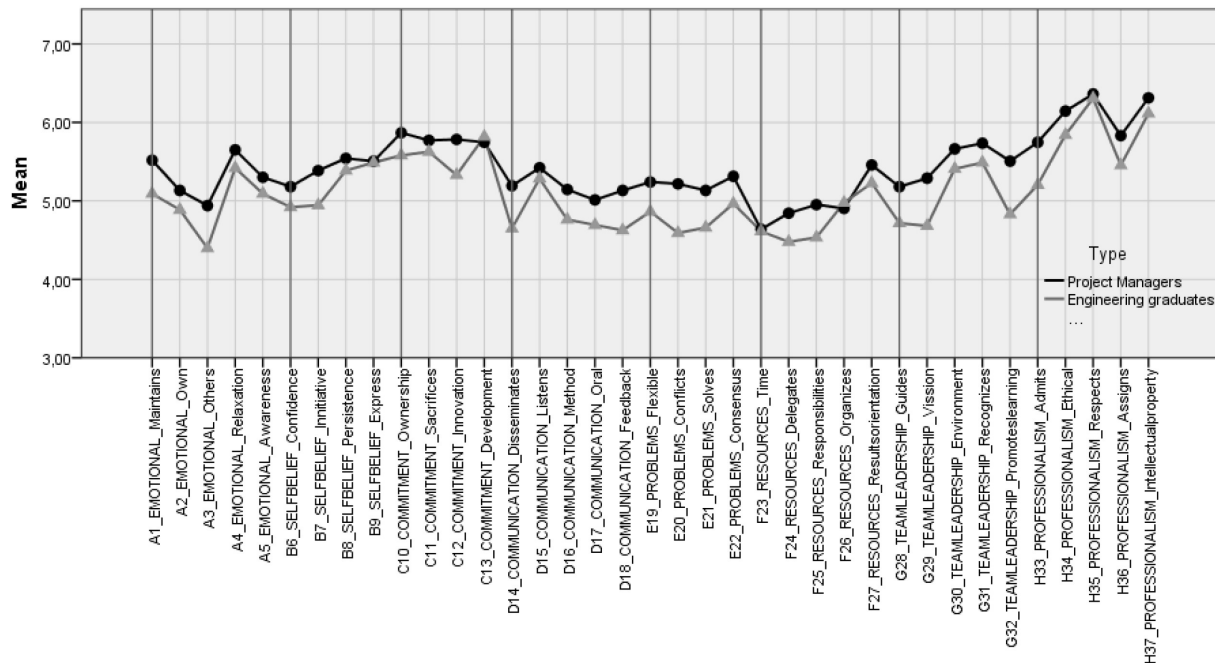


Fig. 3. Performance indicators: personal competency gaps between project managers and engineering graduates.

higher levels of differences based on both the project managers and the engineering graduates. From 37 items, 35 are higher in project managers than in engineering graduates (Fig. 3). Table 3 shows the summary of the major findings for the performance criteria gaps. The results show high positive differences between project managers and engineering graduates related to *Promotes team learning and advocates professional and personal development (G32)* at 14% and *Effectively resolves issues and solves problems that may arise (E21)* at 13.6%. This is followed by remarkable differences in performance indicators for *Transmits the project vision, mission statement, and strategic value needed to inspire the team (G29)* at 13% and *Uses emotional intelligence to manage the emotions of others (A3)* at 12.3%, respectively. Higher differences are also detected for behaviors related to *Disseminates information objectively, accurately and effectively (D14)* (11.7%), *Promotes and uses feedback as a means to continuous improvement (D18)* (11%), *Admits shortcomings and explicitly accepts responsibility for failures (H33)* (10.4%), and *Recognizes and resolves conflicts involving the project team or stakeholders (E20)* (10.2%).

On the other hand, negative differences (but not significant) are perceived only regarding two performance criteria: *Plans and manages for project success in an organized manner (F26)* at -1.5% and *Takes responsibility for own professional and personal development with a future view (C13)* at -1.2%. Although these negative differences were not significant, they could be explained by the fact that

high stress and workload of project managers may complicate organized and the importance given by the engineering graduates for their development and their future, since they are still in the first stage of their professional careers. The lowest and least significant differences are obtained for behaviors such as *Effectively expresses his or her point of view, respecting the opinion of others (B9)* (0.3%), *Manages own time successfully and prioritizes tasks (F23)* (0.5%) and *Respects personal, ethnic, and cultural differences (H35)* (0.9%).

