*International Journal of Engineering Education* Vol. 29, No. 6, pp. 1400–1409, 2013
Printed in Great Britain

0949-149X/91 $3.00+0.00


# Integrated Learning of Production Engineering Software Applications in a Shipbuilding Context*

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A course focused on the acquisition of integration competencies in ship production engineering, organized in collaboration with selected industry partners, is presented 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 with the final one being the construction planning of a vessel. The second part of the course is dedicated to the use of a database manager, MS-ACCESS, in managing production related information. A series of increasing complexity examples is treated, the final one being the management of the piping database of a real vessel. This database consists of several thousand pipes, for which a production timing frame is defined connecting this part of the course with the first one. Finally, the third part of the course is devoted to working with FORAN, an Engineering Production application developed by SENER and widely used in the shipbuilding industry. With this application, the structural elements where all the outfittings will be located are defined through cooperative work by the students, working simultaneously in the same 3D model. In this paper, specific details about the learning process are given. Surveys have been posed to the students in order to get feedback from their experience as well as to assess their satisfaction with the learning process, compared to more traditional ones. Results from these surveys are discussed in the paper.

**Keywords:** project management; database, production engineering; mind map; FORAN; MS-ACCESS; MS-PROJECT; erection diagram; ship production.

## 1. Introduction

There is an ongoing change of paradigm in the way humans relate to computers: as computers are able to carry out activities of increasing complexity, humans have to acquire more competencies in working with them if they want to get the most from this interaction. This acquisition has become a relevant goal in Education. More specifically, the integration of the teaching of software applications within Higher Education arises from this evolution; this is reflected in its increasing added value in university curricula [12].

In a post-graduation and professional environment, productivity becomes a central aspect. A high productivity rate is linked with a proper management of the flow of large quantities of information and related decision making activities inherent to the Engineering processes both in design and more importantly in production activities. Dealing with such problems from an integrated point of view and replicating real scenarios may not be given enough attention in engineering degrees. This lack of attention within learning environments may arise from the difficulties in replicating the real scenarios that take place in engineering processes. This problem is reflected in reference [11] where the software applications used in an Engineering Degree are discussed, revealing that none of these applications relate to Production Engineering and mainly focus on the Design phase.

In the context of Engineering Education, there are a number of courses designed to develop specific competencies, as required by the academic curricula, but not that many in which the integration competencies are the main target. An example of



* Accepted 11 March 2013.

such an approach is discussed in reference [22], 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 Naval Architecture degree. An integration approach can be carried out by treating the same engineering product (a vessel in our case) from several points of view using the appropriate software applications. This integrated approach for teaching IT applications has been found convenient, as documented in reference [10] where it was demonstrated that the teaching of related IT applications in a single module provided better outcomes than separately incorporating the applications into isolated courses.

The integrated approach in an Engineering context can be found for instance in references [6, 7, 9, 19] where a specific design is treated from the point of view of a range of particular branches of academic curriculum. There is nonetheless a fundamental difference with respect to this approach since our aim is to present integration from the point of view of production strategies and information flows whilst in references [6, 7, 9, 19] the integration is referred to the technical part of the design process.

The first part of this course is dedicated to Project Management. The students acquire skills in defining, using MS-PROJECT [13], the work breakdown structure (WBS), and the organization breakdown structure (OBS) in engineering projects, through a series of examples of increasing complexity, the final one being the planning of a vessel construction. Project management teaching has received significant attention in literature. A Project Management learning experience in an Engineering degree through working for real clients has been documented in reference [3]. 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 [13], for managing production related information. A series of increasing complexity examples is treated, the final one being the management of the pipe database of a real vessel. This database consists of a few thousand pipes, of which a subcontracting, reception and installation 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 working with FORAN, an Engineering Production application widely used in the shipbuilding industry [18]. With this application, all the elements of the structure of part 1 exercise vessel, 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 [2], where a virtual model is created which incorporates not only geometrical but material and construction characteristics.

Experts from the three fields taught in this course attend to the lessons incorporating their experience not by descriptive speeches but by guiding the students through the work with the computer on 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 Naval Architecture 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 has 60 face-to-face hours. Three editions of the course have already taken place. The venue where it is taught is a 15 student multimedia classroom, which we consider is a convenient size in promoting an interactive atmosphere during lessons. The enrolment has been full in the 3 editions of the course which, given the large offer of optional courses within the degree, is a significant achievement. As mentioned in the introduction, the course presents an integrated vision of Production Engineering for Shipbuilding relying on problem based learning (PBL) methodologies both in Project Management, Databases and Product Model for Detail Engineering.

