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INTERDISCIPLINARY ROBOTICS PROJECT FOR FIRST-YEAR ENGINEERING DEGREE STUDENTS

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Abstract

The acquisition of both transversal and specific competences cannot be achieved using conventional methodologies. New methodologies must be applied that promote the necessary competences for proper professional development. Interdisciplinary projects can be a suitable tool for competence-based learning. A priori, this might be complicated, as subjects are traditionally studied at the university level in isolated compartments, with a fragmented structure. Taking advantage of the creation of new degree programs in Mechanical Engineering and Electronic Engineering and Industrial Automation, in the 2010-11 academic year we decided to add an interdisciplinary project (IP) to our teaching methodology. The importance of this project lies in the fact that it requires the participation of all the courses in all the academic years in the degree program. The present article explains the methodology used in the interdisciplinary project and how it was implemented in the first year of the Mechanical Engineering and Electronic Engineering and Industrial Automation degree programs. Furthermore, an evaluation is conducted of all four years of the interdisciplinary project, revealing the main problems with its execution and how they have been addressed.

Keywords – Interdisciplinary project, Transversal competences, Work teams, Industrial engineering, Robotics.

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1 INTRODUCTION

The European Higher Education Area (Bologna Declaration, 1999) establishes the need for competence-based training. As a result, traditional methodologies focused on knowledge transfer have become obsolete for this purpose. The term “competence” implies the integration of knowledge with capacities (know-how) and with attitudes and values (behavioral competence) (Le Boterf, 2001; Rychen & Salganik, 2003; Beckett, 2008). Knowledge acquisition must be linked to their application. In the field of engineering, students must analyze the technological, social and environmental impact of their actions, and transversal competences must be developed, such as initiative, autonomy, leadership, etc. This objective can only be reached by changing our teaching methodology (Poblete, et al., 2007; De Miguel et al., 2006; González & Wagenaar, 2003).

However, curricula parcel knowledge out into different course areas. This leads students to draw the conclusion that the purpose is the contents themselves, rather than the competences. It is necessary to coordinate activities and methodologies not only in the courses themselves, but also throughout the entire degree program. It is for this reason that there are increasingly more experiences in which the students are faced with an interdisciplinary problem involving several courses (Hans-Jörg & Alabart, 2006; Pérez, Serrano, Pérez & Peñarrocha, 2010).

Starting with the 2010-11 academic year, new degree programs have been implemented in Spain. Taking advantage of this, our university has included an interdisciplinary project in the curricula, which involves the participation of all the courses in an academic year. This was the case of the integrated Chemical Engineering project developed by Rovira i Virgili University in Tarragona (Font, 2011). This proposal was implemented at our University Colleges in the Business Administration and Management (Antequera Caplliure & Herrero Montagud, 2012), Tourism, Mechanical Engineering and Electronic Engineering and Industrial Automation degree programs, based on collaborative work with Rovira i Virgili University. This new methodology focuses on project-based learning, as it enables the necessary link to be established between theoretical content and its practical application, which is essential in terms of the students' future employability (Yadav, Subedi, Lundeberg & Bunting, 2011; Alberola & Aznar, 2014). From its inception in Canada over 30 years ago, this methodology has been shown to be a key motivating factor for students, as it enables them to play a more active role in their own learning (Dillenbourg, 2000), unlike what has occurred until quite recently, with master classes in which students simply acquired a set of knowledge that the professor (specialist) brought to the classroom (Ponsa, Amante, Román, Oliver, Díaz & Vives-Gràcia, 2009). It is therefore not strange to see a large number of Spanish universities throughout the country applying this methodology in their own university degree programs, at both the undergraduate and Master's levels. The results have been impressive. One example can be seen at the University of Mondragón (Basque Country, Spain), where mechanical engineering students were able to build a prototype for the extraction of underground water for use by farms located far from urban areas, in individual homes (country houses or cottages) or to supply urban areas in countries lacking easy access to drinking water and electricity. As a result, learning takes on the aspect of a commitment to society and the immediate environment, with the aim of providing solutions for their benefit (Wiersema, 2000; Cassany, 2009; Adams et al., 2011).

