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Strengthening Communication Skills in an Innovative Context of Engineering Project Management Learning

Isabel Ortiz-Marcos*, Colsa Angel Uruburu, Benita José Ramón Cobo, Remón Tomás Prieto

Organizational Engineering and Project Management Department, Technical University of Madrid, José Gutiérrez Abascal 2, 28006 Madrid, Spain

Abstract

This document presents an innovative, formal educational initiative that is aimed at enhancing the development of engineering students' specific competences when studying Project Management (PM) subject. The framework of the experience combines (1) theoretical concepts, (2) the development of a real-case project carried out by multidisciplinary groups of three different universities, (3) the use of software web 2.0 tools and (4) group and individual assignments of students that play different roles (project managers and team members). Under this scenario, the study focuses on monitoring the communication competence in the ever growing PM virtual environment. Factors such as corporal language, technical means, stage, and PM specific vocabulary among others have been considered in order to assess the students' performance on this issue. As a main contribution, the paper introduces an ad-hoc rubric that, based on previous investigations, has been adapted and tested for the first time to this new and specific context. Additionally, the research conducted has provided some interesting findings that suggest further actions to improve and better define future rubrics, oriented to communication or even other competences. As specific PM subject concerns, it has been detected that students playing the role of Project Managers strengthen their competences more than those ones that play the role of Team Members. It has also been detected that students have more difficulty assimilating concepts related to risk and quality management. However those concepts related with scope, time or cost areas of knowledge have been better assimilated by the students.

Keywords: Communication competence; communication rubric; virtual learning experience; interdisciplinary learning; competence development in project management

* Corresponding author. Tel.: +34 91 336 31 46
E-mail address: isabel.ortiz@upm.es.

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1. Introduction

There are some important considerations for instructors to take into account when teaching Engineering Project Management (EPM). The first one is its interdisciplinary intrinsic essence, which embraces a significant number of knowledge areas and practical approaches to cover. The second is the character of the solutions to the proposed EPM problems, usually of an open-ended type. The third consideration is common to many other matters - time restrictions.

After coursing for several years at technical schools, engineering students are used to the well-established general approach to problem-solving methodology that gives a well-defined and only-one-right solution to detailed technical problems. Instructors must cope with this reality when teaching EPM, a subject that is based much more on the highly undefined and multidisciplinary nature of the solutions to provide to clients. The length of the course (just six ECTS) is another issue to bear in mind, considering the students' lack of experience.

All of these EPM aspects must be also considered in the actual implementation in Spain of the new educational model that was established by the Bologna process in the European Higher Education Area and which encourages the development of new experiences designed to reinforce students' competences.

Within this global context, we introduce a Bologna-oriented learning framework for effectively teaching the basics of project management to students who possess no prior experience in the subject. This new approach combines theoretical and practical content, individual applied tasks and the use of EPM software systems and Web 2.0 tools, under the project-based learning methodology (instead of the traditional problem-solving approach).

Based on previous experiences, the defined EPM learning framework seems to be very powerful and attractive for students to strengthen their competences.

The objective of this study is to monitor the personal communication competence of students who are studying EPM, taking into account the virtual environment aspects that drive the experience, the particular task to be analyzed (an individual video), and the instructors' requirements for its attainment. Previous experiences have been developed (Uruburu *et al.*, 2012).

As a result, we provide a specific rubric for communication competence. It includes a specific item that is designed to measure how students use the specific vocabulary of Project Management. It has been tested by students of Industrial Engineering at three Spanish universities.

The use of the information obtained, in terms of competence levels acquired, makes possible to bring additional information to the students involved in the experience, as well as the identification of new opportunities of behavioral improvement.

The organization of the paper is as follows. In section 2, the literature review about competences models and rubric's design is presented. Section 3 describes the methodology used. Section 4 provides a description of the results and finally, Sections 5 and 6 present the discussion and conclusions of the study.

