A proposal to develop and assess Professional Skills in Engineering Final Year Projects

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Abstract

In this paper we discuss the result of piloting a methodology for Engineering Final Year Projects (FYP) assessment that takes into consideration professional skills acquisition. The FYP is structured around three milestones; skills are assigned to each milestone according to the tasks required in each phase, and a list of indicators have been designed for every phase. The criteria are specified in a rubric and are made available to students. The FYP implementation includes evaluation methods and a homogeneous assessment throughout the project development in order to provide students with valuable project implementation support, to facilitate the project organization, to improve the quality of projects and thereby to reduce the academic drop-out rate. The proposed methodology has been implemented and piloted at the Barcelona School of Informatics, and the conclusions can easily be generalized to any other Engineering degree. This paper presents the results of the FYP for 1,569 students. The average percentage of students finishing FYP in previous degrees was 65% on average, whereas in the case of the Bachelor Degree in Informatics the percentage rose to 90% with the methodology proposed in this paper. In addition, 95% of these students finished their FYP in less than one year, compared to only 65% who finished it in less than one year in previous Degrees.

Keywords: Final Year Project; assessment of Final Year Project; assessment of professional skills.

1. Introduction

Engineering Degrees compliant with the European Higher Education Area (EHEA) [1] were introduced into Spain from 2010 onwards. The initial three semesters of the degree opened for enrollment in September 2010 and, as a consequence, the first Final Year Projects (FYPs) in the new paradigm were delivered in 2012-2013.

The FYP in Spain was already a mandatory requirement for obtaining a degree in engineering for decades before the EHEA. There existed a long tradition of supervision and evaluation methods that jointly considered subject-specific and professional skills. For example, oral and written presentation skills were assessed in all projects, although a unified criterion was not explicitly agreed. In general, FYPs were evaluated by a committee composed of some professors. The grades were based on a report and a public project presentation. The designated project supervisor monitored the students' work and advised on the writing of the report, while the faculty committee evaluated the technical quality of the project, the quality of the written report and the quality of the oral presentation. These three aspects were usually assessed together and marked as a single grade, which in turn constituted the final grade of the FYP.

In that system, most educational institutions did not provide the students with documentation specifying the project report format or the requirements for the technical content description and presentation. These aspects were regarded as implicit, and the communication to the students was usually left to the discretion of the project supervisor, whose task was to address any shortcomings throughout the period of the FYP. This meant that, in most cases, the project grade depended not only on the quality of the project, but also on the evaluating committee and the experience of the project supervisor (who in most cases was a member of the evaluating committee), as Kumar demonstrated by comparing two separate evaluations of the same project [2]. Different committees would probably assign different grades to the same project, since the evaluation criteria were open to interpretation. Moreover, while communication skills were usually considered, in most cases other professional skills were not considered in the project evaluation.

In the current EHEA, subject-specific contents and professional skills are assessed explicitly. Instead of a single final grade, the new FYP marking should be generated from a set of requirements for the different skills considered. To solve the problem of ambiguity detected in the FYP assessment prior to the EHEA, clear criteria must be established for the evaluation of each type of skill, in such a way as to enable traceability. In addition, the publication of these criteria should serve as a guide to the students in the development and documentation of their FYP.

For this purpose, between 2008 and 2009 the Spanish Ministry of Science and Innovation and the Quality Agency of the Catalan University System funded the project "Guidelines to the evaluation of competencies in the Bachelor and Master Degree thesis in engineering" [3]. This work was presented at the FIE international conference by Valderrama et Al. [4]. The result is, in fact, a guide to help each institution define its own procedure for FYP evaluation. As described in [3, 4], the "Guidelines to the evaluation of competences in the Bachelor and Master Degree thesis in engineering" sets out a design procedure consisting of six stages for assessing the FYP of a degree (see Figure 1):

1. Definition of the skills associated to the FYP and the selection of objective indicators for each skill.
2. Definition of milestones for assessment, the concrete means of assessment to be adopted at each milestone, and the agents who will carry out such actions. Three possible milestones are defined:
    - Initial milestone, with two learning activities to be assessed: an initial written report and an oral presentation.
    - Follow-up milestone, with a single activity to be assessed: a written progress report.
    - Final milestone, with two assessed activities: the final written project report and its presentation in public.
3. Assignation of indicators to the assessment of each milestone and learning activity.
4. Definition of a grading rubric for each indicator, establishing a clear and objective criteria for marking.
5. Definition of the reports for the assessment agents.
6. Definition of the criteria for assigning the final grade to the FYP based on the assessment reports.

