**UP**GRADE is the European Journal for the Informatics Professional, published bimonthly at <http://www.upgrade-cepis.org/>

Publisher
UPGRADE is published on behalf of CEPIS (Council of European Professional Informatics Societies, <http://www.cepis.org/>) by Novática <http://www.ati.es/novatica/>, journal of the Spanish CEPIS society ATI (*Asociación de Técnicos de Informática,* <http://www.ati.es/>)

UPGRADE monographs are also published in Spanish (full version printed; summary, abstracts and some articles online) by Novática

UPGRADE was created in October 2000 by CEPIS and was first published by Novática and INFORMATIK/INFORMATIQUE, bimonthly journal of SVI/FSI (Swiss Federation of Professional Informatics Societies, <http://www.svifsi.ch/>)

UPGRADE is the anchor point for UPENET (UPGRADE European NETwork), the network of CEPIS member societies' publications, that currently includes the following ones:
• Informatik-Spektrum, journal published by Springer Verlag on behalf of the CEPIS societies GI, Germany, and SI, Switzerland
• ITNOW, magazine published by Oxford University Press on behalf of the British CEPIS society BCS
• Mondo Digitale, digital journal from the Italian CEPIS society AICA
• Novática, journal from the Spanish CEPIS society ATI
• OCG Journal, journal from the Austrian CEPIS society OCG
• Pliroforiki, journal from the Cyprus CEPIS society CCS
• Pro Dialog, journal from the Polish CEPIS society PTI-PIPS

Editorial Team
Chief Editor: Llorenç Pagés-Casas, Spain, <pages@ati.es>
Associate Editors:
François Louis Nicolet, Switzerland, <nicolet@acm.org>
Roberto Carniel, Italy, <carniel@dgt.uniud.it>
Zakaria Maamar, Arab Emirates, <Zakaria. Maamar@ zu.ac.ae>
Soraya Kouadri Mostéfaoui, Switzerland,
<soraya.kouadrimostefaoui@unifr.ch>
Rafael Fernández Calvo, Spain, <rfcalvo@ati.es>

Editorial Board
Prof. Wolffried Stucky, CEPIS Former President
Prof. Nello Scarabottolo, CEPIS Vice President
Fernando Piera Gómez and
Llorenç Pagés-Casas, ATI (Spain)
François Louis Nicolet, SI (Switzerland)
Roberto Carniel, ALSI – Tecnoteca (Italy)

UPENET Advisory Board
Hermann Engesser (Informatik-Spektrum, Germany and Switzerland)
Brian Runciman (ITNOW, United Kingdom)
Franco Filippazzi (Mondo Digitale, Italy)
Llorenç Pagés-Casas (Novática, Spain)
Veith Risak (OCG Journal, Austria)
Panicos Masouras (Pliroforiki, Cyprus)
Andrzej Marciniak (Pro Dialog, Poland)
Rafael Fernández Calvo (Coordination)

English Language Editors: Mike Andersson, Richard Butchart, David Cash, Arthur Cook, Tracey Darch, Laura Davies, Nick Dunn, Rodney Fennemore, Hilary Green, Roger Harris, Michael Hird, Jim Holder, Alasdair MacLeod, Pat Moody, Adam David Moss, Phil Parkin, Brian Robson

Cover page designed by RFCalvo, © Rafael Fernández Calvo 2006
Layout Design: François Louis Nicolet
Composition: Jorge Llácer-Gil de Ramales

Editorial correspondence: Llorenç Pagés-Casas <pages@ati.es>
Advertising correspondence: <novatica@ati.es>

UPGRADE Newslist available at
<http://www.upgrade-cepis.org/pages/editinfo.html#newslist>

Copyright
© Novática 2006 (for the monograph)
© CEPIS 2006 (for the sections MOSAIC and UPENET)
All rights reserved under otherwise stated. Abstracting is permitted with credit to the source. For copying, reprint, or republication permission, contact the Editorial Team

The opinions expressed by the authors are their exclusive responsibility

ISSN 1684-5285

Monograph of next issue (October 2006)
**"Web Services"**
(The full schedule of **UP**GRADE is available at our website)

UPGRADE
The European Journal for the Informatics Professional
http://www.upgrade-cepis.org
**Vol. VII, issue No. 4, August 2006**

