OPTIMIZATION AND INNOVATION BACCALAUREATE CURRICULUM DESIGN ACCORDING TO CDIO CONCEPTS

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Abstract
Recent progresses on curriculum undergraduation reformulation in Portugal, due to Bologna Agreement, lead to the development of a new Optimization and Innovation baccalaureate. This course has been structured along a completely new curriculum, inspired on the CDIO paradigm, combining a core curriculum in Mathematics, Management and Information Technologies, with a set of minors in the areas of engineering taught in ISEP, the Porto Polytechnic School.
To promote differentiation, new skills, accurate knowledge and pro-active attitudes will make the difference between success and failure in the competitive labor market. Against the usual background, this baccalaureate was structured in order to develop competences that are really fundamental for an engineer of the 21st century.
Besides technically skilled, the engineer of the 21st century must also denote competences in a variety of professional practices, and those skills must be developed and practiced throughout time.

Introduction

Since 2006 that ISEP – Oporto Polytechnic Institute, has been participating in the CDIO Initiative, through the Informatics Engineering Department with the aim of introduction CDIO principles in the Informatics Engineering baccalaureate (LEI-ISEP), being this process supported by a Portuguese Government grant.

At the fall of 2006, the Mathematics Department at ISEP start designing the curriculum of the Optimization and Innovation baccalaureate (LOI-ISEP), also adopting the CDIO paradigm and principles as the base framework for curriculum and course design. The creation of LOI-ISEP is in fact the result of industry request.

Portuguese industry needs innovation and for that it needs engineers who think like entrepreneurs. So, in addition to being technically proficient, engineers must also be creative in problem-solving, perceptive about the global economy, knowledgeable about management, and able to communicate their ideas effectively.

The traditional approach to fulfill these professional requirements is to incentive graduated engineers to take masters degrees on operation research, after some years in industry. However,

this is costly for both the country (the government finances most of higher education costs) and companies, which sometimes finance the post-graduation and then are expected to give extra wage benefits to a professional with a master degree.

Furthermore, as Portuguese companies move up in supply chain, and try to avoid low cost competition from Far East countries, the need for professionals in the LOI-ISEP market segment is foreseen to grow exponentially. Meanwhile, there are no similar Bachelor curricula (baccalaureate) in Portugal.

Market research indicated that the usual approach (in Portugal) to base engineering related management curricula on the mechanic engineering curricula is very restrictive and doesn't address the changes in the Portuguese industrial base. LOI-ISP thus implements a novel approach of providing a core curriculum and a set of engineering specific minors in an engineering area chosen by the student. This approach has several advantages, not only from the economic point of view (reuse of current courses at ISEP, etc.), but also allows for the possibility of cooperation with other higher education institutions, both in Portugal and abroad.

In this paper, the authors present the rationale behind the curriculum and course design and how the CDIO approach provides the framework for the minor integration in the core curriculum.

Framework

The baccalaureate in Optimization and Innovation aims to integrate mathematical models and techniques in the process of decision support. Nowadays, when the changes are so fast and the enterprise environment is highly competitive, companies must have a clear notion of the consequences of their strategic and operational decisions. On the other hand, so that the companies proceed in the way of innovation and competitiveness, decisions cannot be merely a result of intuition or experience of the manager. They must be supported by a detailed analysis of each problem. Given adequate information, the analyst creates a model to simulate the concrete situation, using appropriate mathematical techniques, and knowledge of the scientific area of management, to find one or more solutions that allow supporting the best decision. This baccalaureate intends to prepare professionals with these specific skills in methodologies of operational research, simulation, statistics, management, and in the creation and development of computational tools. This base knowledge is complemented with one optional component in one classical area of engineering (minor), allowing the contact with current areas of application.

We expect that the demand by the companies for graduates with such a profile tends to increase, given that national companies need to improve their productivity, efficiency and competitiveness, to be able to survive in the global market.

Companies will require this kind of professional mostly is in the design of the decision support process. One evidence that companies already have such need is that currently they tend to hire more than one professional with complementary skills that will be provided in the proposed baccalaureate.

On the other hand, we think it also interesting to allow more diversified formations with curricular variants. For that, we have minors in classical areas of engineering already lectured in ISEP, to improve employability. These diversified backgrounds allow for a wider range of

second cycle courses to be chosen, and promote interdisciplinary. It also assures a more opportunities of mobility in the national or European space.

