

INTEGRATED LEARNING OF COMPUTER APPLICATIONS FOR PRODUCTION ENGINEERING

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"It's important not to confuse being rational with being reasonable. Through rationality we try to understand things in order to better understand how to deal with them. Through being reasonable we try to communicate with each other better, so as to find the best way of living together humanely. Rationality is scientific whilst, in general, being reasonable isn't and can't be: it's not the same dealing with things (that only have intellectual properties) as dealing with people (with and for whom you have relationships and emotions)."

Fernando Savater

Abstract

A high productivity rate in Engineering is related to an efficient management of the flow of the large quantities of information and associated decision making activities that are consubstantial to the Engineering processes both in design and production contexts. Dealing with such problems from an integrated point of view and mimicking real scenarios is not given much attention in Engineering degrees. In the context of Engineering Education, there are a number of courses designed for developing specific competencies, as required by the academic curricula, but not that many in which integration competencies are the main target. In this paper, a course devoted to that aim is discussed. The course is taught in a Marine Engineering degree but the philosophy could be used in any Engineering field. All the lessons are given in a computer room in which every student can use each all the treated software applications. The first part of the course is dedicated to Project Management: the students acquire skills in defining, using Ms-PROJECT, the work breakdown structure (WBS), and the organization breakdown structure (OBS) in Engineering projects, through a series of examples of increasing complexity, ending up with the case of vessel construction. The second part of the course is dedicated to the use of a database manager, Ms-ACCESS, for managing production related information. A series of increasing complexity examples is treated ending up with the management of the pipe database of a real vessel. This database consists of a few thousand of pipes, for which a production timing frame is defined, which connects this part of the course with the first one. Finally, the third part of the course is devoted to the work with FORAN, an Engineering Production package of widespread use in the shipbuilding industry. With this package, the frames and plates where all the outfitting will be carried out are defined through cooperative work by the students, working simultaneously in the same 3D model. In the paper, specific details about the learning process are given. Surveys have been posed to the students in order to get feed-back from their experience as well as to assess their satisfaction with the learning process. Results from these surveys are discussed in the paper.

Keywords: project management, database, production engineering, product data model, mind map.

1 INTRODUCTION

In the professional activities posterior to graduation, productivity becomes a central aspect and a high productivity rate is related with a proper management of the flow of the large quantities of information and related decision making that are consubstantial to the Engineering processes both in design and production activities. Dealing with such problems from an integrated point of view and mimicking real scenarios is not given much attention in Engineering degrees. The reason for such neglect lies on the difficulties for reproducing, in learning environments, the aforementioned information flows. This is reflected in reference [8] where the software used in an Engineerign Degree is discussed, and it turns out that none related to Production Engineering is considered.

In the context of Engineering Education, there are a number of courses designed for developing specific competencies, as required by the academic curricula, but not that many in which integration competencies are the main target. An example of such an approach is discussed in reference [18], where integrated teaching in the context of manufacturing processes is implemented. In our course, the approach is devoted to Production Engineering activities, more specifically it is taught in a Marine Engineering degree. The integration is manifested as well in that the same engineering product (a concrete ship in this case) is treated in the different parts of the course from the appropriate points of view and massive information management software applications. A similar approach can be found for instance in references [5,6,15] where a specific design is treated from the point of view of a range for particular branches of academic curriculum. There is nonetheless a fundamental difference with respect to the present approach. Our aim is to present integration from the point of view of production strategies and information flow; in references [5,6,15] the integration is referred to the technical part of the design process.

The first part of that course is dedicated to Project Management. The students acquire skills in defining, using Ms-PROJECT [9], the work breakdown structure (WBS), and the organization breakdown structure (OBS) in engineering projects, through a series of examples of increasing complexity, ending up with the case of vessel construction. Project management teaching has received significant attention in the literature. An experience of learning Project Management in an Engineering degree through working for real clients has been documented in reference [2]. Their emphasis in presenting problems linked to real world company activities is shared by our approach.

The second part of the course is dedicated to the use of a database manager, Ms-ACCESS [9], for managing production related information. A series of increasing complexity examples is treated ending up with the elaboration of the pipe database of a real vessel, specifically, the one for which the construction plan has been previously devised. This database consists of a few thousand of pipes, for which a production timing frame is defined, which connects this part of the course with the first one.

