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Project Management Training: An Integrative Approach for Strengthening the Soft Skills of Engineering Students*

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The need to rethink project management practices and review how different competences of project managers can be reinforced remains a crucial challenge. This study is intended to explore how soft skills can be measured and strengthened in project management training of engineering students. The purpose is to define and test a valid framework that will help to better design, assess and improve project management training programs. This research has been carried out with 67 engineering students in the role of project managers who lead 456 team members. The main results of this study include the definition of a Soft Skills Index for measurement of soft skills in project management, the assessment of improvements perceived by the students on completion of the training experience and an analysis of the correlation between hard and soft skills.

Keywords: project management; engineering students; competences; soft skills

1. Introduction

Project management has been highlighted by several authors as a critical area of interest [1]. Others have also pointed out the need to "rethink" this practice [2]. Clearly, teaching and learning project management have attracted the attention of numerous scholars [3–6].

The need to reexamine how project managers are educated and trained has been suggested by several authors [7–10].

A review of relevant literature reveals a broad consensus about two different types of project management competences, *hard and soft skills.* Having a greater understanding of the nature and development of personal competences (soft skills) has become an interesting topic in recent years. This has resulted in a growing volume of original research and relevant publications [11–13].

Context changes such, as an increase in project complexity, multicultural issues and the growth of work by virtual teams, has led to a new era in which project managers' soft skills are more and more crucial to better achieve project success [14]. This becomes particularly interesting within the engineering field, where the technical complexity of projects and the need to lead project teams more effectively remains a great challenge.

This article explores how soft skills can be measured and strengthened within project management training of engineering students. The purpose is to define and test a valid framework that will help to better design, assess and improve project management training programs. This research has been carried out with students of the Industrial Engineering School of the Universidad Politécnica de Madrid. The results include the definition of a Soft Skills Index for measurement of soft skills in project management and the assessment of the improvements that the students perceive on completion of the training. In addition, an analysis of the correlation between students' hard and soft skills is presented, with unexpected results.

2. Literature review

2.1 Teaching project management in engineering

Earlier studies suggested the project management skills are core to the leadership attributes of engineers [15, 16]. Some interrelated research streams are available for an understanding of the challenges in teaching and learning both engineering [17] and project management education [4, 18].

Students' experiences have remained a major theme of interest to scholars, especially in the engineering and project management areas [19, 20].

The notion of students' experience in studying project management remains a core element of the wider teaching and learning discourse [21], especially in light of emerging ideas concerning the creation of reflective and creative practitioners [22, 23].

This need to teach and learn project management in engineering schools has been advanced by employers. Project management graduates and postgraduates find a wide range of employment opportunities in all industries, especially in engi-

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neering consulting, construction and energy firms, as well as the public sector [24].

Today, employers expect engineers to excel in many soft skills, including teamwork and group development [24]. They are keen to tap into these vital soft skills that they obtained during their studies and periods of work experience, rather than just degree-specific knowledge [25].

There is a growing demand for project management skills as a consequence of the projectization of organizations. To make the education more relevant to the reality of our companies, many university engineering departments offer project management courses. However, in these technical programs, the focus of most project management training, has been on a technical skills that are deemed to be essential to achieve project success, which is defined as achieving the iron triangle of time, cost and quality [26], with more emphasis given to the rational models, especially planning and control [27]. However, more and more organizations are realizing that an understanding of the people who undertake project work and consideration of management skills is vital for project success [28]. Researchers prove the importance of social sciences on project management models, integrating organization behavioral competences [29–31]. Finally, other trainers and researchers recognize the importance of project management models in integrating contextual competences that consider the exogenous factors that influence the projects [27].

Recently, interesting project management teaching experiences have been published in Engineering Higher Education using different methodologies and strengthening different competences [32, 34].

2.2 Framework of project management competencies

To reexamine how project managers are educated and trained, the first step is to better understand the role of the project manager and what competences they need to acquire to be effective and to achieve project success.

The project manager is a strategic role for business development, growth and survival of organizations, in an environment that is increasingly complex, competitive and changing [35, 36]. The project manager must coordinate and integrate activities along multiple functional lines within the organization, while controlling the resources in time, cost and performance to contribute to the success of the project [37]. The project management function is relevant and requires a wide vision of different areas to coordinate, along with a wide range of personal skills [36–38]. To successfully manage projects, the project manager requires several different skills, including interpersonal ability, technical competencies, and cognitive aptitude, along with the ability to understand the situation and people and to dynamically integrate appropriate leadership behaviors [24].

Competences for project management can be defined as a cluster of knowledge, aptitudes, attitudes and behaviors that are needed to accomplish a piece of work [39]. Along these lines, Parry [40] defines competences 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 by training and professional development.

The importance that is attributed to the strategic role of a project manager in organizations has led in rent decades to the growing development of frameworks of international competencies and professional standards for project management. Some of the main competency frameworks are Project Manager Professional (PMP) certification by the Project Management Institute [35], the International Project Management Association certification [41], the competency framework of the Association for Project Management [42] and the professional standards that have been defined by the Australian Institute of Project Management [43]. These competency standards provide guidance to individuals and organization for the definition, assessment, and development of project manager competence. Their use has been extended internationally.

The Project Manager Competency Development (PMCD) Framework [35] groups competencies by three main aspects—knowledge, performance and personal competence. Knowledge competences concern what the project manager knows about the application of processes, tools, and techniques for project activities. Performance competences concern how the project manager applies project management knowledge to meet the project's requirements. Finally, personal competences involve how the project manager behaves when performing activities within the project environment, his attitude and core characteristics of his personality. Personal competences are grouped into six different units: Communicating, Leading, Managing, Cognitive Ability, Effectiveness and Professionalism.