While competences on project management are part of the curriculum of one mandatory subject in the Naval Architecture degree (Quality management), the time that is dedicated and the context in which they are acquired does not allow for a significant progress of the students on this topic. The other two competences, i.e., the use of databases in managing detailed production information along with its generation, are just not part of the curriculum. In our opinion and that of the students, as will be later discussed, those competences are extremely educational when acquired in an integrated way, as the one presented in this paper, since they promote a global view of the production process of a system. Quite often the courses pay substantial attention to certain design aspects [10] but not as much to production related issues. That is the case in the Naval Architecture and Marine Engineering program of the University of New Orleans (U.S.) discussed in reference [10]; looking at the structure of marine and offshore engineering studies in two reference universities in the field such as the Delft University of Technology and Norwegian University in Science and Technology (NTNU) also shows that no course analogous to the one presented here is found.

### *2.2 Project management (PM)*

Project Management (PM) plays a central role in the professional activities of many engineers, regardless of the specific sector where they work. Due to this, more dedication is given to this part of the course, compared to the other two. This section of the course starts by presenting mind maps [5] as a tool for the initial planning phase. MINDMANAGER is the software application used as a tool for this task [14]. On progression of the course, projects take a more complex structure: building a bookcase, refurbishing a kitchen, organizing a multimedia classroom and building a large property development garden are the selected applications. A general work breakdown structure (WBS) of these projects is carried out using MINDMANAGER. In Fig. 1 a mind map of the WBS of the multimedia classroom project is presented as a sample of the type of WBS the students work with.

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

During this process, the humanistic components of Project Management are highlighted. Managing projects requires not only making rational but also reasonable decisions. Therefore, interpersonal relationships, negotiation capabilities and other humanistic issues are often more relevant than pure technical arguments. We agree with Prof. Nussbaum [16] that human values are extremely important in the education of our students; the intricacies of project planning include working on issues like empathy and 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 proposed to the students. The references available for shipbuilding construction project management teaching are scarce. Iglesias-Baniela and López-Varela [8] rely on their experience as planning managers 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 was not provided to the students until completion of the course in order to promote the development of original ideas from the students in undertaking the ship construction plan.

Taking advantage of the classroom configuration, 5 groups of 3 people are formed and a script with the exercise is provided to each group. A cooperative approach to project planning is adequate to project management learning, as recommended in reference [15]. The information made available to the students consists of a basic Engineering project of a ship, taken from the database of dissertation projects from previous academic years. Within our faculty these are the basic Engineering projects of a vessel. The information is organized in a series of documents, and the students glance over them in order to select those that are relevant for the planning: general arrangement, weights, machinery and budget documents are the ones taken into account. Some characteristics corresponding to the shipyard where the ship would be built, includ-

