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## A new approach for integrating teams in multidisciplinary project based learning

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### Abstract

This paper describes the experience of collaboration among students and teachers in order to develop multidisciplinary projects, and to reproduce as closely as possible, the team's integration into a company environment. A new methodology based on student interaction and content development in a Wiki environment has been developed. Students and Teachers have participated with enthusiasm, due to the correct well-distributed work and the easiness of use of the selected platform in which only an internet connected computer is needed to create and to discuss the multidisciplinary projects. The quality of the developed projects has been dramatically improved due to the integration of the results obtained from the different teams.

© 2010 Elsevier Ltd. Open access under [CC BY-NC-ND license](http://creativecommons.org/licenses/by-nc-nd/3.0/).*Keywords:* Project based learning; active learning; collaborative; multidisciplinary; wiki environment.

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### 1. Introduction

Complex engineering projects are usually carried out by the integration of different work teams, which could even be located geographically distant. Collaborative Web environments (Realf et al., 2000) have shown themselves to be an excellent tool for knowledge repository compilations, and many experiences have been developed in Academia (Hu, 2007) (John & Melster, 2004) or in Industry (Chau & Maurer, 2005).

The Mechanical/Industrial Engineering students of Madrid Polytechnic University receive an in-depth knowledge of mechanical design and manufacturing processes, but the increasing interaction with other engineering branches, induces the need to integrate concepts, which allow students to make an integral design of new products, and to facilitate their subsequent integration into multidisciplinary engineering teams in industry.

Project scope statements were launched over some common projects with their particularities for the four different topics: 'Manufacturing Technology' and 'Simulation in Mechanical Engineering', both from the Mechanical Engineering curriculum at the ETSI Engineering are taught in the sixth semester; 'Manufacturing', from the Organizational Engineering programme is taught in the eighth semester together with 'Computer Aided Design', which is a free choice course that integrates students from different semesters and programmes. Students of these

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topics have been carrying out traditionally different application projects, but the new approach is oriented towards inducing collaboration between multidisciplinary teams in different subjects of expertise (Chao, 2007) (Chun, 2004). The work here presented reproduces the organization of actual engineering projects, and brings it into the classroom.

The main objective of this experience has been to design a set of projects to be developed by students, mainly in the area of automated engineering, where students have to work in cooperative groups (Wodehouse, 2007) of two or three and have to integrate their results with groups from three other different subjects. In order to be able to compare the final level of satisfaction of the students involved in this experience, only one sample of students was taken who coexisted with other groups of students who undertook individual work in each subject in line with the traditional system.

They used a Wiki server (Wang, 2005) to share and prepare their work content (Eris, 2006); this new way of developing “Project Work” documentation and discussion has helped students become self-directed learners who internalize specific topics from different subjects, programmes and courses with their own interests, and has been considered as an easy alternative to promote active learning (Notari, 2006), not only in this area but in other courses.

## 2. Project Structure

This educational initiative has been applied in four topics shown in section 1 and directly affecting 110 students working in different subjects; groups of three students were selected for each project and topic except for CAD which were two-student teams. Initially the teacher and students set the boundaries of the project for each topic. Students in these subjects have carried out application projects for years but with this new experience they are moving towards collaboration between disciplinary teams in different subjects. This project carried out by students is shown in the following figure from four points of view reflected by the typical topics of these subjects and, therefore the tasks to be solved are seen from four different approaches.

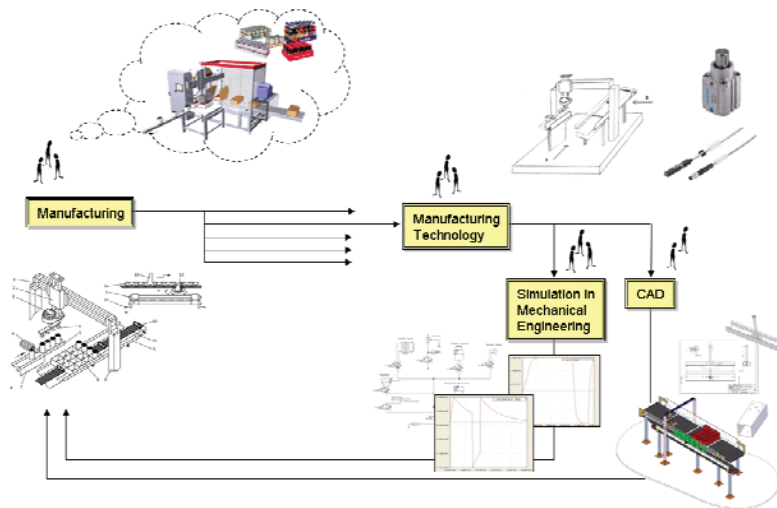


Figure 1. Four different teams for each manufacturing cell project.

