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SELF-MANAGED TEAM CASE STUDY

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***Abstract*—** Nowadays industrial processes imply a complexity in technical procedures in which there is an integration of miscellaneous disciplines. This leads to the need of using dynamic working methods and consequently, interdisciplinary team-work is a must. Undoubtedly, universities cannot afford to keep aside from this global framework. The present paper aims to introduce a multidisciplinary project in Industrial Engineering studies integrated in the above-mentioned technical and industrial framework. The core of this project consists of self-managed teams of students from first year of both the Electronic Engineering and the Mechanical Engineering Degrees.

Keywords- Miscellaneous disciplines; multidisciplinary project; self-managed teams

I. INTRODUCTION

Since the establishment of universities at the Middle Ages in Europe, these institutions have always developed their role as trustees of the humanist tradition and of knowledge. They founded an autonomous body that reflected on itself but that unfortunately, distanced from the real world. It was not until the end of the XX century when other sectors of the society began to claim that universities could not carry on giving their back to their surrounding environments. This is the moment when the education authorities in the European Union started to elaborate on the establishment of a new educational policy that would place the emphasis on the employability of graduates, the development of key competencies, or the encouragement of transnational mobility among others. This ambitious project initiated in such a symbolic place as the University of Bologna (which was the first university to be founded), where the *Magna Charta Universitatum* was created in 1988, which enumerated the fundamental university rights.

This document was followed by the *Declaration of Sorbonne* in 1998 (again a symbolic place, since it was the second university founded after the one in Bologna), which established the first steps towards a convergence of the educational systems. All this finally led to the *Bologna Declaration* signed in 1999 and which established what is known nowadays as the *European Higher Education Area* (EHEA).

29 European countries signed the *Bologna Declaration* and it is important to note that not only the EU member countries agreed on this Declaration but also most EFTA countries (i.e. Iceland, Norway, and Switzerland). The reform described in the Bologna Declaration was finally implemented in 2010 by all EU member countries. The enforcement of this new educational system meant a total change in organizational and methodological systems throughout all European Higher Education institutions, as there was a shift from enhancing contents to fostering competencies such as, leadership, creativity, communication skills, and team-work [1].

However, this was not an isolated reform but spread across the Atlantic. Concerning the US and in particular, the Engineering Education, a similar scenario developed. Undoubtedly, this is the reason why ABET have expanded their accreditation focus on certain competences as well as on the acquisition of knowledge, which was the basis of higher education in the past. Therefore, in their criteria for 2011-2012 [2], they stress out that students should be able to function on multidisciplinary teams; to communicate in an effective way; to develop an understanding of economic, environmental, global, and social issues; and also, to develop an interest for life-long learning. These competences also match some of those established in the European Higher Education Area.

Florida Universitaria is a private institution affiliated to the Polytechnics University of Valencia (Spain) for the Engineering Programs. Therefore, we follow the guidelines established by this public body, which has published the corresponding White Papers for their Electronic Engineering and Mechanical Engineering Degrees [3] [4]. Both documents highlight the need to foster students´ abilities in problem solving, decision-making, creativity, critical thinking/analysis, and communication; also, their skills in working in a multidisciplinary and multilingual environment; and very important, their skills in working in every phase of a project in their respective professional fields which entails the competence of team work too. Hence, and as a consequence of the new educational policy, we have opted for a multidisciplinary methodology which enables our students to develop those competencies required by our Electronic Engineering and Mechanical Engineering Degrees. This new methodological experience initiated in the academic year 2010-2011 together with the introduction of the new ECTS (European Credit Transfer System) paradigm. Therefore, it was a crucial year firstly, because of the need to implement successfully such a number of important changes in the daily development of undergraduate studies; secondly, because we took up the added challenge of integrating an important number of subjects with the objective to come out with a global academic work by means of the Project-Based Learning pedagogy; and thirdly, because we set up this multidisciplinary methodology aiming to carry on with the project work throughout the entire Degree. As a result, our experience can be considered as a