A review of relevant literature, including previous competency frameworks, reveals a broad consensus about two different types of project management competences. The latter are (1) a group of technical and knowledge competences, which integrate the deployment and use of methods and tools for project management, commonly called *hard skills*, and (2) a group of behavioral competences and interpersonal skills for project management, so

called *soft skills.* The literature has traditionally been more concerned with the conceptualization and study of hard skills, as opposed to soft skills, and particularly their assessment and development [44]. Nonetheless, the interest in, and the need for, a greater understanding of the nature and development of personal competences (soft skills) has become a relevant topic in recent years. This has resulted in a growing volume of research and relevant publications [11–13].

2.3 Hard and soft skills in project management

Hard skills have been commonly related to technical competence and knowledge and project management processes application. Technical competence in the field of project management has been operationally defined as an understanding of the technology involved, the engineering tools and techniques employed, product applications, technological trends and evolutions and the relationship among supporting technologies [37, 45]. Technical competences imply an understanding of, and proficiency in, a specific kind of activity, particularly one that involves methods, processes, procedures or techniques [46].

Within the knowledge and application of processes of project management, hard skills are those that are necessary for the initiation, planning, execution, monitoring and closing of projects, as defined in PMBOK® [36] by project management processes groups. Moreover, in project management, conceptualization of hard skills has also been related to contracting, business finance, integrated cost/schedule control, measurement of work performance, monitoring of quality and risk analysis [47, 48].

On the other hand, soft skills within the project management field have been defined as those behaviors, attitudes, and core personality characteristics that contribute to a person's ability to manage projects [35]. This kind of competence connotes the ability of a project manager to work effectively as a group member and to build a cooperative effort within the team that he/she leads [46]. These skills are concerned primarily with working with people, remaining sensitive to the needs and motivations of others in the project and skill in communication [46].

A literature review of soft skills leads to the first theorists and authors on motivation [49, 50], who emphasized that an effective manager requires the deployment of a set of personal competencies that are based on the consideration for other persons, building trust and showing empathy for the emotions of other people, for example, in problem-solving. An effective manager must develop his/her own personal point of view toward human activity [46, 51], so that he/she will: (a) recognize the feelings and sentiments that he/she brings to a situation; (b) have an attitude toward his/her own experiences that will enable him/her to re-evaluate and learn from them; (c) develop ability to understand what others are trying to communicate to him/her by their actions and words (explicitly or implicitly), and (d) develop the ability to successfully communicate his/her ideas and attitudes to others. Soft skills include the set of social and emotional competences that underlie a person's characteristics leading to effective or superior performance [39, 52]. In addition, soft skills unfold through face-to-face behaviors that people use in the desire to achieve something useful [53]. In the field of project management, soft skills also have been related to negotiation, change management and stakeholder management [47, 48].

Hard skills, although necessary, have not been shown to be determinants for distinguishing an acceptable project manager from an excellent one, nor do those skills necessarily lead to effective or superior performance [52, 54]. In a study of the construction sector [55], within a project-based framework, it was concluded that soft skills were better predictors of project managers performance than hard skills. Additionally, the findings of a study of the importance attributed to certain project managers' competency requirements that took into account managers' perception of their recruitment highlighted these "important" and "extremely important" transversal, human and interpersonal skills [56].

The reality is that the demand for soft skills 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 [57]. Project managers are more likely to cope successfully with its tasks if they win the respect of their team members by displaying behaviors, such as being polite and reasonable [58]. People will respond better to these approaches, carrying out voluntarily and with more enthusiasm the project manager's requests or instructions. Effective project managers are people-oriented with strong leadership skills and superb communication abilities. They are flexible, creative, imaginative and adaptable, and can cope with a myriad of unexpected occurrences [59]. More than knowledge and technical skills, it is behavioral and personal competences that are most critical to solve most of the "typical" (primarily human) problems in managing projects [14, 60]. In a research study of effective project managers [46], it was found that human skills were much more valued than conceptual and organizational skills and technical skills.

Table 1. Project management competences classification

PM Competence	Description	Reference
Hard Skills	Understanding the technology involved, the engineering tools and techniques employed; knowledge of product applications; knowledge of technological trends and evolutions; kowledge of the relationship among supporting technologies; use of methods, processes and procedures or techniques; effective application of scientific and mathematical principles to practical ends, such as design, manufacture and operation of efficient and economical structures, machines, processes and systems; assessment of technical concepts, solutions and risks; ability to make trade-off decisions; effective communication with the project team in technical terms; understanding the business impact of different technologies; use of technology for business advantages; knowledge for initiating, planning, executing, monitoring and closing of projects (PMBOK®); skills and roles related to contracting, business finance, integrated cost-/schedule control, measuring work performance, monitoring of quality and risk analysis.	[36–37, 45–48, 61–62]
Soft Skills	Behaviors, attitudes and core personality characteristics that contribute to a person's ability to manage projects; ability to work effectively as a group member and to build a cooperative effort within the team that one leads while remaining sensitive to the needs and motivations of others in the project and skill in communication; consideration for the other person, building trust and showing empathy for the emotions of other people; recognition of feelings and sentiments within a situation; the attitude towards other's experiences, which will enable one to re-evaluate and learn from them; the ability to understand what others, by their actions and words, are communicating; the ability to successfully communicate ideas and attitudes to others; the set of social and emotional competences that underlie the characteristics of a person and lead to effective or superior performance. Face-to-face behaviors in the desire to achieve something useful, with the help of others; flexibility, creativity, imagination and adaptability to cope with a myriad of unexpected occurrences; skills like leadership, problem-solving, communication, negotiation and team work. Skills and roles related to negotiation, change management and stakeholder management.	[14, 35, 36, 39, 46–53, 58]

In general, research evidence shows a trend to increasingly value soft skills, like leadership, problem-solving, communication, negotiation, and team work, rather than specialized knowledge and technical skills. This contrasts with an older era in which technical competence was a salient feature of the literature [14]. Such a trend may be in response to environmental changes: as project complexity and/or novelty increase. These may increase the need for more complex cross-functional project teams or even multiple agencies that require a higher level "human skills." Also, modern project teams are more likely to be multicultural and/or virtual [14].