Another crucial point in project-based learning is its collaborative aspect; team work is fundamental, as it enables students to develop a set of competences that are key to their employability. Management and organization, critical analysis, problem solving, decision making, proactivity, autonomy, initiative and creativity become the natural mode in which students carry out the different assigned tasks that make up the project (McNair, Newswander, Boden & Borrego, 2011; Aznar, Martínez, Zacarés, Ortega, González-Espín & López-Sánchez, 2012).

The objective of the interdisciplinary project at our university is twofold: on the one hand, for the students to understand the concept of a project in terms of what it means and how it is implemented, and on the other hand, to demonstrate the applicability of the contents in the different knowledge areas for solving specific problems. As a result, once the project is finished, the students will have developed both specific and transversal competences.

The present article explains the methodology of the interdisciplinary project, which is evaluated over the four years that the degree programs in Mechanical Engineering (ME) and Electronic Engineering and Industrial Automation (EE) have been in place. The main problems encountered during its implementation are reviewed, along with a summary of the solutions.

2 METHODOLOGY

The interdisciplinary project (IP) consists of carrying out a project in a real context, integrating in an applied manner the knowledge imparted in the different first-year courses in the ME and EE degree programs. Different specific competences of the courses of that particular year of study were developed through the IP, as well as the transversal competences associated with the project: team work (Aznar et al., 2012), conflict resolution, oral and written communication, autonomy, initiative, leadership, ethical commitment, creativity, search for and management of information, conflict resolution, critical thinking, decision making and the capacity for analysis and synthesis.

During the 2010-11 academic year, we began the ME and EE degree programs. The IP was conducted for 4 academic years, as part of the teaching methodology in all courses. On average, the ME degree had 40 students per year, while the EE degree had 20 students. Based on these numbers, 7 and 3 work groups were set up, respectively. In order for the students to understand the importance of each of the courses in relation to the professional field of engineering, all activities were designed with a specific application in mind. In this sense, it was agreed that all courses would be required to include activities related to the design of an industrial robotic arm.

Course	Mechanical Engineering (IP h/week)	Electronic Engineering (IP h/week)
YEAR-LONG		
Mathematics	*1*	*1*
Physics	*0.75*	*0.75*
Project Coordination	*2*	*2*
ONE SEMESTER		
Graphic Expression I	*1*	*1*
Graphic Expression II	*1*	
Chemistry	*1*	*1*
Materials Science I	*0.75*	
Business I		*0.75*
Electricity		*1*
Physics Specialty	*1*	
Computer Science	*1*	*1*
Applied Computer Science	*1*	*1*
Foreign Language I	*1*	*1*

Table 1. Hours per week dedicated to the IP per course in the ME and EE degrees

The IP is coordinated by year and degree. All the courses in a given year have the same credit load and dedicate 25% of their workload to work on the IP; also, the activities they include must strengthen problem-based learning (PBL). In total, 10 courses per degree were involved in the IP, for a total of 12 courses. Each course dedicates approximately one hour per week to activities related to the IP, for a total of 5. In addition, 2 hours per week are dedicated to student in-class work on the IP, with the assistance of the coordinator and the leader of each group (Table 1).

A total of 10 professors from the EE degree program and 9 from the ME degree program participated in the IP. To help the project run smoothly, students and faculty were assigned the following roles in terms of their participation: student, student leader, course professor, project coordinator and the Interdisciplinary Project Management Unit.

The students are required to solve a problem in a real-life context, integrating the specific competences of the courses in an academic year. Completion of the IP is mandatory for all students registered for the first year of studies and its final grade is reflected in the grade of each course as part of the student's individual grade. In a general sense, the work process can be described as shown in Figure 1.