piloting which has provided us with the necessary tools and expertise to expand it into the second-year Engineering studies. In our methodology, the team-work competence plays a key role and this is the reason why we decided to enhance this competence into self-managed working teams [5] [6]. But surely the most relevant aspect to bear in mind is that all the students had to participate in the project. Similar experiences have been carried out in other universities [7] but, differing from other experiences [8] [9], our multidisciplinary project is part of the students´ curriculum and also, it begins in the first academic year of the Degree. Furthermore, it is not either an optional activity for the teachers involved; and surely, no incentive is provided for any of the groups. As a result, we dare say that the outcomes of such an experience are to be taken as objective and realistic. We have developed a multidisciplinary project called *Designing an Industrial Welding Robot* [10] which will be elaborated on throughout the four-year undergraduate curriculum. The objective of the project during the first academic year was to acquire the specialist knowledge in the field of Robotics aiming to apply it to the design of an industrial robot further on. For this reason, all the first-year subjects (9 altogether) were involved with a 25% share of the teaching/learning process. In order to manage this project successfully, there was a need to establish different working roles both for teachers and students. Concerning the former, there is a project coordinator and the various subject teachers. And concerning the latter, there is a team leader – who is a fourth-year student – per team and the other team members, i.e. first-year students. Due to the nature of this project, we cannot claim that the teams went through the initial phase in teamwork, which should be the enthusiasm of the initial stages [11].

On the contrary, students were rather suspicious and expectant, as they were not very sure what they were meant to do, and above all, because it was their first year at university that was at stake. However, they soon reacted and were more willing to carry out their activities because they could see what the goal was exactly about.

To sum up, we aim to present a multidisciplinary project that has been developed by first-year students collaborating together in self-managed teams. We also aim to prove that this kind of methodology improves students´ learning process and consequently, their achievement at the end of the academic year. Moreover, by implementing a project-based methodology we (as students´ instructors) are already working on our students´ employability by providing them with valuable tools that they will definitely need in their future professional careers.

II. METHODOLOGY

Our Multidisciplinary Project was firstly implemented throughout the academic year 2010-2011 (both semesters) with the first-year students in the Electronics Engineering Degree and in the Mechanical Engineering Degree. Both Degrees share a number of subjects i.e. Physics, Mathematics, CAD, Computing, Electronics, Chemistry, Technical English, Applied Computing, Materials, and An Introduction to Business Organization. One of the principles of the Multidisciplinary Project is to involve all the subjects in it so that students can establish the relationship between the contents of those subjects and the development and implementation of a project in their specific fields.

Concerning the students who participated in this Project, 14 belonged to the Electronics Engineering Degree and 27 to the Mechanical one. They were distributed into 3 and 5 working teams, respectively. Every team consisted of 5 or 7 students who must solve a problem based on a real situation. This problem integrated all those specific competencies implemented by the various subjects as well as those general competencies required by the Degree such as, team-work, creativity, critical analysis, or communication. The teachers carried out a continuous assessment of the Project from their own specialized areas. Besides, one of the teachers took the role of Project Coordinator for the different activities and was also in charge of training students on team work. On the other hand, every team had an external leader who was selected from last-year engineering students who were willing to participate in the Project. Their role was to monitor and assist the member teams in accordance with the guidelines established by both the Project Coordinator and the rest of the teachers involved. Therefore, even though teams were self-managed, students were aided with a back-up structure. The innovation of the Project-Based Learning methodology does not lie on the project itself, but on the possibilities it offers in order to implement and develop a number of competencies [12]. Team-work constitutes one of the key transversal competencies that engineering students should acquire.