Optimization and Innovation baccalaureate curricula

The Optimization and Innovation baccalaureate program consists of three years of study. In this bachelor degree the core subjects are mathematics, management and Information Technologies, as is show in the following figure, Figure 1.

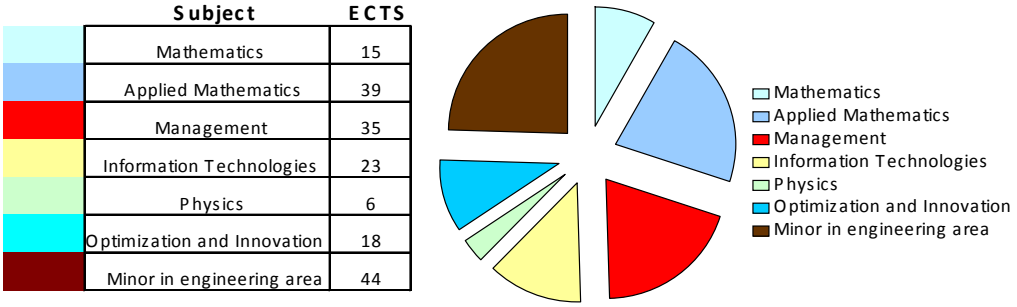

Figure 1. ECTS

Table 1 shows the minors we offer:

Table 1. Minors

Minor Civil Engineer – Building Structure
Minor Civil Engineer – Project management
Minor Electronic Engineering
Minor Power System Engineering
Minor Informatics Engineering
Minor Data Mining
Minor Environment Technology
Minor Geotechnical Engineering
Minor Mechanical Engineering

So, in order to achieve the desired objectives an integrated curriculum is necessary that systematically balances knowledge to be transmitted with skills to be developed, where disciplines are connected and mutually sustained assuring the interdisciplinary. Regular semester activities are planned in order to develop skills like communication, ethics and leadership.

The Optimization and Innovation baccalaureate curriculum have been designed in the context of the CDIO paradigm and principles:

- courses are the organizing principle interwoven with design–build experiences
- inclusion of design–build experiences to motivate and to reinforce learning
- clear connections of learning to utility exist throughout the curriculum
- rigor and breadth of coverage are preserved.

In the Figure 2 we show how the 4th semester courses are interconnected.

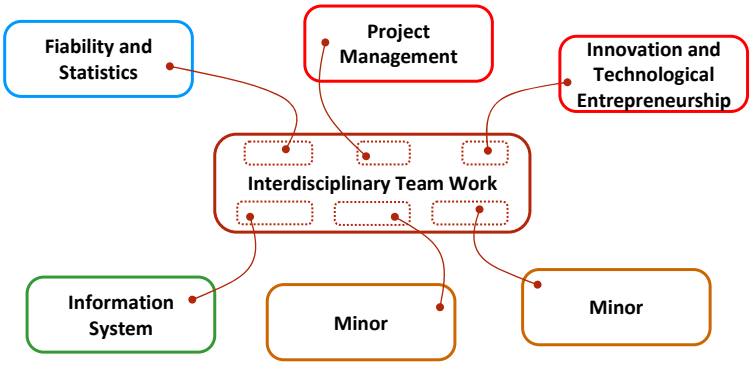

Figure 2. 4th Semester curricula

The curriculum puts the students in a design environment where they learn engineering and technology and when they need to use them. These practices will focus on integrating topics from non-engineering courses with engineering courses.

In addition, they are always required to work as a team, exercise their communication, project management, leadership and other skills. The team students may be on different minors. This approach is a major improvement from the traditional one, which provides the students with the technologic knowledge, but they are not exposed to problems outside their field of expertise. These practices will focus on integrating topics from non-engineering courses with engineering courses.

Multidisciplinary learning prepares the students for the real world. Figure 3 shows the division of courses by the different scientific areas.