The results show a general gap, with the lower performance of engineering graduates in focusing on the team or other stakeholders, which can be explained by the fact that they tend to be more individualist given their relative lack of experience working with teams and the fact that engineering degrees normally do not effectively address development social awareness and team skills.

To teach these competences in schools of Engineering the teaching approach should be modified [69]. This necessity of new teaching practices has changed the traditional lecturing at universities to an active learning methodology [66]. There is a real need for training in active participation to offer students challenges that further their success during their professional life (like has been seen in this experience).

This study highlights the idea that there is tension between the technical specialist and technical manager roles [17] in the engineering field. It provides further knowledge about gaps between the two roles. Other authors have already identified specific

**Table 3.** Performance indicators: personal competency gaps between project managers and engineering graduates

	Competency Unit	Project Managers (n = 83)		Engineering graduates (n = 88)		t-Test (Means) <sup>1</sup>	
Performance indicator (item)		Mean	Std. Dev.	Mean	Std. Dev.	Dif (%)	p-value
Highest differences							
Promotes team learning and advocates professional and personal development ( G32)	Team leadership	5.51	1.16	4.83	1.25	14.0%	0.000***
Effectively resolves issues and solves problems that may arise (E21)	Conflict management	5.22	1	4.59	1.21	13.6%	0.000***
Transmits the project vision, mission statement, and strategic value needed to inspire the team (G29)	Team leadership	5.29	1.14	4.68	1.31	13.0%	0.002***
Uses emotional intelligence to manage the emotions of others (A3)	Emotional management	4.94	1.49	4.4	1.17	12.3%	0.009***
Disseminates information objectively, accurately and effectively (D14)	Communication	5.19	1.23	4.65	1.07	11.7%	0.002***
Promotes and uses feedback as a means to continuous improvement (D18)	Communication	5.13	1.41	4.63	1.42	11.0%	0.021**
Admits shortcomings and explicitly accepts responsibility for failures (H33)	Professionalism	5.75	1.01	5.2	1.25	10.4%	0.002***
Recognizes and resolves conflicts involving project team or stakeholders (E20)	Conflict management	5.13	1.09	4.66	1.02	10.2%	0.004***
Lowest differences							
Respects personal, ethnic, and cultural differences (H35)	Professionalism	6.36	0.86	6.31	1.13	0.9%	0.724
Manages own time successfully and prioritizes tasks (F23)	Resource management	4.64	1.21	4.61	1.5	0.5%	0.905
Effectively expresses his or her point of view, respecting the opinion of others. (B9)	Self-belief	5.51	1.2	5.49	1.27	0.3%	0.927
Takes responsibility for own professional and personal development with a future view (C13)	Commitment	5.75	1.18	5.82	1.02	−1.2%	0.673
Plans and manages for project success in an organized manner (F26)	Resource management	4.9	1.16	4.98	1.31	−1.5%	0.699

<sup>1</sup> T-student hypothesis test for unpaired samples. \*\* p < 0.05. \*\*\* p < 0.01.

challenges facing engineers on their way to becoming project managers that are consistent with the results of this research, such as the need to improve communication skills and how they motivate teams [55, 56]. However, the findings of this research highlight the size of the gap that there is in terms of conflict management and emotional management skills, which is large enough to necessitate the improvement of engineering curricula.

Thus, engineering education curricula should specifically address particular social skills, such as conflict management, team leadership, communication, and emotional management. This can be done either by applying active learning methodologies in already existing courses or by setting up courses directly focusing on the improvement of these competencies. Another issue to be reviewed is student assessment with a view to better inte-

grating the deployment of social skills during their engineering studies [71–73]. The challenge, then, will be to pinpoint appropriate ways and spaces to do this, as well as to find qualified professors and mentors prepared to make this shift. There is a demand for new ways of training engineers for future practice.

Further research into new learning methodologies for project management is required. It has been highlighted that real project development incentivizes competency development [63, 74]. Specifically, the opportunities for engineering students to improve their conflict management skills during project-based learning experiences should be further analyzed and understood. Besides, interesting insights could be gained by exploring the gap between experienced project managers with years of professional practice and recent graduates.