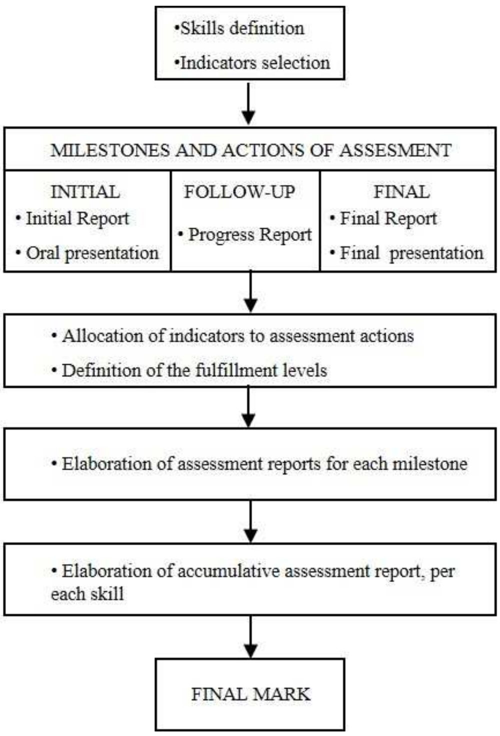

Fig. 1 Procedure proposed on the guide to define the FYP evaluation process.

To create the guide for the Barcelona School of Informatics (FIB) at UPC – BarcelonaTech FYP assessment, a multidisciplinary commission was created (the authors of this paper). The members of the commission met regularly between February and July 2011 to discuss the details of the guide definition process and to take decisions about all aspects not covered by the guide. FIB implemented these proposals between July 2011 and July 2012.

During the pre-EHEA period (1991 to 2010), FIB imparted three engineering degrees in Computing: The Diploma in Computing Software, the Diploma in Computing Systems, and the Computing Engineering Degree. The two diplomas consisted of a three-year curriculum, equivalent to the current bachelor curriculum, while the engineering degree consisted of a five-year curriculum equivalent to the integrated masters' curriculum. Both degrees required the compulsory submission of a FYP, but with different weights in the grade. The engineering project was equivalent to the work of an entire semester, while the diploma projects required work over half a semester.

One of the main problems of the FYPs in the previous engineering degrees was that students took longer than expected to finish them, and a significant percentage of students did not even present their FYP. This was due to several reasons:

- It was not necessary for students to finish the FYP to find employment. In fact, most students combined their last years of study with paid work, so before completion of their degree they concentrated on their jobs and failed to complete their FYP for official graduation. However, some students took up their projects again several years later, either when the degree became important for their career prospects or when changes in the curriculum were imminent, thereby reserving the right to graduate under the former regulations.
- The duration of the project depended on the experience of the supervisor. Even though the project time-frame was clearly stipulated in the curriculum, and was different for the two types of degree courses, professors found it hard to distinguish between them and tended to propose a semester project regardless of whether that student was studying for an engineering degree or for a diploma. The result was that diploma students devoted an inordinate amount of time to their FYP.
- In addition, engineering students also spent longer than the stipulated time on their projects, either because they were unaware of the time-frame and the date of completion, because they were keen to perfect their work, or were under pressure from their supervisor to continue the work until the desired results were achieved. In fact, many engineering projects took up more than 900 hours, an amount of time in excess of the workload for one semester. This often meant that projects took longer than 6 months to complete, or in many cases even longer than a year.

The objective of this work is to evaluate and report the result of the application of our methodology with respect to:

(a) The development and assessment of professional skills of the engineering students during their FYP work.
(b) The adjustment the FYP duration with respect to the theoretical time-frame.
(c) The homogeneity of the evaluation criteria applied by different committees.

The rest of the paper is organized as follows: Section II discusses some related work; Section III presents how the FYP is developed at FIB and the skills evaluated; Section IV describes the indicators considered in each milestone; Section V provides the results in the application of this methodology, and finally Section VI concludes this work.

2. Context and Related Work

The term "professional skills" is used to refer to both academic skills and transferable skills and other kinds of competencies that graduate students will need to acquire for their profession. Our work addresses the introduction of professional skills into academic Engineering curricula, their evaluation and assessment, including the appropriate metrics and application, and it is centered in the Final Year Project.

The assessment of FYPs are constrained in many institutions by accreditation regulations. Accreditation is in fact one of the leading techniques used by academic institutions to ensure the delivery of quality educational programs. One of the leader institutions in providing technical accreditation is the ABET (namely the Accreditation Board for Engineering and Technology), a non-profit organization that accredits postsecondary year programs in applied science, computing, engineering, and technology. The accreditation is intended to certify the quality of these programs. Al-Twaijr et Al. present in [5] an overall framework and an operational description of ABET guidelines.

The ITiCSE'99 Working Group on Integrating Professionalism and Workplace Issues into the Computing and Information Technology Curriculum [6] points out that their graduates require a good understanding of professional and workplace issues as well as technical skills. González-Marcos [7] argues that FYP success cannot be attained with only a technical ("hard") skill set. Because project outcomes are achieved through people using knowledge, creativity and often technology, professional ("soft") skills are as necessary as technical skills in the management of projects. Communication, teamwork, organizational effectiveness, leadership, flexibility, creativity, problem solving and decision-making, for instance, are skills required to manage people and teams and get the best out of them. These ideas are developed in [8] by Fraile. The paper defines the educational outcomes of the FYP for both students and lecturers in order for them to share expectations on aspects of the project. This provides a basis for a subsequent definition of the evaluation process and criteria for the project, which is further developed in [9]. The importance of the FYP in the strengthening of competences of engineering students is analyzed in depth by Ortiz-Marcos et Al. in

[10]. The work shows which personal competences of students are most reinforced during the FYP process, including the preparation, elaboration, presentation and defense stages. The competence model considered is that used by ABET.