The work structure of the project undertaken was based on the fact that the assembly designed in the subject of ‘Computer Aided Design’ should correspond to the size and constructional specifications of the manufacturing cell proposed for a product in the subject of ‘Manufacturing Technology’, which was to be integrated into a specific manufacturing process proposed for the subject of ‘Manufacturing’, where the feasibility of one or more components had to be checked by simulating them in the subject of ‘Simulation in Mechanical Engineering’ (Fig. 1).

The project scope statements for these works were launched with their particularities for the subjects comprising the experience; the difficulty of the projects proposed was uniform, but the work sequence and other specifications had to be set in advance for each topic.

The teachers involved in this experience organised fortnightly coordination meetings in order to coordinate course content timetables. The involvement of the teachers in this programme was one of the hardest parts.

When each team had defined their particular area of contribution the collaborative Web began its task, which was basically to integrate all the information from student contributions and show it to the other teams with the purpose of enhancing the overall quality of the results produced.

### 3. Wiki server

To facilitate an exchange of experiences and communication among the team members assigned to developing each manufacturing cell for the different topics, once a week they could use a collaborative classroom, where the 11 members from the different topics that had designed the manufacturing cell could exchange information face-to-face or solve problems that could not be sufficiently clarified by the Wiki space, the so-named WikiFab collaborative Web (acronym of Wiki Fabrication) ([http://138.100.80.137/wikifab/index.php/MULTIPIE\\_2008-09](http://138.100.80.137/wikifab/index.php/MULTIPIE_2008-09)). MediaWiki 1.11 was chosen for its simplicity of configuration, its popularity (it is used in Wikipedia) and its powerful Wiki functionality.

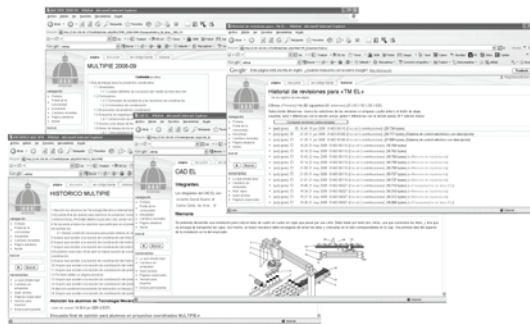


Figure 2. 'WikiFab' collaborative Web.

This Wiki space integrates the information available from all projects with the advantages of having a simple and homogeneous compilation of the documents contributed by students, working as an “out-of-the-classroom” discussion forum with the ensuing improvements in students’ ability to conceptualise, and with the chance to improve other areas of interest.

In this Wiki space, students must perfect the different issues set in the project scope statement. The discussion page contains everything related to working sequence and the starting conditions, such as the parts references provided by the manufacturers or the various design changes. All this information is discussed not only by the team members themselves but they also receive comments from the members of other teams. WikiFab currently allows interacting with the teacher and other team members to be able to discuss the details of the proposed model.

It is important to mention that the recommended format for offering solutions is a graphic format. This forces students to train their synthesis skills to express the objectives of their models through schematic outlines or diagrams.

### 4. Example of applicability: Can Packer

By way of example, in one of the manufacturing cells proposed, the task was to design a facility for placing a set of cans in boxes four at a time as they passed along a conveyor belt. One of the initial premises to arise was that two conveyor belts were needed; one to supply the cans and another to transport them. In addition, a robot arm would be needed to pick up the cans and place them in the appropriate position inside the box.

Following the plan, the main aim was that the ‘Manufacturing’ team should analyse, find and decide on the components needed for the manufacture and assembly of the chosen manufacturing cell and ensure their choice was the best possible one for the performance that would be required of the cell, and that the investment in time and cost was reasonable for such requirements.

As shown in Figure 1, taking the first analyses carried out by those of ‘Manufacturing’, after having firstly pre-dimensioned and chosen the components, the ‘Manufacturing Technology’ team produced their first outline of the appearance and location / programming of different components of the facility. These would serve as a starting point for the other two subjects, ‘Computer Aided Design’ and ‘Simulation in Mechanical Engineering’.