Mathematics	**Information Technologies**
Linear Algebra (AL)	Introduction to Programming (IPROG)
Mathematics I (MATH-I)	Modelling and Processes (MP)
Mathematics II (MATH-II)	Information Systems I (IS-I)
Applied Mathematics	Information Systems II (IS-II)
Statistics (STAT)	**Optimization and Innovation**
Numerical Methods (NUME)	Industrial Placement Project (IPP)
Modelling and Simulation (MODSIM)	**Management**
Fiability and Statistics (FIASTAT)	Management (MANG)
Operation Research (OR)	Project Management (PROJM)
Optimization I (OPT-I)	Innovation and Technological Entrepreneurship (ITE)
Optimization II (OPT-II)	Managerial Finance (MANGF)
Physics	Innovation and Technological Entrepreneurship project (ITE-PROJ)
Applied Physics (APHIS)	Management Systems and Certification (MANGSC)
Minors	

Figure 3. Courses

Figure 4 shows how the course sequence for the six semesters.

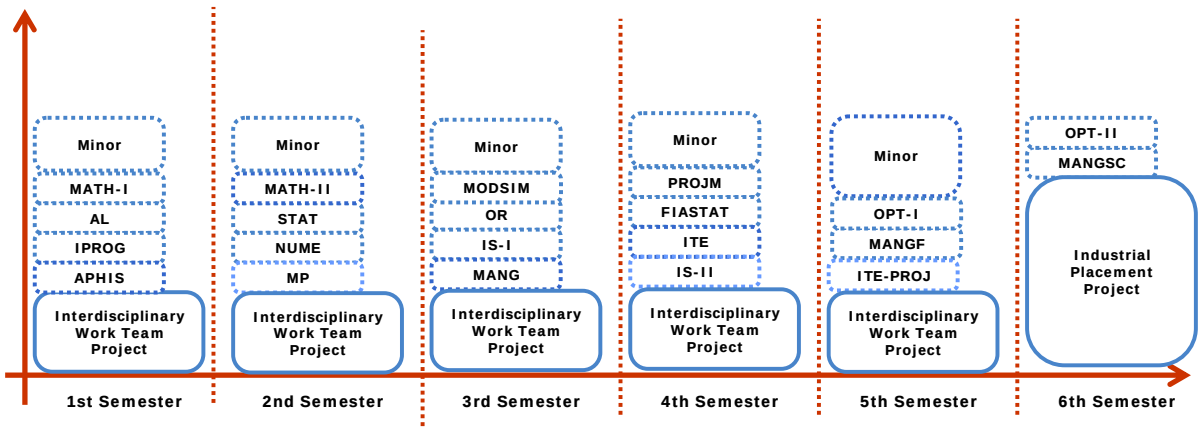

Figure 4. Curricula

Objectives of the LOI baccalaureate

In this section we present the intended profile for this kind of bachelor as well the principles that guided the design of the syllabus.

We intend that the bachelor be able to use and adapt mathematical models to simulate real problems, applied the optimization methods on they solution and computational tools with the objective of developing and interpreting information about the decision support process.

The field of work oh this kind of bachelor is diverse and can be of use on public and private organizations, either banks, insurance companies, consulting, market studies, new technologies, transports, and companies whose principal activity includes the optional engineering area chosen.

The tasks to be carried out by these professionals, although always with the aim of supporting the decision of management, may vary according to the kind of the company, and it can cover the areas of planning and control, resource management, optimization, collection and processing of information.

The intended skills to acquire are:

Generic skills

the ability to:

- apply scientific methods and techniques to decision support processes;
- analyze and utilize information;
- apply and develop computational tools;
- develop, apply and evaluate new solutions to concrete problems;
- understand and apply standard techniques of management.

Specific skills
the ability to:

- apply mathematical knowledge for solving concrete problems, in particular in the chosen engineering area;
- formulate and solve mathematical models;
- collect and interpret information, especially when related to statistical data;
- analyze data and to extract information for prediction;
- propose and evaluate the quality of different solutions for one problem:
- communicate and to do team work;
- develop new ideas to deal with the challenges that are faced by the organizations;
- participate in activities of innovation, entrepreneurship and applied research;
- communicate in English in a Professional environment;
- apply the skills acquired in the area of the minor.

Conclusions

Many challenges and opportunities emerge in engineering education. A new curriculum of the Optimization and Innovation baccalaureate developed in ISEP to face the future trends of the global market economy and the needs of the employers. This project was submitted to the Portuguese Bureau of Science and Superior Education in November 2006 to be evaluated.

The Mathematics Department at ISEP has design a new curriculum of the Optimization and Innovation baccalaureate (LOI-ISEP), adopting the CDIO paradigm and principles. The creation of LOI-ISEP is in fact the result of industry request for trained professionals on operation research and process management. Detailed course content is already developed.

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