Michaluk et Al. [11], also following the ABET's framework, focus on students' critical thinking skills in engineering studies through two assignments based on the Paul-Elder model of critical thinking, which incorporates characteristics of eight elements of thought of critical thinking and has been contextualized specifically for use in engineering. Two methods are employed: problem-based learning and writing for reflectivity.

The need to develop professional values has also been recognized since the IEEE/ACM Computing Curricula 2001 in the Joint Task Force on Computing Curricula [12]. They propose the assessment process in order to i) encourage students to employ good technical practice and high standards of integrity, and ii) discourage students from attempting to complete work without giving themselves enough time. Following this process, Sicilia [13] discusses the introduction and assessment of professional competences in a Computing curriculum.

In order to unify assessment criteria, and based on the work done by Valderrama et Al. [4] described in Section 1, which defines between 4 and 6 stages for assessment, Sánchez [14] presents a proposal for the evaluation of professional skills in the FYP by using a four-level compliance rubric for competence evaluation. The use of rubrics has been extensively adopted in evaluation [15, 16, 17]. As in [17], in our proposal we have drawn up a list of questions to be considered by students as a guide. Bairaktarova et Al. [18] use a similar approach. Following the guidelines of the American Society of Engineering Education (ASEE), they present a FYP Evaluation Rubric. In their paper, and using their rubric, the authors examine how the assignment objectives of a real-world engineering project influenced employment of students' leadership skills and social responsibility awareness.

Different FYP assessment methodologies are used in the universities around the world. Some examples are presented below. Jawitz [19] analyzes the management and assessment practice of FYP of different degrees at the Faculty of Engineering at the University of Cape Town to detect issues that should be addressed, and Webster [20] reports on a study of assessment of undergraduate dissertations in the seven departments which constitute the School of Social Sciences and Law at Oxford Brookes University. Both studies reveal a range of approaches and attitudes to the assessment of the FYP and the use of a wide variety of different methods. The authors reflect on the implications of the lack of consensus in the key issues of the validity of the assessment system, as well as the student perceptions of fairness. So, clear and common assessment criteria should be defined. Rasul [21] focus on the importance of defining guidelines and assessment criteria for the FYP describing the experience in the University of South Australia. FYP is the culminating learning experience of engineering programs. It requires students to demonstrate that they can integrate knowledge, skills and professional graduate attributes developed during the program and perform at a standard expected of graduates. Assessment can take into account different elements such as supervisor's report, technical report, design portfolio, reflective journal, poster, oral presentations, weightings for technical quality and communication, etc. The criteria for grading projects use various rubrics that influence assessment and benchmarking processes. Saunders [22] illustrates how criteria can integrate both analytical and global quality measures of students' work. Drawing from an analysis of assessments of an undergraduate dissertation, the authors argue that criteria need to be debated periodically if consistency is to be maintained. The importance of clear assessment procedures is highlighted.

Regarding the assessment of specific professional skills, teamwork is one of the most popular professional skills, and it is difficult to assess. Grading individual students in teams or projects has always been problematic. To accurately gauge individual learning outcomes, students' grades need to be based on what they have learned as an individual within the team or project context. However, within engineering team-based projects, individuals have traditionally been assigned a grade heavily influenced by the team's project outcomes. Engineering FYP suffer from similar problems, especially in the case the project is not individual. Howard [23] examines in depth these problems in the framework of several Australian universities.

Finally, Saka [24] suggests that the selection of teachers to supervise FYP should also be considered: "Findings suggest that the profiles of teachers who seek out these professional development programs vary based on the programs' objectives. The findings also suggest that recognition of who is being served in professional development must be considered in the construction of those professional development experiences".

3. Organization and skills of the FIB's Final Year Project

The FIB curriculum defines a FYP of 18 ECTS credits (European Credit Transfer System. One credit is equivalent to 25-30 hours of student work during one semester.). FYP is divided into two blocks: a first one of 3 credits in which the student is instructed in project management (PM), and a second one of 15 credits for the project development. Since the FIB students can do their FYP in a foreign university through a mobility program, and most European universities establish a FYP of 15 credits, it is easy to set up validations in accordance with mobility agreements.

Many foreign universities also have subjects similar to the PM, so it is simple to achieve full compatibility with the FIB's FYP.

3.1. The Project Management course (PM)

The PM is organized as a semi-intensive three-week seminar. It is offered twice a year, coinciding with the start of a semester of regular classes. Doing the PM at the beginning of a semester allows access to the PM for those students who are on an exchange program and do not have a subject similar to the PM at the center where they are doing their FYP. It is likewise made available for those students who are doing the FYP at a national or foreign company. The course can be followed on-line.

Progress through the PM requires students to present several reports in which the knowledge acquired is applied to their FYP. Around mid-course, students present the documentation generated in a brief whole-body video, which is then sent to the professor who provides a quick feedback.