Finally, the third part of the course is devoted to the work with FORAN, an Engineering Production package of widespread use in the shipbuilding industry [14]. With this package, samples of the piping definition, from functional systems drafts, is carried out by the students, thus providing the information for the piping database. The approach is analogous to the Knowledge-Based Engineering (KBE) one, as discussed in reference [1], where a virtual model is created which incorporates not only geometrical but material and construction characteristics.

Experts from the three fields turn up for specific parts of the course, incorporating their experience not by descriptive speeches but by guiding the students through the work in the computer with exercises and real world cases.

The paper is organized as follows: the course structure is first discussed, describing the methodology used in the three parts. Following, the assessment of the course is treated, covering the assessment of the students' work and the results of both an institutional and an internal survey. Finally, some conclusions and future work threads are summarized.

2 COURSE STRUCTURE

2.1 General

The course is taught with an optional character within the Marine Engineering degree offered by the Technical University of Madrid (UPM) in Spain. The name of the course is "Information Technologies Applied to Shipbuilding (TICN)" and the course takes a maximum 60 face-to-face hours. The third edition of the course is ongoing at the moment of the submittance of this paper. The venue where it is taught is a 15 places computers room. Although the group size is limited by the room size, a 15 people group we consider has a reasonable size for a good interactive atmosphere during the lessons. The enrollment has been complete for the three editions of the course which is a significant achievement due to the large offer of optional courses within the degree. As mentioned in the introduction, the course presents an integrated vision of Production Engineering for Shipbuilding relying on problem based learning methodologies both in Project Management, Databases and Product Model for Detail Engineering.

2.2 Project Management (PM)

Project Management (PM) is a central part in the professional activities of many engineers, regardless of the specific sector where they work. Due to this reason, this part is the one to which more effort is dedicated during the course, compared to the other two. This part of the course starts presenting mind maps [4] as a tool for initial planning activities. MINDMANAGER is the software application used for this purpose [10]. Increasing complexity projects are discussed: building a bookcase, refurbishing a kitchen, organizing a multimedia classroom and building a garden are the selected applications. A tentative work breakdown structure (WBS) of these projects is carried out using MIND MANAGER. In figure 1 a mind map of the WBS of the multimedia classroom project is presented as a sample of the type of WBS the students deal with.

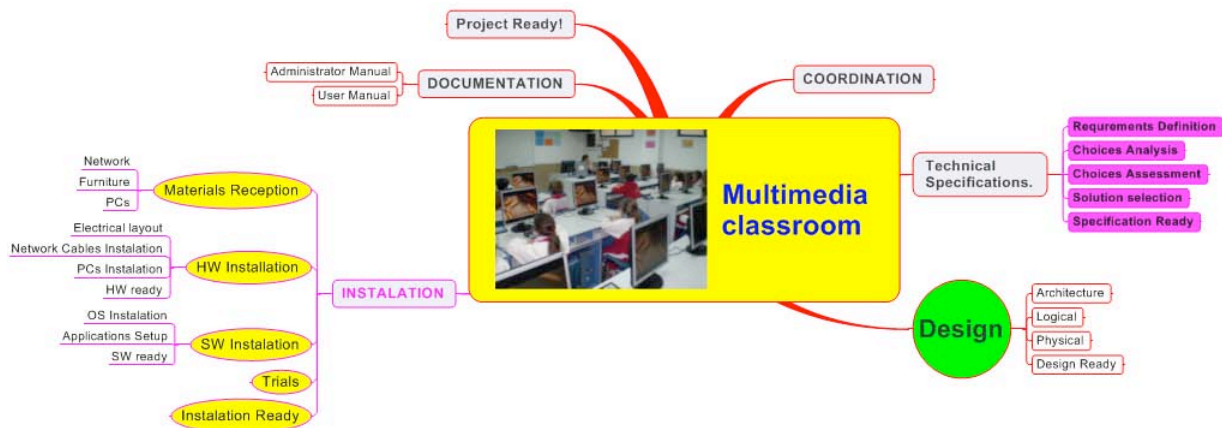


Figure 1: Multimedia classroom WBS mind map.

The WBS is exported directly into Ms-PROJECT in order to establish the relationships between the tasks and in order to assign the resources. Resources assignment techniques based on work and measurements are covered. Some simulations regarding the monitoring of the project during its lifetime are also performed. Finally, combined projects using a common resources pool are covered.