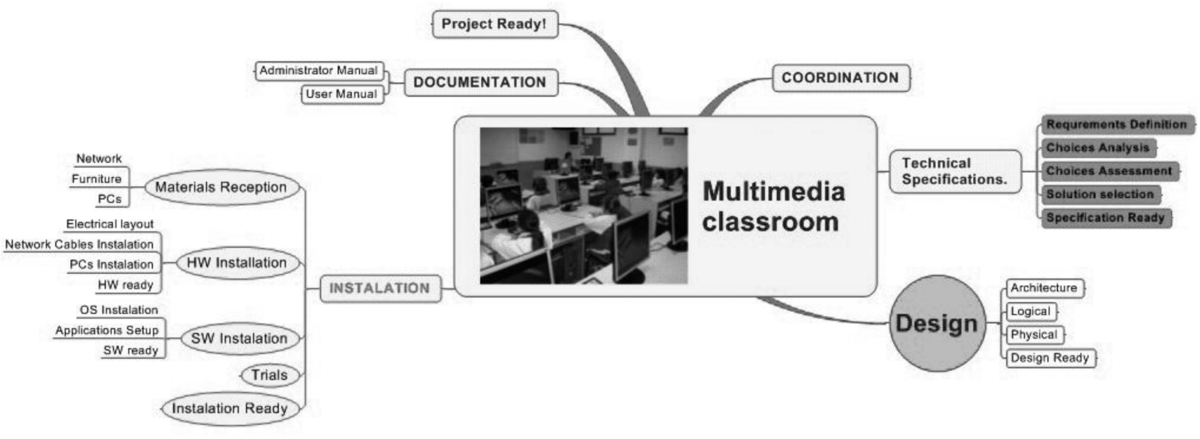


**Fig. 1.** Multimedia classroom WBS mind map.

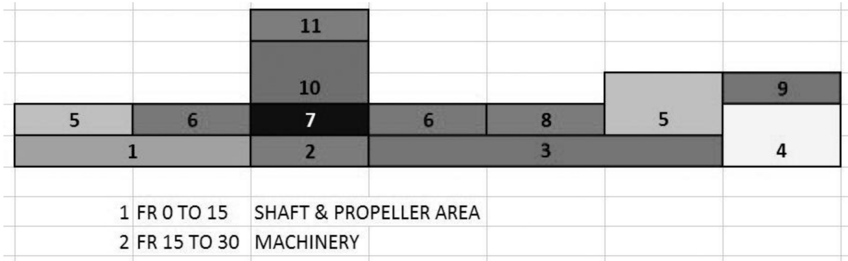


**Fig. 2.** Erection diagram example solution for the proposed exercise.

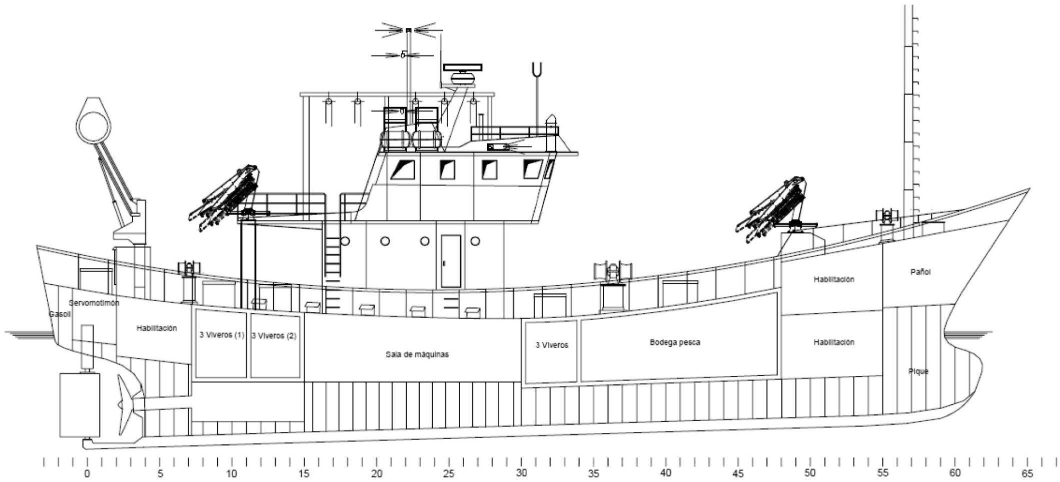


**Fig. 3.** General arrangement plan provided for the proposed exercise.

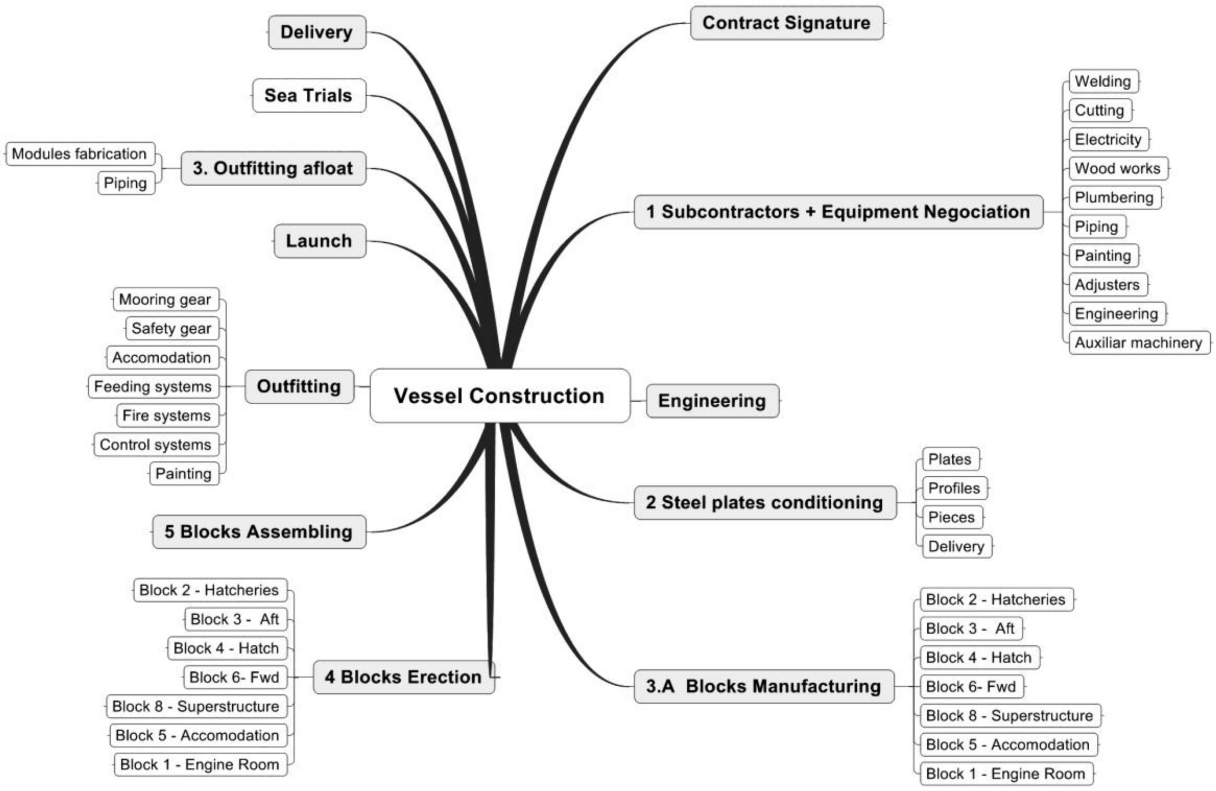


**Fig. 4.** Mind map for the vessel planning exercise.

ing cranes capabilities, dry-docks dimensions, etc. are given.