This trend is not expected to decline in the near future, but to continue to grow in more changing, complex, multidisciplinary and international contexts. In these circumstances, it is expected that training of future project management practitioners will take into account the need for understanding, designing and assessing methods for the development of both hard and soft skills, in an integrative way. This will be particularly relevant if we focus on project management within the engineering field, where the technical complexity of projects and the need to lead project teams more effectively remains a great challenge.

3. Research methodology

3.1 Research objectives

This research focuses on gaining a better understanding of how soft competences in project management can be measured and strengthened, in a specific learning and training environment of engineering students and, thereby, answering the following research questions:

- Is it possible to use a standardized index for the measurement of soft skills in project management?
- What soft competences are most reinforced in a project management learning context using Project Based Learning (PBL) methodology?
- Is there a correlation (positive or negative) between hard and soft competence development for engineering students in the project management field?

The answer to these questions may determine the strategy to adopt for the design, assessment and improvement of project management training programs for engineering students. Having a better understanding of the measurement, reinforcement and relation between these competences during learning processes will help in making better decisions.

3.2 Project based learning experience

Project Based Learning (PBL) is a model in which learning opportunities are organized around projects [63]. If we consider the definitions that are found in PBL papers, projects are complex tasks that are based on challenging questions or problems that involve students in design, problem-solving, decision-making, or investigative activities [64].

In PBL, the project is the central teaching-learning strategy. Students encounter and learn the central concepts of discipline by means of the project.

PBL experiences are excellent teaching-learning tools, especially in Engineering. They guide students towards their future working lives in industry, which will involve not only solving technical or financial problems on a daily basis but also human problems [65]. This teaching-learning methodology has attracted particular interest in engineering because of its potential to increase student engagement and improve skill development [66]. This is why the experiences that are presented here are conducted using this methodology with Bachelor and Master degree engineering students.

With this experience, professors provide real-world problems to engineering students, which reinforces concepts and improves learning in ways that are not available with traditional lecture methods or predefined case problems [67]. Students develop problem-solving skills, project management skills, communication and teamwork skills and a sense of professionalism from such experiences. It involves the assumptions of cognitive and social processes of learning and values interactions in problem-centered environments [68].

In the context of the Universidad Politécnica de Madrid (UPM), there are some initiatives to highlight with respect to the implementation of PBL strategies. They involve: (1) strengthening communication skills by working in virtual environments [33], (2) a methodological process of promoting professional Project Management (PM) competences from graduate to postgraduate programs [32], (3) PBL in the teaching of design in aeronautical engineering that is similar to real working conditions [69] and (4) the improvement of a teaching strategy to associate product design and machine design in Mechanical Engineering [65].

The experience that is presented here is conducted by this methodology with Bachelor and Master degree students always in the context of Project Management teaching of Engineering students in the Industrial Engineering School of UPM.

3.3 Sample overview

The subjects that were used to develop this research were ''Engineering Projects'' for Bachelor degree students in their fourth and last year and ''Project management'' for Master degree students in their first year. Both were conducted using PBL methodology as has been stated. This meant that the students completed practical work based on real projects with objectives (scope, time and cost) that were defined by professors. The work was undertaken by teams in which one of the students assumed the role of project manager. The data corresponds to the academic courses 2014–15 and 2015–16.

In total, the competences of 67 project managers leading around 456 engineering students were measured. Table 2 shows the composition of the sample.

3.4 Data collection and treatment

As has been mentioned previously, 456 students were involved in this study in 67 working teams. In the analysis, the objective was to assess the 67 leaders or Project Managers. To complete fulfill this objective, a large number of variables were analyzed. They can be separated into three groups:

- *Group A: Personal variables*. Year of the course, sex and degree of each student.
- *Group B: Soft skills in project management.* Self-assessments by students who are serving as project managers during training experience. The performance criteria were assessed using a soft skills questionnaire that used an extended Likert scale (from 1 to 7) that was adapted from the original personal competences that were defined by PMI [35]. The total number of items within this group was 81. They were separated into six groups (see Table 3): Communicating (12); Leading (15), Managing (11), Cognitive ability (17), Effectiveness (16) and Professionalism (10). All variables were measured at the beginning and the

Table 2. Sample characteristics of the engineering students participating in the research

Degree	Project Engineering and Project Management	Project Managers	Students involved in the experience (team members)
Bachelor degree programs	Degree in Industrial Engineering	19	189
	Degree in Chemical Engineering	8	42
	Degree in Power Engineering	10	70
	Total Bachelor PM	*37*	*301*
Master degree programs	Master of Industrial Engineering Master of Engineering	26	135
	Master of Management	4	20
	Total Master PM	*30*	*155*
	TOTAL	**67**	**456**

end of the training process to measure how the experience had strengthened these competences. So, in practice, each student had two measurements. To be sure that all students understood the questions, instructions were provided. This helped to avoid misunderstandings and highlighted the intention to use the results only with research proposals and would not affect the students' grades in the subject.

- *Group C: Hard skills.* A selection of qualifications obtained by the students in different subjects of the course in their transcripts of their academic records. This selection includes global measures of students' files (average grades for each year and the final average grade of the degree that was completed previously), qualifications of subjects related to hard skills (calculus, physics, differential equations, etc.) and other subjects that are more related to project management (see Table 3).