During this process, the humanistic components of Project Management are highlighted. Managing projects requires not only making rational but also reasonable decisions, in which interpersonal relationships, negotiation capabilities and other humanistic issues are often more relevant than pure technical arguments. We agree with Prof. Nussbaum [12] that human values are extremely important in the education of our students; the intricacies of project planning require working on issues like empathy, knowledge of the other, etc...

In order to integrate the skills acquired and to apply them in the shipbuilding context, an exercise focusing on the planning of the construction of a ship is undertaken. The references that can be used for shipbuilding construction project management teaching are scarce. Iglesias-Baniela in reference [7] relies on his experience as planning manager of Gondán Shipyards in Spain to write an interesting manual on the topic, which has served as relevant reference in the course for the lecturers. The reference has nonetheless been provided to the students once the course was finished since we were interested in promoting the development of original ideas from the students in undertaking the ship construction plan, starting from those acquired through the aforementioned examples.

Taking advantage of the classroom setup (matrix of 5x3 places), 5 groups of 3 people are formed and a script with the exercise is provided to each group. Cooperative approach to project planning seems a sensible approach to project management learning, as recommended in reference [11]. The information made available to the students consists of a basic engineering project of a ship, taken from the database of diplom works from previous academic years, which in our faculty consist on the basic engineering project of a vessel. The information is organized in a series of documents, and the students peep over them in order to select those that are relevant for the planning: general arrangement, weights, machinery and budget documents are the ones to take into account. Some indications regarding the shipyard where the ship would be built are given, comprising the cranes capabilities, drydocks, etc...

The problem based learning (PBL) approach is used with all its intensity in this exercise, where the students are free to take the decisions they believe more convenient for delivering the ship within a certain limit date. They are asked to present their work in a slide based presentation which must

comprise at least a blocks erection diagram, like that of figure 2, which corresponds to the general arrangement of figure 3, a WBS mind map like that of figure 4 and a Gantt diagram like the one of figure 5. The latter is presented in order to show the complexity of the tasks that the students are able to manage, and not to specifically highlight any aspects of the planing, which are covered specifically by other references (see e.g. [7]).

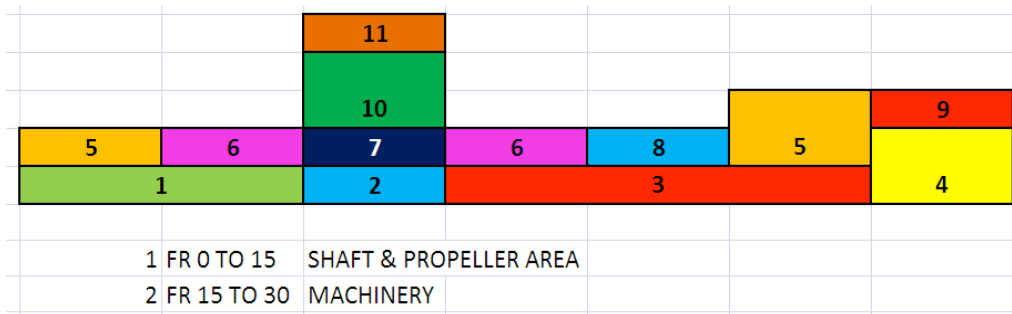


Figure 2: Erection diagram example solution for the proposed exercise

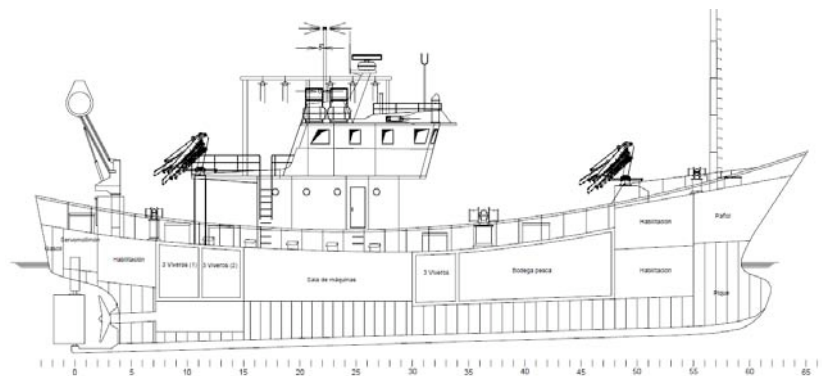


Figure 3: General arrangement plan provided for the proposed exercise



Figure 4: Mind map for the vessel plan exercise.