The PM objectives are arranged in four modules, three common to all students and the fourth specific to the specialty in which the student is enrolled:

- Module 1: Information Technology tools to support the management of projects and teams, covering specific applications of project management, Internet resources for management, and management of the FYP through the network.
- Module 2: Basics of project management, covering integral project management, scope management, time management, economic management and project sustainability.
- Module 3: Personal and professional skills for the management of projects and teams, covering management of people and equipment, information skills, sustainability and efficient communication techniques.
- Module 4: Project management for the field of specialty.

One week after the completion of the four modules, students must submit a document summarizing all deliverables achieved so far (introduction and state of the art, scope of the project, temporary planning, budget, preliminary sustainability analysis and bibliographical references consulted) and give a public presentation of the work. The PM professor then evaluates this presentation, and both the PM professor and the project supervisor evaluate the deliverables. The whole process for evaluating the FYP is detailed in Section 4.

3.2. Evaluated Skills

Both technical and professional skills are evaluated in the FYP at FIB. The assessment is detailed in Section 4. The seven professional skills evaluated are as follows:

- Entrepreneurial attitude and innovation
- Sustainability and social commitment
- Effective oral and written communication
- Information literacy
- Autonomous learning
- Appropriate attitude towards work
- Reasoning

Foreign language evaluation is only carried out when the project report or the public presentation is done in English (or another language different from Spanish or Catalan).

4. Evaluation milestones and indicators

The authors propose an FYP evaluation consisting of three evaluation actions distributed over three milestones: Initial, Follow-up and Final Milestone. Each milestone has a different evaluator agent. Evaluation is done by using a set of indicators, each indicator being related to one or more professional skills. The evaluation for each indicator is accurately defined by means of a rubric incorporated into an application to make the process easier. A four-level compliance is used for competence evaluation for each indicator: not reached; almost reached; reached as expected, and reached with excellence. The final FYP grade is automatically calculated by the application using the information from the three evaluation actions.

4.1. The Initial Milestone

Students undertake the Initial Milestone during the first month of the FYP, while they are following the PM course. In this milestone, the deliverables submitted by PM students and the public presentation are evaluated, as explained in Section 3. The initial milestone rubric has eight indicators:

1. Problem formulation.

2. Work planning (including budget).
3. Methodology, monitoring tools, and methods for evaluation of results.
4. Initial sustainability analysis.
5. Clear and correct written expression.
6. Oral communication: verbal language.
7. Oral communication: body language.
8. Oral communication: adequate use of support elements.

On completion of the Initial Milestone, the PM teacher may ask for any corrections to be made, and students propose and schedule the Follow-up Milestone assessment, around halfway stage of the FYP (approximately 2-3 months later).

4.2. The Follow-up Milestone

In the Follow-up Milestone, the supervisor evaluates student progress. The milestone rubric evaluates eight indicators to identify deviations from the initial planning and assesses student attitude. The main goal is to check that the FYP is progressing properly and request corrections if necessary. This milestone may be repeated if the supervisor considers it is not accurate enough. In that case, a new date is proposed by the student and re-evaluation is conducted. The evaluated indicators are as follows:

1. Project contextualization (background and analysis of candidate solutions and technologies).
2. Planning monitoring, justifying any deviation.
3. If any changes have been made to the methodology, justification and description of new methodology.
4. Justification of the option selected to solve the problem presented by the project.
5. Student ability to take initiatives and decisions, weighting risks and opportunities.
6. Student ability to engage in work, showing a professional attitude and behavior.
7. Integration of knowledge and generation of creative solutions.
8. Identification of regulations (laws, rules, etc.) that may potentially affect the project.

4.3. The Final Milestone

The Final Milestone must be completed no later than one year after student enrollment in the project. Otherwise, the student must re-enroll for the project (UPC rules). In this milestone, the final report and the public presentation are evaluated by a committee on the basis of ten indicators:

1. Resolution of the initially formulated problem and scope of the proposed objectives.
2. Planning monitoring, justifying any deviation.
3. Existence of enough information to reproduce the process of analysis, synthesis and evaluation.
4. Complete sustainability analysis.
5. Structure and organization of the work.
6. Clear and correct written expression.
7. Use of information resources.
8. Oral communication: verbal language.
9. Oral communication: body language.
10. Oral communication: correct use of support elements.

All milestone rubrics, as well as the information regarding the FYP assessment, are accessible on the FIB web site [25]. The Committee is specific for each specialty and consists of one chair and two members. At least two committee members should be able to assess the technical skills of the project. The FYP supervisor cannot be a member of the committee.

Two assessment periods are defined each semester, one at mid-semester and the other at the end. The FYPs are grouped into blocks of up to four projects which are evaluated by the same committee. This structure makes it easy for supervisors to avoid evaluating their own projects; it also prevents overload for committee members and ensures that at least two of the board members can make a technical assessment.

4.4. The Student's Guide

Rubrics are very useful as a guide for evaluator agents to unify criteria. In the case of an FYP evaluation, where different evaluator agents are involved, it is very important to have precise rubrics to eliminate, as far as possible, the degree of subjectivity present in any evaluation. However, precise rubrics contain too much information to provide useful guidance for the students. For this reason, we have developed a student guide based on the Socratic Method [26], which consists of a set of questions that students should consider while developing their FYP. The answers to some of these questions should be reflected in the final FYP report, while other questions should help students to address issues that facilitate progress in the right direction. The complete list of questions is provided in Table 1.

