INTED2008

International Technology, Education and Development Conference

Conference Proceedings

March 3rd-5th, 2008 Valencia

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March 3rd-5th, 2008 Valencia

Published by
International Association of Technology, Education and Development (IATED)
www.iated.org

INTED2008 Abstracts Book
Edited by
L. Gómez Chova, D. Martí Belenguer, I. Candel Torres
International Association of Technology, Education and Development
IATED, Valencia

ISBN: 978-84-612-0192-1
Depósito legal: V-1024-2008
Imprime: Graphimage Graffor, S.L.

Book cover designed by
J. L. Bernat Tomás

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A SURVEY TO ANALYZE IF UNIVERSITY STUDIES ARE ACCORDING TO THE REAL REQUIREMENTS OF COMPUER INDUSTRIES AND THE MAIN INTERNATIONAL CURRICULUMS FOR COMPUTER ENGINEERING

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Among the main objectives of the European Union are in the field of education and, most especially, higher education, in which various countries have already taken decisions towards reform of the structure and organization of their university education to encourage the construction of the European Higher Education Space.

This European Higher Education Area and the demand on part of governments to define new curriculums into of this European space, offer an excellent opportunity to modify studies in such a way that computer engineering adjusts to demands of market, always changing, in this area, without giving up basic aspects of all engineering.

In order to study the current situation of our formal education we have analyze the curriculum of the main Universities and we have realized a survey to more than 500 computer professionals with different profiles asking them about the utility and the real necessity of the main topics learned in their formal education.

This paper presents this survey and analyzes the obtained results about if university studies are appropriates and about if requirements of computer industry on different professional profiles are according to the training of computing engineers.

Also we study the main international curriculums for Computer Engineering analyzing the subjects and knowledge areas that are considered more important on the education of future professionals and we analyze if the current curriculum of Spanish Universities is according to international curriculum and if it is necessary to adapt them.

A SURVEY TO ANALYZE IF UNIVERSITY STUDIES ARE ACCORDING TO THE REAL REQUIREMENTS OF COMPUER INDUSTRIES AND THE MAIN INTERNATIONAL CURRICULUMS FOR COMPUTER ENGINEERING

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Abstract

Improvement of education, particularly of higher education, is among the main objectives of the European Union. Various member countries have already taken decisions towards a reform of the structure and organization of their university education, aiming to encourage the construction of the European Higher Education Area.

This European Higher Education Area, along with the demand on the part of governments for new curricula to be set up within this European space, offers an excellent opportunity to modify studies. Computer engineering could adjust to the ever-changing demands of the market in this area, without giving up basic aspects of all engineering.

In order to study the current situation of our higher education, we have analyzed the curriculum of the main Universities and the main international curricula for Computer Engineering, analyzing the subjects and knowledge areas, together with the recommendations and guidelines of the Computer White Book. That has given us a set of the main topics that are represented in most curricula. Performing a survey on more than 100 computer professionals of varying profiles, we have asked them about the usefulness of, and the real need for, the main topics they have been taught in their education.

This paper presents that survey and analyzes the results obtained. We study whether university studies are appropriate and if the requirements of the computer industry for different professional profiles correspond to what computing engineers are receiving on their courses. The results of this survey should be considered when a new curriculum is defined or whenever a current one is modified, so that Universities do indeed adapt to both the European Higher Education Area and to the real needs of IT professionals.

Keywords
Computer science education, European higher education, Survey

1. INTRODUCTION

The construction of a Europe of knowledge has given rise to an important movement, which has as its goal the development of a European Higher Education Area. This will, in turn, make it easier for qualifications to be recognised, ensuring the best possible training for students and guaranteeing their integration into a unified, borderless labour market.

What is known as the Bologna Declaration [1] sets out the objectives for the adoption of a system of qualifications that is easy to interpret, which at the same time makes comparisons simple. It will also set up an international system of comparable credit transfers (ECTS), to foster mobility of students, teachers and researchers and it will encourage European cooperation in the quest to guarantee the quality of higher education. The aim, in short, is to make it possible for there to be a European dimension in higher education.