The PBL approach is used with all its intensity in this exercise, where the students are free to take the decisions they believe most adequate in delivering the ship within a deadline. They are asked to present their work in a Power Point type presentation which must include a blocks erection diagram, like that of Fig. 2, which corresponds to the general arrangement of Fig. 3, a WBS mind map like that of Fig. 4 and a Gantt diagram like the one of Fig. 5. The latter is shown in this paper in order to highlight the complexity of the tasks that the students are able to plan.

### *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 an immense amount of tiny operations which have to be organized specifically at a 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 are needed. The most powerful tool for treating information at their disposal before taking this course is a

| Id | Task | D | Beg | End |
|---|---|---|---|---|
| 1 | 1 Contract Signature | 0 h | vie 27/04/12 | vie 27/04/12 |
| 2 | **2 Engineering** | **2 d** | **vie 27/04/12** | **mar 01/05/12** |
| 3 | 2.1 Especification | 1 d | vie 27/04/12 | lun 30/04/12 |
| 4 | 2.2 Purchase | 1 d | lun 30/04/12 | mar 01/05/12 |
| 5 | **3 Subcontractors + Equipment Negociatic** | **14 d** | **vie 27/04/12** | **mar 22/05/12** |
| 6 | 3.1 Welding | 2 d | mar 01/05/12 | jue 03/05/12 |
| 7 | 3.2 Cutting | 2 d | vie 27/04/12 | mar 01/05/12 |
| 8 | 3.3 Electricity | 2 d | vie 27/04/12 | mar 01/05/12 |
| 9 | 3.4 Wood works | 2 d | vie 04/05/12 | mar 08/05/12 |
| 10 | 3.5 Plumbering | 2 d | vie 04/05/12 | mar 08/05/12 |
| 11 | 3.6 Piping | 2 d | vie 04/05/12 | mar 08/05/12 |
| 12 | 3.7 Painting | 2 d | mar 08/05/12 | jue 10/05/12 |
| 13 | 3.8 Adjusters | 2 d | vie 11/05/12 | mar 15/05/12 |
| 14 | 3.9 Engineering | 2 d | mar 15/05/12 | jue 17/05/12 |
| 15 | 3.10 Auxiliar machinery | 2 d | vie 18/05/12 | mar 22/05/12 |
| 16 | 3.11 END of subcontrating negotiation | 0 d | mar 22/05/12 | mar 22/05/12 |
| 17 | **4 Steel plates conditioning** | **60 d** | **mar 22/05/12** | **mar 04/09/12** |
| 18 | 4.1 Plates | 3 me | mar 22/05/12 | mar 04/09/12 |
| 19 | 4.2 Profiles | 3 me | mar 22/05/12 | mar 04/09/12 |
| 20 | 4.3 Pieces | 3 me | mar 22/05/12 | mar 04/09/12 |
| 21 | 4.4 Delivery | 0 me | mar 04/09/12 | mar 04/09/12 |
| 22 | **5 Blocks Manufacturing** | **56 d** | **mar 09/10/12** | **mar 15/01/13** |
| 23 | 5.1 Block 2 - Hatcheries | 8 d | mar 09/10/12 | mar 23/10/12 |
| 24 | 5.2 Block 3 - Aft | 8 d | mar 23/10/12 | mar 06/11/12 |
| 25 | 5.3 Block 4 - Hatch | 8 d | mar 06/11/12 | mar 20/11/12 |
| 26 | 5.4 Block 6- Fwd | 8 d | mar 20/11/12 | mar 04/12/12 |
| 27 | 5.5 Block 8 - Superstructure | 8 d | mar 04/12/12 | mar 18/12/12 |
| 28 | 5.6 Block 5 - Accomodation | 8 d | mar 18/12/12 | mar 01/01/13 |
| 29 | 5.7 Block 1 - Engine Room | 8 d | mar 01/01/13 | mar 15/01/13 |
| 30 | **6 Blocks Erection** | **52 d** | **mar 23/10/12** | **mar 22/01/13** |
| 31 | 6.1 Block 2 - Hatcheries | 4 d | mar 23/10/12 | mar 30/10/12 |
| 32 | 6.2 Block 3 - Aft | 4 d | mar 06/11/12 | mar 13/11/12 |
| 33 | 6.3 Block 4 - Hatch | 4 d | mar 20/11/12 | mar 27/11/12 |
| 34 | 6.4 Block 6- Fwd | 4 d | mar 04/12/12 | mar 11/12/12 |
| 35 | 6.5 Block 8 - Superstructure | 4 d | mar 18/12/12 | mar 25/12/12 |
| 36 | 6.6 Block 5 - Accomodation | 4 d | mar 01/01/13 | mar 08/01/13 |
| 37 | 6.7 Block 1 - Engine Room | 4 d | mar 15/01/13 | mar 22/01/13 |
| 38 | 7 Blocks Assembling | 40 d | mar 13/11/12 | mar 22/01/13 |
| 39 | **8 Outfitting** | **21 d** | **mar 22/01/13** | **mié 27/02/13** |
| 40 | 8.1 Mooring gear | 3 d | mar 22/01/13 | lun 28/01/13 |
| 41 | 8.2 Safety gear | 3 d | lun 28/01/13 | jue 31/01/13 |
| 42 | 8.3 Accomodation | 3 d | vie 01/02/13 | mié 06/02/13 |
| 43 | 8.4 Feeding systems | 3 d | mié 06/02/13 | mar 12/02/13 |
| 44 | 8.5 Fire systems | 3 d | mar 12/02/13 | lun 18/02/13 |
| 45 | 8.6 Control systems | 3 d | lun 18/02/13 | jue 21/02/13 |
| 46 | 8.7 Painting | 3 d | vie 22/02/13 | mié 27/02/13 |
| 47 | 9 Launch | 0 h | mié 27/02/13 | mié 27/02/13 |
| 48 | **10 Outfitting afloat** | **23 d** | **mié 27/02/13** | **mar 09/04/13** |
| 49 | 10.1 Modules fabrication | 4 s | mié 27/02/13 | mié 27/03/13 |
| 50 | 10.2 Piping | 5 s | mar 05/03/13 | mar 09/04/13 |
| 51 | 11 Sea Trials | 2 s | mar 09/04/13 | mar 23/04/13 |
| 52 | 12 Delivery | 0 h | mar 23/04/13 | mar 23/04/13 |