3 From The Editor's Desk
**UP**GRADE: A Project for The Current Day and Age

**Monograph: The Bologna Process and The Informatics Profession (published jointly with Novática*)**
Guest Editors: *Juan-José Cuadrado-Gallego, Luigi Buglione*

4 Presentation. The Bologna Process and The Informatics Profession — *Juan-José Cuadrado-Gallego, Luigi Buglione*

7 Professionalism in IT — *Charles Hughes*

11 Towards A Real Change (or The Modification of Computer Engineering Studies through The Eyes of A Student) — *Mikel Salazar-Peña*

13 Evolution of Computer Science Studies in Spain in The European Higher Education Area — *Juan-José Cuadrado-Gallego, León González-Sotos, Daniel Rodríguez-García, Miguel-Ángel Urban-Sicilia*

22 Bologna Process: The Italian Experience — *Luigi Buglione*

27 The Dutch Experience of Carrying Out the Bologna Process — *Maya Daneva*

34 Historical Evolution of Courses of Study in Computer Science: A German Experience Report — *René Braungarten, Martin Kunz, and Reiner R. Dumke*

45 ECTS Pilot Scheme for the Technical Engineering Degree in Data Processing and Computer Systems — *José Luis Álvarez-Macías, Manuel J. Redondo-González, Javier Aroba-Páez, Beatriz Aranda-Louvier, Patricio Salmerón-Revuelta*

UPENET (UPGRADE European NETwork)

53 From **Pro Dialog** (PTI-PIPS, Poland)
Human-Computer Interface
High Performance Computing Technology, Applications and Business — *Maksymilian Cierniewski, Jan Kniat, Pawe Marciniak, Marcin Zduniak, and Micha Zygmunt*

66 From ***Novática***
ICT Security
Anatomy of An Intrusion
*Miguel Sánchez-López*

* This monograph will be also published in Spanish (full version printed; summary, abstracts, and some articles online) by **Novática**, journal of the Spanish CEPIS society ATI (*Asociación de Técnicos de Informática*) at <http://www.ati.es/novatica/>.

# Evolution of Computer Science Studies in Spain in The European Higher Education Area

*Juan-José Cuadrado-Gallego, León González-Sotos, Daniel Rodríguez-García, Miguel-Ángel Sicilia-Urbán*

*The current situation of Computer Science studies in Spain and most European countries has been affected by the Bologna Process which aims to establish a European Higher Education Area by 2010. This paper provides an overview of the situation in Spain and explains how the Spanish system is adopting the Bologna agreement and the new credit system at both undergraduate and postgraduate levels.*

**Keywords:** European Credit Transfer System, European Higher Education Area, Spanish Computer Science Education.

## 1 Introduction

The Bologna Process, which aims to create a European Higher Education Area (EAHA), has affected most European countries. It includes objectives in the following areas: the introduction of undergraduate and postgraduate levels in all countries; a common European Credit Transfer System; and mobility of students and teachers. This paper describes how the Bologna Process is being introduced in Spain.

This paper is structured as follows. Section 2 describes the current situation. Section 3 explains how Computer Science studies are being aligned with the Bologna process. The new European Credit Transfer System is covered in Section 4. Finally, Section 5 concludes the paper.

## 2 Computer Science Studies in The Current Situation

In Spain, official studies related with Computer Science and their corresponding degrees started in the 70s when the Computer Science Institute was created by Royal Decree 554/1969 of March 29. Computer Science studies were offered in 5 courses. The Ministerial Order of 28 July 1971 made it possible to homologate those courses and accredit professionals and experts who had been entering what until then had been a relatively new career, either through unofficial channels or by studying abroad.

Since then, and especially in the 90s, the Computer Science profession has grown in leaps and bounds. There are currently more than 70,000 graduate professionals, with more than 70 centres offering Computer Engineering related degrees (both public and private) and carrying out important research activities.