## 6. Limitations

Some limitations of this study involve the features of the sample, as students participating were all from the same university and project managers were all from the same country (Spain). In addition, some bias could have arisen from measurements based on self-perception of personal competencies. In some cases, it is likely that students tend to perceive their competencies more strongly since they did not have the opportunity to work as project managers in the company. Perhaps they do not perceive what project success means and how their personal development would be affected.

## 7. Conclusions

Regarding Research Question (What is the main gap between engineering graduates and project management profiles in terms of the personal competencies needed to successfully lead projects?), it is possible to conclude that the main gaps between engineering graduates and project managers in terms of personal competencies are linked with *Problems and conflict management* (9.6% difference), *Team Leadership* (8.7% difference) and *Communication* (7.9%). In all cases, project managers perceive that their competencies are stronger than engineering graduates, which is reasonable considering their experience.

It is highly recommended to foster learning and development of personal competencies from the early stages of engineers' and project managers' careers in a way that adequately combines training for both technical and personal skills. From the beginning, special emphasis should be placed on

strengthening the competencies related to interacting with others, such as conflict resolution, leadership and communication. Transformational programs can be an adequate means of strengthening these skills and help to prepare better professionals needed in this new era. On the other hand, since project managers and engineering graduates have proven to be responsible and committed, while having difficulties in managing their personal resources, there is a clear need for support and training of these professionals that gives priority to skills related to time management, delegation and clarifying expectations of team members.

Therefore, this study provides a better understanding of how to develop and measure student personal competencies in engineering contexts by analyzing the gap that there is today between students and practitioners in the project management field. There is a huge variety of personal competencies. However, study focuses on the most-demanded skills, which helps to prioritize the resources required for their improvement.

The world is in a state of flux, and the speed of change is increasing exponentially. Projects are immersed in this complex environment, and project managers have the challenge of preparing to manage them competently. If the goal is to educate engineers in how actually implement solutions to address serious social ills, then project management requires us to consider seriously how to reinforce competencies to assist the project manager to understand culture, politics, ideology, economic theory and the dynamics of power as well as maintaining their technical knowledge when working on engineering projects. Further research could be carried out to consider these reflections.

## References

1. V. Hermanto and N. Martín-Cruz, The role of top management involvement in firms performing projects: A dynamic capabilities approach, *Journal of Business Research*, **69**(9), pp. 3447–3458, 2016.
2. Y. G. Schoper, A. Wald, H. T. Ingason and T. V. Fridgeirsson, Projectification in Western economies: A comparative study of Germany, Norway and Iceland, *International Journal of Project Management*, **36**(1), pp. 71–82, 2018.
3. J. Söderlund, Developing project competence: empirical regularities in competitive project operations, *International Journal of Innovation Management*, **9**(4), pp. 451–480, 2005.
4. Project Management Institute, *Project manager competency development framework 3rd ed.*, Project Management Institute, Newton Square, PA, 2017.
5. Project Management Institute, *A guide to the project management body of knowledge: PMBOK guide. Sixth Edition*, Project Management Institute, Newton Square, PA, 2017.
6. J. Thomas and T. Mengel, Preparing project managers to deal with complexity – Advanced project management education, *International Journal of Project Management*, **26**(3), pp. 304–315, 2008.
7. Project Management Institute, *PMI 2018 Pulse of the Profession® In-Depth Report*, Philadelphia, 2018.
8. L. Ballesteros-Sánchez, I. Ortiz-Marcos and R. Rodríguez-Rivero, The project managers' challenges in a projectification environment, *International Journal of Managing Projects in Business*, **12**(3), pp. 522–544, 2019.
9. K. Bredin and J. Söderlund, Project managers and career models: An exploratory comparative study, *International journal of project management*, **31**(6), pp. 889–902, 2013.
10. D. K. Ahadzie, D. G. Proverbs and P. Olomolaiye, Towards developing competency-based measures for construction project managers: Should contextual behaviours be distinguished from task behaviours, *International Journal of Project Management*, **26**(6), pp. 631–645, 2008.
11. R. E. Boyatzis, Competencies in the 21st century, *Journal of management development*, **27**(1), pp. 5–12, 2008.