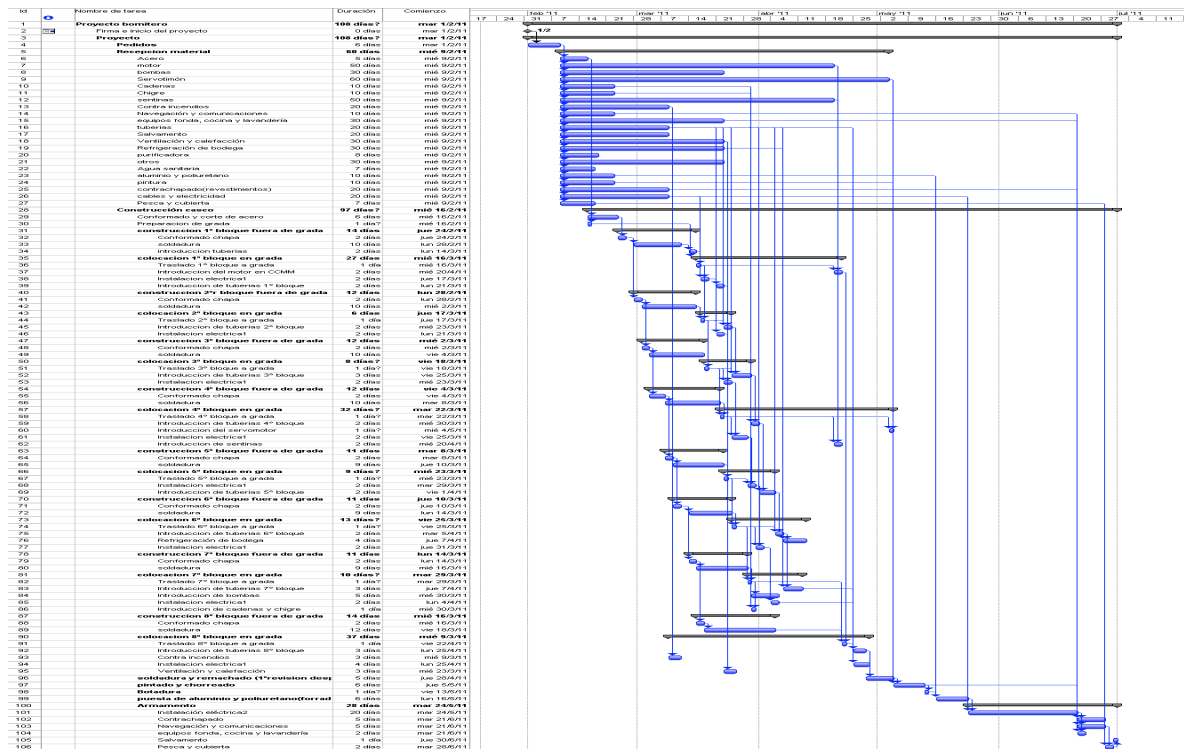


Figure 5: Gantt chart to the vessel plan exercise.

2.3 Databases (DB)

With the project planning the students acquire skills in establishing the necessary tasks to undertake a complex engineering project. They also get the understanding that each of these tasks consists of a tremendous amount of tiny operations which have to be organized specifically at more basic management level (plates, pipes, electrical and insulation elements, etc....) In order to organize these operations it is made evident to the students that more powerful tools than MS-PROJECT for treating information are needed. The most powerful tool for treating information at their disposal is a spread sheet manager, mainly EXCEL. It becomes necessary to present the database technologies as something different and to show them that EXCEL is not enough for treating such an amount of information with the required safety and efficiency.

Once, after some discussions, this intuition is acquired, managing database skills are the next learning target. The teaching of databases to Engineering students at the undergraduate level has proven challenging for multiple reasons [16,17]. These courses are usually taught in computer science degrees, where the students are used to the concepts that are consubstantial to databases and to a level of abstraction for which the Engineering students are not trained. In addition, Engineering students prefer the problem-solving, hands-on, and project-based method of learning over the coverage of database design concepts. For these reasons, again the PBL methodology is applied, presenting the ideas starting from a simple database, which stores main dimensions of some ships to finally being able of managing a database of 5000 pipes of a real vessel. For this database, for which the relationships are presented in figure 6, queries and reports are carried out, considering information needed by the production department, by the shipyard store, by the purchasing department, etc..