The European Higher Education Area (EHEA) [2] sets out to establish a system of courses and credit points [3] that is common to all the EU states (The Credits of ECTS – European Credit Transfer System). The EHEA sets out only a series of guidelines and does not specify the exact content that each course should have; that is a job that they leave to the committees of experts in each country.

In Spain, a committee of The Assembly of Deans and Heads of Computer Engineering Departments (Conferencia de Decanos y Directores de Informática (CODDI), drew up a white paper on how to adapt Computer Science studies to the EHEA. This is known as *Computer Engineering Courses and European Convergence* (Estudios de Informática y Convergencia Europea - EICE) [4]. In this Project, the authors studied the various different qualifications that exist in different countries in the realm of Computer Engineering. To do this, they took as their starting point the main international curricula (see section 2 for more details). In the production of the different proposals, a number of factors were borne in mind, such as the European reference framework. By this we mean the academic, social, economic, professional and labour environments, along with the definition of the professional profiles and the general and specific skills that students need to acquire. This framework also implies involvement of the people who are in these professional fields as they validate the professional skills, etc.

In addition to what we have just outlined, the Ministry of Education and Science (Ministerio de Educación y Ciencia - MEC), using the white book as its basis, proposes a series of guidelines such as the number of credit points for basic-level training and the number of credits required for further training. It also sets out to distinguish between foundation subjects and those which are particular to the course in question, as well as to make other specific comments on the creation and development of study plans for degree courses in Computer Science. The intention is to encourage the creation of courses which have common-core content, thus making it easier not only to give recognition to credits in different courses, but also to foster curricular mobility.

With this tuning-in of course programmes to the EHEA framework, we are being given a great opportunity to analyse and modify the present syllabus of Computer Science courses and to make them fit into the real needs and demands of the market. The current study-plans may thus be made to be appropriate to, on the one hand the EHEA, and on the other, what the profession is really asking for. This kind of adjustment requires special cooperation on the part of professionals in the IT sector. By means of surveys from these people, we can obtain opinions, feedback and comments on the training they have been given, as we do so finding out about the usefulness in the job market of the knowledge they have obtained.

The purpose of this article is, by means of a survey performed on IT professionals, to obtain an assessment of the different subjects studied in the various different Spanish university degree courses. That assessment should be taken into account when drawing up new syllabuses, if we are to propose the content that is really important and necessary for Computer Engineering professionals, rather than just putting together plans of study that are dictated by the knowledge of those lecturing on those subjects or by the resources available in each centre or university. The survey set out in this article will help us to become acquainted with what people out there working in the field need and therefore with what any syllabus of Computer Engineering should cover.

In the following section a description of the main international curricula related to Computer Engineering courses will be given. Section 3 sets out the syllabus content of Spanish universities, along with the list of subjects that have been taken into account on conducting the survey. How the survey was drawn up and an explanation of its working, together with the objectives, questions chosen, professional profiles identified and all that has to do with the creation and development of the survey, will be dealt with in Section 4. In Section 5 the results of this study will be shown and we shall analyse these, going on then to interpret them. Finally, section 6 is where our conclusions are presented.

2. INTERNATIONAL CURRICULA

In this section a study is carried out of the main international curricula which are related to Computer Engineering and which are used to draw up syllabi for Computer Engineering courses. (SWEBOK, Computing Currícula 2001, IRMA/DAMA 2000, ACM/AIS MSIS 2000, ISCC 1999, AND IFIP/UNESCO ICF-2000).

1.1. Computing currícula 2001

In 1998 ACM and the Computer Society of the IEEE set up a scientific committee known as the Year 2001 Model Curricula for Computing (CC2001), which was asked to revise the 1991 curriculum and to develop a set of curricular guidelines which would tackle the most recent developments in information technology in the decade leading up to that point. These guidelines would have to be able to maintain their relevance for the ten years following the recommendations [5]. The CC2001 is divided into five parts: A volume that is general (general principles together with the parts that are common in all the other volumes on the particular and specific subject areas) and four volumes on the specific subject areas, which are the following: 1) Computer Science (CS 2001). 2) Computer Engineering (CE 2004). 3) Software Engineering (SE 2004). 4) Information Systems (IS 2002). 5) Information Technologies (IT 2005).