Regarding the work to be done by the ‘Computer Aided Design’ team, the initial measurements provided were simply for guidance and would probably need to be modified to produce a fit for all the final components and above all to make a coherent match of the heights between the conveyor belts and the horizontal frame. For greater detail, the webpage of the initial components supplier was consulted (<http://www.festo.com>), from which it was possible to download the CAD models as well as their plans in order to fit the different parts so that existing commercial models could be used to lower the final cost. When designing some parts some discrepancies were found between the information originally supplied for the subjects of ‘Manufacturing’ and ‘Manufacturing Technology’. So, for example, two initial alternatives were given for the metal sheets that had to support the horizontal linear actuator. Finally, after correctly joining the various parts and commercial components and having adapted the rest of the initial design, the 3D model was had as well as the different plans of all the parts of the final assembly (Fig. 1).

As previously stated, the subject of ‘Manufacturing Technology’ performed an initial pre-dimensioning of all the automation required for the different processes involved in the designed manufacturing cell. From the point of view of the subject of ‘Simulation in Mechanical Engineering’, before taking the solution adopted by the other subject as valid, a prior simulation was performed as a basis for optimising the different parameters. The electro-pneumatic outline of this machine comprises four actuators, two cylinders, a single purpose one (can counter) and a double purpose one (separator), and a suction assembly comprising four suckers. Each of these components had its respective monostable valve to regulate fluid flow to make it function as required. Thanks to the analysis of the opening / closing times of the different valves, as well as a study of the results (Fig. 1) the initially chosen components were able to be validated.

Therefore, after a successive analysis one after the other of the contributions made by each subject team and the suggestions made by the teacher, who simply acted as an advisor, the proposed manufacturing cell was successfully developed. This consisted of a facility for placing a set of cans in boxes four at a time as they passed along a conveyor belt.

## 5. Analysis and Results

Every week, the students involved had to fill in a set of reports to evaluate team progress, interaction with other members and the competencies acquired. These evaluation reports were prepared using Google Docs forms.

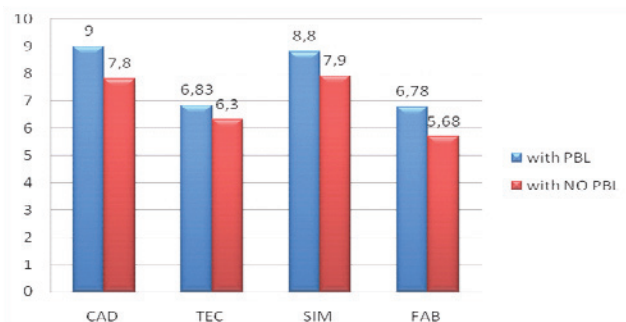


Figure 3. Average mark obtained by students in the different topics

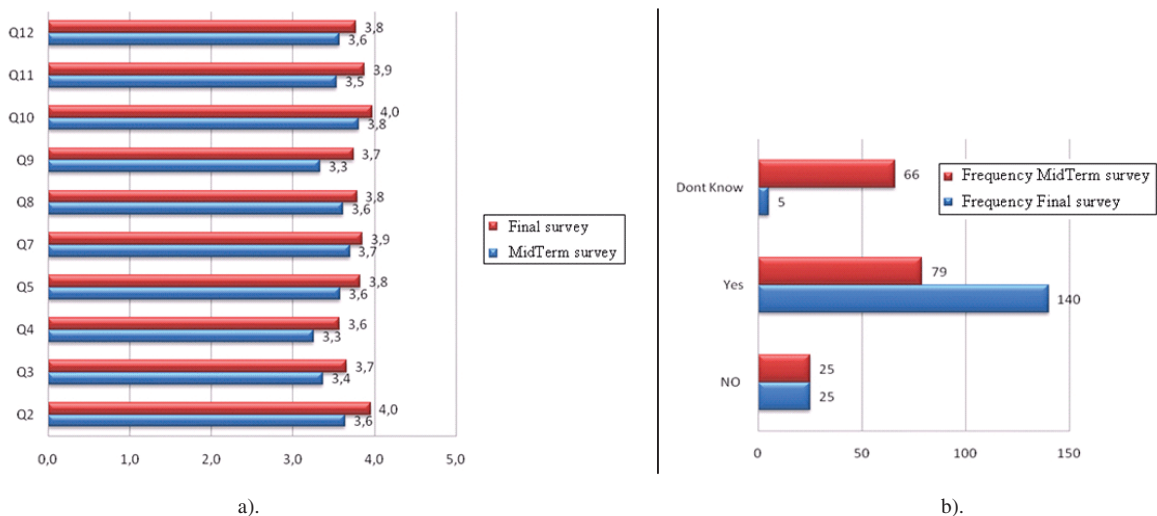
Figure 3 shows the average mark attained by students who took part in this experience (Project Based Learning PBL) and those who did not. It can be seen that there is about a one point difference between the two in the different topics as well as in the progress of the competencies developed.