However, due to administrative apathy, no legal framework has been developed to regulate IT practices and their associated legal responsibilities, competencies, and powers. As a result, in the field of Information and Communication Technologies, there is a lack of definition in related areas, especially Telecommunications Engineering and specializations such as Telematics, and Electronics and some Industrial Engineering specializations. This is causing de-

**Authors**

**Juan-José Cuadrado-Gallego** works in the Department of Computer Science at the *Universidad de Alcalá*, Madrid, Spain and the *Universitat Oberta de Catalunya*, Barcelona, Spain. He previously held positions at the *Universidad de Valladolid* and the *Universidad Carlos III de Madrid*, Spain, where he obtained his Doctorate in Computer Sciences Engineering in 2001. His research interests are centred in the area of Software Engineering and especially Software Measurement. He is the president of the Spanish Function Points Users Group (SFPUG), Spain. <jjcg@uah.es>

**León González-Sotos** is full professor of the department of Computational Sciences at the *Universidad de Alcalá* (Madrid) and is currently the director of the ETS (Higher Technical School) of Computer Engineering at the same university. Prior to that he lectured at the *Universidad de Sevilla* and the *Universidad Pública de Navarra*. He holds a Ph.D. in Mathematical Sciences and has researched in the field of fuzzy logic. He has participated in national and European projects and has supervised a number of doctoral theses on this subject. Since his appointment as director of the ETS in early 2004 he has taken part in the activities of the Conference of Deans and Directors of University Computer Science Centres concerning the problems of adopting the EHEA in the field of ICT. <leon.gonzalez@uah.es>

**Daniel Rodríguez-García** is a lecturer in the Department of Computer Science at the University of Reading. He received his B.Sc. degree in Computer Science from the *Universidad del País Vasco*, Spain, in 1995 and his Ph.D. from the University of Reading, UK, in 2003. His research interests are in the area of software engineering including empirical software engineering, and the application of data mining techniques to software engineering. <d.rodriguez-garcia@reading.ac.uk>

**Miguel-Ángel Sicilia-Urbán** obtained an M.Sc. degree in Computer Science from the *Universidad Pontificia de Salamanca*, Madrid (Spain) in 1996 and a Ph.D. degree from the *Universidad Carlos III* in 2003. He has worked as a software architect in e-commerce consulting firms, forming part of the development team of a Web personalization framework at Intelligent Software Components (iSOCO). He currently heads the Information Engineering Unit at the Computer Science Department, *Universidad de Alcalá*. His research interests are primarily in the areas of adaptive hypermedia, learning technology, and human-computer interaction. He is co-author of more than twenty refereed publications in these areas, and he also heads the AIS SIG on reusable learning objects (http://www.sigrlo.org). <m.sicilia@uah.es>

© Novática

lays and tensions in the process of designing new degrees in the European Higher Education Area (EHEA) which Spain has been part of since the inception of the Bologna process.

The Bologna Process aims to set up mechanisms to facilitate the mobility and exchange of students, academics, and professionals among European member states. It will significantly modify the design and practice of the various facets of academic activity in Spain and, in particular, the existing catalogue of degrees, their structure, study methods, and accreditation systems in order to harmonize the different systems to be found in the various countries.

To this end, since the first semester of 2003 a number of governmental initiatives have been developed to adapt the Spanish system to the EHEA within a certain timeframe. However, due to political changes its subsequent development has lacked continuity and progress has been slow and uncertain.

In view of this, the Spanish National Agency for Quality Assessment and Accreditation (ANECA, *Agencia Nacional de Evaluación de la Calidad y Acreditación*) was created to analyse the Spanish situation and perform comparative studies with other countries. In our area, since 2004 the Deans and Directors of University Computer Science Centres (CODDI, *Conferencia de Decanos y Directores de Centros Universitarios de Informática*) in collaboration with professional and student associations have been developing the University Studies in Computer Science and European Convergence (EICE, *Estudios Universitarios de Informática y Convergencia Europea*) project. The aim of this project was to describe the present day situation of the field of computer science and it led to a White Book proposal on the design of new degree courses. The proposed White Book was agreed on by the participating universities and includes a description of the context and purpose, objectives, methodological aspects, analysis of competencies and profiles, proposed structure and curricula guidelines, evaluation and validation methods, and quality indicators.

The current context is that of the aforementioned number of professionals, students and institutions, and study programmes that are currently available for the 3 degrees: Computer Engineer, Technical Engineer in Data Processing and Technical Engineer in Computer Systems. These degrees are described in the following sections.

### 2.1 Computer Engineer

Royal Decree 1459, of October 26, 1990 [2], establishes the official degree in Computer Science and sets out general guidelines for the study programmes leading to it. In its only article, this decree establishes that the Bachelor Degree in Computer Science (in Spain, Computer Science Engineering degree) will be official and valid in all regions of Spain. In addition, in an appendix it sets out the general guidelines for the study programmes that need to be completed for the degree to be awarded and homologated.