The initial phase of the study consisted of reducing the information related to each of the six personal competences defined by the PMI. For each soft skill, an index has been constructed that combines lineally assessments of its different items, using principal components technique. Scores obtained for the six competences were also combined to obtain a global index (Soft Skill Index).

These indices extract maximum information from the data that has been gathered and enables them to be studied in a simplified way. The soft skill index that was determined previously was used in principal component analysis, whereas a selection of qualifications obtained during the degree was used for hard skills. An unexpected result, which attracted great interest in the study, was the lack of any correlation between hard and soft skills.

The effectiveness of the training process was analyzed by contrasting the means of the scores that were obtained before and after the course. A summary of the results and their interpretation are presented in the following sections.

4. Results and analysis

4.1 Principal components: the soft skill index (SSI)

Principal components is a multivariate analysis technique that is recommended for the study of a large number of variables that show high correlation. It was applied in this study for the 81 variables of competences related to soft skills. Bartlett's sphericity contrast indicates that there are highly significant correlations among these variables. Most correlation coefficients are positive and significant (p-value < 0.05).

Table 4 shows the results of principal component analysis (PCA) for the six groups of competences that are described above. As explained below, each of the six PCAs gives rise to an index. The last block of Table 4 combines these six indices to construct a global index. In the column called C1 in Table 4, correlations of each variable are shown with the corresponding first component (the index of the corresponding competence). The three highest values in each column t have been marked. The first component of each group explains 40 to 50 per cent of the observed variability of the original variables (the last row of Table 4 shows these values). Taking into account the objective of reducing the number of variables, the result can be considered to be satisfactory, although it is true that the components, as usual, do not retain all of the information. In this case, the number of variables has dropped from 81 to 6. These six new variables (indices) retain almost 50% of the information of the original 81 variables. The analysis by

Table 3. Data collection procedure

Soft Skills (Group B)	**Hard skills (Group C)**
Source: self-assessment (questionnaire adapted from PMI) (81 items) • *Communicating:* Effectively exchanges accurate, appropriate and relevant information with stakeholders using suitable methods. (12 items) • *Leading:* Guides, inspires and motivates team members and other project stakeholders to manage and overcome issues to effectively achieve project objectives. (15 items) • *Managing:* Builds and maintains the project team; plans and manages for project success in an organized manner; resolves a conflict involving project team or stakeholders. (11 items) • *Cognitive Ability:* Applies an appropriate depth of perception, discernment and judgment to effectively direct a project in a changing and evolving environment. (17 items) • *Effectiveness:* Produces desired results by using appropriate resources, tools and techniques in all project management activities. (16 items) • *Professionalism:* Conforms to an ethical behavior governed by responsibility, respect, fairness, and honesty in the practice of project management. (10 items)	**Source:** transcript of records **Subjects considered:** • Calculus (level 1) • Physics (level 2) • Differential equations • Business • Manufacturing • Drawing (level 1) • Engineering projects Grade (average) at the end of each study year and final degree average.