2. Literature Review

2.1. Project Based Learning

Project Based Learning (PBL) is a model in which learning opportunities are organized around projects (Jones *et al.*, 1997). According to the definitions found in PBL papers, projects are complex tasks that are based on challenging questions or subjects that involve the students in design, problem-solving, decision making, or investigative activities. They give the students an opportunity to work relatively autonomously over extended periods of time and culminate in the creation of realistic products or presentations (Thomas *et al.*, 1999; Turner *et al.*, 2002; Williams van Rooij, 2009). In PBL, the project is

the central teaching strategy. Students encounter and learn the central concepts of the discipline by means of the project. There is a longstanding tradition in schools of "doing projects," incorporating "hands-on" activities, developing interdisciplinary themes, conducting field trips, and implementing laboratory investigations (Fruchler & Lewis, 2003).

There is a shift in emphasis within engineering education from technical knowledge to performance skills (Schmidt, 1987). These skills include problem analysis and problem solving, project management and leadership, analytical abilities and critical thinking, dissemination and communication, interdisciplinary competencies, intercultural communication, innovation and creativity, and social abilities. PBL has proved to be an excellent method for development of new forms of competencies (Graaff & Kolmos, 2003; Kolmos & Kofoed, 2002).

Research has shown that students retain minimal information in the traditional, didactic, teaching environment and frequently experience difficulty in transferring the acquired knowledge to new experiences (Schmidt, 1987). A PBL environment enables students to draw upon their prior knowledge and skills, brings a real-world context to the classroom, and reinforces the knowledge acquired by both independent and cooperative group work (Schmidt, 1993).

The research presented fulfils the criteria that a project should have to be considered an example of PBL (Thomas & Mergendoller, 2000): centrality, a driving question, constructive investigation, autonomy and realism.

2.2. Rubrics for assess Competences

There are several proposals of rubrics to evaluate various project management skills: co-operative work (Delgado & Fonseca-Mora, 2010; Guneysu & Tekmen, 2010; Kaur Judge *et al.*, 2011), learning in a science curriculum (Manson & Olsen, 2010), writing attitudes (Morozov, 2011), and the effect on students of problem solving (Sulak, 2010).

Focusing on the main objective of this study, we have selected a reference rubric that specifically allows us to evaluate the students' individual communication competence when working on engineering project management and in a PBL methodological context. This rubric must be suitable for use in virtual environments, since the deliverable to be submitted by the students is a video, which is three minutes in duration. Also considered was how students use the vocabulary and methodologies of Project Management that were developed during the course.

The rubric that is presented in Table 1 has been chosen for the particular interest of this investigation, once the existing rubrics' models have been reviewed in the literature and having taken into account all the above mentioned factors.

Some key factors are not reflected in the rubric and should be considered specifically for virtual environments as well as vocabulary and methodologies regarding Project Management. They include corporal communication and the stage selected. Therefore, this study provides in the methodology section an adapted rubric that meets the particular requirements of virtual communications, as one of its main contributions to the research question of how to measure the achievement of this competence in this particular context.

3. Methodology

3.1. Experience Framework

This experience was been carried out among three universities, The Technical University of Madrid (UPM), the University of La Rioja (UR) and the University of Leon (UL). Students of Engineering

Project Management (EPM) of all three universities are involved in the development of a specific project in a collaborative manner, consisting of all technical and economic aspects related to the construction of plant to produce pizzas and frozen products in a given location.