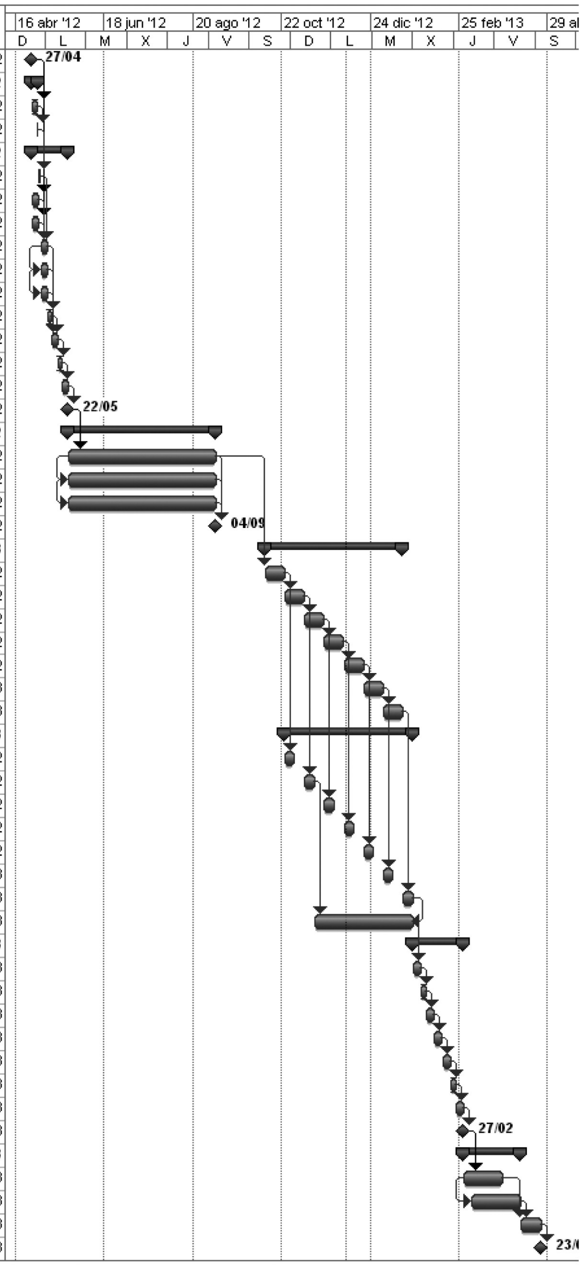


**Fig. 5.** Gantt chart to the vessel planning exercise.

spread sheet manager, usually MS-EXCEL. It is important to demonstrate to the students that EXCEL is not sufficient for managing this volume of information within the required safety and efficiency standards. This will be clear for them by the end of this section of the course, in which the acquisition of competencies in database management is the learning target.

