COMPARISON OF EXISTING COMPUTING CURRICULA AND THE NEW ACM-IEEE COMPUTING CURRICULA 2013

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Abstract

The ACM-IEEE Computing Curricula 2005 was published by the Association for Computing Machinery (ACM), the Association for Information Systems (AIS) and the Computer Society (IEEE-CS). After few years and many updates, the new version was published at the end of 2013 year. This last version can be named ACM-IEEE Computing Curricula 2013 (CC2013).

In this paper, we present a comparison of the computing curricula degree programs from five countries (Ecuador, France, Germany, Poland and Spain) and the CC2013. The comparison takes into account both the duration and the content of the studies. This comparison can provide several benefits. Firstly, this comparison highlights the differences that exist among the five analysed countries; it can be used to define correspondence tables between different degree programs. Secondly, this comparison also shows the differences from the CC2005 and the following updates (e.g. CC2013) and it shows what should be changed to align with the latest updates.

Keywords: Computing curricula, curriculum design, student mobility, educational trends.

1 INTRODUCTION

Since the 1960s, some professional and scientific computing societies have tried to define standard curriculum recommendations. In 2005, Computing Curricula 2005 (CC2005) [1], a cooperative project of the most important societies related to computing (The Association for Computing Machinery, The Association for Information Systems and The Computer Society), established an educational standard for the different kinds of undergraduate degree programs in computing. The main objective of this project was to unify the dramatic increase in the number and type of computing degree programs available to students. The CC2005 defined five basic computing degree programs: computer engineering (CE), computer science (CS), information systems (IS), information technology (IT), and software engineering (SE).

Computing is in continuous evolution and new computing-related fields emerge every day. Because of this, the CC2005 has been updated and additional reports with updated versions of the five basic disciples have been published since 2005: in 2008, the Computing Curricula Information Technology was approved; in 2010, the Computing Curricula Information Systems was completed and published; Computer Science 2013 (CC2013) [2], the curriculum guidelines for undergraduate programs in Computer Science published in December 2013, has been the last update of the CC2005. Therefore, the last version of Computing Curricula 2005 can be named Computing Curricula 2013 (CC2013). Despite the existence of the CC2005/CC2013, not all higher education centres have adopted it as a reference or have fully met their guidelines. Because of this, the existing variety of degree programs in computing presents a huge barrier for the international mobility of students. For example, the European Higher Education Area tries to ensure more comparable, compatible and coherent systems of higher education in Europe. Although important results have been achieved in that direction, e.g. the definition of the Diploma Supplement or the European Credit Transfer and Accumulation System, there are still important differences in important areas such as the subjects and the content of the subjects of the degree programs. Due to this, an Erasmus student can face severe difficulties when travelling to another university in a different European country.

In this paper, we present a comparison of the computing curricula degree programs from five countries (Ecuador, France, Germany, Poland and Spain) and the CC2013. The comparison takes into account

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2 CURRICULA COMPARISON

When comparing computing curricula from different countries, important differences in the structure of the academic planning appear. Besides, there are differences in the emphasis given to the study of computing within a degree program: some curricula are oriented toward software engineering, whereas other curricula are oriented toward computer science. In addition, there are different approaches to defining the focus of degree programs. For example, in some curricula, there is a very strong sense of a core for each discipline. The core for each discipline is intended as a specification of those elements of the discipline that are deemed fundamental and which all students of that discipline should fully understand.

2.1 Computer Science Curricula 2013

The project called Computer Science Curricula 2013 (CS2013) was finished in 2013. It was made as a joint task by the Association for Computing Machinery (ACM) and IEEE Computer Society (IEEE-CS). The results of this project were published in December 20, 2013 [2] as a final report. This report is a comprehensive revision of two previous Computer Science curricula reports released in 2001 and reviewed in 2008.