The second provision of the first section of the appendix establishes that the study programmes approved by universities can be implemented in two ways: (i) as a first or second cycle course with a duration of at least 2 years per cycle and 4 or 5 years in total; or (ii) as a second cycle course only with a duration of 2 years after successfully completing any first year cycle providing approved direct access to the course. The provision also establishes that each cycle requires at least 120 credits.

The third provision of the appendix lists the core subjects to be included in all study programmes leading to a degree in computer science. Table 1 provides a summary of the subjects, the number of credits assigned, a brief description of their content, and links to one or more knowledge areas.

The interpretation, and therefore the implementation, of this Royal Decree has been very varied in the 41 out of the 48 Spanish public universities that offer the computer science degree. All 3 possible scenarios are in evidence (see Table 2).

### 2.2 Technical Engineer in Data Processing

Royal Decree 1459, of October 26, 1990 [2], establishes the official degree in Technical Engineer in Data Processing and sets out general guidelines for the study programmes leading to it. In its only article, this decree establishes that the degree will be official and valid in all regions of Spain. In an appendix it sets out the general guidelines for the study programmes that need to be completed for the degree to be awarded and homologated.

The second provision of the first section of the appendix establishes that the study programmes approved by universities must be part of the first cycle with a duration of 3 years. It also establishes that this degree requires at least 180 credits.

The third provision of the appendix lists the core subjects to be included in all study programmes. It also provides a summary of the subjects, the number of credits assigned, a brief description of their content, and links to one or more knowledge areas (see Table 3).

### 2.3 Technical Engineer in Computer Systems

Royal Decree 1459, of October 26, 1990 [2], establishes the official degree in Technical Engineer in Computer Systems and sets out general guidelines for the study programmes leading to it. In its only article, this decree establishes that the degree will be official and valid in all regions of Spain. In an appendix it sets out the general guidelines for the study programmes that need to be completed for the degree to be awarded and homologated.

The second provision of the first section of the appendix establishes that the study programmes approved by universities must be considered as part of the first cycle. It also establishes that this degree requires at least 180 credits.

The third provision of the appendix lists the core subjects to be included in all study programmes. It also provides a summary of the subjects, the number of credits assigned, a brief description of their content, and links to one or more knowledge areas (see Table 4).

 © Novática

| Core subjects | Credits | Knowledge Areas |
|---|---|---|
| **First Cycle** | | |
| Statistics | 6 | Artificial Intelligence and Computational Sciences<br>Statistics and Operations Research<br>Applied Mathematics |
| Abstract Data Types and Data Structures | 12 | Artificial Intelligence and Computational Sciences<br>Computer Systems and Languages |
| Computer Structure and Technology | 15 | Computer Technology and Architecture<br>Electronics<br>Systems Engineering<br>Electronic Technology |
| Foundations of Computational Physics | 6 | Electronics<br>Electromagnetism<br>Applied Physics<br>Physics of Condensed Materials<br>Electronic Engineering<br>Electronic Technology |
| Foundations of Mathematics for Computing | 18 | Algebra<br>Mathematical Analysis<br>Artificial Intelligence and Computational Sciences<br>Applied Mathematics |
| Methodology and Programming Technology | 15 | Artificial Intelligence and Computational Sciences<br>Computer Systems and Languages |
| Operating Systems | 6 | Artificial Intelligence and Computational Sciences<br>Computer Systems and Languages<br>Computing Technology and Architecture |
| Automata Theory and Formal Languages | 9 | Algebra<br>Artificial Intelligence and Computational Sciences<br>Systems Engineering and Automatic Control<br>Computer Systems and Languages |
| **Second Cycle** | | |
| Computing Engineering and Architecture | 9 | Computing Technology and Architecture<br>Electronics<br>Systems Engineering<br>Electronic Technology |
| Software Engineering | 18 | Artificial Intelligence and Computational Sciences<br>Computer Systems and Languages |
| Artificial Intelligence and Knowledge Engineering | 9 | Artificial Intelligence and Computational Sciences<br>Systems Engineering and Automatic Control |