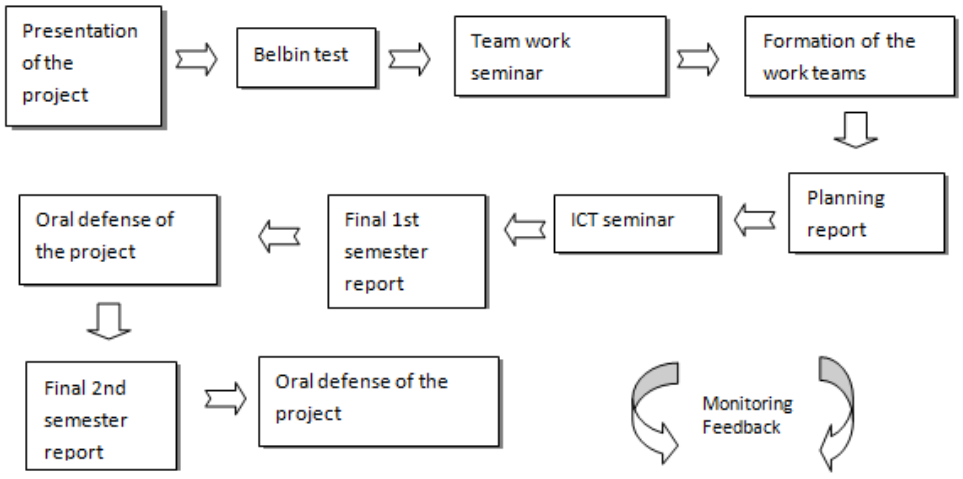

Figure 1. IP work process

Students are a fundamental part of the IP. Groups consist of 5 to 7 students from the same degree, heterogeneously selected according to the results of a Belbin test (Belbin Associates, 1988). The intent of this test is to discover different roles that, when properly balanced on a work team, facilitate the smooth functioning of the team: creativity, resource investigator, driver, team worker, implementer, monitor-evaluator and completer/finisher. Students must work as a team, carrying out the activities planned by the professors in order to reach the IP objective. Prior to this, they will have actively participated in seminars on: team work, oral communication, preparation of documents, organization and accessing and using documentation (Moursund, 2002). The result is that, as the protagonists of the active teaching-learning process, the students take responsibility for the tasks, presenting them on time, in the correct format and with acceptable levels of quality. Students also participate in the assessment of the work and the functioning of the team to develop their capacity for critical thinking. At the beginning, students must submit an IP planning report and at the end, a technical report on the work carried out; they are also required to deliver an oral presentation of the project.

The leader is a student in the final year of the degree program, who already has prior experience, since he/she has participated in the IP since the first year of the program, and who has also demonstrated skills as a work team catalyst. During this latter stage, the student participates in leadership seminars, receiving training in a series of skills such as motivation, the division of responsibilities and leading the team's progress on a group and individual level; this individual is also a conflict mediator and maintains a degree of empathy with the group. The leader's functions range from supervising the planning to monitoring the work, preparing for and arranging meetings (ensuring that minutes are written), and reviewing any incidents and the overall progress of the work team with the coordinator. He/she also ensures that the deliverables (planning and results reports and presentations) meet a minimum level of quality and is responsible for the final assessment of the team work competence of each team member.

The course professor determines the learning objectives to be targeted by the IP and incorporates them into the course guide. He/she also plans and schedules activities inside and outside the classroom to achieve the objectives of the IP. At the start of the semester, one classroom work session is set aside to ensure that the students understand the course objectives in the IP and identify the necessary tasks, integrating them into the planning report. During this process, the professor tutors and advises the students so that they reach the objectives, maintaining an open line of communication with the IP coordinator in the event of any incident affecting the progress of the project. The professor also continuously evaluates the progress of each IP from the point of view of his/her course. Professors have the opportunity to give their impressions of the performance and results of the IP, along with the rest of the professors for that academic year, in order to identify areas for improvement.

The project coordinator is responsible for writing the project course guide, which includes the plan for the activities to be carried out and the learning objectives of the courses involved. He/she also coordinates the faculty and student work teams, with their respective leaders. The coordinator periodically records the progress made on the project and is also a basic part of the assessment process, participating on the panels evaluating each project. Finally, he/she analyzes and assesses the performance and results of the IP, along with the professors for that academic year, in order to identify areas for improvement.