Table 4. Principal Component and Improvements Ratio

SOFT SKILLS (PERSONAL COMPETENCES_PMI)																		SOFT SKILL INDEX (SSI)	
1.COMMUNICATING (COM_T)			**2.LEADING (LEAD_T)**			**3.MANAGING (MAN_T)**			**4.COGNITIVE ABILITY (COGN_T)**			**5.EFFECTIVENESS (EFFECT_T)**			**6.PROFESSIONALISM (PROF_T)**				
Performance criteria	*CI*	*Impr*	*Performance criteria*	*CI*	*Impr*	*Performance criteria*	*CI*	*Impr*	*Performance criteria*	*CI*	*Impr*	*Performance criteria*	*CI*	*Impr*	*Performance criteria*	*CI*	*Impr*	*Components*	*CI*
1.1. LISTENS	0.507	**7%***	2.1. EXPECTATIONS	0.693	**8%***	3.1. EXPECTATIONS	0.617	**7%***	4.1. NEEDS	0.669	3%	5.1. SOLVINGTECH	0.658	**8%***	6.1. SUPPORTSMISSION	0.727	**6%***	COM_T	0.830
1.2. UNDERSTANDS	0.678	7%*	2.2. DEVELOPMENT	0.689	6%*	3.2. ATTITUDE	0.680	2%	4.2. IMPACT	0.758	**8%***	5.2. VALIDATES	0.649	4%	6.2. COOPERATES	0.776	3%	LEAD_T	0.882
1.3. RESPONDS	0.731	6%*	2.3. TEAMWORK	0.714	4%	3.3. TALENT	0.690	**5%***	4.3. STRUCTURE	0.748	7%*	5.3. CHOOSSESSOL	0.759	**6%***	6.3. SACRIFICES	0.657	**7%***	MAN_T	0.888
1.4. ENGAGES	0.472	3%	2.4. PERFORMANCE	0.701	**5%***	3.4. WORKLBALANCE	0.615	3%	4.4. POLITICS	0.734	8%*	5.4. MOTIVATION	0.769	3%	6.4. LEGAL	0.769	3%*	COGN_T	0.943
1.5. DISSEMINATES	0.628	**6%***	2.5. RELATIONSHIPS	0.741	4%	3.5. SCOPE	0.579	**6%***	4.5. EMINTELLIGENCE	0.544	4%	5.5. PROJCTSTATUS	0.749	**4%***	6.5. ETHICALSTNDRS	0.737	1%	EFFECT_T	0.940
1.6. MAINTAINS	0.464	2%	2.6. TRUST	0.782	3%	3.6. STANDARDS	0.559	3%	4.6. SIMPLIFIES	0.596	**5%***	5.6. INCLUDEXPERT	0.260	–2%	6.6. CONFLICTINTEREST	0.486	4%	PROF_T	0.748
1.7. SOURCES	0.649	**5%***	2.7. RESPECT	0.606	3%	3.7. PRACTICES	0.643	**9%***	4.7. CONCEPTS	0.597	5%*	5.7. OBJECTIVITY	0.625	3%	6.7. CONFIDENTIALITY	0.580	**2%***		
1.8. ACCURATE	0.684	5%*	2.8. VISION	0.675	**4%***	3.8. PROCESSES	0.534	10%*	4.8. LESSONSLEARNED	0.459	5%*	5.8. ADAPTCHANGE	0.747	**5%***	6.8. INTPROPERTY	0.550	1%		
1.9. VALIDATION	0.553	11%*	2.9. REWARDS	0.760	10%*	3.9. TEAMRULES	0.673	3%	4.9. AGGREGATES	0.680	2%*	5.9. FLEXIBILITY	0.706	5%*	6.9. SELFCONTROL	0.444	0%		
1.10. RELEVANT	0.778	7%*	2.10. MENTORING	0.714	8%*	3.10. RECOGCONFL	0.633	2%	4.10. OBSERVESDATA	0.722	6%*	5.10. ACTIONS	0.773	3%	6.10. RESPFAILURES	0.498	1%		
1.11. AUDIENCE	0.733	4%*	2.11. OWNERSHIP	0.558	4%*	3.11. RESOLVECONFL	0.720	**5%***	4.11. UNDRSTNDTOOL	0.695	13%*	5.11. FRIENDLYENV	0.688	5%					
1.12. ENVIRONMENT	0.595	2%	2.12. GOALS	0.714	3%				4.12. SELECTTOOLS	0.766	14%*	5.12. CHNGEAGENT	0.715	3%					
			2.13. SUPPORTS	0.698	2%				4.13. APPLIESTOOLS	0.799	12%*	5.13. INITIATIVE	0.537	4%					
			2.14. INFLUENCING	0.468	3%				4.14. ADRESSOPPORT	0.790	3%	5.14. DECISION	0.596	3%					
			2.15. EXPERTS	0.479	7%				4.15. IMPROVEVALUE	0.751	**6%***	5.15. PERSISTENCE	0.725	3%					
									4.16. SEIZESOPPORT	0.720	5%*	5.16. AMBIGUITY	0.590	**4%***					
									4.17. CONSOLIDATES	0.752	4%*								
Explained variance: 39.806%			**Explained variance:** 45.219%			**Explained variance:** 40.170%			**Explained variance:** 48.853%			**Explained variance:** 44.979%			**Explained variance:** 40.184%			**Explained variance:** 76.443%	

* Improvement (%), significant differences before and after training experience (T-Student contrast).

block facilitates the interpretation of each index, since it is a combination of the items in each group. A single analysis of the 81 variables complicates their interpretation.

The results of each block of variables are briefly described below:

- *Communicating Index (COM_T)*: The number of original variables is 12. The first component explains 39.8% of all information and it is obtained by combining 12 variables that have positive weights (proportional to the correlations shown). The variables that have the highest weigh in this component is *Relevant* (*1.10: Provides relevant information)* with 0.778, followed by *Audience (1.11: Uses suitable communication method for the audience)* with 0.733 and *Responds* (*1.3: Responds to and acts upon expectations, concerns and issues*) with 0.731. It appears that variables that are related to tailoring communication to the audience are relevant.
- *Leading Index (LEAD_T)*: The first component retains 45.2% of the information that is contained in 15 variables. The most relevant variables of this dimension were *Trust (2.6. Builds trust and confidence with stakeholders*) with a correlation of 0.782, followed by *Rewards* (*2.9 Rewards performance according to organization guidelines*) with 0.760 and *Relationships* (*2.5 Confines relationships to work-related matters appropriate to the project and local culture*) with 0.741. Thus, in this case it seems that building and maintaining effective relationships is relevant. The remaining variables also show positive correlations with the index, although lower. They include *Influencing* (*2.14 Applies appropriate influencing technique to each stakeholder*) with a correlation coefficient of 0.468.
- *Managing Index (MAN_T)*: Of the 11 variables, the first component explains 40.17% of the total variability. This group mainly highlight variables *ResolveConfl* (3.11 *Resolves conflicts*) with 0.720, followed by *Talent (3.3. Identifies, evaluates, and selects internal and external talent)* with 0.690 and *Attitude (3.2. Maintains a positive attitude and effective relationships among team members)* with 0.680. The building and maintenance of the project team appear to be important here.
- *Cognitive Ability Index (COGN_T)*: The group with the most variables, 17, and a higher grade of commonality, 48.85%. In this case, the variables with the highest correlation correspond to *AppliesTools* (4.1.3 *Applies selected tools and/or techniques to project management*) with a value of 0.799, *SelectTools* (4.12 *Selects appropriate tools and/or techniques*) with 0,766 and *Impact (4.2 Understands how project actions impact other areas of the project, other projects, and organizational environment*) with 0.758. The aspect of the use of appropriate project management tools and techniques prevailed in this case.
- *Effectiveness Index (EFFECT_T)*: This contains 16 variables and the index retains 44.9% of the variability. The variables that were highlighted were *Actions* (*5.10 Takes positive actions to capitalize on opportunities or to resolve present problems*) with a correlation of 0.773, followed by *Motivation* (5.4. *Uses stakeholder communication to maintain stakeholder motivation*) with 0.769 and *Choossessol (5.3. Chooses solutions that maximize project benefit and minimize negative impacts*) with 0.759.
- *Professionalism Index (PROF_T)*: With 10 variables the principal component explains 40.18% of the total variance. In this case, the relevant variables were *Cooperates* (6.2 *Cooperates with all stakeholders to achieve project objectives*) with 0,776, followed by *Legal* (6.*4 Adheres to all legal requirements*) with 0.769 and *Ethicalstndrs* (6.5 *Works within a recognized set of ethical standards*) with 0.737. Thus, this group highlighted the operation with integrity as the most influential element.