Table 1. Number of core lecture hours CS2013 in comparison with previous curricula. Source: [2]

Knowledge Area	CS2013 Tier1	CS2013 Tier2	CS2008 Core	CC2001 Core
AL-Algorithms and Complexity	19	9	31	31
AR-Architecture and Organization	0	16	36	36
CN-Computational Science	1	0	0	0
DS-Discrete Structures	37	4	43	43
GV-Graphics and Visualization	2	1	3	3
HCI-Human-Computer Interaction	4	4	8	8
IAS-Information Assurance and Security	3	6	--	--
IM-Information Management	1	9	11	10
IS-Intelligent Systems	0	10	10	10
NC-Networking and Communication	3	7	15	15
OS-Operating Systems	4	11	18	18
PBD-Platform-based Development	0	0	--	--
PD-Parallel and Distributed Computing	5	10	--	--
PL-Programming Languages	8	20	21	21
SDF-Software Development Fundamentals	43	0	47	38
SE-Software Engineering	6	22	31	31
SF-Systems Fundamentals	18	9	--	--
SP-Social Issues and Professional Practice	11	5	16	16
Total Core Hours	**165**	**143**	**290**	**280**
All Tier1 + All Tier2 Total	**308**			
All Tier1 + 90% of Tier2 Total	**293.7**			
All Tier1 + 80% of Tier2 Total	**279.4**			

CS2013 has introduced three level of knowledge description. A set of topics named "Core" in previous reports has been divided into two subsets: "Tier-1" and "Tier-2". Set named "Elective" changed a little. The main aim of new division is description some topics as full mandatory (all CS students must cover it) – "Tier-1" and almost mandatory ("all students encounter the vast majority of this material" [1]) – "Tier-2". All CS programs must include significant elective materials. CS2013 defined minimum number of hours (only lectures) needed to teach courses from new sunsets (see Table 1). The developers of CS2013 redefined the Body of Knowledge. Now it contains the list of 18 Knowledge Areas (KAs). Many of KAs are derived from previous curricula (CC2001/CS2008). They have been revised and reorganized due to the CS discipline development. For the same reason there are new areas, such as: Information Assurance and Security (IAS), Platform-based Development (PBD), Parallel and Distributed Computing (PD) and Systems Fundamentals (SF). The new CS2013 curricula seem to be better adapted to the modern understanding of the CS discipline.

3 COMPUTING CURRICULA IN FIVE COUNTRIES

3.1 Ecuador

In Ecuador, each university can define their own computing curriculum. Nevertheless, the curriculum must be verified and certified by the "Council of assessment, accreditation and quality assurance of higher education" (*Consejo de evaluación, acreditación y aseguramiento de la calidad de la educación superior*, CEAACES).

The National Polytechnic School (NPS), founded in 1869, is one of the best universities in Ecuador. The NPS established the studies of computing in 1985. Since then, the curriculum has gone through several stages of reform and update, the last being in November 2011. The degree in computing engineering is 4 year long, according to the Regulation of Undergraduate and Graduate Degree Programs [3] where the subjects are distributed in areas of training and a predetermined number of credits, as it is shown in Table 2.

Table 2. Areas of training at the National Polytechnic School in Ecuador

Areas of training	Credits	ECTS
Basic Training	48	76.8
Professional Training	146	233.6
Elective Training	30	48
Humanistic Training	4	6.4
Total	228	364.8

To calculate the European Credit Transfer and Accumulation System (ECTS) equivalent of the Ecuadorian credit system, the following transformation was performed: the classroom credit corresponds to 16 contact hours in the semester; however the ECTS equals 10 hours of actual work, therefore the Ecuadorian credit must be multiplied by 16 and divided by 10.

Currently, the country has established new curriculum guidelines, in which the government has determined to harmonize curricula across the country, curriculum proposals in the area of Computer Science and related disciplines conform to the ACM. This is crucial for the current curriculum redesign is being done. The NPS wants to strengthen the disciplines of Computer Science and Information Systems, trying to update their curriculum to the new proposal of the CS2013 [2].

3.2 France

In France there mainly exist two official documents issued by the national French public services for higher education containing directives for setting up curricula in the computer science field at the bachelor level. The first document [4] concerns any standard licence degree issued by a French university (3 years of higher education, 180 ECTS). It is mainly skill-oriented and just set up the general frame of the corresponding curricula. The second document [5] is much more detailed and gives strict rules for the curriculum associated to the DUT Informatique (*"Diplôme Universitaire de Technologie Informatique"* or University Technology Diploma in Computer Science). After obtaining a DUT (2 years of higher education) students may complete their training either by a *"Licence Professionnelle"* (Professional Licence Degree) that gives them a professional specialization in the computing field and enter the workplace after 3 years or by joining the standard university trainings for longer studies.