In 2005 the so-called Computing Curricula 2005 (CC2005) [5], was published, which has clearly evolved from CC2001 and which consists of a report known as the “Overview Report”. This gives a summary of the body of knowledge in the degree course programmes in each of the five subjects mentioned above, highlighting what they have in common and where they differ from each other.

The ACM/IEEE CS 2001 Curriculum

The CS 2001 sets out the following main areas within the body of knowledge for Computer Science: Discrete Structures (DS), Programming Fundamentals (PF), Algorithms and Complexity (AL), Arquitecture and Organization (AR), Operating Systems (OS), Net-Centric Computing (NC), Programming Languages (PL), Human-Computer Interaction (HC), Graphics and Visual Computing (GV), Intelligent Systems (IS), Information Management (IM), Social and Professional Issues (SP), Software Engineering (SE), Computer Science and Numerical Methods (CN)

The ACM/IEEE SE 2004 Curriculum

The document known as SE 2004 Software Engineering 2004 – Curricular Guidelines for Undergraduate Degree Programs in Software Engineering) [6] was drawn up by the ACM and the education task force of the IEEE-CS. The main objective in this document is to offer guidelines to academic institutions and accreditation agencies as to what ought to be the make-up of a degree course in Software Engineering. The two main contributions of the document are i) The software engineering knowledge that any and every graduate should possess, known as SEEK - Software Engineering Education Knowledge), and ii) The curriculum; in other words the different ways in which this knowledge, along with the skills associated with it, may be acquired.

The ACM/IEEE IS 2002 Curriculum

The currículum of Information Systems (IS) [7], is an initiative of the ACM, AIS and AITP which has enjoyed widespread acceptance, becoming a basis for accreditation of degree programmes in information systems. The document specifies a set of subjects grouped in the following way: 1) Prerequisites: IS2002.PO: Personal Productivity with information system technology. 2) Information systems fundamentals: IS2002. 1: Foundations of information systems. IS2002.2: Electronic Business Strategy, Architecture and Design. 3) Information Systems Theory and Practice: IS2002.3: Theory and practice of information systems. 4) Information technology: IS2002.4: Information technology hardware and software. IS2002.5: Programming, data, file and objects structures. IS2002.6: Networks and telecommunications. 5) Information Systems Development: IS2002.7: Analysis and logical design. IS2002.8: Physical design and implementation with DBMS. IS2002.9: Physical design and implementation in emerging environments. 6) Information Systems Deployment and management: IS2002.10: Project Management and practice.

The ACM/IEEE IT 2005 curriculum

Information Technology, in its broadest sense, takes in all aspects of computer technology. IT, as an academic discipline, focuses on knowledge about the users within an organizational and social context by means of the creation, integration and administration of computing technology.

1.2. The IRMA/DAMA 2000 curriculum

This curriculum is the result of two years of joint effort on the part of North American professional organizations who were of great relevance in the field of databases: IRMA[1] and DAMA[2], and who in 1998 began a revision of the edition that had existed to that date.

In this curriculum there is great insistence on the need for computer engineers not to limit their knowledge to those aspects of IS which are technical. They ought to have a more complete vision of these, which would include aspects of management. To that end they propose the adopting of a more all-embracing focus than data management alone gives, considering data management to be part of Information Resource Management (IRM).

1.3. The ACM/AIS MSIS 2000 curriculum

The need to revise the curricula in IS, especially the one provided by the ACM in 1982 and IS'97, leads to the creation in January 1998 of a Joint Curricular Committee-JCC-). This was made up of the ACM and the AIS, and their purpose was to draw up a Master's course curriculum for IS, the MSIS 2000 [8].

The model curriculum is designed in tour interrelated blocks: 1) IS Foundations, which takes up three academic years of IS97: i) Fundamentals of IS, IT hardware and software; ii) programming, data and object structures; iii) Management foundations (accountancy, marketing, organizational behaviour). 2) IS Core. This is a group of subjects which are core ones for all students; Data Management, Analysis, Modelling and Design, Data Communications and Networking, Project and Change Management, IT Policy and Strategy. 3) Integration, which allows students to synthesise what they have learnt: Integration of the company, Integration of IS function, Integration of IS technologies. 4) Specialisations or Career Tracks. Each career track is made up of four or more elective subjects which prepare students for a particular specialisation. It suggests that schools choose their own specialisation, taking into account the needs of local industry and the specific capacities available in the department.