12. M. Chipulu, J. G. Neoh, U. U. Ojiako and T. Williams, A multidimensional analysis of project manager competences, *IEEE Transactions on Engineering Management*, **60**(3), pp. 506–517, 2013.
13. M. I. Cheng, A. R. Dainty and D. R. Moore, What makes a good project manager?, *Human Resource Management Journal*, **15**(1), pp. 25–37, 2005.
14. V. Druskat and P. Druskat, Applying emotional intelligence in project working, *The management of complex projects: A relationship approach*, pp. 78–96, 2006.
15. D. H. Stevenson and J. A. Starkweather, PM critical competency index: IT execs prefer soft skills, *International Journal of Project Management*, **28**(7), pp. 663–671, 2010.
16. H. Kerzner and P. Saladis, *What Executives need to know about Project Management*, Ed. John Wiley & Sons, 2011.
17. D. Hodgson, S. Paton and S. Cicmil, Great expectations and hard times: The paradoxical experience of the engineer as project manager, *International Journal of Project Management*, **29**(4), pp. 374–382, 2011.
18. R. E. Boyatzis, Managerial and leadership competencies: A behavioral approach to emotional, social and cognitive intelligence, *Vision*, **15**(2), pp. 91–100, 2011.
19. E. Chong, Managerial competencies and career advancement: A comparative study of managers in two countries, *Journal of Business Research*, **66**(3), pp. 345–353, 2013.
20. F. J. Lara and A. Salas-Vallina, Managerial competencies, innovation and engagement in SMEs: The mediating role of organisational learning, *Journal of Business Research*, **79**, pp. 152–160, 2017.
21. L. Ballesteros-Sánchez, I. Ortiz-Marcos and R. Rodríguez-Rivero, The Impact of Executive Coaching on Project Managers' Personal Competencies, *Project Management Journal*, **50**(3), pp. 306–321, 2019.
22. B. J. Bauer, T. M. Richardson and J. W. Marion Jr, Project Manager 'Management Competency' vs. 'Technical Competency'. Which is more important to overall project management success?, *International Journal of Engineering Research and Applications*, **4**(4), pp. 269–273, 2014.
23. S. Brière, D. Proulx, O. N. Flores and M. Laporte, Competencies of project managers in international NGOs: Perceptions of practitioners, *International Journal of Project Management*, **33**(1), pp. 116–125, 2015.
24. N. Clarke, Emotional intelligence and its relationship to transformational leadership and key project manager competences, *Project Management Journal*, **41**(2), pp. 5–20, 2010.
25. K. Liikamaa, Developing a Project Manager's Competencies: A Collective View of the Most Important Competencies, *Procedia Manufacturing*, **3**, pp. 681–687, 2015.
26. X. Meng and P. Boyd, The role of the project manager in relationship management, *International Journal of Project Management*, **35**(5), pp. 717–728, 2017.
27. R. Müller and J. R. Turner, Attitudes and leadership competences for project success, *Baltic Journal of Management*, **5**(3), pp. 307–329, 2010.
28. G. J. Skulmoski and F. T. Hartman, Information systems project manager soft competencies: A project-phase investigation, *Project Management Journal*, **41**(1), pp. 61–80, 2010.