The teaching of databases to Engineering students at the undergraduate level has proven challenging for multiple reasons [20, 21]. Such courses are usually taught in Computer Science. Engineering students prefer the problem-solving, hands-on, and project-based method of learning over the coverage of database design concepts. Therefore, again the PBL methodology is applied, presenting the ideas starting from a simple database, which stores main dimensions of vessels, to finally being able to manage a database of 5000 pipes of a real vessel. For this database, of which the relationships are presented in Fig. 6, queries, forms and reports are developed, taking into account the information needed by the production department, by the shipyard store, by the purchasing department, etc. For those pipes, subcontracting deadlines and on board installation schedules are defined, which links this section of the course with the initial one. The collaboration with the industry co-authors of ACCIONA Energy and ALTRAN Group, with substantial experience in the topic, has been crucial in order to set a realistic framework for this part of the course.

### *2.4 Detailed 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 [18]. The motivation for this section of the course arises on questioning how the detailed Engineering information is generated in large projects. More specifically the students become curious in understanding how the information for the huge pipe database discussed in section 2 of the course is obtained, departing from the Basic Engineering Project. Since the definition of the piping system elements is too complex for the time frame of the course, the structural elements are considered in turn. This is carried out will full detail through cooperative work by the students, working in the same 3D model (Fig. 7). The approach is analogous to the Knowledge-Based Engineering (KBE) one, as discussed in reference [2], where a virtual model is created which incorporates not only geometrical but material and construction characteristics.

FORAN licensing policy is quite restrictive and implementing a license contract for the modules to be used in the course is difficult. Even if a proper licensing policy of the software would be possible, installing FORAN in the faculty computers is so complicated that it becomes basically unfeasible. Due to these reasons, a smart solution has been found enabling the use of FORAN in the faculty multimedia room. The software is run in remote mode on SENER servers at the company headquarters, using a CITRIX technology web application [4]. This, in addition, facilitates simultaneous work of the students on the same geometrical model, thus replicating real world scenarios in modern Detailed 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 (Fig. 7), the hull plates, longitudinal beams, etc. The information needed for this task is obtained by analysing the structure definition document (Fig. 8) and the general arrangement document (Fig. 3) contained in the dissertation project used in section 1. A list of elements is exported, that can be read directly by MS-ACCESS in order to feed the database. This is facilitated by the FORAN engine being ORACLE based [17].