1.4. The ICF-2000 of IFIP/UNESCO

The IFIP[3] y UNESCO[4] have designed the Informatics Curriculum Framework (ICF-2000), whose aim is to get to grips with the situation of constant change faced by Information Technology. As its name indicates, it is really a framework from which different curricular implementations can be built directly. In the document itself [9], eight curricular specifications are given for eight categories of professional roles.

1.5. ISCC'99

The ISCC´99 curriculum (Information Systems-Centric Curriculum) sets out to prepare information technology specialists for the development and use of large-scale information systems. It has been developed by a team made up of members of both the university community and of business groups [5].

This currículum proposes an inverted model of learning in which students first of all have experience in an IS context, going on afterwards to study the details, underlining information as the active ingredient in organizations. It also proposes, among other things, the use of *just-in-time* learning based on mentors in which interpersonal abilities and systematic thought are explicitly integrated

1.6. SWEBOK

[1] Information Resources Management Association
[2] Data Administration Management Association
[3] International Federation on Information Processing
[4] United Nations Educational, Scientific and Cultural Organization

SWEBOK [10]was originally put forward by the Software Engineering Coordinating Committee of the IEEE Computer Society y ACM, although the ACM withdrew its support from it in 2000. Its goals include the accreditation of university curricula and the certification of professionals; to that end it identifies a basic body of knowledge which characterizes the Software Engineering discipline.

SWEBOK is organized into ten areas of knowledge: Requirements, Design, Construction, Testing, Maintenance, Configuration Management, Engineering Management, Engineering Process, Engineering Tools and Methods and Quality. Apart from these main areas, they consider there to be a set of related disciplines: Computer Engineering, Computer Science, Management, Mathematics, Project Management, Quality Management, Software Ergonomics and Systems Engineering.

3. TOPICS SELECTED

By going through the different international curricula and by analysing the guidelines proposed at national level, we may identify a set of subjects that should be present in any syllabus of a Bachelor's course in Computer Engineering.

Id	Main topics	Related concepts
T1	Automatics	Simulation; Industrial automation; Robotics
T2	Computer Architecture and Engineering	Parallel Architectures; Architecture- oriented Applications and Languages
T3	Databases	Fundamentals ; Design and Administration; Distributed Databases; Advanced Database System
T4	Economy	Economics; Business Administration
T5	Statistics	Descriptive Statistics; Probability and Statistical methods applied
T6	Data Structures and Information	Abstract Data Types; Structure and Data-handling Algorithms; Structures; Files
T7	Structure and Computing Technology	Functional Units: Memory, processor, peripheral, languages and machine assembler; Scheme Operation; Electronics; Digital Systems; Peripherals
T8	Physical Foundations of Computing	Electromagnetism, Solid State; Circuits
T9	Computational Science	Algebra; Numerical Analysis; Mathematical Analysis; Discrete Mathematics; Numerical Methods
T10	Software Project	Management (Planning and Management of Projects
T11	Languages	Technical English
T12	Software Engineering	Software Requirements and Specifications; Software Design; Software Validation; Software tools and Environments; Software Processes
T13	Artificial Intelligence and Knowledge Engineering	Heuristics; knowledge based systems; Neural networks; Learning; Perception
T14	Interfaces and Peripherals	Systems Interaction; Graphical Interfaces, Graphical Display and Interaction
T15	Legislation Computing	Laws, Regulations; Computer Law
T16	Methodology and Software Technology	Algorithm Design, Algorithm Analysis, Programming Languages, Programs Design: Modular Decomposition and Documentation; Verification Techniques and Testing
T17	Final Project	Referring to project contents
T18	Networking	Network Architectures; Communications; Network Security
T19	Security	Information System Security; Audit; Cryptography
T20	Information Systems	Analysis Methodology; Configuration, Design, Management and Evaluation of Information Systems; Information System Environments; Advanced Technologies of Information Systems; Project Computing Systems
T21	Operating Systems	Overview and Principles of Operating Systems; Memory and Process Management; Device Management; File Systems
T22	Theory of Automata and Formal Languages and Language Processors	Sequential Machines and Finite Automata; Turing Machine; Recursive Functions; Grammars and Formal Languages, Compilers, Translators and Interpreters; Phase Compilation, Code Optimization; Microprocessors; Logic