29. S. M. Takey and M. M. de Carvalho, Competency mapping in project management: An action research study in an engineering company, *International Journal of Project Management*, **33**(4), pp. 784–796, 2015.
30. R. Jafari-Marandi, B. K. Smith, V. R. F. Burch, S. C. Vick, Engineering Soft Skills vs Engineering Entrepreneurial Skills, *International Journal of Engineering Education*, **35**(4), pp. 988–998, 2019.
31. T. Redomero, V. Caggiano, J. L. Poza-Lujan and V. A. Piccione, Fostering and assessing soft skills of Engineering students, *International Journal of Engineering Education*, **35**(6), pp. 1656–1666, 2019.
32. A. H. Bayo, I. O. Marcos, A. C. Díaz, M. D. M. de la Fuente, J. L. Martín, M. L. M. Muneta, V. Rivera and M. R. Hernández, Integral framework to drive engineering education beyond technical skills, *The International Journal of Engineering Education*, **30**(6), pp. 1697–1707, 2014.
33. ABET, Criteria for accrediting Engineering Programs 2020-2021. ABET Engineering Accreditation Commission, Baltimore, 2019. Retrieved on June 2020 from <https://www.abet.org/wp-content/uploads/2020/03/E001-20-21-EAC-Criteria-Mark-Up-11-24-19-Updated.pdf>
34. K. Hölzle, Designing and implementing a career path for project managers, *International Journal of Project Management*, **28**(8), pp. 779–786, 2010.
35. M. de Cos Castillo, *Teoría General del Proyecto (Vol. 1 – Dirección de Proyectos/Project Management)*. Madrid, España: Editorial Síntesis, SA, 1997.
36. S. Paton, D. Hodgson and S. Cicmil, Who am I and what am I doing here? Becoming and being a project manager, *Journal of Management Development*, **29**(2), pp. 157–166, 2010.
37. D. McKevitt, R. Carbery and A. Lyons, A profession but not a career? Work identity and career satisfaction in project management, *International Journal of Project Management*, **35**(8), pp. 1673–1682, 2017.
38. K. Palm and M. Lindahl, A project as a workplace: Observations from project managers in four R&D and project-intensive companies, *International Journal of Project Management*, **33**(4), pp. 828–838, 2015.
39. M. Thite, Leadership styles in information technology projects, *International Journal of Project Management*, **18**(4), pp. 235–241, 2000.
40. S. El-Sabaa, The skills and career path of an effective project manager, *International Journal of Project Management*, **19**(1), pp. 1–7, 2001.
41. K. R. Brousseau, M. J. Driver, K. Eneroth and R. Larson, Career pandemonium: Realigning organizations and individuals, *Academy of Management Perspectives*, **10**(4), pp. 52–66, 1996.
42. R. E. Boyatzis, *The competent manager: A model for effective performance*, In John Wiley & Sons, New York, 1982.
43. S. B. Parry, Just What Is a Competency? (And Why Should You Care?), *Training*, **35**(6), pp. 58–60, 62, 64, 1996.
44. L. H. Crawford, P. Morris, J. Thomas and M. Winter, Practitioner development: From trained technicians to reflective practitioners, *International Journal of Project Management*, **24**(8), pp. 722–733, 2005.
45. International Project Management Association, *Individual competence baseline for project, programme & portfolio management*, International Project Management Association, Netherlands, 2015.