**Table 1:** Core Subjects to be included in The Official Computer Science Degree.

© Novática

| 2 Cycles. Duration 4 years First and Second Cycle 2 years | 2 Cycles. Duration 5 years First Cycle 3 years. Second Cycle 2 years | Second Cycle of 2 years |
|---|---|---|
| Universidad de Alcalá<br>Autónoma de Madrid<br>Complutense de Madrid<br>Universidad de León<br>Pompeu Fabra | Universidad de Alicante<br>Autónoma de Barcelona<br>Universidad Cantabria<br>Universidad de Castilla La Mancha<br>Universidad de A Coruña<br>Universidad de Extremadura<br>Universidad de Girona<br>Universidad de Granada<br>Jaume I<br>Universidad de Las Palmas de Gran Canaria<br>Universidad de Málaga<br>Universidad de Murcia<br>Universidad del País Vasco<br>Politècnica de Catalunya<br>Politécnica de Madrid<br>Politècnica de València<br>Rey Juan Carlos<br>Universidad de Sevilla<br>Universidad de Valencia<br>Universidad de Zaragoza | Universidad de Almería<br>Universidad de Burgos<br>Universidad de Córdoba<br>Universidad de Huelva<br>Universitat de les Illes Balears<br>Universidad de Jaén<br>Universidad de La Laguna<br>Universidad de Lleida<br>Universidad de Oviedo<br>Universidad Pública de Navarra<br>Rovira i Virgili<br>Universidad de Salamanca<br>Universidad Nacional de Educación a Distancia<br>Universidad de Valladolid<br>Universidad de Vigo |

**Table 2:** Structure of The Computer Science Degree in The Spanish Public Universities.

## 3 Computer Science Studies in The New Study Programme

At the moment the reform process in Spain is to a certain extent on hold, at the whim of political changes. There is regrettable uncertainty about what will be the official response to the proposals made (EICE project, White Book) and it is unclear what the development timeframe is to be or whether the work already done is valid, even with regard to such fundamental aspects as the possible new catalogue of degrees or how degrees are to be structured in terms of cycles.

In the field of ICT, the situation is made more complicated still by the present, somewhat atypical, structure in Spain whereby the subject is divided into two branches of engineering, Computer Science and Telecommunications, whereas in other countries a clearer division is made (Computer Science and Electronics). The situation is further complicated by the fact that Telecommunications is legally regulated in terms of competencies and powers, and professional colleges, which means that strong pressure can be brought to bear on decision-making political bodies, which perhaps explains some of the current foot dragging.

With due caution regarding the final outcome of the process, we go on to describe what has been done so far.

### 3.1 Higher Education Degrees

Royal Decree 55/2005 of January 21 establishes the new structure of university degrees and regulates official higher degree qualifications in the European Higher Education Area initiated with the Bologna declaration in 1999.

The second Chapter defines the structure of higher university education, specifically in the article 6: "*University Degrees leading to official and valid degrees throughout the Spanish territory will be composed of undergraduate and postgraduate studies organized in cycles*".

Also, Chapter 2, Article 7, defines higher education degrees thus: "*The first cycle of university studies will be composed of general basic studies plus other studies focused on preparing for activities of a professional nature*".

Chapter 3 regulates higher degree qualifications. Arti-

 © Novática

| Core subjects | Credits | Knowledge Areas |
|---|---|---|
| Statistics | 9 | Artificial Intelligence and Computational Sciences<br>Statistics and Operations Research<br>Applied Mathematics |
| Data Types and Data Structures | 12 | Artificial Intelligence and Computational Sciences<br>Computer Systems and Languages |
| Computer Structure and Technology | 9 | Computing Technology and Architecture<br>Electronics<br>Systems Engineering and Automatic Control<br>Electronic Technology |
| Foundations of Mathematics for Computing | 18 | Algebra<br>Mathematical Analysis<br>Artificial Intelligence and Computational Sciences<br>Applied Mathematics |
| Programming Methodology and Technology | 15 | Artificial Intelligence and Computational Sciences<br>Computer Systems and Languages |
| Operating Systems | 6 | Artificial Intelligence and Computational Sciences<br>Computer Systems and Languages<br>Computer Technology and Architecture |
| Computer Networks | 6 | Computer Technology and Architecture<br>Artificial Intelligence and Computational Sciences<br>Telecommunications Engineering<br>Systems Engineering and Automatic Control<br>Computer Systems and Languages |
| Automata Theory and Formal Languages | 9 | Algebra<br>Artificial Intelligence and Computational Sciences<br>Systems Engineering and Automatic Control<br>Computer Systems and Languages<br>Applied Mathematics |

**Table 3:** Core subjects to be included in The Official Technical Engineering Degree in Data Processing.

cle 9 describes issues related to the establishment of official university degrees. Section 3 sets out the content of the report that the University Coordination Council must send the Council of Ministers for its approval (as stated in the Section 1 of the Article). The report must contain explicit reference to at least the following five aspects:

1.Specific title of the degree, total number of credits, common core content, and the minimum number of credits assigned to each module.