	Initial Milestone (PM teacher) rubric	**Follow up Milestone rubric**	**Final Milestone rubric**
Problem formulation	What problem does the project address? Has the problem already been solved? If so, can an existing solution be used/adapted, or does a new solution need to be designed? What are the aims of the bachelor's thesis? Are they clearly and comprehensively specified? Is the scope of the project delimited? Who is the product intended for? Who will use the solution? Who will benefit from the results? Is the project complex enough to be considered a bachelor's thesis? Is there sufficient justification for it to be carried out by a technical engineer?		To what extent does the project solve the initial problem?
Contextualisation of the project		Does the student give an adequate definition of the framework in which the bachelor's thesis is carried out? Does the student describe how the problem in question is currently managed? Does the student consider the availability of similar or related products? Does the student justify his/her choice of technologies?	
Work plan	Does the student provide an initial work plan for the project? Does the student provide an initial cost analysis (efforts and resources)? Does the student provide an estimation of constraints and/or risks?	Have changes been made to the initial work plan? If so, are these changes justified, and does the student provide a definitive work plan? How do these changes affect the objectives or the implementation of the project? What impact do these changes have on costs? What stage of the work plan has been reached?	Has the student reviewed the commitments (objectives, scope, work plan, costs, etc.) acquired from the previous milestones? If so, are sufficient reasons given for the changes? Does the student provide a quantification of the work carried out and an economic evaluation of the project?
Methodology and rigour	Does the student describe his/her methodology? What tools will be used to monitor the project? Does the student describe the validation method for the project results?	Have changes been made to the initial methodology? If so, does the student explain why the changes were made?	Does the student clearly explain how the solution has been reached? Does the student clearly explain how the solution has been validated? Does the student give sufficient details for the analytical, synthesis and evaluation procedures to be reproduced? If a numerical evaluation is given, are the figures correct and duly explained?
Analysis of alternative solutions		Are the different alternatives to solve the problem analysed? Is the chosen option justified?	
Sustainability and social commitment	Is the social, environmental and/or economic impact that the project may have on the environment in which it is framed analysed? For example, will the project improve, directly or indirectly, the quality of life of people? Will the project reduce the ecological footprint? Will the project be economically viable? Is a study of the state of the art performed on how the problem addressed by the project is currently solved? Is a description provided of how the project proposal will improve the current solutions in the social, economic and environmental aspects? Are indicators proposed to measure the project's impact on the three sustainability dimensions?		Is there a chapter in the report dedicated to the sustainability analysis? Is an analysis of the social, environmental and economic impact of the project carried out in this chapter by using the sustainability matrix? Are all questions from the sustainability matrix adequately answered, calculating in a reasonable way the sustainability degree of the project? Has the student appropriately quantified the economic, environmental and social impact of the project? Is there an analysis of risks and a proposal to reduce them? Are personal conclusions about the sustainability of the project clearly presented?
Initiative and decision-making		Has the student been proactive in his/her decision-making? Has he/she adequately justified the decisions? Has the student demonstrated initiative in carrying out the project? Has the student demonstrated an ability to address/overcome obstacles?	
Commitment to the project		Has the student acted professionally and ethically throughout the project?	

Integration of knowledge		Does the student integrate knowledge from a range of disciplines? Does the student propose creative solutions?	
Identification of applicable laws and regulations		Are the main project actions governed by a particular law/regulation? If so, does the project comply with this law/regulation?	
Correct structure and organisation			Does the report include an abstract (in Spanish, Catalan and English)? Is there a table of contents, and are pages and sections numbered? Does the report have a coherent structure? Is the report complete? Is there a separate conclusions section summarising and establishing links between the different topics addressed? Are the conclusions well-reasoned? Do the abstract, introduction and conclusions give a clear idea of the project's content?
Clear and correct written expression	Are the documents written with sufficient clarity for readers with no prior knowledge of the project? Are they orthographically, syntactically and semantically correct and does the student express ideas with precision? Does the student give definitions of new terms when necessary? Has the student given the documents a final read-through before submitting them?		Is the report written with sufficient clarity for readers with no prior knowledge of the project? Is the report orthographically, syntactically and semantically correct and does the student express ideas with precision? Does the student give clear definitions of new concepts when necessary? Having completed the report, has the student given it a final read-through?
Use of resources			Does the student identify potentially confusing aspects of the project and clarify them with examples and explanations? Are footnotes or endnotes included, if required? Are the tables and figures self-explanatory without reading the text? Are the references correctly cited? Are the sources of cited text and/or third party figures/images clearly identified?
Verbal communication	Does the student use appropriate technical language? Does the student use appropriate intonation, avoid the use of filler words and maintain an audible tone of voice? Do the student's answers link to other aspects of the thesis? Does the student give clear explanations of the fundamental aspects of the project? Does the student express himself/herself naturally? Does the student show evidence of preparation and practice?		Does the student use appropriate technical language? Does the student use appropriate intonation, avoid the use of filler words and maintain an audible tone of voice? Do the student's answers link to other aspects of the thesis? Does the student give clear explanations of the fundamental aspects of the project? Does the student express himself/herself naturally? Does the student show evidence of preparation and practice?
Non-verbal communication	Does the student control and influence the audience with non-verbal messages such as hand gestures, facial expressions or choice of clothing? Does the student display good time management skills? Does the student make effective use of pauses? Does the student successfully draw attention to his/her voice, when the key message is oral, and to the corresponding slide, when the key message is visual?		Does the student control and influence the audience with non-verbal messages such as hand gestures, facial expressions or choice of clothing? Does the student display good time management skills? Does the student make effective use of pauses? Does the student successfully draw attention to his/her voice, when the key message is oral, and to the corresponding slide, when the key message is visual?