The professors of each year and the project coordinator decide on the topic of the IP and review the proposed schedule of activities. They also agree on the competences to be developed in the different courses and their assessment procedures in order to adequately distribute the volume of student work and avoid overload between the courses and the project. Each professor adds a description of the project to his/her course guide. Evaluation matrices designed by the Project Management Unit are used for assessment purposes.

The Interdisciplinary Project Management Unit is composed of all the IP coordinators from all the degree programs and years. It is responsible for establishing the academic foundations of the IP with regard to its approaches to competences, methodologies, assessments and organization.

CRITERIA	EXCELLENT	GOOD	SATISFACTORY	UNSATISFACTORY	SCORE
OBJECTIVES AND TASKS	The objectives and tasks required to carry out the project are very well identified. The tasks are correctly linked to the objectives.	The objectives are well-defined and, in general, the tasks identified are correct, although some adjustments are needed.	The project objectives have been determined, but the related tasks are not correctly identified.	Little effort has been made to identify the objectives. The tasks described are not complete enough to carry out the project and are not linked to the objectives.	30%
PROJECT PLANNING	The project is very well planned. It includes project milestones, tools to review the results and meetings to monitor and assess the project. Both the timing and the allocation of resources are very appropriate. Time has obviously been spent on project planning. A Gantt diagram is included.	The project reflects valid timing and resource allocation, but certain adjustments are needed with regard to time, volume of work and proportionality in order for it to be achievable. It is missing some project milestones, tools to review the results or meetings to monitor and assess the project. A Gantt diagram is included.	The project reflects a timing that is not realistic enough. Resources have not been equitably allocated in terms of time, volume or proportionality. There is a lack of coherence in project milestones and the dynamics of team work. A Gantt diagram has not been included or it is not well developed.	The project does not reflect adequate timing in order to achieve the objectives. Resource allocation is random (the criteria used for resource allocation are not clear). No project milestones, tools to review the results or meetings have been specified. No Gantt diagram is included.	30%
ORGANIZATION OF WORK	Details are provided on how the team will be organized, how members will communicate with one another and how documentation will be managed. Guidelines are also included specifying how the team will work and how specific situations will be dealt with.	Team organization, communication and documentation have been sufficiently well described. Certain basic guidelines for how the team will work are also included. No specific situations have been addressed.	The team organization, communication and documentation have been superficially described. Guidelines for how the team will work are not clearly described, and specific situations are not addressed.	There is not a sufficient description of how work will be done as a team, how team members will communicate with one another or how information will be organized. Furthermore, there are no clear guidelines for how the team will work and it is uncertain whether there are any specific cases.	30%
FORMAL PRESENTATION	Well done and visually attractive; original and innovative.	Carefully done and well constructed.	Acceptable presentation, but with no added value.	Careless presentation; not very attractive.	10%

Table 2. Evaluation matrix for the planning report

Evaluation was continuous, based on the monitoring of the progress of the project by the professors and the coordinator. In addition, the planning report, final technical report and oral presentation are also considered in the evaluation.

Each student receives a single project grade, which is the same for each of the courses involved, accounting for 25% of the final grade for each course. This grade reflects the level at which the specific and transversal competences associated with the project have been acquired; it consists of the sum of the grade obtained by the team and the individual grade. The grade is calculated each semester, based on the following indicators: planning report (10%), final report (40%), project presentation (15%), individual oral defense (15%) and individual process evaluation (20%). According to these percentages, students receive a team grade with a weight of 65% and an individual grade worth 35%.

CRITERIA	***EXCELLENT***	***GOOD***	***SATISFACTORY***	***UNSATISFACTORY***	***SCORE***
SEARCH FOR INFORMATION	*A thorough search for information has been conducted, and the best sources have been chosen. The consulted sources have been properly cited.*	*In general, an effort has been made to find materials, and they have been correctly selected. The sources are not cited.*	*While a noticeable effort has been made to find materials, those selected are not always the most appropriate.*	*Little effort has been made to find materials and few or no sources have been consulted.*	*10%*
CONTENT PREPARATION	*Content has been well prepared, meets the proposed requirements and its focus is original and innovative.*	*The content has been fairly well prepared and meets the proposed requirements.*	*The content is sufficient to meet the proposed requirements, but it provides no added value.*	*The content does not meet the proposed requirements and it is not well prepared or supported. It contains uncited material copied and pasted from the Internet.*	*35%*
DRAFTING OF THE CONCLUSIONS	*The work ends with a well-supported final conclusion that shows the depth of the students' reflection.*	*Conclusions are written and accompanied by a brief reflection.*	*The work ends with a brief conclusion, but it provides little added value to what has already been commented.*	*No conclusions have been included, or they are very poor and do not evidence any final reflection by the students.*	*35%*