## 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 (it works as an external

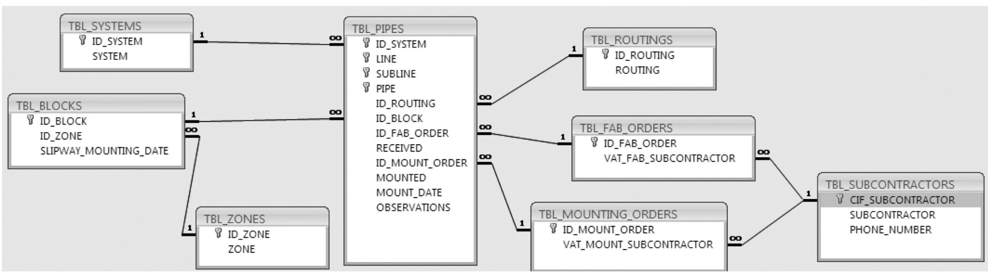


**Fig. 6.** Piping database relationships.

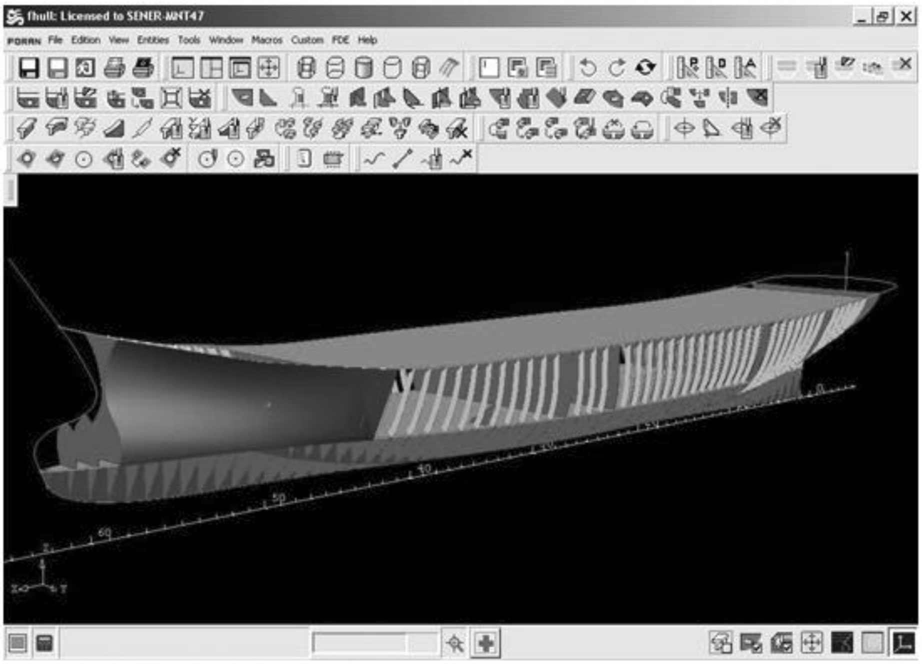


**Fig. 7.** FORAN structural elements definition carried out during the course.

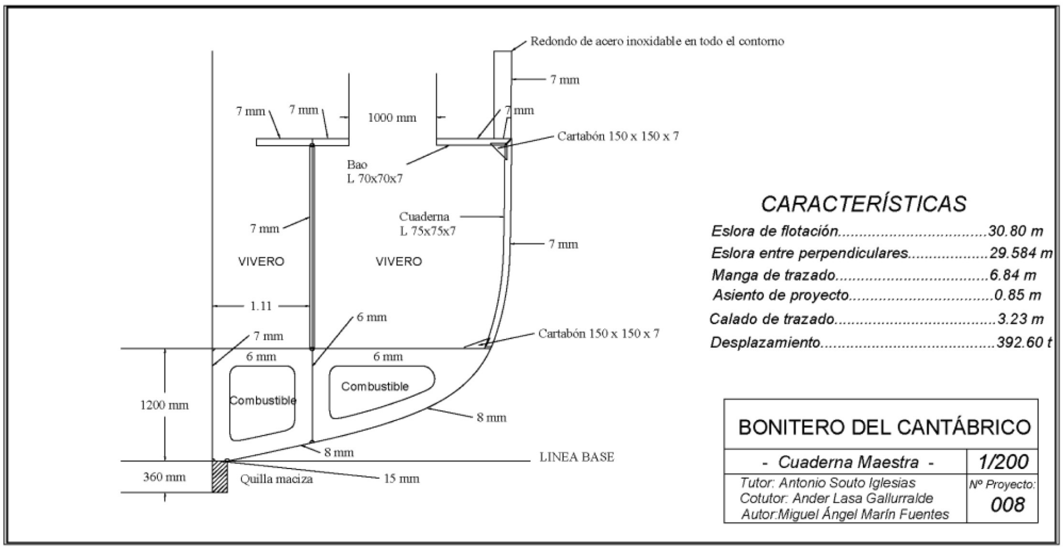


**Fig. 8:** main section used as reference for the structure definition.

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 is optional. It is well known that success rates in optional courses are close to 100% in Spanish university degrees (e.g. 94% success rates in our faculty in the first semester in academic year 2009-2010 compared to 55% in mandatory subjects). On top of this, the offer of optional courses is large in our faculty. It is easy to infer that if a course is offered with a history of low success rates, enrolment may be too low for it to be given. Therefore, the success rate has to be high and an itinerary is designed to allow the achievement of the course objectives while guaranteeing high success rates.

In this context, we have organized the course such as to keep the students active and learning whereby they give a 100% contribution during the face-to-face lessons. This is achieved by setting up the course so that students receive just a few tips and then follow the process by working on the computer, following the elaboration of a specific example by the professor or doing an exercise by themselves. The classroom computer network allows file-sharing, presenting the student's exercises on the projector, etc.

Since face-to-face lessons are the core of the course, the attendance is mandatory. If an attendance rate of at least 85% is not met, the student fails the course. Once this attendance is met and provided the student is active in the classroom then success is guaranteed. High grades are given, which is appreciated by the students, compared to the low grades they usually get in most of the mandatory courses. Summarizing, the enrolment and academic success rates have been 100% in the 3 editions of the course.

### *3.3 Institutional survey*

UPM started in 2009 the implementation of the Spanish Ministry of Education DOCENTIA program [1]. This program aims at assessing the staff's teaching activities as one important step forward in the implementation of quality control procedures. Such procedures are essential in the adaptation of the Spanish Higher Education system to the European Higher Education Area (EHEA). One of the actions included in the DOCENTIA program is to offer the academic staff the possibility of having the teaching activity assessed and more specifically to conduct surveys with the students related to every course. We decided to have the present course surveyed and the results are now presented. This survey is important for us since it is an external assessment that can be presented, officially reporting the student's opinion on the course.

The grades in this survey are up to 5 points. Our own grades together with the average marks and standard deviations of all the surveys in our own faculty, the Naval Architecture Department (ETSIN), are made available to us. Questions are targeted on the course and on the lecturer's performance. We present in Table 1 the questions that have assessed the course, our course grade (TICN column), the faculty average one (MEAN column) and the percentile, assuming a Gaussian distribution, in which the course ranks (BEST%). The results correspond to the academic years 2009–2010 till 2011–2012. It is relevant to highlight that the course grades are close to 5 throughout the survey and rank within the 20% highest grades in all items analyzed.

