Monitoring the communication competence in an innovative context of engineering project management learning

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Abstract—**This document presents an innovative, formal educational initiative, aimed at enhancing the development of engineering students' specific competences. Project management subject is the common theoretical and practical framework that articulates an experience carried out by multidisciplinary groups. Full utilization of Web 2.0 platforms and Project Based Learning constitute the applied methodology. More specifically, this study focuses on monitoring the communication competence when working in virtual environments, providing an ad-hoc rubric as a final result**

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

I. INTRODUCTION

There are some important considerations to take into account for the instructors when teaching the subject Engineering Project Management (EPM). First one refers to its interdisciplinary intrinsic essence, which embraces a significant number of knowledge areas and practical approaches to be covered. Second one is related to the character of the solutions to proposed EPM problems, usually open-ended type, and third one is common to many other matters: time restrictions.

After coursing several years at Technical Schools, engineering students are used to the well-established general approach to problem-solving methodology, which is commonly applied to give a well defined and only-one-right solution on detailed technical problems. Thus, instructors have to cope with this reality when teaching EPM, a subject much more based on the highly undefined and multidisciplinary nature of the solutions to provide to the clients. The length of the course (just 6 ECTS) is another issue to keep in mind, considering the lack of experience of the students.

All these EPM aspects must be also considered under the actual implementation in Spain of the new educational model, established by the Bologna process in the European Higher Education Area, which encourages the development of new experiences aiming at the reinforcement of students' competences.

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

The new defined EPM's learning framework is considered as very useful in order to implement and develop innovative experiences with the final purpose of the students' competence strengthening.

Then, more specifically, the objective of this study is to monitor the communication personal competence of students attending EPM subject, taking into account the virtual environment aspects that drove the experience, the particular task to be analyzed (an individual video), and the instructors' requirements for its realization.

As a result, we provide a specific rubric adapted for that purpose, and we also contrast it with two groups of students, corresponding to two different specializations (Automatic and Electronic Engineering, Organizational Engineering) in order to find significant differences (if any).

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 personal improvement.

The organization of the paper is as follows. In section II the literature review about competences models and rubric's design is presented. Section III describes the Methodology used. Section IV corresponds to results description and finally, Sections VI and VII presents the discussion and conclusions of the study.

II. LITERATURE REVIEW

A. Project Based Learning

Project Based Learning (PBL) is a model in which learning opportunities are organized around projects [1]. According to the definitions 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. They give students an opportunity to work relatively autonomously over extended periods of time and culminate in realistic products or presentations [2] [3] [4]. 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 [5].

There is a shift in emphasis in engineering education from technical knowledge to performance skills [9]. 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 [7] [8].

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 [9]. 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 [10].

The research presented fulfils the criteria that a project should have in order to be considered an instance of PBL [11]: centrality, driving question, constructive investigation, autonomy and realism.

B. Competences

There are several proposals about rubrics to evaluate some topics about project management skills: co-operative work [12][13][14], the learning in science curriculum[15], the writing attitudes [16][17], and the effect of problem solving in students [18].

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 subject and into a PBL methodological context. Additionally, this rubric must be suitable to be applied in virtual environments, since the deliverable to be submitted by the students is a three minutes-duration video.

The rubric presented in the "Table I" 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.

TABLE I. COMMUNICATION COMPETENCE REFERENCE RUBRIC

Communication Competence Factors	**Achievement Levels**			
	Unsatisfactory	***Needs Improving***	***Satisfactory***	***Excellent***
The student organizes the content of the presentation and uses the adequate style to ease the instructors' understanding.	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 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 uses graphic and other resources to effectively communicate the information.	Neither graphic nor additional resources are used.	Graphic and/or other resources are poorly used or inadequately applied.	Graphic and/or other resources are commonly used, not always adequate to the content of the presentation.	Graphic and/or other resources are perfectly used, in a professional manner.
The student appropriately uses the oral communication techniques.	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 actively listens to instructor, clearly and precisely answers to questions or comments.	Interruptions, low effort to understand the questions and different answers made to the questions.	Don't pays enough attention to the conversations, nor able 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.

There are some key factors that are not reflected in the rubric and should be considered specifically for virtual environments, such as the 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.

III. METHODOLOGY

A. Design of the Experience

This experience has been carried out between two Universities, The Technical University of Madrid (UPM) and University of La Rioja (UR). Groups of students of Engineering Project Management (EPM) subject of both centers are involved in the development of a specific project, consisting in all technical and economical aspects related to the construction of a biomass facility to be placed in a given location.

In this way, the course begins by asking the students to propose the definition and configuration of a solution to the problem to solve. Multicriteria decision making processes, milestones, different technologies and disciplines must be considered, since there is not a one-right solution but a group of partial answers given to specific issues.