Through the Multidisciplinary Project, and particularly through team-work, students will be capable to manage their work; to reach a consensus on creative and innovative proposals; to reach a consensus and also amend proposals according to peers´ opinions; to make improvement proposals to the work presented by their peers; and to include all the remarks and suggestions introduced by other members of the team. These competencies enable to work on a number of skills such as, management and organization, critical analysis, problem solving, decision-making, pro-activity, autonomous performance, initiative, and creativity. Moreover, by observing the contributions made by the team leader, students can have a reference to value on leadership. We wish to place emphasis on the fact that it is extremely important to make sure that we assign students a number of tasks which are so complex as to force them interact among themselves in order to implement them instead of giving students the possibility to undertake their tasks working on an individual basis. Otherwise, the concept of team-work collapses and the whole project becomes a failure.

Once the teams are formed, a number of phenomena occur that are related to the nature of team-work itself. We can compare the team to a human being in the sense that it develops through a series of stages during its lifespan. These stages do not respond to a linear function, that is, teams may go forwards and backwards depending on every specific team and its circumstances. Furthermore, not every team must go through all the phases. This will depend on the level of work demand required by teachers and also, on the level of maturity of the team members both individually and as a team.

Seven phases have been identified that present their particular features:

1. *Initial enthusiasm*, where the team will be successful if this stage is channeled correctly. Team leaders become the pillar of the working system.
2. *Data gathering* refers to the moment when students start perceiving and analyzing information and material in a different way.
3. *Group divergence* is the consequence of the phase when students tend to take things personally. At this stage, a moment should come when students reach some consensus or compromise to make an effort.
4. *Group convergence* is the result of becoming goaloriented. This is essential otherwise there might be frustration and the awareness of a likely failure in completing the assignment before deadline.
5. *Group panic* typically arises when work completion depends on others´ effort and not only on individual work. Consequently, this is the moment for ego defense.
6. *Group effort* is the consequence of having reached a certain maturity as a team and so, there is a clear notion in the group that the work must be completed. Therefore, a group meeting becomes a must in order to analyze what has to be done, when, how, and by whom.
7. *Group accomplishment* is the final phase once the work has been completed. It is at this stage when students tend to forget previous frustration and disappointment.

Students represent the core of the Multidisciplinary Project and then, the configuration of the teams becomes a crucial point. Our teams were formed in a heterogeneous way aiming to create a group consisting of people with very different identities. However, they have a common goal and predetermined roles. This was done through the Belbin test [13]. How we tend to act inside a team creates the so-called team roles and the more we know about them, the better professional efficiency we can achieve in our careers. Bearing this in mind, 9 roles are identified which can be grouped into three main categories:

1. *Mental roles*: the plant; the monitor evaluator; the specialist.
2. *Action roles*: the shaper; the implementer; the completer finisher.
3. *Social roles*: the resources investigator; the coordinator; the team-worker.

A number of meetings were scheduled with the team leader and the Project Coordinator with the objective to do the work planning, to check processes and outcomes, and to identify those issues that should be improved. At the same time, students had to undertake a number of assignments for the Multidisciplinary Project from every one of the subjects during class-time sessions. These assignments revolved around the specific learning targets identified for each subject. In these cases, teachers were present only to act as facilitators when/if needed. These sessions take the 25% share of face-to-face lectures in every subject (between 8 and 12 hours per semester). Additionally, every team had extra sessions to work either autonomously or in their teams depending on what was needed at the time. These additional sessions aimed to achieve the expected outcomes for the project and to comply with the deadlines that the students themselves established in their planning report. Furthermore, teams must meet four hours per week. The Project Coordinator attended one of those hours and the team leader was also present for another hour. In this way, students had two hours scheduled per week in order to develop their project work in an autonomous way inside their teams. Likewise, 14 hours were scheduled for the different training seminars at the beginning of the academic year.