Table 3. Evaluation matrix for the final report on the sections assessed by the professors

The planning report must include the purpose of the work, a description of the general and specific objectives that are to be achieved and the planning of the work in terms of deadlines and the division of tasks. The professors assess whether the project objectives, tasks and planning are adequate and the coordinator evaluates the organization of the work and the formal presentation. Table 2 shows the evaluation matrix used.

CRITERIA	EXCELLENT	GOOD	SATISFACTORY	UNSATISFACTORY	SCORE
PRELIMINARY PREPARATION	It is evident that preparation has gone into the presentation; the times of each part have been perfectly monitored and the resources available have been used wisely.	It is evident that preparation has gone into the presentation; the times of each part are fairly well monitored and the resources available have been used wisely, although some sort of improvisation is evident.	It is evident that preparation has gone into the content, but there is a great deal of improvisation during the presentation.	There has been no advanced preparation and the presentation contains conceptual errors.	15%
CONTENT DEVELOPMENT	The content has been well prepared, meets the proposed requirements and its focus is original and innovative.	The content has been fairly well prepared and meets the proposed requirements.	The content is sufficient to meet the proposed requirements, but it provides no added value.	The content does not meet the proposed requirements and it is not well prepared or supported.	35%
VISUAL AIDS	The visual aids used during the presentation are entirely appropriate for the speech given.	The visual aids used during the presentation are appropriate for the speech given, but other better aids could have been used to aid comprehension.	Even though the presentation is well organized, visual aids are not effectively used, either because there are too many or too few.	No visual aids accompany the presentation and the type of speech given requires them.	15%
ORAL LANGUAGE	Full communication is established with the audience members; the speech generates interest and engagement.	Gets the audience's attention, but there are some shortcomings in verbal fluency.	While the speech is more or less coherent, it does not engage an important part of the audience.	Boring, unengaging and there are shortcomings in oral expression.	20%
NON-VERBAL COMMUNICATION	The speech is accompanied perfectly by gestures, tone, proxemics (use of space) and facial expressions.	Most of the time, the speech is accompanied by gestures, tone, proxemics (use of space) and facial expressions.	Acceptable use of non-verbal communication, but with no added value.	The oral speech is not accompanied by any non-verbal components whatsoever, resulting in monotony, a lack of involvement and the disengagement of audience members.	20%

Table 4. Evaluation matrix for oral presentations

Special care must be taken with both the partial and final technical reports to ensure that they follow the format specified in the style guide established at our university. These reports must include a description of the interdisciplinary work carried out, the results and the conclusions that justify having reached the overall or partial objectives defined in the different IP activities. The professors assess the search for and management of information, the content and the conclusions, while the coordinator once again assesses time management and the formal presentation (Table 3).

The students orally present and defend the work that has been carried out. All team members must participate in the oral presentation, which is to be supported with visual aids. During the presentation, the preliminary preparation, development of the content, graphic elements, oral language and non-verbal communication are assessed. In addition, the students are asked questions to obtain an individual assessment of the defence of their work. The project coordinator and at least two professors participate in this assessment. Table 4 shows the evaluation matrix used to assess the oral presentation.

Finally, the students, the coordinator and the professors participate in an individual evaluation of the process, based on all of the evidence gathered during the process of carrying out the project (attendance at training seminars, the minutes of meetings, peer assessment and class attendance and participation, as well as the coordinator's and professors' monitoring reports).