46. Association for Project Management, *APM competence framework*, United Kingdom: Association for Project Management, 2008.
47. Australian Institute for Project Management, *Professional Competency Standards for Project Management*, Sydney: Australian Institute for Project Management, 2008.
48. J. R. Turner and R. Müller, The project manager's leadership style as a success factor on projects: a literature review, *Project Management Journal*, **2**(36), pp. 49–61, 2005.
49. A. K. Munns and B. F. Bjeirmi, The role of project management in achieving project success, *International Journal of Project Management*, **14**(22), pp. 81–87, 1996.
50. A. Pacios Alvarez, J. R. Cobo-Benita, I. Ortiz-Marcos and F. J. Sánchez-Alejo, Acquiring negotiating skills by playing in project engineering, *International Journal of Engineering Education*, **27**(3), pp. 610–618, 2011.
51. M. D. Rosenau and G. D. Githens, *Successful project management: a step-by-step approach with practical examples*, John Wiley & Sons, 2011.
52. E. Fisher, What practitioners consider to be the skills and behaviours of an effective people project manager, *International Journal of Project Management*, **29**(8), pp. 994–1002, 2011.
53. B. Z. Posner, What it takes to be a good project manager, *Project Management Journal*, **28**, pp. 51–54, 1987.
54. N. E. Thornberry and J. R. Weintraub, The project manager: what it takes to be a good one, *Project Management Institute*, 1983.
55. G. Moretti, Engineers find surprises as they move into management, *EDN*, **47**(19), pp. 67–71, 2002.
56. M. Davis, Better communication between engineers and managers, *Science and Engineering Ethics*, **3**(2), pp. 171–212, 1997.
57. L. H. Crawford, *Project management competence: the value of standards*, DBA Thesis, Henley Management College, Henley-on-Thames, 2001.
58. C. M. Baca, Project manager! Who? Me?, *Machine Design*, **79**(20), pp. 64–66, 2007.
59. L. Ballesteros-Sánchez, I. Ortiz-Marcos, R. Rodríguez-Rivero and J. Juan Ruiz, J. (2017), Project Management Training: An Integrative Approach for Strengthening the Soft Skills of Engineering Students, *International Journal of Engineering Education*, **33**(6-A), pp. 1912–1926, 2017.
60. J. Pallant, *SPSS survival manual*, McGraw-Hill Education, UK, 2013.
61. H. J. Passow, Which ABET competencies do engineering graduates find most important in their work?, *Journal of Engineering Education*, **101**(1), pp. 95–118, 2012.
62. H. J. Passow and C. H. Passow, What competencies should undergraduate engineering programs emphasize? A systematic review, *Journal of Engineering Education*, **106**(3), pp. 475–526, 2017.
63. A. Uruburu Colsa, I. Ortiz-Marcos, J. R. Cobo-Benita and A. Moreno-Romero, Improving Engineering students' communication competence: designing innovative learning strategies, *International Journal of Engineering Education*, **31**(1), pp. 361–367, 2015.
64. K. Litchfield, A. Javernick-Will and A. Maul, Technical and professional skills of engineers involved and not involved in engineering service, *Journal of Engineering Education*, **105**(1), pp. 70–92, 2016.
65. W. Sunthonkanokpong, Future Global Visions of Engineering Education, *2nd International Science, Social-Science, Engineering and Energy Conference 2010: Engineering Science and Management. Procedia Engineering*, **8**, pp. 160–164, 2011.
66. R. Colomo-Palacios, T. Samuelsen, C. Casado-Lumbreras and X. Larrucea, Students' selection of teamwork tools in software Engineering Education: lessons learned, *International Journal of Engineering Education*, **36**(1), pp. 309–316, 2020.
67. C. S. Nair, A. Patil and P. Mertova, Re-engineering graduate skills—a case study, *European journal of engineering education*, **34**(2), pp. 131–139, 2009.
68. E. Meyer, *The Culture Map: Decoding How People Think, Lead, and Get Things Done Across Cultures*, Ed. PublicAffairs, U.S, 2017.
69. S. H. Pulko and S. Parikh, Teaching 'soft' skills to engineers, *International Journal of Electrical Engineering Education*, **40**(4), pp. 243–254, 2003.
70. J. Walther, S. E. Miller and N. W. Sochacka, A model of empathy in engineering as a core skill, practice orientation, and professional way of being, *Journal of Engineering Education*, **106**(1), pp. 123–148, 2017.
71. L. Bosman, J. C. Keller, N. Mentzer and A. E. Sparkling, Applying multiple modes of assessment to evaluate the team work competence, *International Journal of Engineering Education*, **36**(1), pp. 317–327, 2020.
72. J. Paoletti, T. M. Bisbey, D. L. Reyes, M. A. Wettergreen and E. Salas, A checklist to diagnose teamwork in engineering education, *International Journal of Engineering Education*, **36**(1), pp. 365–377, 2020.
73. X. Neumeyer and S. C. Santos, The Effect of Team Conflict on Teamwork Performance: An Engineering Education Perspective, *International Journal of Engineering Education*, **36**(1), pp. 502–509, 2020.
74. M. B. Arthur, R. J. DeFillippi and C. Jones, Project-based learning as the interplay of career and company non-financial capital, *Management Learning*, **32**(1), pp. 99–117, 2001.
75. T. Creasy and V. S. Anantatmula, From every direction – How personality traits and dimensions of project managers can conceptually affect project success, *Project Management Journal*, **44**(6), pp. 36–51, 2013.
76. D. Goleman, R. E. Boyatzis and A. McKee, *The new leaders: Transforming the art of leadership into the science of results*, 2002.