3.2.1 Standard licence degrees

The French licence degree competence referential [4] has been established with respect to the TUNING European project [6] which concerns the convergence of European education programs. Two different kinds of competences are identified: generic competences (either pre-professional or transferable competences) and specific (or disciplinary) competences. A general description of generic competences that is common to any licence degree is given and each different licence degree is then described in terms of objectives of the training and disciplinary competences. For the case of the licence degree in computing science, the objectives indicate a large application field for this discipline and it is stated that the training should be open to other disciplinary or inter-disciplinary specialities.

The specific computing competences are summarized below.

- to participate in the design and implementation of software:
  - to know several programming paradigms/approaches,
  - to understand the different kinds of information (data, process, knowledge, texts),
  - to understand the logical and algebraic fundamental tools and their relations with programming and modelling,
  - to work with analysis methods to design algorithms and software with regard to some given partial needs analysis,
  - to choose between the best adapted algorithms and data structures for a given problem,
  - to work with imperative, functional, object-oriented and multi-tasks paradigms,
  - to design, implement and use databases,
  - to understand the importance of software testing and to realize basic tests,
- to comprehend hardware and software:
  - to identify pieces and technical specifications of hardware,
  - to understand the basis of software systems and networks,
  - to be aware of the software security concept
- to evaluate existing software:
  - to analyse and interpret the results produced by a program execution,
  - to explain and document a technical solution,
  - to know the basic concepts of complexity, calculability, decidability, software checking.

The complementary competences are summarized below.

- to know how to demonstrate,
- to know how to build a synthetic and rigorous mathematical proof,
- to understand the concepts of probability and statistic and their application to data processing,
- to know some scientific or formal computing software,
- to solve a complex problem by sequential approximations.

Taking into account [4], each university may propose its own program for the upcoming accreditation campaign in France: so far the official title for licence programs related to computer science were generally "applied mathematics and computer science" but it will be no more allowed since the French law has restricted the possible titles for licence degrees and the "mathematics" mention will from now on be separated from the "computer science" mention.

3.2.2 "DUT Informatique" (University Technology Diploma in Computer Science)

DUT are vocational diplomas delivered in France after 2 years of higher education programs (120 ECTS). These training are mainly designed for vocational studies but many students continue their studies after obtaining it. There are many DUT specialities. Some of them are more or less related to computer science (e.g. "information technology and communication", "telecommunication and network engineering") but there exists the "computer science" speciality. For many years, the program of each DUT speciality is strictly ruled by a "national pedagogical program" (NNP). This program is very detailed and states not only the different competences but also the whole program structure. Each course is described in terms of objectives, targeted competences, prerequisites, contents, keywords and of course associated ECTS and contact hours. The NPP for the computer science speciality [5] applies to any university proposing this training (about 40 different places in France) and presents the structure displayed on Table 3.

Once they obtained the DUT in computer science students get employed, they join longer study programs such as the standard licence (see 3.2.1) or they complete their training by a *"Licence Professionnelle"* (professional licence) program (one year, 60 ECTS) to reach a vocational bachelor level. There are several professional licence programs proposed in France and they can differ from a university to the other. Professional licence programs generally concern further specialization after a DUT (e.g. web developer, system administrator, and so on).

Table 3. Structure of de NPP for the computer science speciality in France

Modules for computer science	
Subject	**ECTS**
Introduction to computing systems	3.5
Introduction to algorithms and programming	3.5
Data structures and fundamental algorithms	2.5
Introduction to databases	3.5
Design of numeric interfaces and documents	2.5
Software project (Discovery)	1.5
Basic architecture and programming of computing systems	1.5
Network architecture	1.5
Basis of object-oriented programming	3.5
Basis of object-oriented analysis and design	2.5
Introduction to Human Computer Interface	2.5
Management and programming of databases	2.5
Software project (documentation and planning)	2.0
Principles of operating systems	2.5
Network services	1.5
Advanced algorithms	1.5
Web programming (server side)	2.5
Advanced object-oriented programming and design	2.5
Advanced databases	1.5
Systems and networks management	1.5
Distributed programming	1.5
Web programming (rich client)	1.5
Design and implementation of mobile software	1.5
Computer science complements for pre-professionalization	1.5
Software project (complements	2.5
Total	55
Modules for scientific, social and human culture (summarized)	
Subject	**ECTS**
Mathematics, probabilities, statistics	15
Economics, law and management	13
Expression and communication	7
English	8
Personal development	3
Pre-professionalization	7
Mathematics, probabilities, statistics	15
Economics, law and management	13
Expression and communication	7
English	8
Personal development	3
Pre-professionalization	7
Total	53
Professional internship	
Internship	12
Total	120