Important dates	***Description***
Week 1	*Presentation of the project*
Week 2	*Comments on the planning report*
Week 3	*Submission of the planning report*
Weeks 4-6	*Written communication workshops*
Week 8	*Peer assessment (qualitative)*
Week 11	*Oral communication workshop*
Week 12	*Comments on the final report*
Week 13	*Submission of the final report*
Week 14	*Peer assessment*
Week 15	*Oral presentation and defense*

Table 5. Sequence of the important dates in the integrated project

At the start of the academic year, the students have all the information available that will help them carry out the IP: guide for writing the planning report, model for writing minutes of the meetings, guide for managing the meetings, instructions for combining documents with PDFCreator, guide for presenting work, guide to the final report and instructions on peer assessment. In addition, they have a calendar that indicates the most important dates for completing the project (Table 5).

In order to evaluate the students' perception of the IP, a survey was administered, divided into five basic areas: objective, methodology, assessment, student assistance and overall evaluation. The objective section contains five questions: does it improve your education?, does it develop competences and attitudes for your professional future?, does it promote the connection with the present socioeconomic environment?, does it complement your personal development and does it make your learning process more attractive?. The methodology section refers to the presentation session, the course guide, the training seminars, the correct use of contact time in the classroom, the volume of work and study materials. The assessment section addresses knowledge of the assessment criteria, the relationship between assessment and the degree to which the competences are acquired and monitoring by the coordinator and the professors. The student assistance section focuses on the assistance provided by the coordinator. Finally, a question was asked aimed at the overall evaluation of the IP.

3 RESULTS

The IP was intended to promote transversal competences in students and to motivate them in their engineering studies. However, during the first year in which the project was implemented, the evaluations from the students were quite low in the Mechanical Engineering degree (Table 6). The overall score of 3.9 out of 10 and several comments indicating that the IP should be eliminated as a teaching methodology caused a great deal of concern among the faculty members participating in the project.

Academic year	***2010-11***		***2011-12***		***2012-13***		***2013-14***	
Degree in	***ME***	***EE***	***ME***	***EE***	***ME***	***EE***	***ME***	***EE***
Objectives of the integrated project	*4.6*	*6.6*	*5.3*	*4.6*	*6.4*	*6.3*	*5.0*	*8.6*
Methodology	*4.5*	*6.0*	*4.8*	*5.2*	*6.0*	*6.1*	*5.1*	*8.5*
Assessment	*5.3*	*6.5*	*5.5*	*6.4*	*6.5*	*6.9*	*5.6*	*8.5*
Student relations and assistance	*8.0*	*8.2*	*5.5*	*6.5*	6.2	*7.2*	*5.6*	*8.1*
Overall evaluation	*3.9*	*7.3*	*6.1*	*7.9*	*6.4*	*7.7*	*6.5*	*8.6*

Table 6. Evaluation of the integrated project in the first year of Mechanical Engineering

The reasons for the poor acceptance of the IP among the first year Mechanical Engineering students were analyzed:

- Interdisciplinary projects had previously been conducted among some of the courses in the Electronic Engineering and Automation degree program, and therefore the faculty had a certain level of experience with them (López et al., 2008). On the contrary, in the ME degree program, this was the first time that a project of this scale had been undertaken. Furthermore, the number of students enrolled in ME is twice that of those in EE.
- The work proposed involved carrying out several activities focused on a common theme, but this was not a project that involved several or all of the courses.
- In some courses, the IP activities began at the end of the semester, thus resulting in an overload of work at the end. Students were required to carry out the IP activities, write the technical report and prepare for the written exams during the last weeks of the course.
- Depending on the involvement of the professor in the IP, the project limit of 25% of the course workload was not always followed.
- In some cases, the contents studied in the IP were repeated in other areas, through other types of activities, creating an excessive volume of work for the students.
- The work was not divided evenly by the students, and those who were more responsible failed to see this reflected in their final project grade.

Due to the novelty of the IP, the leader was a student in the last year of the Industrial Engineering program who had no experience in projects on this scale. There is little doubt that a misconception existed on the part of the project coordinator, who believed that since these students were about to finish the degree and were therefore prepared and experienced in both the content and team work, they would be perfectly capable of playing a leadership role with first-year students. This led to a certain relaxation in the monitoring and follow up of the work performed by these leaders, and as a result, negative results in terms of the initial expectations.