2.Specification of the objectives of the degree, and required knowledge, aptitudes, and skills to obtain the degree with reference to the common core content

3.Professional profile associated with the degree

4.Relevance of the degree to knowledge development and to the Spanish and European job markets

5.Rationale for including the degree in the catalogue of official university degrees taking into particular account its alignment with European Higher Education Area guidelines.

Section 1, Article 10 of Common Guidelines in the same Chapter establishes that "*the total number of credits required*

© Novática

| Core subjects | Credits | Knowledge Areas |
|---|---|---|
| Statistics | 6 | Artificial Intelligence and Computational Sciences<br>Statistics and Operations Research<br>Applied Mathematics |
| Data Types and Data Structures | 12 | Artificial Intelligence and Computational Sciences<br>Computer Systems and Languages |
| Computer Structure and Technology | 15 | Computing Technology and Architecture<br>Electronics<br>Systems Engineering and Automatic Control<br>Electronic Technology |
| Foundations of Physics for Computing | 6 | Electronics<br>Electromagnetism<br>Applied Physics<br>Physics of Condensed Materials<br>Electric Engineering<br>Electronic Technology |
| Foundations of Mathematics for Computing | 18 | Algebra<br>Mathematical Analysis<br>Artificial Intelligence and Computational Sciences<br>Applied Mathematics |
| Programming Methodology and Technology | 12 | Artificial Intelligence and Computational Sciences<br>Computer Systems and Languages |
| Operating Systems | 6 | Artificial Intelligence and Computational Sciences<br>Computer Systems and Languages<br>Computing Technology and Architecture |
| Engineering of Management Software | 12 | Artificial Intelligence and Computational Sciences<br>Computer Systems and Languages |
| Organizational Techniques and Enterprise Management | 12 | Economics and Accounting<br>Organizations Structure |

**Table 4:** Core Subjects to be included in The Official Technical Engineering Degree in Computer Systems.

*to obtain the official degree shall be between 180 and 240*". By credits is meant *European Credit Transfer System* (ECTS) credits, which will be explained later in this document.

With regard to application, the Royal Decree establishes in its third and final provision, Regulatory Development, that "*it is the responsibility of the Ministry of Education and Science and the Universities to dictate, within the scope of their respective competencies, the provisions required to enact this Royal Decree*".

**3.1.1 Computer Engineer**

In accordance with Royal Decree 55/2005 of October 2005, the Spanish Ministry of Education and Science began to implement the proposals for an initial set of higher education degrees. This work was concluded in February 2006 with the creation of a technical specification [5] (in accordance with Section 1 of Article 9), an explanatory document, and an example of the first set of degrees. Among those, there is the degree of Engineering in Computer Science.

 © Novática

The technical specification of each Computer Science degree (section 1, Article 9) should state:

■Title of Degree: Computer Engineer

■Total number of credits:

-Basic Training: 180 ECTS

-Additional Training with an academic or professional orientation: 60 ECTS credits; of those credits at least 30 must correspond to the final year project (FYP).

■The common core content and minimum number of credits assigned to each module:

-Programming: 27 ECTS

-Software Engineering, Information Systems, and Intelligent Systems: 30 ECTS

-Computer Engineering: 18 ECTS

-Operating Systems, Distributed Systems, and Computer Networks: 21 ECTS

-Professional Aspects of Computer Science Engineering: 6 ECTS

Section 2 of Article 13 of the Royal Decree states that "*for each subject of a given study programme, Universities must specify objectives, knowledge, aptitudes and skills to be acquired, description of content, and the number of credits assigned to each subject*".

With regard to graduate studies, the Royal Decree allows universities the freedom to establish their length. Section 4 of Article 13 states: "*The study programmes shall specify the academic structure of their content and schedule …*". Consequently, the official study programme for Computer Science Engineering does not include any schedule.

However, the White Book for a Computer Science Engineering Degree published by the National Agency for Quality Assessment and Accreditation (ANECA) [6] shows the results of the work carried out by a network of Spanish universities. Chapter 11 entitled "*Studies on the structure and model of the Degree*" sets out the proposal for undergraduate studies with 240 ECTS over 4 years.