Table 1: Topics

Study programmes leading to a degree in Computer Engineering ought to include at least 60% of Common Core Contents, organized into 4 categories: 1) Scientific Foundations (Mathematical and Physical Foundations of Computer Engineering); 2) General Content of Engineering (Programming, Software Engineering, Information Systems and Intelligent Systems; Operative Systems, Distributed Systems and Networks; Computer Engineering. 3) Specific content of Computer Engineering

(Management of Organizations; Ethics, Legislation and the profession; Professional Skills); and 4) End of course project. The other 40% of the content is determined by the university itself.

The Common Core Content proposal set out in the White Book [4] should be understood as a recommendation to universities. It is a basis on which to structure their syllabi, but at the same time it allows enough flexibility for them to be able to plan course content according to the profile of the labour market and give them a character that marks them out from others, so enriching the Spanish and European scene.

Using the recommendations and guidelines from the White Book and from international curricula, together with a prior study on course programmes from various of the main universities in Spain (Castilla-La Mancha, Politécnica de Madrid, Valencia, Seville and Barcelona), we have proposed a set of subjects that are similar to each other, as can be seen in Table 1.

4. SURVEY DEFINITION

To be able to dispose of a basis that would allow us to establish changes in current course programmes, we have carried out a study of present-day requirements in the workplace, using a survey that gathers the opinion of professionals, representing different professional profiles, on how suitable the subjects which are studied by Computer Engineers in the main Spanish universities are.

The questionnaire is made up mainly of 4 questions applied to each of the topics which we have identified in Section 3 (Table 1). In Table 2 we can see the list of questions that we have posed. These questions are based on the work of Lethbridge [11] and they set out to obtain knowledge on the subject content, according to what we have learnt, or forgotten, in relation to our professional needs (Questions 1 and 2). On the other hand, the questions aim to gather individuals' personal assessment of the course material, according to how useful we consider it to have been (Questions 3 and 4). We use values of between 0-4 to answer each of the questions. They represent the degree to which the objective pointed to in the question has been reached.

Question 1
How much do you think you learnt about this subject in your university education?
Answer: 0: nothing, 1: something 2: enough 3: a lot 4: a lot and in depth
Question 2
How much do you think you know now about this subject, after gaining professional experience and knowledge?
Answer: 0: nothing, 1: something 2: enough 3: a lot 4: a lot and in depth
Question 3
How useful has it been to you in your professional life to have studied this subject?
Answer: 0: not at all 1: of very little use 2: useful, 3: very useful 4: essential
Question 4
Do you believe that a more in-depth study (by means of courses, seminars, talks) of this subject is necessary for your professional career?
Answer: 0: not at all 1: of some use 2: important, 3 necessary 4: essential

Table 2: Questions

Similarly, the questionnaire also gathers other data of interest, such as the time taken to answer the survey, the Firm, University or Body to which the person answering belonged, what they had studied, the year they finished, the sex of the person replying and for how many years they had been working in the IT sector.

The particular career track of the person taking part in the survey is another important piece of data which is given special attention. This is because, as we remarked before, for the survey to represent the majority of those working in the field, we need to take into account their needs and analyse them on the basis of the different professional profiles that are in existence. So we have put together a group of profiles, analysing those provided by the PAFET report [6], in such a way that each participant, on filling in the questionnaire, can choose his or her personal career type from among the following: Teacher/Researcher, Analyst/Developer, Consultant, Hardware Developer, Network Specialist, IT Specialist and Other.

As a data-collecting instrument, we have used an adaptation of the Empirical-WebGen[5] tool developed by the Alarcos Group in the Department of Computer Engineering in Ciudad Real. This is a tool with a Web interface which makes it possible to have access to, and carry out, the survey on a greater number of people. Thanks to its flexibility, it allows the setting up of whatever kind of experiment or survey we wish. The tool was developed on the Microsoft .Net platform and it was put into operation in the ASP.NET 2.0 and Visual Basic NET languages, using Microsoft SQL Server 2005 as the server.