Thanks to the experience gained during these first few years, a series of improvements have been implemented in how the project is conducted. Consequently, progress has been made as compared to the start of the project in terms of the students' evaluations in the ME degree, as well as a progressive improvement in the evaluations from the students in the EE degree (Table 6).

Generally speaking, the measures proposed to improve the students' evaluation of the IP have been the following:

- Relations among the professors have been strengthened in order to share experiences and better coordinate the different IP activities.
- During the 2012-2013 and 2013-14 academic years, an activity was proposed that encompassed almost every course in the degree program. This made it possible to engage in interdisciplinary work, which was precisely the objective of the project (Table 7).
- The course guide includes a section on the interdisciplinary project where the professor must state the activities that the students must complete, as well as their scheduling (Table 8).
- The Management Unit and project coordinator periodically insist on the importance of the IP in the teaching methodology. This results in greater involvement of the professors, who tend to abide by the project limit of 25% of the course workload.
- It was indicated at different faculty meetings that the contents studied in the IP must be assessed and graded only as part of the project.
- The coordinator, students and professors participate in individual assessments that produce an individual grade for each student, worth 35% of the final assessment for the IP.
- Since there were no students with experience in conducting IPs, it was decided that during the 2011-12 and 2012-13 academic years, there would be no leader, and instead an attempt was made to identify a leader in each group using the Belbin test. However, in the 2013-14 academic year, this role was introduced, this time with a student who had experience with interdisciplinary projects. This new leader has contributed experience to the group in terms of organization, responsibility and oral presentations.

Of all the measures taken, we believe the fact that we are working in all the courses based on a common activity to be of great importance. Specifically, during the first semester we succeeded in involving all the courses with a single activity: a kinematic analysis of a cylindrical robot arm under specific operating conditions. This activity specifically addressed the Physics (PHY) and Mathematics (MAT) courses. In addition, the students were asked to draw the structure of the robot and all its trajectories in AUTOCAD, which involved the Graphic Expression (GRA) course. In order to produce the drawing of the trajectories, students needed to obtain a matrix of the positions, which was created in Excel in the Applied Computing (AC) course. Finally, the students created a program in C++ to automatically produce the results calculated in the kinematic analysis of the robot; this programming language is studied in the Computing course (COM). The specific aim of this project is focused on the kinematic analysis of a cylindrical robot from its initial position A until it returns to this same position after having picked up a part at point P and deposited it at another point Q in an optimal amount of time (the speed of each stage must be minimal). In order to change the instructions each year, the combined movement of two of the three degrees of freedom (extension, rotation and elevation) is required. Different tasks are included that the students must perform in order to correctly complete the IP. Each task involves a course whose professor supervises the work of the students (Table 7).

Week	Educational activities	Student tasks	Course
1	Presentation of the project	Taking a Belbin test to form the groups	IP
2	Problem approach	Identifying variables and data and defining the different stages of the movement	PHY
3	Coordinate systems	Using the proper coordinates to correctly complete the exercise	MAT
4	System of equations	Obtaining the system of equations to solve the problem	PHY
5	Technical report	Writing the planning report	IP
5	Graphic representation	Orthographic projection of different types of robots	GRA
6	C programming	Creating basic functions in C	COM
6	Solving systems	Obtaining the functions that make it possible to calculate the variables of a problem	MAT
7	Work with Excel	Creating tables in Excel in order to obtain the variables	AC
7	C programming	Programming the structure without the functions to be implemented	COM
8	Work with Excel	Representing the robot movements in graphic form	AC
9	Graphic representation	Representing the location of the robot in different spaces	GRA
9	C programming	Implementing the functions in the C program	COM
10	Analysis of the results	Extracting information from the results obtained	PHY-MAT
10	Text editor	Using the equation editor in the technical report	AC
11	Graphic representation	Creating an orthogonal and isometric exploded drawing of the robot	GRA
12	Graphic representation	Using Inventor to create a graphic representation of the robot's movements	GRA
13	Presentation editor	Creating transparencies to explain the work carried out	AC
14	Written expression	Writing the technical report	All
15	Oral expression	Oral presentation of the work carried out	All