3.3 Germany

The "Gesellschaft für Informatik" (GI), the German society for computer science, comprises several working groups including a working group concerned with recommendations for curricula in higher education. This working group has issued a document describing two typical curricula of a bachelor degree in computer science that should be accredited by any agency. A bachelor of computer science comprises 180 ECTS including 15 ECTS for a bachelor thesis and its defence. Both curricula should include modules in the four categories presented in Table 4.

Table 4. Modules of bachelor of computer science in Germany

Modules	ECTS
Knowledge and methods for computer science (60%)	90
Mathematical, scientific and technical principles (20%)	30
Interdisciplinary principles (20%)	30
Other transversal competences (20%)	30
Total	**180**

Table 5. Curriculum application-oriented in Germany

Modules for Knowledge and Methods for computer science	
Subject	**ECTS**
Software Engineering I (Modelling)	5
Software Engineering II (Principles and Technics)	5
Software Engineering III (Human-Computer Interfaces)	4
Programming I (Principles of programming and programming concepts)	6
Programming II (Programming practice)	8
Software Project	8
Theoretical Computer Science	8
Algorithms and Data Structure	6
Computer Networks, Web Applications	6
Operating Systems	5
Distributed Systems	5
Database and Information Systems	6
Computer Architecture	5
Security and Technics for Security	5
Other compulsory course in computer science	5
Total	**90**
Modules for Mathematical, scientific and technical principles	
Hardware Principles	8
Analysis	6
Numerics	4
Algebra I (Linear Algebra)	6
Algebra II (Discrete Mathematics, Structures, Logic)	4
Principles of Probabilities and Statistics	4
Total	**32**
Modules for other Interdisciplinary principles	
Introduction to economics	8
Introduction to computer science and law	4
Total	**12**
Modules for transversal competences	
Seminar for project and project management (to accompany the module Software Project)	4
Seminar for self-development (for example on computer science and society)	4
Seminar for developing transfer and social competences (Rhetoric, communication skills)	4
Seminar to develop analytical competences (themes from science and practice)	4
Total	**16**
Total	**150**

Both curricula described below are based on the recommendations of the GI [7]. The first curriculum is more application oriented and contains a 15 ECTS internship in a company (see Table 5). Therefore, all modules sum up to 150 ECTS. The second curriculum is more oriented towards fundamentals and replaces the 15 ECTS internship with supplementary modules in special application domains and, consequently, all modules sum up to 165 ECTS (see Table 6). The second curriculum is quite similar to the one adopted by the university of Paderborn, Germany.

3.4 Poland

According to Polish law there are two profiles of higher education: academic (general academic) and practical. Both profiles are defined by [8]. Studies of the practical profiles must have a long professional internship of student (min. 3 months) and module of vocational courses, used by the student to gain practical skills.

Table 6. Curriculum fundamentals-oriented in Germany

Subject	ECTS
Modules for Knowledge and Methods for Computer Science	
Subject	**ECTS**
Modelling	10
Software Engineering (Design)	4
Fundamentals of Programming 1	8
Fundamentals of Programming 2	4
Fundamentals of Programming Languages	4
Software Project (including Project Management)	10
Introduction to Computability, Formal Languages and Complexity	8
Algorithms and Data Structure	8
Fundamentals of Database	6
Computer Architecture	5
Hardware Practice	5
Software Engineering (Technics)	6
Models and Algorithms	6
Human-Computer Interaction	6
Information Systems	6
Embedded Systems	6
Total	**102**
Modules for Mathematical, Scientific and Technical Principles	
Fundamentals of technical computer science	**5**
Mathematics 1 (Principles)	**8**
Mathematics 2 (Discrete Algebraic Structures)	**8**
Stochastic	**4**
Total	**25**
Modules for other Interdisciplinary principles **Application modules from economics, electronics, mechanics, or mathematics**	
Application module 1	**8**
Application module 2	**8**
Application module 3	**8**
Total	**24**
Modules for Transversal Competences	
General studies	**6**
Seminar for self-development	**4**
Seminar with state of art and Presentation	**4**
Total	**14**
Total	**165**