### 3.2 Postgraduate Studies

Royal Decree 56/2005 of January 21 [7] regulates official postgraduate studies within the European framework for higher education, which was initiated by the Bologna Process in 1999.

Chapter 1, Article 2 of the Royal Decree states that the organization of postgraduate studies will be established in integrated programmes leading to Master's or Doctoral degrees. It also defines the aim of postgraduate studies thus: "*The purpose of official postgraduate studies is to provide specialized training in a student's academic, professional, or research field*".

Articles 4 and 5 of Chapter 1 describe issues related to the "*Development and approval of official postgraduate studies*". With regard to the development of these studies, it is stated that the programmes will be developed and organized as each university sees fit. They will be proposed by a Committee of Doctoral Studies set up by the university and approved by the university board of governors.

With regard to the approval of the programmes established by universities, Article 5 states that the implementation of official postgraduate programmes will be subject to satisfactory reports from the corresponding autonomous community and from the University Coordinating Council, after which the Ministry of Education and Science will issue a list of official postgraduate programs to be published in the Official State Gazette.

In relation to the structure of postgraduate structures.

■For Master's degrees, Chapter 2 Article 8 section 1, states: "*Second cycle university degrees leading to a Master's degree will have a minimum of 60 credits and a maximum of 120*".

■For Doctoral degrees, Chapter 3 Article 10 Section 1 states that Doctoral degrees may be organized as courses, seminars, or other activities aimed at the training of research personnel and must include the presentation of a doctoral thesis.

With regard to entrance requirements for postgraduate studies.

■For Master's degrees, Chapter 1 Article 3 states that it is necessary to have obtained a bachelor degree or another explicitly equivalent qualification.

■For Doctoral degrees, Section 3 of the same article defines entrance requirements as a minimum of 60 credits of official postgraduate studies and a minimum of 300 credits in total (under- plus postgraduate studies). Also, universities are free to decide the selection criteria.

#### 3.2.1 Master in Computer Science

Following the criteria stated in the Royal Decree and with the aim of unifying criteria, the Conference of Deans and Directors of University Computer Science Centres held in Alicante in June 2006 suggested an initial design for an official Master in Computer Science composed of 5 blocks[8]:

■Complementary Subjects (MC): These must be covered, before the rest of the blocks if possible, by students who do not have a degree in Computer Science.

■Professional Common Core Subjects (CFCP): To include subjects directly related with the practice of the profession.

Technical Common Core Subjects (CFCT): To include technological content at a more advanced level than the content that may already have been covered in the bachelor degree course.

■Specialization (E): Subjects referring to technologies, systems, processes, or new methods not yet implemented in the market but which may provide new solutions in the future.

■ Final Project: Master (TFM): Students who completed a final year project (FYP) of 30 credits in Computer Science or a related subject do not need to produce a Final Master Project.

Based on the previous blocks and taking into account how the student has accessed this course, there is a preliminary proposal organised in 4 blocks totalling between 60

© Novática

and 120 credits:

■Model 1: Students who have successfully completed undergraduate studies in Comp Science (240 ECTS, including 30 ECTS of the FYP) have 3 options:

-Option A: Students must complete 15 ECTS of CFCP, 30 ECTS of E and 15 ECTS of TFM, i.e., a total of 60 ECTS or one academic year.

-Option B: Students must complete 15 ECTS of CFCT, 30 ECTS of E and 15 ECTS of TFM, i.e., a total of 60 ECTS or one academic year.

-Option C: Students must complete 15 ECTS of CFCP, 15 ECTS of CFCT and 30 ECTS of E, i.e., a total of 60 ECTS or one academic year.

■Option 2: Students who have completed undergraduate studies in Computer Science Engineering (210 ECTS, without FYP) will have 1 option:

-15 ECTS of CFCP, 15 ECTS of CFCT, 30 ECTS of E and 30 ECTS of TFM, i.e., a total of 90 ECTS or one and a half academic years.

■Option 3: Students who have completed undergraduate studies in Computer Science Engineering (180 ECTS, without FYP) will have 1 option:

-30 ECTS of MC, 15 ECTS of CFCP, 15 ECTS of CFCT, 30 ECTS of E and 30 ECTS de TFM, i.e., a total of 120 ECTS or 2 academic years.

■Option 4: Students who have completed undergraduate studies in other degrees

-30 ECTS of MC, 15 ECTS of CFCP, 15 ECTS of CFCT, 30 ECTS of E and 30 ECTS de TFM, i.e., a total of 120 ECTS or 2 academic years.