Table 7. Activities and tasks proposed for the entire integrated project "Kinematic analysis of a cylindrical robot arm"

Week	Educational activities	Student tasks
1	Presentation of the project	Presentation on how the project is related to the course.
2 and 3	Use of chemistry in robotics. Applications in robot operations	Brainstorming (creativity). Information search and exchange in class groups. Afterwards, each group writes a memorandum (guidelines, recommendations, etc. for how to approach the chemistry plan). Each group hands in the memorandum to the professor.
5 and 6	What to do in a power outage. Designing a battery	
7 and 8	Producing a battery	The correct response to a power outage to prevent computer memory loss of information. The power needed to operate a computer. Identifying and interpreting the components of a redox reaction and how to adjust it. Determining an ordered sequence of the concepts applied.
9 and 10	What to do at the end of a robot's service life	Proposing a battery model and building it in a chemistry laboratory session, writing a final report at the end. How the different battery components should be recycled, developing a study of them. Conducting a study of their environmental impact and how to reduce it, establishing an action plan.

Table 8. Example of the assignment of activities and tasks in the Chemistry course as part of the IP, as it would appear in the course guide

During the 2013-14 academic year, a setback occurred in the evaluation of the objectives, methodology and assessment, as well as in student relations and assistance in the ME degree; however, the overall evaluation in that degree remained the same. Analyzing this academic year in detail, the conclusion was reached that the temporary leave of absence taken by the coordinator for health reasons may have been the cause of the lower evaluation scores. This conclusion was drawn based on interviews with students who confirmed a certain lack of guidance and monitoring of their work. It should be kept in mind that these are first-year students, and not only is the IP new to them, so is the entire university methodology. In this aspect, the importance of the project coordinator is evident, as this person provides the students with a global vision of the project.

Even though the trend is towards improvement, certain recurring problems from previous years can still be observed in some courses, such as the fact that the classroom sessions dedicated to the IP continue to account for less than 25%.

4 CONCLUSIONS

The improvements in the IP have resulted from better coordination among the faculty members. In general, they have consisted in defining a series of activities that are common to several courses, where each course is dedicated to a specific part of the project. This gives the students a more global vision of the research work. During the first semester, all courses successfully shared a single activity within the IP. In the future, the goal is for all of the first-year courses to work on a single activity and to extend this to later years. This new vision of the IP, in which the proposed activities are interrelated among the different courses, has generated increased interest in the more applied part of the courses among the students. In addition, it has facilitated a more socialized learning of the contents, creating multiple visions and perceptions of the same problem. Thus, by performing this series of collaborative activities, better communication was achieved between students and professors, while at the same time fostering independence by means of autonomous learning and the distribution of group time.

The experience of working on the IP over these four years, from 2010-11 to 2013-14, has enabled us to identify the following considerations to improve the quality of the project and increase student interest:

- The interdisciplinary project, which was initially carried out as an incentive for students to study, can backfire if not properly managed and implemented.
- Introducing all the courses in the development of an interdisciplinary project is quite complicated and requires the involvement and experience of all faculty members.
- To attain greater motivation among the students, it is a recommended that the courses involved in the IP work in a coordinated manner on a single activity.
- Faculty members must indicate in the course guide the work to be carried out in the IP, which must be communicated to the students from the start of the year, because otherwise this has an influence on the students' planning.
- The course workload of the IP must be followed and the contents studied in the IP must be assessed only within the context of the project itself.
- It is necessary to perform an individual evaluation and grading procedure separate from that of the group to prevent a lack of participation and involvement of certain members in the IP activities.
- In cases where a leader (a student in his/her final year of studies) participates in the IP, this student must have prior experience; otherwise, it is recommended to not use this role.
- The job of the project coordinator is very important for the progress of the IP. The support of a substitute coordinator must be available so that in the event of a temporary absence of the coordinator, the students still receive continuous support.

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