The functionality of the above tool can be summed up as follows

- Design of questionnaires and experiments, starting from a definition of tasks (Yes/No, True/False type questions Multiple Choice, Open Answer and exercises which allow the solution file to be increased.
- Register of Users, administration of users, management of authorizations.
- Availability in Spanish and English.
- Support for the carrying out of questionnaires and experiments by registered users.
- Generation of reports in Crystal Reports (times and answers) which are exportable to other PDF, RPT, RTF, Word and Excel formats.

The survey has been distributed throughout Spain, both in Universities (Castilla-La Mancha, Politécnica de Madrid, Alicante, Málaga, etc) and in IT companies (Indra, Tecnobit, STL, Sicaman, Senasa, etc.), thus covering a large number of professionals of all kinds of career types.

The participants are assumed to have the knowledge needed to answer questions without any prior training, since they possess a career profile that is directly related to Computer Engineering and in their courses they will have studied the majority of subjects or topics under consideration. In any case, and to help those professionals who may have come done other degree courses, a short description of each topic is given. On the other hand, those taking part are motivated, since the survey offers them the two-fold possibility of criticising the present system and of assisting in the attempt to change it and make it more in tune with the true needs of the labour market.

To date, we have more than 100 questionnaires in hand, of which some 40% correspond to professionals involved in teaching or research and about 60% to IT professionals from the other groups being considered (analyst/developer, consultant, hardware developer, etc). With regard to the studies carried out by those surveyed, almost 90% have completed a Computer Engineering degree course, 5% have a diploma in Computer Engineering and the rest have other qualifications. If we observe the years of experience in IT, 20% have at least 3 years experience, 60% have between 3 and 10 years experience and 20% have been working in the field for more than 10 years.

5. RESULTS

The survey having been carried out, in this section we will go on to analyse the results obtained. First of all we conducted a phase to filter information in which we detect in our set of questionnaires those which present anomalies coming from the wrong type of user and then eliminate these. The tool used controls by itself any other kind of anomalies such as incomplete questionnaires or answers that are not within our scale.

To carry out the analysis of results and starting from the career types we have identified, we have put the surveys received into two groups: one corresponding to the teaching/research group; the other group is made up of the rest of the IT professionals taking part.

For each of these groups we have calculated the average for each one of the 4 questions asked and for each topic, so in Figure 1 the average values which correspond to the teacher/researcher profile are shown, while in Figure 2 we see those coming from the IT professionals.

Questions 1 and 2 refer to the knowledge acquired in this subject in the person's education and to what they now know after gaining on-the-job experience. So by analysing the difference between both replies we can know how much of the subject has been forgotten due to its not being necessary for that individual's work. We can also work out how to what extent the subject has required reinforcement through the study of more aspects than those already dealt with in our education.