#### 3.2.2 Doctor in Computer Science

As stated previously in this paper, each university will be responsible for developing its own doctoral studies and consequently there is no specific proposal for doctoral studies in computer science in Spain. However, as has also been stated previously, students must have obtained a minimum of 60 credits in postgraduate studies and 300 in total (undergraduate and postgraduate studies). Taking all this into account, the 60 credits in postgraduate studies can be obtained in two ways: (i) through courses, seminars or other activities as established by Royal Decree 56/2005 Article 10 Section 1 or (ii) as Master's studies. Thus, in a meeting in held in June 2005, the CODDI decided that although the official Master proposed is professionally oriented and therefore essentially an exit course, it should allow students to access doctoral studies.

## 4 Analysis of The Difference between The Current Credit System and The ECTS

The current credit system is very simple. One credit consists of 10 academic hours and only theoretical or practical hours of class are computed.

ECTS (European Credit Transfer System) credits provide the unit of measurement and are regulated by Royal Decree 1125/2003 of September 5.

According to the Article 3 of the Royal Decree, one ECTS credit represents the amount of work students must do to complete the study programme. Credits are obtained when a student passes each of the subjects making up the degree's study programme. Credits are valid throughout the country.

### 4.1 Assignment of Credits to A Subject

The Article 4, Section 3, states that credits will be assigned to each subject comprising the curriculum by computing the number of hours required by the students to obtain the knowledge, capabilities, and skills. This assignment must include hours of:

a.Theoretical and practical classes
b.Personal study
c.Seminars
d.Assignments, practicals, or projects
e.Exam preparation
f.Exam sitting

Section 5 of the same article states that the minimum number of hours per credit is 25 and the maximum 30.

The procedure for assigning ECTS credits is not simple. Although the computation of hours for *a*, *c* and *f* is easily computable (those must be planned by the module convenor), the credits for *b*, *d* and *e* vary depending on the student's capabilities. However, taking into account Section 1 of Article 5 concerning the assignment of credits once an exam or evaluation has been passed, it is possible to compute the number of credits statistically. This requires the collaboration of the student and consists of:

1.A questionnaire is designed to find out the number of hours that a student has devoted to activities *b*, *d* and *e*. This questionnaire should be filled in by students on a daily basis as they do each subject, noting down the numbers of hours spent each day on each of the 3 activities.

2.Once the subject is completed, it is possible to compute statistically the results obtained assigning, for example, the average number of hours that students devoted to activities *b*, *d* and *e*.

Although this procedure is only an approximation, it may be very useful in the initial phase of the EHEA adoption process. It has already been successfully applied in the department of Computational Science at the *Universidad de Alcalá* to adopt the EHEA. However, according to Article 4, Section 6 of Royal Decree 1125/2003, the number of credits assigned to a subject is to be determined by the government on the basis of a report from the University Coordinating Council.

## 5 Conclusions

The Bologna Process aims to establish a European Higher Education Area by 2010. In this paper we have described how the legal framework of the Spanish education system is adopting the process at both undergraduate and postgraduate levels. It is also affecting the way credits are computed as a result of adopting the European Credit Transfer System. Although it is still in its infancy, this adoption process is expected to facilitate the mobility of students and

 © Novática

teachers throughout participating states, achieve a greater involvement of students, and promote lifelong learning.

**References**

[1] Royal Decree 1459/1990 issued on 26 October 1990 (Official Gazette - BOE 278 of 20 November 1990, pp 34401).
[2] Royal Decree 1459/1990 issued on 26 October 1990 (Official Gazette - BOE 278 of 20 November 1990, pp 34403).
[3] Royal Decree 1459/1990 issued on 26 October 1990 (Official Gazette - BOE 278 of 20 November 1990, pp 34404).
[4] Royal Decree 55/2005 issued on 21 January 2005.
[5] Trial Technical Specification for University Degrees, Ministry of Education and Science.
[6] White Book: University Degrees in Computer Engineering, National Agency for Quality Assessment and Accreditation (ANECA), 2005.
[7] Royal Decree 56/2005 of January 21, 2005.
[8] CODDI Report. Conference of Deans and Directors of University Computer Science Centres (*CODDI, Conferencia de Decanos y Directores de Informática*).

*Translation by the authors*

© Novática