After setting up the teams, their work begins by establishing the aim of the Project and also, by providing a description of both general and specific objectives that should be reached throughout the project. This information is then collected in a document called “Planning Report” which will be their guide throughout the academic year. This document also includes their work planning and deadlines as well as the tasks distribution among the team members. The team and its members must take on a number of responsibilities because of the need to plan and specify who, when, and how every task must be accomplished, thus enhancing learning through interaction. As a result, every team must name a Secretary who will draw up an agenda for their weekly meetings with the Coordinator, with their leader or on their own. Then, they must write out the Minutes which will describe, among other things, the agreed tasks, who becomes responsible for them, and deadlines. This document becomes an essential tool for the subsequent assessment among members of the team; and this assessment conditions the individual assessment of the Project.

Students were given a number of tools in order to provide them with some support material. One of them was a document called “A Multidisciplinary Project Guide” in which teachers and Coordinators described the project; the general aims; the different subjects involved in it and their specific objectives and tasks to be accomplished together with their timeline. ICT tools are indispensable for the development of the Project work. These have been focused on a collaborative learning that allows students to achieve several of those competencies before mentioned. There is a virtual learning environment created by our institution which students and teachers use throughout the Multidisciplinary Project. Teachers submit there all the necessary documentation that students will need regarding seminars and resources to develop the Project. Furthermore, every team can make use of a collaborative space in which to share documents, chat on the Forum, and upload their Minutes. Consequently, this virtual learning environment becomes a virtual meeting point for both teachers and students. Another ICT option is the Google tools, such as Google docs and Google Calendar, which are user free. This option enables students to share their work and use the virtual calendar in real time. The Google tools facilitate work planning to students [14].

Summarizing this section, we have defined the structure of the project and we have explained how a number of competencies were acquired through this kind of methodology. We have then shortly described the theoretical phases team work would go through. Then, we have explained how the teams were formed and how all the stakeholders planned and structured the work to be undertaken. Finally, we have highlighted those tools that were essential to develop the team work in the Project.

III. RESULTS AND DISCUSSION

In order to assess the working methodology, questionnaires were sent to both students and teachers. The students´ opinions centred on the acquisition of competencies related to teamwork and also, to team management. On the other hand, teachers provided their views concerning the students´ teamwork and their commitment. Table I shows the results of a survey carried out with the students in order to assess their view on acquiring competencies through team-work. Students were asked to assess from 1 to 10 whether they totally disagreed or they totally agreed with the issues they were asked about. As can be seen, students felt they had acquired those competencies achievable through team-work. Although all the results are positive, it is worth noting that the Electronics Engineering students considered they had acquired a greater capacity to reach consensus and amend proposals and opinions, and also to introduce improvement proposals.

Through team-work I have improved my capacity for:	**Assessment Mechanical students**	**Assessment Electronics students**
Time management	7.2	7.5
Reaching consensus and amending proposals according to my peers´ opinions	6.0	7.8
Introducing improvement proposals for my peers´ suggestions	6.2	7.2
Integrating my peers´ comments on my own work	7.0	7.0

Another survey (table II) was carried out in order to assess the Belbin test as a valuable tool for distributing students according to their attitudes. The corresponding questionnaire was sent to students, teachers, and Project Coordinators. The results were not positive, particularly if we observe those by the Mechanical Engineering students. According to some remarks submitted by the surveyed teachers, the Belbin test works out teams on the basis of attitudes rather than motivation and consequently, we can come across imbalanced teams.

TABLE I. STUDENTS´ ASSESSMENT ON COMPETENCIES ACQUIRED THROUGH TEAM-WORK (OUT OF 10).

Belbin Test			
Electronics Students	Mechanical Student	Teachers	Project Coordinators
5.0	4.4	6.6	5.5

In order to manage and plan their work, students wrote out the Minutes of every team meeting so that they could describe their agreements on task development and its accomplishment. We believe those Minutes were done in a correct way at a formal level, however they were not useful to invigorate the team work, as they were not regularly monitored and assessed. As a result, not all the students accomplished their meeting assignments.