2.4 Detail Engineering information generation (DEIG).

Finally, the third part of the course is devoted to the work with FORAN, an Engineering Production package of widespread use in the shipbuilding industry [14]. The motivation for this part arises from questioning how the information for the huge pipe database is generated from the Basic Project in the ship building exercise and how is later managed to organize the database which has been previously discussed. With FORAN, the frames and plates where all the outfitting will be carried out are defined

with all detail through cooperative work by the students, working in the same 3D model (figure 7). The approach is analogous to the Knowledge-Based Engineering (KBE) one, as discussed in reference [1], where a virtual model is created which incorporates not only geometrical but material and construction characteristics.

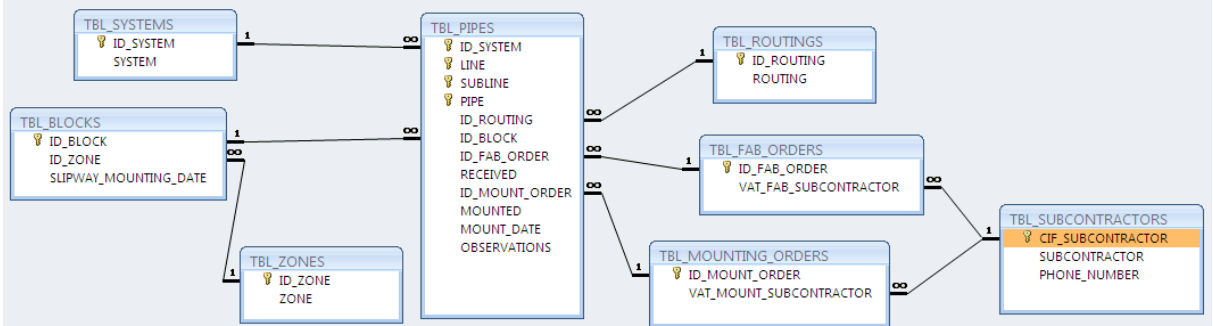


Figure 6: Piping database relationships

FORAN module for frame definition is called FHULL. FORAN licensing policy is quite restrictive; setting up the software locally at the faculty computers has proven to be so complicated that it has become basically unfeasible. Due to this reason, a sophisticated solution has been used. The software is run in remote mode at SENER servers in the company headquarters, using a CITRIX technology web application [3]. This, in addition, facilitates that the students can work simultaneously in the same geometrical model, thus mimicking the real world scenarios in modern detail Engineering technologies. Every student carries out the definition of a transversal frame placed at a specific longitudinal location, with the corresponding holes for longitudinal stiffeners (figure 7). A list of elements is exported, that can be read directly by MS-ACCESS in order to feed the database. Actually, the FORAN engine is ORACLE based [13]. Piping definition is significantly more complex than frame definition and due to time restrictions has not yet been implemented.