The global index (SSI: Soft Skill Index) is a combination of the six previous indices, that can be expressed as:

$$SSI = 0.83\ COM\_T + 0.882\ LEAD\_T + 0.888\ MAN\_T + 0.943\ COGN\_T + 0.940\ EFFECT\_T + 0.748\ PROF\_T$$

Where Cognitive Ability Index and Effectiveness Index with weighs (correlation) of 0.943 and 0.940 are the most important indices. The remaining indices also have high positive weights. SSI index collects 76.44% of the information that is contained in the six indices. This final analysis shows that the set of indices are highly correlated. Table 5 shows the solution with two components. The second component has a low correlation with all of the indices, except PROF_T. The second index is much less important than the first one (it explains % of variability). Fig. 1 helps to interpret the relations

Table 5. Component Matrix

COMPONENT MATRIX		
SOFT SKILLS	***Comp 1***	***Comp 2***
COM_T	0.830	–0.194
LEAD_T	0.882	–0.194
MAN_T	0.888	–0.149
COGN_T	0.943	–0.037
EFFECT_T	0.940	0.012
PROF_T	0.748	0.652

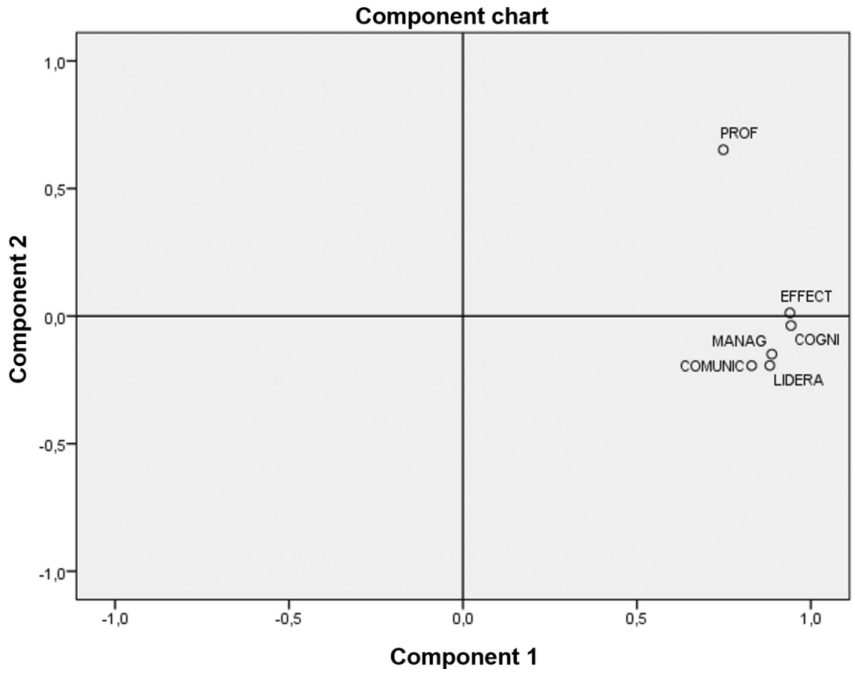

Fig. 1. Component graphic.

between indices. It can be seen that five indices very close to each other, whereas the sixth (PROF_T) differs considerably from the others. This second component may indicate the existence of two profiles within the category of professionalism, which conforming to an ethical standard of behavior that is characterized by responsibility, respect, fairness, and honesty in the practice of project management.

4.2 Developing soft skills

One of the main objectives of the planning phase of the study, was to measure how the *new* project managers perceived and assessed the training that they *received.* Different soft skills were measured (self-assessments) before and after the course. The mean values and standard deviations of the results appear in Table 6. The results underline the high starting scores (the scale is from 1 to 7) that students gave themselves (self-assessment) for most of soft skills. This may be interpreted as a high level of self-esteem of the leaders. Note that they willingly chose to join the project team. In any case, the final assessment (after the course) had ended improved slightly, but significantly, as shown by the contrasts of means of the results. In all cases, the highest mean scores were for the group of soft skills that were related to *Professionalism*, followed by *Communicating*. For the overall improvement perceived, an increase in all competences was identified. The increase was highest for groups of *Cognitive Ability* with 6.2% of improvement, followed by *Communicating* with 5.3% and Managing with 5% (see Table 6).

In Table 4, the improvements perceived for each performance criterion (specific behavior within each category of soft skills) is shown in the third column of each block. A comparison of means has been developed for paired data using the t-Student contrast. Significant differences can be seen in the table. As can be seen for all competences, the score

Table 6. Improvement in Project Management Soft Skills

	MOMENT OF MEASUREMENT				
	Before Training		**After Training**		
Soft Skill Category	**Mean**	**Standard deviation**	**Mean**	**Standard deviation**	**Improvement**
1. Communicating	5.31	0.24	5.59	0.21	5.3%
2. Leading	5.08	0.68	5.32	0.65	4.7%
3. Managing	5.24	0.45	5.50	0.43	5.0%
4. Cognitive Ability	4.97	0.42	5.28	0.35	6.2%
5. Effectiveness	5.24	0.57	5.44	0.62	3.8%
6. Professionalism	5.60	0.25	5.76	0.24	2.9%