The virtual platform developed at Florida for academic activities was highly used by the teams and also, it became a meeting point for all the parties involved in the Project. Both teachers and Project Coordinators submitted there information concerning tasks to be developed. On the other hand, students submitted their semester and final papers for the Multidisciplinary Project. Moreover, this virtual platform was used as a communications tool among the team members, the teachers, and the Project Coordinators. Students were expected to use Google tools to particularly write out their work reports by means of Google Docs, as suggested by their Coordinators, since we all know that the new generations have developed an expertise with the new information and communication technologies. However, this tool was not generally used in team-work. Our belief is that students were reluctant to use it, as it was for working and not for leisure, which is what they are used to doing when getting access to ICT tools. Therefore, if we want our students to work with this kind of tools, we must force them to do so, monitor its use, and finally assess it. Concerning the phases that teams would go through, the results did not always match the theory. To begin, the *initial enthusiasm* phase was not present. In general, students were not eager to accept the Multidisciplinary Project work probably because it was a new methodology for them. It was the first time they were going to get confronted with Project-Based Learning and also, it was the first time a whole lot of subjects for the academic year would integrate in this kind of activity.

Referring to the *data gathering* phase, the lack of experience, of maturity, and of knowledge resulted in a different understanding on how to develop team-work. It was evident that conflict was starting to generate. Dealing with the *group divergence* and *group convergence* phases, students generally had problems to reach a convergence point in the development of their work. We even found out that a team could not end up working correctly and therefore, it was decided to dissolve the team and distribute its members among the other teams. Only one of the Electronics Engineering student teams managed to reach fast the convergence stage probably because one of the members provided the rest of the team with valuable working professional experience. It is also worth noting that at the time when divergence arose, some students were more interested in criticizing their peers´ work than in getting ahead with their project work.

With the exception of the above-mentioned Electronics team, the rest of the teams wasted valuable time in beginning to work in an adequate way and so, it was very difficult for them to follow the planning they had presented in their initial report. This led to a worrying situation (*group panic* phase). Generally, teams did not work in a continuous way, as they were expected. On the contrary, they left a great deal of their work near to deadline.

During the *group effort* phase, we could experience an improvement in the level of maturity of some members of the team. This was probably due to either professional experience or to the acquisition of work habits. These were the students who became responsible for coordinating the team in order to comply with deadlines and assignments in the submission of their final report. Concerning the final group accomplishment phase, students were expected to feel satisfied with their work. However, the results varied in both groups of students (table III). The Electronics Engineering students did reach a satisfaction stage but the Mechanical Engineering students were not satisfied with the project-based methodology.

TABLE III. GLOBAL ASSESSMENT OF THE TEAM-WORK DEVELOPED UNDER THE MULTIDISCIPLINARY PROJECT (OUT OF 10).

	Mechanical students	**Electronics students**
Global assessment	3.9	7.3

In order to obtain a more detailed opinion on the Multidisciplinary Project, students were required to describe positive as well as negative aspects of team-work. In general, they highly valued team-work and they also commented that they were able to learn other working methods from their peers. The negative aspect students commented concerned the workload. They were happy neither with the amount of work that the Multidisciplinary Project meant for them, nor with falling out with members of the team.

TABLE IV. A QUANTITATIVE ANALYSIS OF THE STUDENTS´ NEGATIVE COMMENTS ON TEAM-WORK (OUT OF 10).