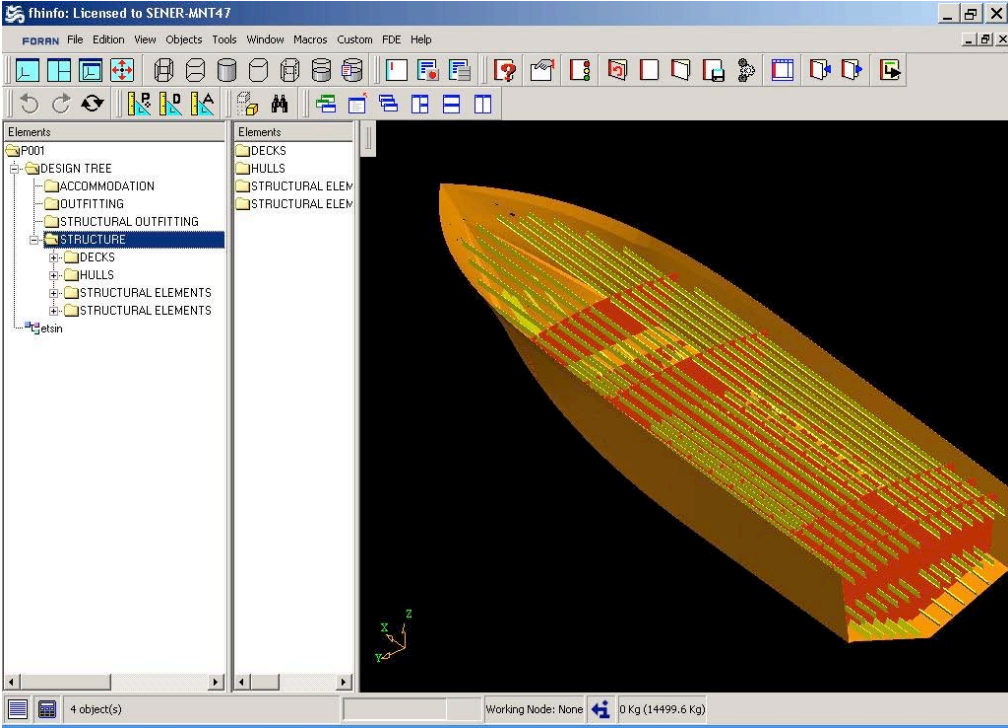


Figure 7: FORAN FHULL module frame definition

3 ASSESSMENT

3.1 General

Three levels of assessment are considered. First, the students work assessment is briefly described; second the teaching/learning process is assessed by an institutional survey (for us, it is an external assessment) and third, we ourselves conduct an internal survey, which targets specific aspects of the course. The outcomes of these assessments are presented in the following sections.

3.2 Students' work assessment

Assessing the work of our students is in our opinion a fundamental part of education. As mentioned in section 2.1, the present course has an optional character. It is well known that success rates in optional courses are close to 100% in the Spanish university degrees. On top of this, the offer of optional courses is large in our faculty. It is easy to deduce that if a course is offered with a history of low success rates, the enrolment will be pretty limited and eventually the course may not have enough students to be taught. Therefore, the success rate has to be high and we have to design an itinerary that allows achieving the course objectives while guaranteeing high success rates.

For us, as lecturers, the main target is that the students are active and learning through the face-to-face lessons. This is achieved by setting up the course so that students are receiving just a few tips and then all the process is hands on the computer, either following the elaboration of a specific example by the professor, either doing an exercise themselves.

Since the face-to-face lessons are the center of the course, the attendance is compulsory. If an attendance rate of at least 85% is not met, the student fails the course. Once this attendance is met, if the student is active in the classroom (and from our experience they all are), then the success is guaranteed. The specific marks are high, because that is appreciated by the students in a degree where marks are usually very low. To illustrate the view of the students about this procedure, we quote one comment from one student in the internal survey: *"This course would be passed by a mushroom in front of the computer. Sure yes. But the best thing is that the mushroom would get a 90% mark and would be capable at the end of the course of managing a database and planing a project."*

Summarizing, the academic success rates have been 100% in the 3 editions of the course. The enrolment has been 100% in the 1st and 3rd editions and 87% in the second where two students dropped due to schedules' lack of compatibility, once the course timetable was established.

3.3 Institutional survey

UPM started in 2009 the DOCENTIA program, aiming at assessing the staff teaching activities as one important step forward in the adaptation process to the European Higher Education Area (EHEA). One of the actions was to offer to the academic staff the possibility of having the teaching activity assessed and more specifically, to conduct surveys to the students related to every course. We decided to have the present course surveyed and the results are now presented. The marks are over 5 points maximum, and we are provided our own marks together with the average marks and standard deviations of all the surveys in our own faculty, the Naval Architecture Department (ETSIN). The questions target on one side the course and on the other the lecturers activity. We present in table 1 the questions that have assessed the course, our course mark (TICN column), the faculty average one (MEAN column), and the quantile, assuming a Gaussian distribution in which the course ranks (BEST %). It is relevant to highlight that the course marks are close to the maximum value in all the questions, and ranks always between the 20% highest marks for all the questions.

Question 1 indicates that the students think that the teaching methodology is appropriate for the goals. Question 2 shows that the contents taught in the course, focusing on Production Engineering Information flows, do not overlap with other courses in the degree which is a salient conclusion. Question 6 informs us that the students think the assessment procedure is in accordance with the type of tasks that are undertaken in the course. Summarizing, we think the results are good.