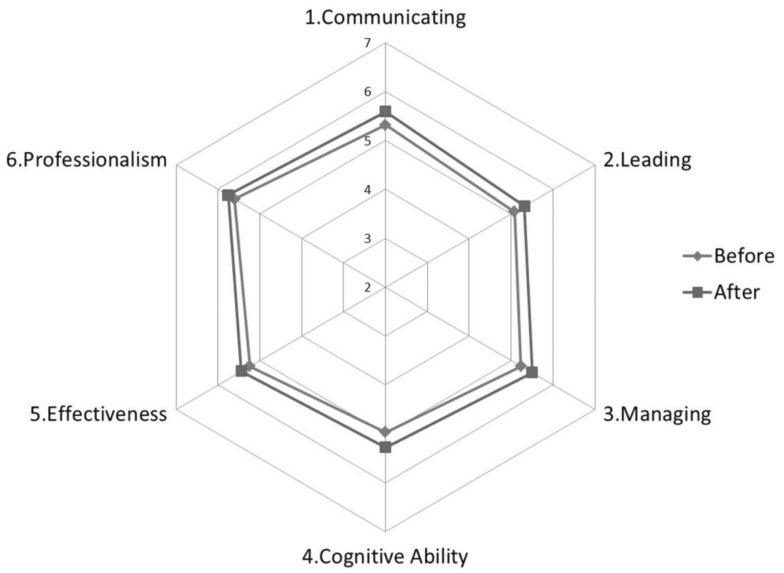

Fig. 2. Improvement in Project Management Soft Skills after the Training Experience.

increases after completion of the course. The competences that were most strengthened upon completion of this experience seem to be related mainly to the ability to listen actively, understand and respond to stakeholders and to uses appropriate project management tools and techniques. Five of the 10 items that have undergone major changes correspond to the category of Cognitive Ability and three of 10 to Communicating.

Competences that were less strengthened seem to be more closely related to handling personal and team adversity adequately, and maintaining lines of communication. They highlight the presence of competences within the Professionalism group.

However, in considering competences that, perhaps, should be strengthened, several criteria have been considered: (1) competences that did not improve significantly as a result of the training experience, (2) competences that have a mean score bellow the overall mean, and (3) competences for which the weight that is based on principal components seem to be relevant. After checking this criterion, the following items were specially designated: 2.5. Relationships (confine relationships to work-related matters that are appropriate to the project and local culture), 5.12. Change agent (acts as a change agent), 4.14. Adressopport (provides a framework to address opportunities and concerns), 4.5. Emintelligence (uses emotional intelligence to understand and explain others' past actions and current attitudes, and to anticipate future behavior), 4.1. Needs (understands project stakeholders' needs, interests and influence for project success) and 3.6. Standards (applies organization or industry, standards and generally accepted practices to the project).

4.3 Correlation of soft and hard skills

This section presents the relationships between soft and hard skills. The participants in this research were students who had completed an engineering degree at Universidad Politécnica de Madrid. Like most universities in this area, this university focuses its teaching on a solid training in basic and technological subjects. It was interesting to compare the transcripts of student records with the results of soft skill measurements obtained during the experience. It was decided to select subjects, such as Calculus, Physics, Business or Manufacturing, as well as the average grades for each course as representative of students' hard skills. Later, the correlation of hard and soft skills was determined. The results appear In Table 7.

The results obtained were quite unexpected. As Table 7 shows, there was no significant correlation (p-value > 0.05) of any of the hard skills variables to the soft skill index (SSI).

Similarly, possible correlations of each Hard Skill to each Soft Skill category (Leading, Communicating, etc.) were verified, without identifying any statistically significant relationship. Especially noteworthy was the lack of relationship between the soft skill index and the project's subject mark, in view of the fact that this mark reflects the evaluation of the degree of acquisition of knowledge of the subject where the PBL experience of this research was carried out.

5. Discussion

This research has included the assessment and strengthening of soft skills during the training of engineers in the field of project management. This

Table 7. Soft and hard skills correlations

			CORRELATIONS						
PM SKILLS			**SSI**	**COM_T**	**LEAD_T**	**MAN_T**	**COGN_T**	**EFFECT_T**	**PROF_T**
SOFT SKILLS	*SSI (Soft Skill Index)*	Pearson Correlation	1	**0.830****	**0.882****	**0.888****	**0.943****	**0.940****	**0.748****
		Sig. (bilat.)		0.000	0.000	0.000	0.000	0.000	0.000
HARD SKILLS	*Calculus_I*	Pearson Correlation	–0.017	0.074	0.059	0.117	0.002	–0.066	–0.213
		Sig. (bilat.)	0.906	0.608	0.684	0.418	0.990	0.650	0.133
	Physics_II	Pearson Correlation	0.014	0.106	0.028	–0.002	0.116	–0.051	–0.042
		Sig. (bilat.)	0.923	0.459	0.846	0.989	0.418	0.725	0.772
	Differential_Eq	Pearson Correlation	0.055	0.140	0.037	0.027	0.088	0.039	0.025
		Sig. (bilat.)	0.708	0.326	0.799	0.851	0.538	0.786	0.862
	Business	Pearson Correlation	0.099	0.224	0.064	–0.011	0.105	0.056	0.067
		Sig. (bilat.)	0.499	0.114	0.657	0.941	0.463	0.702	0.640
	Manufactur-ing	Pearson Correlation	0.000	0.048	0.044	–0.027	0.050	0.016	–0.046
		Sig. (bilat.)	1.000	0.744	0.764	0.855	0.734	0.915	0.756
	Drawing_I	Pearson Correlation	–0.065	–0.058	–0.101	0.020	–0.047	–0.085	0.071
		Sig. (bilat.)	0.660	0.684	0.485	0.890	0.742	0.557	0.619
	Projects	Pearson Correlation	0.121	0.037	0.119	–0.019	0.189	0.141	0.132
		Sig. (bilat.)	0.406	0.798	0.412	0.897	0.184	0.329	0.355
	Mean_1st	Pearson Correlation	–0.011	0.050	–0.043	0.093	0.068	–0.040	–0.110
		Sig. (bilat.)	0.942	0.732	0.769	0.524	0.640	0.784	0.445
	Mean_2nd	Pearson Correlation	0.095	0.205	0.025	0.085	0.150	0.052	–0.042
		Sig. (bilat.)	0.517	0.149	0.862	0.559	0.294	0.721	0.770
	Mean_3rd	Pearson Correlation	0.085	0.092	0.001	0.041	0.131	0.121	–0.029
		Sig. (bilat.)	0.560	0.523	0.992	0.779	0.360	0.403	0.842
	Mean_4th	Pearson Correlation	0.165	0.197	0.063	0.078	0.191	0.178	0.111
		Sig. (bilat.)	0.263	0.170	0.667	0.593	0.184	0.221	0.444
	Final_mean	Pearson Correlation	0.150	0.200	0.089	0.149	0.202	0.128	–0.016
		Sig. (bilat.)	0.304	0.160	0.539	0.301	0.156	0.377	0.914