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 those of 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 throughout the course which adheres to the student quote referred to in the previous section. Summarizing, we think the results are quite satisfactory.

### *3.4 Internal survey*

Apart from the external survey, we conduct an internal survey, with 50 questions covering a wide range of topics. The survey is carried out online using a HTML file that generates, using a basic CGI application, an ASCII type file with the answers. The survey is anonymous, but the identification numbers of the people who carry the survey are stored independently in order to later apply a participation grade bonus, which amounts to 5% of the total grade. The most relevant results of this survey are presented in Table 2.

From the questions and answers in Table 2, it becomes apparent that the relationship between IT and productivity has been made more evident to the students with this course than with any other course in the degree (questions 1 and 2). Also, the links between the parts of the course are evident for the students on completion (questions 3 and 4). The main activities in each section of the course are considered useful to assimilate the main ideas (questions 5, 6 and 7). Also, the methodology used in the course is seen by the students as radically different from most of the other courses in the degree; they believe it helps in achieving the goals of the course

**Table 1.** Institutional survey results

| | **Question** | **TICN** | **MEAN** | **BEST %** |
|---|---|---|---|---|
| 1 | The tasks (theory, practical, individual, team, etc.) are connected with the teaching activity goals. | 4.76 | 3.57 | 16 |
| 2 | In the development of this teaching activity there is no overlap with other teaching activity contents. | 4.71 | 3.45 | 12 |
| 3 | Theoretical and practical tasks are adequately coordinated. | 4.69 | 3.25 | 9 |
| 4 | The volume of contents and tasks within this teaching activity is proportional to its credits. | 4.68 | 3.10 | 11 |
| 5 | The effort required is in accordance with that documented in the program. | 4.75 | 3.11 | 10 |
| 6 | The assessment is in accordance with the type of tasks undertaken throughout the course. | 4.76 | 3.35 | 12 |
| 7 | I have improved my departure level, in relation to the course competences. | 4.69 | 3.32 | 13 |

**Table 2.** Internal survey results

| | Question | Yes |
|---|---|---|
| 1 | Has this course (TICN) helped you in relating productivity to information technologies (IT)? | 100% |
| 2 | Has TICN been the course in which this relationship has most clearly been established? | 100% |
| 3 | Do you think TICN is well structured, with the 3 parts PM, DB & DEIG? | 100% |
| 4 | On completion of the course, is the importance of the relationship between the 3 parts clear for you? | 97% |
| 5 | Do you think the exercise of planning a ship construction allows the integration of the skills acquired during the PM part of the course? | 100% |
| 6 | Do you think the exercise of managing a pipes DB of a real ship allows the integration of the skills acquired during the DB part of the course? | 100% |
| 7 | Do you think the exercise of defining the structural elements of a real ship allows the integration of the skills acquired during the DEIG part of the course? | 97% |
| 8 | Do you think TICN is, methodologically, radically different from most other courses in the degree? | 92% |
| 9 | Do you think the methodology (practical lessons with classroom work based assessment and mandatory attendance) facilitates achieving the goals of the course? | 100% |
| 10 | We try in the course of replicating real world scenarios and solutions. Have you had this impression during its development? | 100% |
| 11 | Would you recommend this course to a friend? | 100% |

(questions 8 and 9). Another important outcome of the survey is that the students report that the course has provided a real world environment learning experience (question 10). Finally the students report that they would recommend the course to a friend, thus meaning that the overall impression generated by the course is positive (11).

## 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. This is achieved through a series of examples of increasing complexity ending with the planning of a 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 resulting in the elaboration of the pipe database of a real vessel. This database consists of a few thousand pipes, for which a production timing frame is defined connecting this section 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 structural elements of a vessel are defined through cooperative work by the students, working simultaneously in the same 3D model. This promotes the students to understand how the information for the production scheduling databases is generated, linking this section with the previous ones. This integration methodology could be applied in many branches of Engineering. This would be accomplished using the same Project Management and Database software applications, and similar learning strategies. It would be necessary to only alter the Detailed Engineering software application, depending on the specific branch considered, i.e. building, civil, aeronautical, etc.

Surveys have been posed to the students in order to get feedback 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.

*Acknowledgements*—In starting and improving this course, we have received help from a number of persons, mainly from the industry: Jesús Vilacañas from Zamakona Shipyards, Sebastián Abril-Pérez and Miguel Angel Marín-Fuentes from NAVANTIA, Salvador Aguilera from PACECO and Pedro Ros from Vulkan Shipyards. Also, we sincerely thank the students who have taken this course so enthusiastically over the last 3 years. Finally we thank Una Fitzpatrick and Hugo Gee for their help in proof reading the English spelling of this paper.

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