The students are organized by teams from different universities and specializations, playing the two roles defined for the experience: (1) Project Managers (PM), and (2) Team Members (TM). PM's must define the work breakdown structure (WBS) and organize the TM's tasks to be done according to the scope negotiated with the instructors.

Teams performance' follow-up could be done at every moment through the software-based support system, where meeting minutes and auto-evaluations must be also regularly uploaded.

The instructors support the students' groups by playing a 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 a more detailed way in [26] [27].

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

B. Platform Selection

Regarding the selection of the most appropriate web tool, main objective was to provide to the students with the best common platform for ease the collaboration, communication and interaction among them.

In this sense, some requirements were consider especially relevant for the experience's success, such as:

- Collaborative multiuser Web 2.0 environment.
- 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.
- Security management, roles and permissions.
- Multiple business capability in the same application.
- Management options for multiple projects and sub-projects.
- Documentation management tools.
- Task assignment functions.
- Real-time supervision of the resource consumption.
- Broad range of reports for the project supervision.
- 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 the use of the different roles that coexist in the management of a project, enabling the team members to communicate and work together even though they might be located at distant locations.

C. Development of the Experience

Just as an example, a screen-view of an on-going project carried out by a team of students under the project.net software tool is provided in "Fig. 1".

According to PM or TM role, accessibility to certain contents and platform functions are permitted or not. Additionally, effort dedicated to each task (in terms of hours), must be regularly updated by all the students.

Figure 1. Screen-View of a project

As competence acquisition concerns, this collaborative, virtual environment allows the students to develop specific abilities related not only with EPM subject issues but also those others usually considered as "behavioral" ones.

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

D. Design of the Rubric

As mentioned in the literature review section, there is a lack of specific rubrics oriented to evaluate all the relevant aspects concerning to virtual individual communication competence. In this sense, once the reference rubric of the Table I has been selected, we propose now a better adapted one for our investigation. This rubric includes two new factors: 1) corporal communication, and 2) stage selected for the video realization. Both factors and evaluation levels are shown in the below "Table II". In addition, the "active learning" factor has been eliminated as it has no sense in this particular context, and the previous two-leveled sub-factors in "Table I" has been splited into two main factors.

E. Research Design

A contrast analysis was designed in order to test the new rubric. A sample of 30 students was selected, 15 of total 21 (71%) from Automatic and Electronic Engineering (AEE), and 15 of total 47 (32%) from Organizational Engineering (OE).

The three-minute duration videos (.flv format) were done by the students at the end of the first semester of 2011, once the course was finished. All the personal works were recorded and uploaded in a specific site only available for instructors, guaranteeing the privacy of the materials provided.

As the contents of the presentation concerns, detailed guidelines were given to students in order to get the most possible homogeneous presentation from all of them. That included the main aspects of the global project conducted by the group, tasks assigned, personal contributions to overall work, difficulties found and perception of the virtual experience.

Evaluation of the 30 videos was conducted by two expert professors in EPM subject and competences from the UPM Industrial Engineering School. Both people were involved in the rubric design of this study as well.

TABLE II. COMMUNICATION COMPETENCE RESEARCH RUBRIC

Communication Competence Factors	**Achievement Levels**			
	Unsatisfactory	***Needs Improving***	***Satisfactory***	***Excellent***
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.	Graphic and/or other resources are commonly used, not always adequate to the content of the presentation.	Graphic and/or other resources are perfectly used, 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 the well-understanding for the instructors	The stage selected could be somehow better in terms of lighting, color and general atmosphere	The stage selected is ideal for the video presentation

Punctuation were given considering “1” for “unsatisfactory level”, “2” for “needs improving”, “3” for “satisfactory level” and “4” for “excellent”. All the visual materials were independently double-peer reviewed. Results of the research are shown in the next section.

IV. RESULTS

Statistical means are presented in “Fig. 2”, “Fig. 3” and “Fig. 4”, taking into account the total students, AEE and OE groups separately.

All the factors included in the research communication rubric are also evaluated, categorized in the same manner and punctuated as per above already described way. In addition, the bars graphic shows the results by peer revision, permitting the full contrast analysis.

So, first result to highlight is that the global communication competence for this specific virtual work is evaluated with 3.0 over maximum 4.0 points, varying centrally to this figure from 2.8 (peer 2) to 3.2 (peer 1). Theoretically this number corresponds to “satisfactory” level.

The competence factor best evaluated is the “message structure” one, 3.4 points and +0.4 versus the global competence value. On the contrary, the worse one corresponds to both “corporal language” and “stage” factors (-0.2 points).