This survey is important for us since it is an external assessment that can be presented officially to report the student's opinion regarding the course. Internal survey

Apart from the external survey, we conduct an internal online survey, with 50 questions covering a wide range of topics. The survey is carried out online using an html file that creates, using a cgi little application, an ASCII file with the answers of all the students. The survey is anonymous, but the ids of

the persons that have completed it are stored independently in order to later apply the corresponding mark plus, which amounts to 5% of the mark. The most relevant results of this survey focusing on the issues treated in this paper are presented in table 2 and thereafter discussed.

| | Question | TICN | MEAN | BEST % |
|---|---|------|------|--------|
| 1 | The tasks (theory, practical, individual, team, etc.) are connected with the teaching activity goals. | 4.62 | 3.55 | 17 |
| 2 | In the development of this teaching activity there is no overlap with other teaching activities contents. | 4.69 | 3.48 | 13 |
| 3 | Theoretical and practical tasks are adequately coordinated. | 4.62 | 3.30 | 13 |
| 4 | The volume of contents and tasks within this teaching activity is proportional to its credits.. | 4.62 | 3.10 | 12 |
| 5 | The effort required is in accordance with that documented in the program. | 4.69 | 3.11 | 10 |
| 6 | The assessment is in accordance with the type of tasks. | 4.77 | 3.35 | 12 |
| 7 | I have improved my departure level, in relation to the course competences. | 4.54 | 3.33 | 16 |

Table 1: Institutional survey results.

| | Question | |
|----|--|---------|
| 1 | Has this course (TICN) helped in your relating productivity and information technologies (IT)? | 1/1 |
| 2 | In how many courses that relationship has been fostered with more strength than in TICN? | 0 (all) |
| 3 | Do you think TICN is well structured, with the 3 parts PM, DB & DEIG? | 1/1 |
| 4 | After taking the course, the importance of the relation between the 3 parts is clearer for you? | 0.92/1 |
| 5 | Do you think the exercise of planing a ship construction allows the integration of the skills acquired during the PM part of the course? | 1/1 |
| 6 | Do you think the exercise of managing a DB of pipes of a real ship allows the integration of the skills acquired during the DB part of the course? | 1/1 |
| 7 | Do you think the exercise of defining the frames of a real ship allows the integration of the skills acquired during the DEIG part of the course? | 0.92/1 |
| 8 | Do you think TICN is methodologically, radically different from most other courses in the degree? | 0.85/1 |
| 9 | Do you think the methodology (practical lessons with classroom work based assessment and compulsory attendance) facilitates achieving the goals of the course? | 1/1 |
| 10 | We try in the course of mimicking real world scenarios and solutions. Have you had this impression during its development? | 1/1 |
| 11 | Would you recommend this course to a colleague? | 1/1 |

Table 2: Internal survey results.

From the questions/answers in table 2, it becomes apparent that the relationships between IT and productivity has been made patent with this course more than in any other course in the degree. Also, the connections between the 3 parts of the course are patent for the students after taking the course. The main activities in the three parts seem to be useful to assimilate the main ideas. Also, the methodology used in the course is seen by the students as radically different from most of the other courses in the degree and that it facilitates achieving the goals of the course. Another important outcome of the course is that the students get the impression of learning in a real world environment and that they would recommend the course to a colleague, thus meaning that the global impression got from the course is positive.

4 CONCLUSIONS

A course devoted to developing integration competencies in the context of Production Engineering by linking productivity with the management of huge amount of information flows is described in this paper. The first part of the course is dedicated to Project Management: the students acquire skills in defining, using Ms-PROJECT, the work breakdown structure (WBS), and the organization breakdown structure (OBS) in Engineering projects, through a series of examples of increasing complexity, ending up with the case of vessel construction. The second part of the course is dedicated to the use of a database manager, Ms-ACCESS, for managing production related information. A series of increasing complexity examples is treated ending up with the elaboration of the pipe database of a real vessel. This database consists of a few thousand of pipes, for which a production timing frame is defined,

which connects this part of the course with the first one. Finally, the third part of the course is devoted to the work with FORAN, a Detail Engineering Production package of widespread use in shipbuilding industry. With this software, the frames and plates where all the outfitting will be installed are defined through cooperative work by the students, working simultaneously in the same 3D model.

Surveys have been posed to the students in order to get feed-back from their experience as well as to assess their satisfaction with the learning process. Results from these surveys show that the students think the methodology fosters the acquisition of the goals of the course.

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