Confident use of supporting materials	Has the student made an appropriate selection of the project sections to be presented? Do the supporting materials (generally slides) contain all the required elements (numeration, title page, final slide, etc.)? Is the use of tables, figures, images, colour, blocks of text, font size, etc. conducive to an enjoyable presentation? Are points organised logically to match the structure of the project and does the presentation flow naturally?		Has the student made an appropriate selection of the project sections to be presented? Do the supporting materials (generally slides) contain all the required elements (numeration, title page, final slide, etc.)? Does the use of tables, figures, images, colour, blocks of text, font size, etc. make the project more enjoyable? Are points organised logically to match the structure of the project and does the presentation flow naturally?
Writing skills in a foreign language			Ability to write technical documents correctly in English.
Third Speaking Language			Make a presentation in English, explaining the ideas and concepts in an understandable way and using a broad technical vocabulary.

Table 1 Students' Guide Criteria.

4.5. Final Assessment

The process described so far is applied to the assessment of professional skills. Given the enormous casuistry of FYPs, the same process cannot be applied to the technical skills of a degree or specialty. The authors' proposal is that the assessment of technical skills should be done in accordance with the school criteria. The criterion adopted by the FIB has been to evaluate technical skills altogether during the Final Milestone. In other words, the committee decides on the corresponding qualifications for grading the FYP technical skills. For this reason, the assessment of the technical part of the project should be subject to the expertise of the committee members.

Regarding the final grade calculation, technical skills account for 60% of the mark and professional skills for the remaining 40%. One way to justify this distribution is by answering that question: "What grade would you give to an excellent project with a horrible report and bad oral presentation?" Using the proposed weight distribution, that project should receive a grade of 6 (out of 10).

The authors have determined that all indicators relating to professional skills should be weighted equally within each milestone. To that end, they have defined the following weights for each milestone: 25% for the Initial, 25% for the Follow-up and 50% for the Final Milestone. Since these percentages correspond to assessment of professional skills, which accounts for 40% of the total FYP grade, the result is that the Initial Milestone constitutes 10% of the final grade, the Follow-up Milestone another 10%, and the Final Milestone 80% (20% to assess professional skills and 60% to assess technical skills).

Since some indicators are evaluated in more than one milestone, as shown in Table 2, it is appropriate to disregard some bad indicator results for the final qualification, but only when improvements in the indicator are detected. This enables any corrections of deficiencies detected by the students during the FYP implementation to be taken into consideration.

Indicator	Initial milestone	Follow-up milestone	Final milestone
Problem statement	X		X
Contextualization		X	
Planning	X	X	X
Methodology and Rigor	X	X	X
Considering different alternatives		X	
Sustainability	X		X
Initiative and decision making		X	
Attitude and professional behavior		X	
Integrating knowledge and creative problem solving		X	
Identification of regulatory elements and norms		X	
Organization and structuring of work			X

Appropriated knowledge of written skills	X		X
Use of information resources			X
Oral communication: verbal language	X		X
Oral communication: body language	X		X
Oral communication: use of supporting elements	X		X
Prepare reports in English			X
Conduct presentation in English			X

Table 2 Distribution of the milestone indicators.

Finally, the committee’s report on the Final Milestone contains an option to indicate whether the FYP deserves the award of an extra point for any merit that the committee might consider. This award must be justified and, in no circumstances, may match any of the indicators that have already been evaluated. The aim of this measure is to detect those exceptionally good FYPs with an outstanding evaluation that merit an award with honors. Projects graded with a final score greater than 9.5 may be distinguished with honors according to the committee criteria.

The final assessment is arrived at quite easily by means of a software application. The committee's task during the Final Milestone consists in selecting the assessment of every indicator from its rubrics by a single click, assessing the technical skills of the project with a numerical grade, and deciding whether it is an FYP of exceptional quality or not. Since professional skills are assessed independently, a grade for each professional skill is automatically extracted from the indicators evaluated in the three milestones (see Table 3).