Comparing both peer reviews, differences relatively high (0.7, 0.6 and 0.6) can be respectively found in three of five categories (“oral style”, “corporal language” and “technical resources”).

Interestingly, the students of both specializations courses exactly achieve the same punctuation for the global communication competence (3.0), being the gap between professors’ evaluation the same as well (+0.4) points.

To end, the analysis by factor and by specialization group shows a similar pattern for the maximum and minimum punctuation as well, as per below figures.

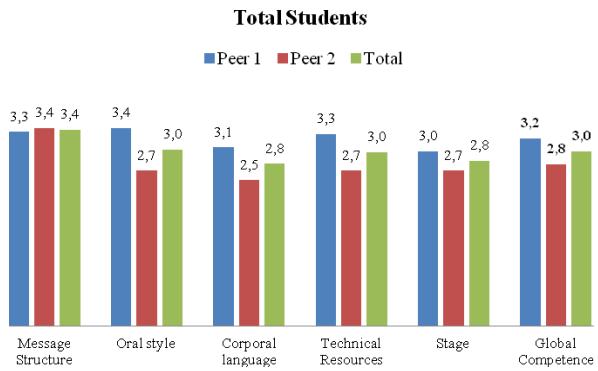

Figure 2. Communication Competence global results.

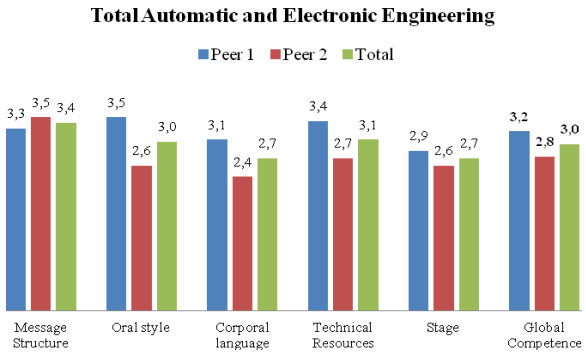

Figure 3. Communication Competence AEE results.

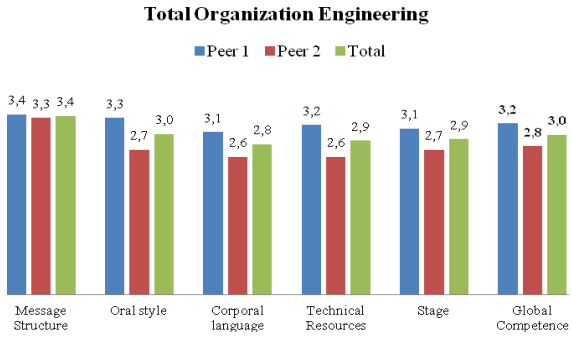

Figure 4. Communication Competence OE results.

V. DISCUSSION

This paper analyzes oral communication factors to be considered in a virtual PBL context and for specific applications. Generally speaking, there are two ways to do such kind of interaction: 1) face to face synchronous electronic means with or without image (e.g. skype, telephone), and asynchronous electronic means (e.g. video). The results presented in this paper are referred to the latter; formal communication recorded by video.

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

In this sense, our discussion focuses in what to do with the need to adapt the behavior to each of the 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 and our contribution has been to add the influence of using electronic means and the appropriate stage

When we communicate by video, technical means are very important to ensure an excellent communication. This will not be achieved if we cannot hear properly or if the image is weak

or if we have a distorted stage that difficult the listener's attention. Arguably, we can affirm that if the basic technical communication standards are not met then, communication collapses. Moreover, the use of texts, original staging or other resources, reinforces positively the communication and thus the predisposition of the receiver.

We can focus the discussion as well on how far students and teachers are aware that what we have considered traditional communication elements (message, speech and body language) are affected and have less importance. 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. Considering this, the stage had the lowest results for both groups of students analyzed so this should be trained intensively with students.

The evaluation exercise that has been developed shows that there are differences in the interpretation of the rubrics, which means that the behavior observed by the evaluator has elements of subjectivity that are important. This fact has implications and it should be considered whether there has to be a previous alignment of the evaluators or if rubrics should be revised to be more precise, or both.

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

Regarding the coincidence of results of the two groups of students that have been evaluated, it can be interpreted in the sense that the treatment of transversal competences is quite homogeneous in the different majors of engineering, allowing common improvement of study plans.

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

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

As particular contributions concerns, this study has firstly 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.

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

In third place, the research introduces a rubric developed by the authors and based on existing ones, but more specifically adapted to assess the communication competence in students when using video presentations.

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

To end, this investigation can be used as a reference for the design and implementation of similar innovative experiences, aligned with the global objective of the development of students' personal competences.

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