Table 1. Communication Competence Reference Rubric

Communication Competence Factors	**Achievement Levels**			
	Unsatisfactory	***Needs Improvement***	***Satisfactory***	***Excellent***
The student organizes the content of the presentation and uses an adequate style to facilitate the instructors' understanding	The presentation is disorganized and lacks a logical structure.	The presentation is structured in a confusing way. The organization by sections, titles, points, etc. is not clear.	The presentation is generally clear, although some points are not well structured.	The structure of the presentation is clear, coherent and logical.
	The vocabulary used and overall level of the communication is not suitable for the audience.	In many aspects, the presentation is neither well structured, nor oriented to the audience	The style is adequate for the audience, although some ideas are expressed in a simple or complicated manner.	The presentation was done perfectly according to the audience, including the style and vocabulary used.
The student uses graphics and other resources to effectively communicate the information.	Neither graphics, nor additional resources are used.	Graphics and/or other resources are poorly used or inadequately applied.	Graphic and/or other resources are commonly used, not always suitable for the content of the presentation.	Graphic and/or other resources are perfectly used, in a professional manner.
The student uses oral communication techniques appropriately.	The presentation was done in a hesitant fashion or nervous state or supported by notes. Oral techniques were not used.	The presentation is not well supported by communication techniques.	Communication techniques are generally well used, although sometimes the volume and the oral expression are not correct.	Message is reinforced, getting the audience attention and using adequately the communication techniques.
The student listens actively to the instructor, and answers questions and comments clearly and precisely.	Interruptions, little effort to understand the questions and responses that answered different questions than those that were asked.	Insufficient attention given to the conversations, unable to answer some questions.	Actively listens to formulated questions, although sometimes seems not to understand.	Shows interest by the comments appeared. Clearly answers to proposed questions.

Two types of students have been involved in the experience. They played different roles, depending on their different degrees as shown in Table 2 below.

Table 2. Students involved in the experience.

Role	Master	Industrial Engineer
Project Manager (PM)	12	5
Project Manager Work Package (PMwp)	-	52
Team Member (TM)	-	248

Master's Degree students (PM) developed the Work Breakdown Structure (WBS) as well as the Dictionary of the WBS at a high level for the full project (subdividing it into subprojects). Multidisciplinary teams of 9 to 12 students were formed taking into account the different home

universities and specialization. Two roles were considered in order to fulfill EPM academic objectives: (1) Project Managers of Work Package (PMwp), and (2) Team Members (TM). Each PMwp had to define the WBS of the subproject that had been assigned to him/her and to organize the TMs' tasks to be done according to the scope negotiated with the instructors.

The course begins by asking the students to propose the definition and configuration of a solution to the problem to be solved. Multicriteria decision-making processes, milestones, different technologies and disciplines must be considered, since there is no one-right solution, but a group of partial answers to specific issues.

Teams' performance follow-up could be done at any point throughout the software-based support system, to which minutes of meeting and auto-evaluations must also be regularly uploaded.

The instructors support the student groups by playing the role of technical, management and IT consultants, thus facilitating a smooth process workflow during the course. The above-mentioned basic fundamentals of similar experiences can be found in greater detail in (Crespo *et al.*, 2011; Uruburu *et al.*, 2011).

As the particular interest of this study concerns, all the students must do an individual video presentation at the end of the course, to be uploaded in a specific web site in order to be evaluated by the instructors of the experience. As a global conclusion, the most relevant aspects of the project developed have to be remarked, i.e. achievements, weaknesses, found difficulties and main team's and personal's contributions.

Taking into account all of the aspects that characterize the experience, careful selection of the software-based support system is fundamental for its success, as well as for monitoring and evaluating the impact of Web 2.0 collaborative software tools on the acquisition of competences.

As regards the selection of the most appropriate web tool, the main objective was to provide to the students the best common platform to facilitate collaboration, communication and interaction among them. In this sense, some requirements were considered to be especially relevant for the experience's success. They are the following:

- Collaborative multiuser Web 2.0 environment and open-source software.
- Number of collaborative tools provided (blogs, wikis, forums, news, automatic e-mail reports, unified project calendar, document repository and forms to name a few).
- Possibility of real-time supervision of the work developed by the students (activity tracking), and forensic analysis.
- Performance logs and security management, roles and permissions.
- Multiple business capability in the same application.
- Management options for multiple projects and sub-projects.
- Documentation management tools and task assignment functions.
- Real-time supervision of the resource consumption.
- Import and export options from and to other applications like Openproj or MS Project.