Indicators/ skills	Entrepreneurship and Innovation	Sustainability and social	Oral and written communication	Appropriate use of information	Autonomous learning	Appropriated attitude to work	Foreign language	Reasoning
Problem statement								X
Contextualization				X	X			
Planning	X					X		
Methodology and Rigor								X
Considering different alternatives	X				X			X
Sustainability	X	X						
Initiative and decision making	X				X	X		
Attitude and professional behavior						X		
Integrating knowledge and creative problem solving	X				X	X		X
Identification of regulatory elements and norms		X		X	X			
Organization and structuring of work			X					
Appropriate knowledge of written skills			X				X	X
Use of information resources			X	X				
Oral communication: verbal language			X			X	X	
Oral communication: body language			X			X		
Oral communication: use of supporting elements			X	X				
Prepare reports in English							X	
Conduct presentation in English							X	
TOTAL	5	2	6	4	5	6	4	5

Table 3 Distribution of indicators according to professional skills.

5. Results and discussion

Figures 2 and 3 present the results obtained by 1,569 students in the different degrees offered by the FIB since 2007: 345 students of the Diploma in Computer Software, 369 students of the Diploma in Computer Systems and 855 students of the Bachelor Degree in Informatics Engineering. As regards the duration of the FYP, Figure 2 compares the duration, in months, that the students needed to complete their FYP in the Bachelor over the last five years with those of the previous engineering degrees (data from six years in Diploma in Computer Software and Diploma in Computer Systems). Only 65% of the students who finished the project in the diplomas managed to finish it in less than a year. However, 95% of the Bachelor students who finished the project presented their FYP in less than a year, and approximately 60% of the students took between 6 and 12 months. The reason for the last statistic is that the UPC regulations make it easy to obtain a six months' extension for the FYP defense at almost no extra cost. Some students therefore take advantage of this circumstance and complete their FYP within the following term.

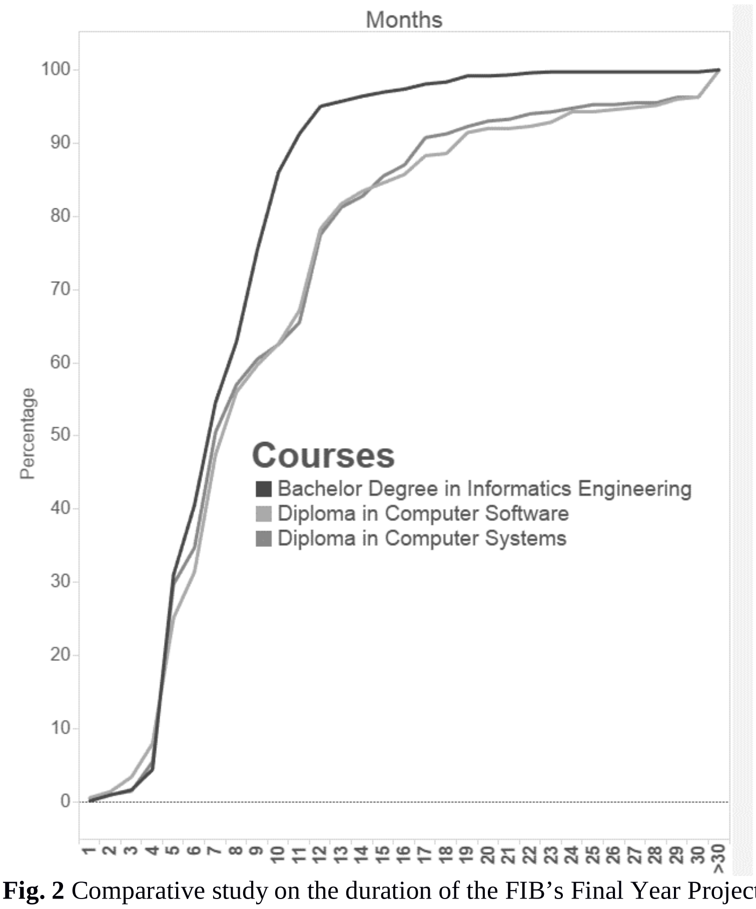

Fig. 2 Comparative study on the duration of the FIB's Final Year Project.

Figure 3 presents the percentage of students who pass or fail their FYP. The fail is mainly produced when the FYP is not presented, so these data reflect the percentage of students who present the FYP. The average percentage of students finishing FYP was 64.92% and 66.12% respectively in previous degrees, whereas in the case of the Bachelor the average percentage rose to 89.35% with the methodology proposed in this paper. Note also a great improvement in year 2016, the last course evaluated (more than 95% finish their FYP, most of them in less than a year). We think this is because these students have only known this evaluation methodology of FYP and that the PM subject has stabilized. Like any new subject, it has undergone some changes during its first years of teaching in order to improve its results. This comparison is interesting since it highlights the contrast existing between students taking the new engineering degree who directly enrolled in this course as freshmen (close to 90%) and the lower success ratio achieved by students in previous degree courses (65% approx. on average). As can be seen in Figure 3, a significant improvement occurs in the last two years of the diplomas. The increase in the percentage of FYP presented is due to the fact that they were the last years that the degrees were given, and both students who completed the diplomas that years and those who had FYP pending from previous years made an effort to present it. If this anomaly is discounted, the improvement of the Bachelor's results regarding diplomas is even greater.

Due to the fact that this evaluation methodology is relatively new, and has been recently implemented, the results presented are limited to the last five years for the Bachelor Degree in Informatics. However, we think data are enough to show that the proposed methodology clearly improves previous results.