has enabled the establishment of a framework to measure the competences of students who assumed the role of Project Managers and whose main goal was to lead their teams to successfully achieve the project's objectives. This assumes a foundation with which to continue assessing the effectiveness of different training methodologies and techniques in project management.

Similarly, results of self-assessment in certain dimensions of personal competence that were obtained by component analysis have provided an insightful arrangement to work with. This arrangement assigns a different weight to each performance criterion and establishes an index for each of the six personal competence dimensions that were defined by PMI [35] (PMI, 2007) and one overall Soft Skill Index (SSI) for all of them. Principal component analysis has also highlighted different profiles of team leaders, indicating two profiles within the category of professionalism. It would be of interest to delve further into this topic in order to better understand the implications of these profiles and their impact on project success.

The training methodology (PBL) has been shown

to be effective to improve 44 of 81 performance criteria of personal competences. Nevertheless, a review is recommended to boost the strengthening of those competences that experienced little change and have relative high weight for overall measure of soft skills (SSI). Taking into account these criteria, specific competences on which to focus are (1) confine relationships to work-related matters, (2) act as a change agent, provides a framework to address opportunities and concerns, (3) emotional intelligence, (4) understands project stakeholder's needs, and (5) applies organization or industry standards and generally accepted practices to the project.

Some limitations have been identified during the development of this study that must be considered. The features and size of the sample make us to be cautious in terms of generalizability and validity of the results. As mentioned previously, the students participating in the study have high homogeneity, since almost all have an excellent academic background, necessary to access to this university. The size of the sample, 67 students playing the role of project managers, although representing a total number of 456 team members, could be larger to better guarantee the reliability of the results.

6. Conclusions

In regard to the first objective of this study, a Soft Skill Index (SSI) has been defined that can be applied to improve soft skills strengthening of engineering students enrolled in project management courses. Cognitive Ability and Effectiveness have shown a high correlation with this index, and, therefore, are relatively important for the assessment of soft skills. This suggests that more attention must be given in the future to this group of competences for its assessment and development.

With respect to learning soft skills during the training process based on PBL methodology, significant changes were detected for performance criteria following the experience. The greatest improvements were in the Communicating and Cognitive Ability dimensions. It can be noted that some of the changes in competences that were most strengthened had to do with appropriate use of techniques and tools in project management, which is linked more to hard skills.

The analysis of correlation between soft and hard skills of engineers during this training experience, did not identify any significant correlation. This is a surprising result. The lack of such a correlation should be interpreted in a reflective way. A possible cause of this lack of correlation could be the homogeneity of the participants in the study, since almost all have an excellent academic background, which is required for admittance to access to this university. This reduces the variability of both hard and soft skills and makes the measurement of correlations between variables more complex.

Nevertheless, we could extrapolate these results to project managers, since they also normally have a strong academic background and experience, which would reduce the variability. Moreover, many of the present engineering students will become project managers in the future (particularly in the engineering field). Considering this, the lack of correlation makes us realize the importance of designing training programs that combine in parallel the learning of techniques, methods and tools for project management with the development of social and personal competences of the individual. The key would be to combine the development of both kind of competences, not only by giving them adequate relative importance for them, but also by integrating specific training methods that can strengthen both competences at the same time. Moreover, the definition of profiles or training itineraries that are differentiated by this type of competence would not be justified, since everything would be necessary for all students.

If this is seriously considered, a new challenge appears that Project Manager professors will need to prepare to face. To achieve these results, new methodologies and tools will be needed in the classroom and professor will need to prepare for this. A more comprehensive knowledge of these competences will be required as well as more effective ways how to teach and strength them.

Considering the importance given by the literature to soft skills for the achievement of project management success, it could be concluded that there is still a long way to go. In project management training programs, the importance attributed to the acquisition of technical skills and knowledge (hard skills), in comparison to soft skills, is still predominant. If there is no clear correlation between these competences, what are we doing to encourage engineers to acquire these personal competences that are so relevant to the management of projects? How are academic programs preparing to face it? These considerations might also be applied to the recruitment and selection of Project Managers, where considering both types of competences to assess candidates for project management functions is highly recommended. No inferences that are based only on one group of competences, either hard or soft, to select the best candidate could be made, since these dimensions would not be related to each other.

While demands for successful Project Manager continue to increase, which is a reality that we can accept today, the challenge will continue to be to better understand the key competences of these

professionals and how to strengthen them effectively. Future research could focus on these subjects.

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