According to these parameters, the software environment selected was Project.net (http://www.project.net). This software facilitates the students' adoption of the different roles that coexist in the management of a project, enabling the team members to communicate and work together even though there might be a significant distance separating them.

As competence acquisition concerns, this collaborative, virtual environment allows the students to develop specific abilities related not only with EPM subject issues, but also with other subjects' issues that are usually considered to be "behavioral," such as leadership, working in teams, and problem solving.

In this way, the communication competence is reinforced through both traditional and new interaction channels, on an individual and group basis.

3.2. Research Design

As mentioned in the literature review section, there is a lack of specific rubrics that are oriented to evaluate all relevant aspects of individual communication competence. Thus, once the reference rubric of the Table 1 has been selected, we propose one that is better adapted to our investigation. This rubric includes three new factors: 1) corporal communication, 2) a stage for the video realization and 3) the proper use of the vocabulary and methodologies developed during the project management course. Factors and evaluation levels are shown in Table 3 below. In addition, the "active learning" factor has been eliminated, as it has no use in this particular context, and the previous, two-level sub-factors in Table 1 have been separated into two main factors.

Table 3. Communication Competence Research Rubric

Communication Competence Factors	**Achievement Levels**			
	Unsatisfactory (1)	***Needs Improving (2)***	***Satisfactory (3)***	***Excellent (4)***
The student clearly organizes the content of the presentation	The presentation is disorganized and lacks of a logic structure.	The presentation is structured in a confusing way. The organization by sections, titles, points, etc. is not clear.	The presentation is in general clear, although some points could are not well structured.	The structure of the presentation is clear, coherent and logic.
The student uses the adequate oral style to ease the instructors' understanding.	The vocabulary used and overall level of the communication is not adapted at all to the audience.	In many aspects, the presentation is neither well structured nor oriented to the audience	The style is adequate to the audience, although some ideas are expressed in a simple or complicated manner	The presentation is perfectly done according to the audience, including the style and vocabulary used.
The student appropriately uses the corporal communication language.	Presentation is done under nervous status or supported by notes. Oral techniques are not used.	Presentation is not well supported by communication techniques.	Communication techniques are generally well used, although sometimes the volume and the oral expression are not correct.	Message is reinforced, getting the audience attention and using adequately the communication techniques.
The student uses graphics and other technical resources to effectively communicate the information.	Neither graphic nor additional resources are used. Video sound and/or image are not clear.	Graphic and/or other resources are poorly used or inadequately applied.	Graphics and/or other resources are commonly used, but are not always adequate for the content of the presentation.	Graphics and/or other resources are perfectly used and in a professional manner.
The student selects the appropiate stage for the presentation.	The stage doesn't help at all to the explanation of the presentation	The stage selected made it difficult sometimes for the instructors to understand well	The stage selected could be better somehow in lighting, color and general atmosphere	The stage selected is ideal for the video presentation
The student uses the vocabulary of Project Management properly in its areas of knowledge or processes (initiation, planning, implementation, monitoring and control and closing).	The students doe not use the vocabulary and methodologies properly.	The student handles with difficulty the vocabulary and methodologies developed in class.	The student handles with ease the vocabulary and methodologies developed in class.	The student handles properly the vocabulary and methodologies developed in class.

A contrast analysis was designed in order to test the new rubric. It has been used in a sample of 54 students. The students were drawn from three universities that offer the degree of Industrial Engineer. The

sample consisted of 13 students with the role of PMwp and 41 who played the role of TM.

The three-minute videos (.flv format) were prepared by the students at the end of the second semester of 2011, after the course had finished. All personal works were recorded and uploaded to a specific site that was available only to instructors, guaranteeing the privacy of the materials provided.