[5] http://encuestaalarcos.webportalquality.com

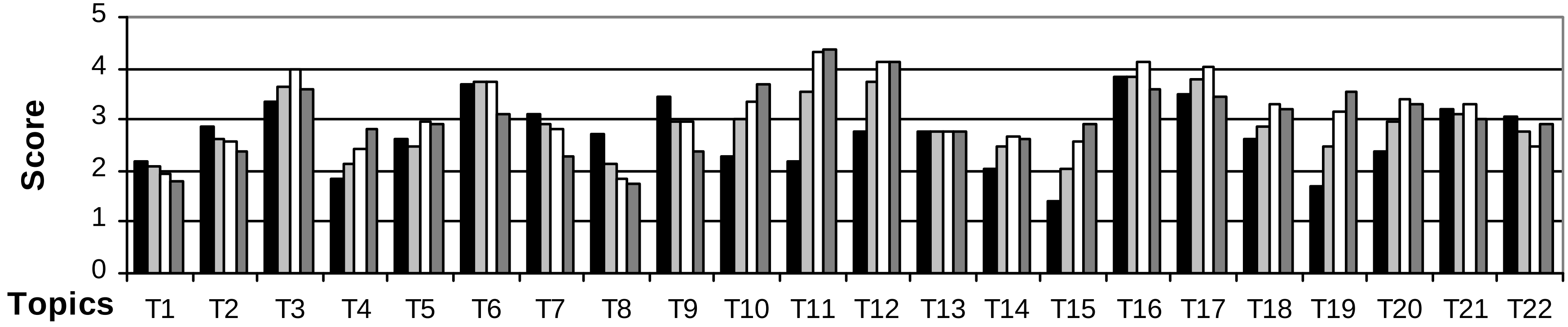

Figure 1: Averages for Teacher/Researcher profile

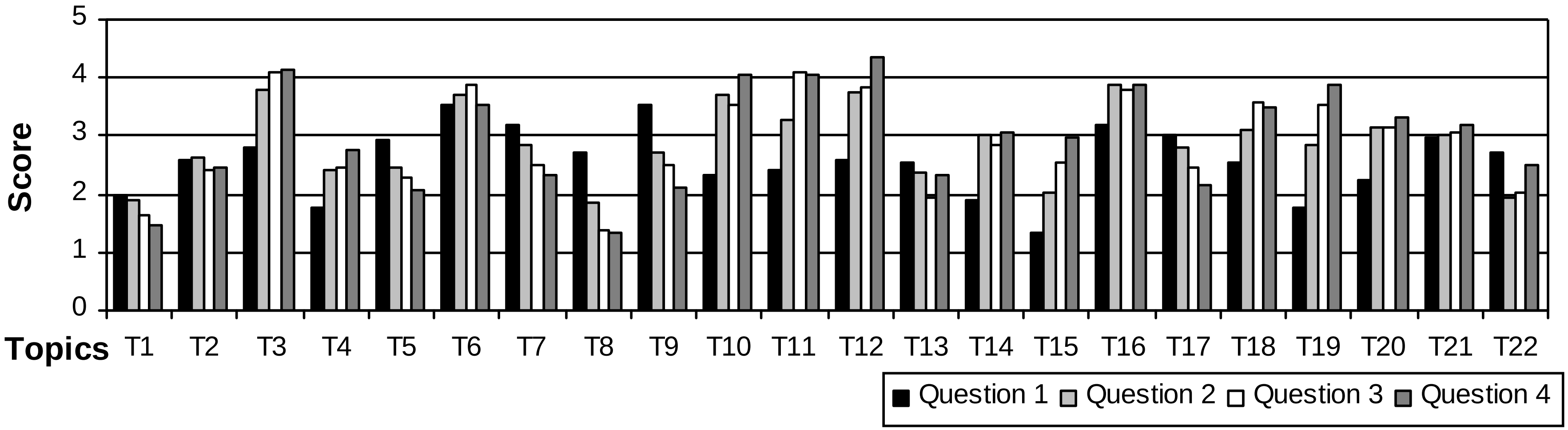

Figure 2: Average for IT profile

We can see that the teacher/researcher profile has had to reinforce knowledge in subjects such as Software Project Management (T10), Languages (T11), Software Engineering (T12) and Security (T19) and to a lesser extent in subjects such as Databases (T3), Economics (T4), Interfaces and Peripherics (T14), Computer Engineering Legislation (T15) and Information Systems (T20). On the other hand, the IT professionals coincide to a large extent with these results but there is more reinforcement in Databases (T3), Economics (T4), Interfaces and Peripherics (T14) and Networks (T18).

On the other hand, the subjects considered to be those which are most usually and most extensively forgotten by teachers/researchers are Physical Foundations of Computer Engineering (T8) and Mathematical Foundations of Computer Engineering (T9). The IT professionals coincide in these subjects, adding Theory of Automata and Formal Languages and Language Processors (T22) and to a lesser extent Statistics (T5) Structure and Technology of Computers (T7).