## APPENDIX

The performance indicators and competency units for assessing personal competencies of the participants in this study, including the main references on which the indicator was based, are presented as follows.

### A. EMOTIONAL MANAGEMENT

[A1] Maintains self-control in all situations and responds calmly [4, 75].

[A2] Uses emotional intelligence to manage their own emotions [Expert interviews, 76].

[A3] Uses emotional intelligence to manage the emotions of others [Expert interviews, 76].

[A4] Maintains a positive attitude and relaxation when required [4, 45].

[A5] Uses reflection and awareness to identify own strengths and weaknesses and improve performance [45, 76, Expert interviews].

#### B. SELF-BELIEF

[B6] Shows confidence in the responsibilities derived from his role, believing in his own worth and capabilities [Expert interviews, 76].

[B7] Takes the initiative and makes the appropriate decisions when required, taking the necessary actions ([4, 45, 76].

[B8] Shows persistence and consistency in actions [4].

[B9] Effectively expresses his or her point of view, respecting the opinion of others [Expert interviews].

#### C. COMMITMENT

[C10] Demonstrates ownership of, accountability for, and commitment to the project [4].

[C11] Makes sacrifices where necessary to move project forward [4].

[C12] Keeps an attitude oriented towards change, innovation and learning [46, 75–76].

[C13] Takes responsibility for own professional and personal development with a future view [Expert interviews].

#### D. COMMUNICATION

[D14] Disseminates information objectively, accurately and effectively [4].

[D15] Actively listens [4, 46].

[D16] Uses suitable communication methods and means for the audience [4].

[D17] Uses oral communication techniques (meetings, presentations, etc.) correctly [Expert interviews, 28].

[D18] Promotes and uses feedback as a means of continuous improvement [Expert interviews, 28, 46].

#### E. PROBLEMS AND CONFLICTS MANAGEMENT

[E19] Demonstrates flexibility, adapting to changing situations and uncertainty [Expert interviews, 4].

[E20] Recognizes and resolves conflicts involving project teams or stakeholders [4, 46, 76].

[E21] Effectively resolves issues and solves problems that may arise [4].

[E22] Facilitates consensus and mutually beneficial compromise solutions for all stakeholders [Expert interviews].

#### F. RESOURCES MANAGEMENT

[F23] Manages own time successfully and prioritizes tasks [Expert interviews].

[F24] Delegates and redistributes tasks and functions in a responsible and coordinated manner with team members [Expert interviews, 28].

[F25] Defines, understands and clarifies the responsibilities and expectations of team members [4, 46]

[F26] Plans and manages for project success in an organized manner [4].

[F27] Keeps a results orientation and project objectives [Expert interviews, 45, 46].

#### G. TEAM LEADERSHIP

[G28] Guides, accompanies and adequately trains project team members [Expert interviews, 45].

[G29] Transmits the project vision, mission statement, and strategic value needed to inspire the team [4, 46, 76].

[G30] Creates and develops an environment of confidence, respect and openness within the project team [4, 46].

[G31] Recognizes the work of others, expressing positive expectations and motivation toward the achievement of the project's objectives [Expert interviews, 4, 46].

[G32] Promotes team learning and advocates professional and personal development [4, 46].

#### H. PROFESSIONALISM

[H33] Admits shortcomings and explicitly accepts responsibility for failures [4].

[H34] Conforms to ethical behavior governed by responsibility, respect, fairness, and honesty [4, 46, 76].

[H35] Respects personal, ethnic, and cultural differences [4].

[H36] Assigns team members in an unbiased way to appropriate tasks [4].

[H37] Respects the intellectual property of others [4].

**Luis Ballesteros-Sánchez** is an industrial engineer who holds a PhD from the Universidad Politécnica de Madrid and also a Master's degree in the psychology of human behavior. He is Assistant Professor of Engineering Projects at this university. Luis is Executive Coach and a member of the Project Management and Quality Research Group. His research fields of interest are the development of project management personal competences, such as leadership and communication that apply to project success.

**Isabel Ortiz-Marcos** is a mechanical engineer who holds a PhD in industrial engineering from the Universidad Politécnica de Madrid. She is Associate Professor of Engineering Projects at this University. Dr. Ortiz-Marcos has been certificated as Project Manager Professional (PMP) since 2006. She is a member of the Project Management and Quality Research Group and her current research fields of interest are competences and professional skills applied to Project Management in a multicultural context and international development projects and quality management.

**Rocío Rodríguez-Rivero** has a PhD in Industrial Management and she also holds a MSc in Electrical Engineering at Universidad Politécnica de Madrid (UPM). She has been experienced in international engineering projects and currently works as an assistant professor of Engineering Projects, and Project Management at UPM. She is a member of the Project Management and Quality Research Group, and a member of the international development group Production, Management, and Development. The research fields of interest to her are Risk Management and skills development in multicultural environments and international development projects.