With regard to the content of the presentations, detailed guidelines were given to students to ensure the most possible homogeneous presentation from all of them. That included the main aspects of the global project that was conducted by the group, the tasks assigned, one's personal contribution to the overall work, any difficulties encountered and one's perception of the virtual experience.

Evaluation of the 54 videos was conducted by four professors from the UPM Industrial Engineering School who are experts in EPM and competences. In addition, both persons had been involved in the rubric design of this study.

The responses were tabulated, assigning "1" for "unsatisfactory level", "2" for "needs improving", "3" for "satisfactory level" and "4" for "excellent". The results of the research are shown in the next section.

4. Results

Figure 1 presents statistical measures of competence, taking into account the total number of students and the roles that they developed during the experience (Team Member or Project Manager of Work Package).

The first result to highlight is that the results for competence are always higher for those students who have the Project Manager´s role than for those students who work on the project as Team Members.

The communication competence factor that is best evaluated is the "message structure (M)" (3.2 points for PMwp and 2.5 points for TM) with a difference of +0.7 between the two groups of students. The factor "oral style (O)" (2.8 points for PMwp and 2 points for TM) presents a difference of +0.8 between the two groups of students, the highest for all factors. The factor "corporal (C)" obtained the lowest evaluation by both groups (2.5 points for PMwp and 2 points for TM) with a difference of +0.5 between the two groups of students. The "technical (T)" factor (2.6 points for PMwp and 2.3 points for TM) did not have a great difference between the two groups (+0.3). Finally, factor "stage (St)" (2.6 points for PMwp and 2.4 points for TM) gave the lowest difference, +0.2, between the two groups of students.

With regard to the proper use of Project Management´s vocabulary (V), the highest results were obtained by PMwp as well (2.7 points for PMwp and 2 points for TM). The difference between the two groups of students was +0.7.

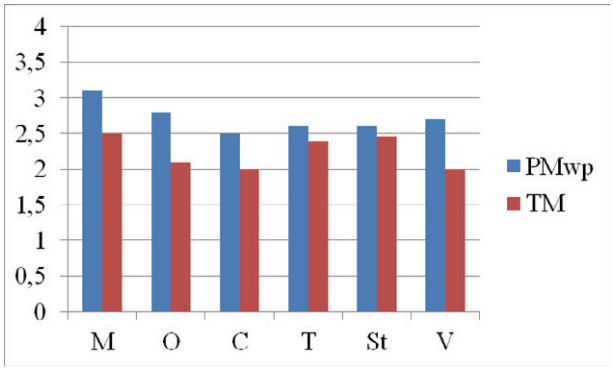

Fig. 1. Communication Competence results.

The highest results for the proper use of Project Management´s vocabulary were also obtained by PMwp (2.7 points for PMwp and 2 points for TM). The difference between the two groups of students was +0.7.

In summary, the analysis shows that the results are always higher for those students who develop the Project Manager role during the experience.

5. Discussion

This paper analyzes oral communication factors and the proper use of the Project Management vocabulary for consideration in a virtual PBL context and for specific applications with Industrial Engineering students. Generally speaking, there are two ways to communicate orally: 1) by face to face synchronous electronic means with or without image (e.g., Skype, telephone), and by asynchronous electronic means (e.g., video). The results presented in this paper refer to the latter; formal recorded communication by video.

For each of these means the importance and characterization of the different behaviors that make up the oral communication competence differ. There are elements that acquire much more importance (the expression of the face) and others which lose importance (the expression of the hands). We also find elements/behaviors that are entirely new, such as the proper use of corporal language or the selection of the stage.

In this sense, our discussion focuses on what to do with the need to adapt the behavior to each electronic mean used. Even more, in the modern IT world it is critical to take the former into account. The conclusion is that a review of the rubric of the competence is clearly needed. In this regard, our contribution has been to add the influence of using electronic means and an appropriate stage.