Two general checks were also made midterm and at the end of the semester to evaluate satisfaction and the evolution of competencies. The questions contained in the survey were scored on a scale of 0 (zero) to 5 (completely in agreement), the results being as follows (Table 1). The results of these surveys were analysed statistically, obtaining the data described below.

Table 1. Check Questions

Q. Number	Question	Q. Number	Question
Q1	Select your subject.	Q7	Score the WikiFab tool
Q2	The 'multidisciplinary' work method is preferable to classic 'teacher-delivered lectures'	Q8	I have improved my ability to work in multidisciplinary environments
Q3	I think my work assessment method is correct	Q9	I can estimate work execution times more accurately
Q4	The teacher recognises the extra effort required to do work outside the classroom	Q10	I am more precise in the work I do
Q5	The effort made to take part in the project is worthwhile. It would be a mistake not to take part in the project	Q11	I have improved my ability to work with different teams by having to exchange information .
Q6	Would you recommend it to a friend?	Q12	I have more leadership ability

Figure 4.a reflects how at the end of the semester the scores for satisfaction showed a perceived improvement in competencies, although not in a major way, since from the start of the programme students perceive a positive improvement in their competencies. The multidisciplinary method used compared to the traditional one is scored favourably (Q2). Regarding question Q6 “Would you recommend it to a friend?”, in figure 4.b it can be seen how in midterm students are doubtful of the benefits of the programme; however, at the end they are satisfied.



An ANOVA analysis was made of the different student opinions regarding the subject they were studying. These data refer to the final survey conducted in the semester. The response to Q2 shows discrepancies between the groups of the ‘Computer Aided Design’ and ‘Manufacturing Technology’ subjects (Figure 5.a).

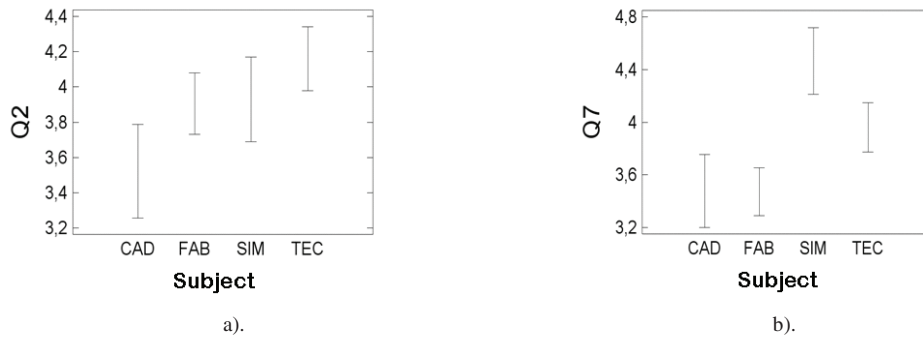


Figure 5. ANOVA (means and 95,0 Percent LSD Intervals), a). Q2 results, b). Q7 results

However, question Q7 did show more disparate performance as Figure 5.b shows. The students of the ‘Simulation in Mechanical Engineering’ and ‘Manufacturing Technology’ subjects gave very positive scores, which was not the case with the other groups. The ‘Simulation in Mechanical Engineering’ students found the Wiki to be a very useful tool for developing their work and the ‘Manufacturing Technology’ group, moreover, was driven by a teacher who was highly enthusiastic about its use and deployment.

## 6. Conclusions

We have presented an experience for a large number of students involved in four subjects from two different specialisations related to the Mechanical Engineering course of the Industrial Engineering degree. The use of a collaborative Web environment by using WikiFab space has made it possible for students to work in multidisciplinary teams. Students analyse, reason, discuss and decide on the solutions that their companions keep suggesting until completion of the project. This project has enabled students to approach a problem from four different points of view and mould them to the opinions of the other contributions from different subjects.

This new way of carrying out the project in this paper and its subsequent discussion has been very enthusiastically received by the student body and the teaching staff who consider it a simple alternative for promoting collaborative tasks between different groups.

The Web structure will let a major set of automated manufacturing case studies be collected in a homogeneous format that may well become a virtual reference space in this area.

## Acknowledgements

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