Questions 3 and 4 tell us the importance that the person surveyed places on the teaching of this subject for him/her to carry out his/her work in the future, as well as to what extent the study of the subject ought to be given greater impetus. The teachers/researchers believe that the subjects that should be strengthened are Software Project Management (T10), Languages (T11), Software engineering (T12), Computer Engineering Legislation (T15), Networks (T18), Security (T19) and Information Systems (T20). The IT professionals also place importance on these subjects but, as well as those already mentioned, they believe that Databases should also be strengthened (T3), along with Economics (T4), Interfaces and Peripherics (T14), Methodology and Technology of Programming (T16) and Networks (T18).

On the other hand, the teachers/researchers think that the subjects that should have less lecture time given to them and which should be studied in less depth due to their being less useful for their professional future are Structure and Technology of Computers (T7), Physical Foundations of Computer Engineering (T8), Mathematical Foundations of Computer Engineering (T9) and a lesser extent Arquitecture and Engineering of Computers (T2). The IT professionals coincide in these subjects and apart from those include Automatics (T1), End of course project (T17) and Theory of Automata and Formal Languages and Language Processors (T22).

6. CONCLUSIONS

We need to strive to define exactly what subjects or topics are fundamental in Computer Engineering, as well as to say which are the resources and credits that are needed to teach them. This survey tries to assist when decisions are being taken on the importance that a given subject has and just how useful it will be in the professional market. There is a need to adapt the study programme to what is being demanded by professionals, making new professionals possessors of the knowledge, skills, foundations and abilities which the ever-changing market is calling for and awaiting.

Having analysed the results obtained in this questionnaire, we can say that the professionals have acquired knowledge in a wide range of subjects. In some cases this knowledge is too broad, in others too scanty. For that reason, we ought to reach a consensus on what a computer engineer needs to know in depth. That kind of knowledge will require a greater number of credits or a greater level of content within that field of knowledge. We will also ascertain what needs to be known to a lesser extent but which requires to be taught as basic knowledge, this requires less weight of credit points in those cases.

The replies of those in the workplace focus on the reality that many of the subjects they studied have not been put into practice, signifying therefore that the majority of the people working in the field have forgotten their knowledge in those subjects, or that their knowledge has diminished in those subjects. Examples of this could be Physics, Mathematical topics, Electronics, Processors, etc. It is true to say, however, that the subjects that have been studied and which the market has demanded most have encouraged ongoing growth, learning and improving of knowledge and abilities. This content would include subjects such as Databases, Software Engineering, topics of Software Management, Security and Law, etc.

We may conclude that the new curricula should fit in with the demands of the IT sector and that this demand requires a large amount of knowledge in technical aspects and management, apart from in communicative skills and in those of leadership guidance. There is less need for the scientific subjects and theoretical computer engineering of traditional engineering courses. As we may observe in the PAFET report, the professional profiles that are most in demand are programmers, analysts and systems consultants. That kind of work is associated with a broad knowledge of programming languages, design, specification, software analysis, databases, management and system assessment, to management and organization of projects, to everything that has to do with the evaluation, management, design, analysis, maintenance and configuration of information systems. A knowledge of languages (in this case English) is equally important, as of course are communicative skills and the ability to head up work for the presentation of projects. Also necessary are conviction and leadership in projects as well as management of these and all that surrounds them (the customers, the team and the resources). For this type of person in this type of job, knowledge of Physics, Algebra, Numerical Analysis, microprocessors, neural networks, robotics, filing systems or memory management or other subjects will not be very useful for their work. It is true, however, that as an engineer that person should have knowledge in these areas whether or not it turns out to be useful in his/her professional life.

The data and conclusions obtained in this work allow us to have at our disposal a basis for reforming study programmes and for the assignation of credit points in each subject so that they are as appropriate as possible to needs in the workplace. With all this in mind, we are at present working in the improvement of our survey, using comments contributed by those taking part. We also plan to extend this to a greater number of professionals, not only in Spain but in other European countries.

ACKNOWLEDGMENTS

This research is part of the ESFINGE (TIN2006-15175-C05-05) Project financed by the Spanish Ministry of Education and Science, and of the MISTICO (PBC-06-0082) Project financed by the FEDER and the Regional Science and Technology Ministry of Castilla-La Mancha (Spain). We would like to thank all the universities and companies which have taken part in this survey. Special thanks go to Francisco Novillo Pérez, creator of the Empirical-WebGen tool.

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