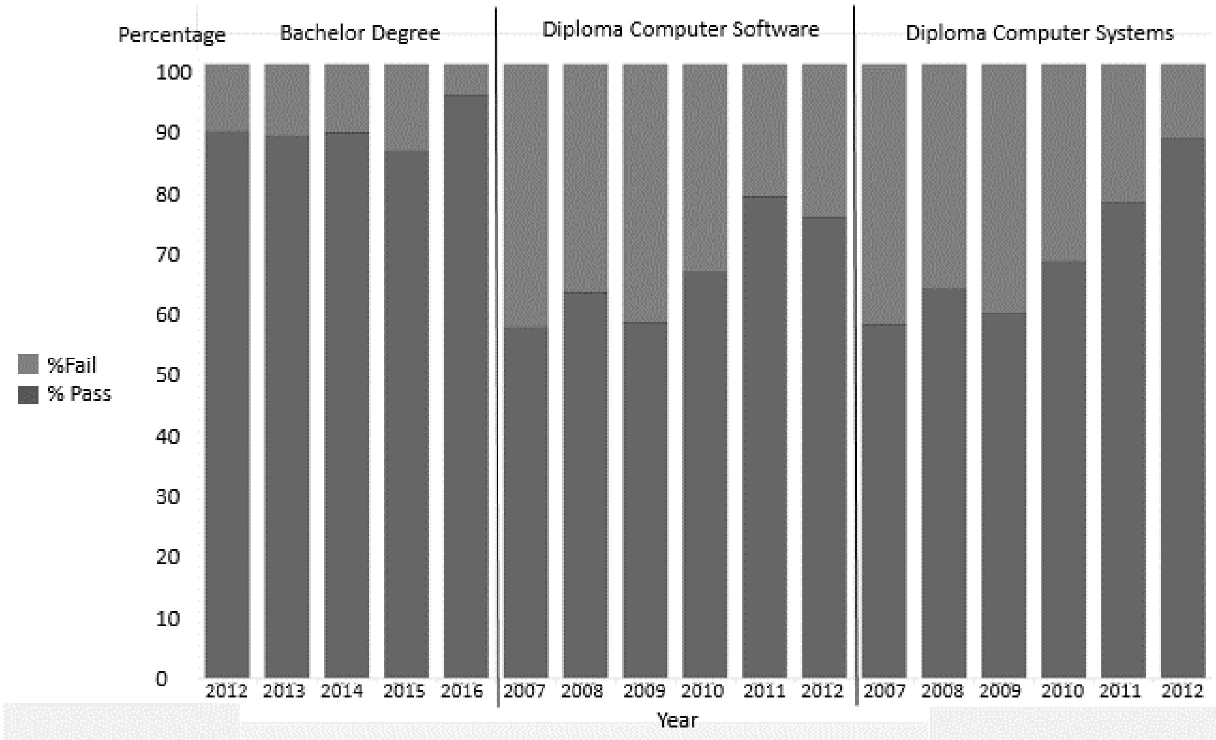

Fig. 3 Percentage of students completing their FYP per academic year.

6. Conclusions

The Final Year Project (FYP) is the last academic exercise required of engineering degree students. Students are expected to demonstrate that they have acquired the skills necessary for the successful completion of the degree course. However, the FYP is not only their final and definitive assessment, it is also their last training activity. In this paper, we present a methodology for conducting a competence-based evaluation of the FYP, and in addition propose tracking the FYP to complete student training in the discipline. The assessment consists of three milestones: Initial, Follow-up and Final. The methodology defines a set of indicators to be assessed at each milestone; these indicators are related to the skills that students must acquire and are evaluated in accordance with different evaluator agents by using the criteria in a rubric.

Professional skills are hard to be evaluated, since they are more subjective than the technical skills, and no assessment methodologies has been analyzed in the literature extensively to describe the benefits of using a specific approach. The scope of this work is limited to the assessment of professional skills. The rubrics for technical skills are highly dependent on the nature of each individual project. Since the committee members of the final milestone are experts in the field, the assessment of the technical skills is not as prone to subjectivity as the professional skills. Using the proposed methodology, arbitrariness in the evaluation is not totally eliminated, but it is considerably reduced.

The methodology proposed in this paper has been implemented for the past five years in the Bachelor Degree in Informatics at the Barcelona School of Informatics. The results obtained during this time (89% of students finished their FYP compared to only 65% of previous degrees; and 95% of these students finished their FYP in less than a year, compared to only 65% who did in the Diplomas) have shown that monitoring the assessment of the FYP improves the ratio of students who deliver it, and has also reduced the time required to complete it.

Before the application of this methodology, only one act of assessment was carried out when the project was completed. Consequently, a significant percentage of students took a long time to finish the project and some of them never managed to complete it.

This methodology improves not only the number of students that finish the project, but also reduces the time needed to develop it, and also reduces the arbitrariness on the evaluation of the professional skills, and ensures traceability of the assessment and transparency of the assessment criteria. Furthermore, we believe this methodology may easily be applied to other contexts and degree courses.

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