Studies of general academic profile have significantly shortened internship (4 weeks or not at all) and have module of theoretical courses, used by the student to gain in-depth theoretical skills. Some classes on the practical profiles studies can be carried out by practitioners from industry and they have reduced requirements for teaching staff. Studies of the practical profile formally functioning since 2005 and lasts one semester longer. However, they are very low recognized in Poland. At the moment, most students graduate with a general academic profile.

In Poland there is a breakdown higher education studies on the area science: technical and non-technical. Differentiated are also achieved professional degrees. Basic differences in the types of studies are shown in Table 7.

“Informatics” (Computing Science, CS) historically derived from the humanities universities and polytechnics (universities of technology). Therefore it is classified both in technical sciences and non-technical. Consequently, in Poland there are two different programs of CS on the first cycle.

Until the implementation of the Polish National Qualifications Framework (NQF), inspired by the European Qualifications Framework (EQF), the standard curricula in Informatics (both technical and non-technical) functioned in Poland. At the moment they have been replaced by the standard of qualification requirements for each area of education. Most programs, however, maintains the "old" standards. In them, the learning content is divided into groups: the minimum number of ECTC for non-technical and studies are listed in Table 8.

Table 7. Comparison of the first cycle of university studies in Poland

	Non-technical	Technical
Number of semesters	6	7
Number of ECTS credits	180	210
Percentage of practical courses	n.a.	50%
Professional title	licentiate	engineer

Table 8. Modules of bachelor of computer science in Poland

Modules	ECTS
Basic (mathematics, physics)	20/27
Directional (programming, algorithms and data structures, computer architecture, operating systems, networks, computer graphics, artificial intelligence, databases, software engineering, embedded systems, ICT ethics)	67/69
Humanistic (languages, social, intellectual property etc.)	9/12
Final diploma preparation and thesis defence	10/15

Table 9. Curricula for Informatics in Lublin Technical University in Poland (only main courses)

Subject	ECTS
Physics	5
Elementary functions	4
Discrete mathematics	8
Analysis and algebra	8
Statistics and probabilistic	5
Theoretical basis of informatics	7
Fundamentals of programming	6
Computer architectures	4
Algorithms and data structure	6
Operation systems	6
Programming in assembler	3
Object-oriented programming	5
Numerical methods	5
Circuit theory and signal	5
Metrology	4
Electronics	5
Digital techniques	4
System programming	2
Java programming	4
Computer networks	5
Web technology	4
Computer graphics	4
Data bases	5
Distributed networks	5
Microprocessor techniques	4
Software engineering	5
Information systems security	4
Web applications developing	5
Computer modelling and simulation	4
Embedded systems	4
Parallel and distributed programming	4
Programming paradigms	3
Team software project	6
Set of electives courses (six courses) *	20
Diploma seminar	15
Practice	4
Total	**197**
* 3 different courses are proposed per each course. Students have rights to choose.	

The standard curriculum defined a 30% share of elective subjects in education. This allowed universities to quite a large modification of study programs. At the moment universities have a wide freedom to create their own study programs, which, however, must comply with the NQF standards. The example of curricula in Informatics is presented in the Table 9. Technical courses (which are not in the curricula of non-technical studies) are bold.

3.5 Spain

In Spain, each university can define their own computing curriculum that must be verified and certified by the "National Agency for Quality Assessment and Accreditation" (*Agencia Nacional de Evaluación de la Calidad y Acreditación*, ANECA). The aim of this agency is to provide external quality assurance for the Spanish Higher Education System and to contribute to its constant improvement through evaluation, certification and accreditation. ANECA evaluates the proposals of study plans (curricula) designed in line with the European Higher Education Area (EHEA).

At the University of Alicante, all subjects in the degree in computer engineering are worth 6 ECTS each, and they are organized into semesters. Students must enrol 5 subjects each semester in order to complete 30 credits per semester and 60 credits per academic year. All the degree sums up a total of 240 credits over the four academic years.