	Mechanical students	**Electronics students**
The workload is adequate	3.6	4.8
Team-work has been carried out in an egalitarian way	4.8	5.4
Co-assessment must be done to evaluate team-work	7.6	5.6

In reference to these negative issues, and aiming to obtain a quantitative indicator, students were asked whether they considered adequate their workload and also, whether carrying out co-assessment was necessary to control the involvement of all the team members (table IV). Students, and particularly Mechanical students, believe that the Multidisciplinary Project means an excessive workload. However, it is important to highlight that this Project implies a 25% workload for the students, that is, on the one hand, students must dedicate an average of 375 hours to it; and on the other, teachers must use a 25% share of their teaching time to develop the Project tasks in class-time. As a result, we have concluded that it is convenient to monitor the number of working hours done by the students. In general, this perception is the result of the spread practice of leaving task accomplishment for the last minute. In order to avoid this, both teachers and coordinators set deadlines for regular task submissions. Moreover, Mechanical students in particular believe that the Project workload was not equally distributed among the team members. This is probably one of the factors why workload is so negatively assessed together with their inefficient task scheduling.

In reference to an egalitarian distribution of the workload, students valued in a positive way the possibility to carry out more co-assessment in order to evaluate the workload for every member of the team. In particular, the Mechanical Engineering students felt that their peers had not work on equal terms. This non-egalitarian distribution of the workload, due to the lack of commitment by some of the team members, was the reason that caused conflict in the teams. In order to solve this problem, more co-assessment was carried out among the different team members. Also, at the end of the Project they had to defend their project work on an individual basis. Assessment for these two entries could entail a 25% variation in the final grade of every member of the team related to the team grade. Students commented that this variation should be bigger to make sure that those students who had not worked in a responsible way would not benefit from it. Moreover, we truly believe that we should have taken into consideration the accomplishment of the explicit agreements and commitments enumerated on the Minutes in order to value the final grade for every member of the team.

This piloting experience has therefore evidenced a number of pitfalls. Firstly, all the Project stakeholders believe that the distribution of members inside the teams through the Belbin test has not been a decisive factor at the time of making up homogeneous groups. Also, students had to write meeting Minutes and make use of the virtual learning environment as team-work tools, but they did not manage to exploit the potential of Google tools at the time of doing collaborative work. Besides, all the teams went through the seven phases listed and described above, although the *initial enthusiasm* and *group accomplishment* stages have not been as successful as expected. Lastly, the general assessment that the students made on the Project-Based

Learning methodology presents very different results depending on the Degree. Students assessed positively the acquisition of new competencies through teamwork.

However, they were very critical concerning the workload and the heterogeneous distribution of tasks among the team members.

IV. CONCLUSIONS

The involvement of all the subjects in the first-year course curriculum in a single project has permitted to achieve a comprehensive view on how to apply team-work to an engineering project which is very close to a professional setting. Team-work has turned out to be an efficient method to acquire general competencies that could not be achieved by using traditional learning methodologies. Thus, management and organization, critical analysis, problem-solving, decisionmaking, pro-activity, autonomous performance, initiative, and creativity become a natural way for students to develop their assigned tasks. As a piloting experience, the methodology was completely new both for students and teachers and as a result, success factors and pitfalls arose throughout the development of the project. However, this experience will allow teachers to address this kind of methodology in the light of improvements to overcome those pitfalls but also, to enhance the successful outcomes. One of those negative issues related to the dissatisfaction showed by a certain number of students in the last phase of their team-work (i.e. the *group accomplishment stage*) because of the unequal workload among the members of the group and how this reflected on their final grades. Therefore, there will be an increase in the monitoring of workload distribution through the Minutes of students´ meetings (in particular, the number of hours worked by every member), and a more accurate reflection of this work in their final grades. Nowadays, the individual grade can vary about 25% in respect to the team grade. We propose to set a higher assessment to the involvement and contributions of every team member. This would mean a variation of their individual grades up to 50%. To conclude, we believe this experience has been very positive, although not all the students valued it in the same way probably due to the innovation of the methodology and their reluctance to accept such a change in their study habits. Therefore, our research will continue with the new comers so that we can strengthen this project methodology with the improvements we are introducing; and also, to find out whether the reaction against this kind of learning by some students was actually a reaction against the methodology itself or it was only an attitude displayed by a specific group of students in a specific academic year.

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