When we communicate by video, technical means are very important to ensure excellent communication. Excellent communication is not achieved if we cannot hear properly, if the image is weak or if we have a distorted stage that makes it difficult to hold the listener's attention. Arguably, we can affirm that, if the basic technical communication standards are not met, communication collapses. Moreover, the use of texts, original staging or other resources, reinforce communication positively and thus the predisposition of the receiver.

We also can focus the discussion on the extent to which students and teachers are aware that what we have considered to be traditional communication elements (message, speech and body language) are affected and are less important. The conclusion is that, since we are aware of this importance, some basic guidelines should be given to students. Our contribution to this is the rubric for oral communication by video recording as a basis for evaluation.

As identified, the rubric should be more precise and, since this is a key competence that may have a wide scope of coverage, the evaluators must adapt their behavior and rubrics to the case and the profile of the environment assessed.

The differences in results for the two groups of students (PMwp and TM) who were evaluated can be interpreted as meaning that those that play a Project Manager role strengthen their competences more than those are playing a Team Member role. This should be considered for further initiatives.

Regarding the proper use of the Project Management vocabulary, the evaluation of the 54 videos confirms that students begin to use it properly, but only for some areas of knowledge. The terms used most often by students are Work Breakdown Structure, Work Package, scheduling, critical path, resource allocation, and resource conflict.

It may be noted that those terms refer to scope, time and cost management of the project. A lack of knowledge of other areas, like risk or quality management, has been noticed. Those areas are not taught adequately. Thus, the program needs to be redesigned accordingly.

6. Conclusions

The development of transversal and behavioral competences is one of the most important challenges that the global educational community has to face under the new implemented Bologna framework.

Under this scenario, the Industrial Engineering School of UPM University has established as a key strategic objective its firm commitment to the implementation of related activities within the current and future studies' plans.

Taking into account the complexity that implies the coordination of the standard curriculum with this global and wide objective along the different courses, this project has been understood to be carried out on a medium/long term basis, supervised and managed by the Head of the Institution.

Engineering Project Management presents an ideal framework for the development of both intrinsic technical and extrinsic transversal competences. Leadership, teamwork and communication are considered to be of fundamental importance within the second group for good, practical learning of EPM basics.

Additionally, the new powerful software Web 2.0 platforms allow new possibilities for teaching EPM in a way that is completely different from traditional problem-solving methods.

It is important to highlight that, in the context of PBL, competences are more strengthened when students play different roles than when they play the Project Manager's role.

As a particular contribution, this study has discussed the goodness of the combined Project-Based Learning and virtual context methodology for the implementation of innovative, value-added experiences aimed at strengthening students' individual competences.

Secondly, a description of an already carried-out activity has been made in order to clarify all relevant aspects needed to understand the subsequent research objectives.

Thirdly, the research introduces a rubric that was developed by the authors and based on existing ones, but more specifically adapted to assess the communication competence of students in their use of video presentations.

Results and discussion sections have provided some interesting points that suggest further actions to improve and better define future rubrics that are oriented to communication or other competences.

It has been noticed that students who play the role of Project Managers have better results in strengthening their competences than those ones who play the role of Team Members. In future initiatives this should be considered and all students should be afforded the opportunity to develop the role of Project Managers during the course. This could be achieved by collaborating with teachers in charge of other subjects where students can perform the role of Team Members as part of their learning process. Those students enrolled in the course of project management could develop it in depth. The model could be redesigned in order to reinforce the PMwp role.

Concepts related to risk and quality management should be explained thoroughly in view of the difficulties that students encounter in acquiring them. Specifically, tools and techniques concerning risk identification and qualitative analysis and methodologies to quality assurance and control should be applied during this collaborative experience.

Finally, this investigation can be used as a reference for the design and implementation of similar innovative experiences that are aligned with the global objective of developing students' personal competences.

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