The degree in computer engineering is structured around three main areas. The first part of the degree programme contains the core subjects, and it sums up a total of 60 ECTS. The second part of the programme contains the compulsory subjects, aimed at guaranteeing that students acquire the required skills associated with the degree. This part sums up a total of 108 ECTS, in addition to the compulsory final project (12 ECTS). The final project is carried out in the final semester and is aimed at assessing the level of skills acquired. Prior to evaluation for the final project, the student must provide evidence of ability in a foreign language.

The last part of the programme contains the 60 optional ECTS, of which 48 correspond to one of the specialisations [9] (see Table 11), while the other 12 ECTS allow students to combine and choose from work experience (internship), optional subjects from other degrees, and English courses

Table 10. Degree in computer engineering at the University of Alicante in Spain

Modules	ECTS
Core	60
Compulsory	108
Optional	60
Final Project	12
Total	**240**

Table 11. Specialisations of the degree in computer engineering at the University of Alicante in Spain

Subject	Semester
Software Engineering	
Advanced Software Specification Techniques	6
Versatile Software Development Methods	7
Distributed Applications On The Internet	7
Web Engineering	7
Collaborative Design Of Applications	7
Software Design Security	8
Software Quality Management	8
Methods And Technologies For Systems Integration	8
Computer Engineering	
Computer And Network Maintenance Engineering	6
Real Time Systems	7
Concurrent Programming	7
Domotics And Intelligent Environments	7
Industrial Systems	7
Embedded Systems	8
Software Development In Parallel Architectures	8
Automation And Robotics	8
Informatics	
Analytical Processing	6
Theory Of Informatics	7
Automated Reasoning	7
Interactive Graphic Systems	7
Programming Challenges	7
Artificial Vision And Robotics	8
Language Processing	8
Robotic Technology And Architecture	8
Information Systems	
Electronic Business Management	6
Data Processing For Information Systems	7
Integrating Business Applications And Processes	7
Requirements Engineering	7
Business Management	7
Technological Scenarios In Organisations	8
Business Intelligence And Process Management	8
Data Management	8
Information Technologies	
Management And Implementation Of Computer Networks	6

Developing Internet Applications	7
Management And Implementation Of Internet Services	7
Database Administration And Management	7
Network Interconnections	7
Security Strategies	8
Information Technology Management And Control	8
Internet Content And User Management Systems	8

4 COMPARISON AND CONCLUSIONS

Despite the existence of the European Higher Education Area (EHEA) and despite the efforts to harmonize higher education in the member countries of EHEA, in this study it has been found that there are significant differences in computing curricula (see Table 12). Therefore, there are still important differences in important areas such as the subjects and the content of the subjects of the degree programs.

Table 12. Summary of the structure of the academic planning

	Length (years)	ECTS
Ecuador	4	364.8 + 32 = 396.8
France (std. licence degree)	3	180
France (DUT)	2	120
Germany	3	180
Poland (non-technical)	3	180
Poland (technical)	3.5	210
Spain	4	240

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REFERENCES

[1] The Joint Task Force for Computing Curricula (2005). Computing Curricula 2005 - The Overview Report. ACM and IEEE.

[2] The Joint Task Force on Computing Curricula (2013). Computer Science Curricula 2013. ACM and IEEE.

[3] Escuela Politécnica Nacional (2013). Reglamento del Sistema de Estudios de la Escuela Politécnica Nacional de Quito.

[4] Ministère de l'enseignement supérieur et de la recherche (2012). Référentiels de compétences en licence. Internet: http://cache.media.enseignementsup-recherche.gouv.fr/file/Plan_licence/61/4/referentiel_227614.pdf (May 19, 2014).

[5] Ministère de l'enseignement supérieur et de la recherche (2013). Plan pédagogique national du Diplôme Universitaire de Technologie Informatique. Internet: http://www.iut-informatique.fr/docs/ppn/fr.pdf (May 19, 2014).

[6] The TUNING project (2014). Internet: http://www.unideusto.org/tuning/ (May 19, 2014).

[7] Gesellschaft für Informatik e.V (2012). Curricula recommendations of the GI. Internet: http://fg-ish.gi.de/ish/empfehlungen-dokumente-und-umfragen.html (May 15, 2014).

[8] ACT of 27 July 2005. Law on Higher Education (in Polish: USTAWA z dnia 27 lipca 2005 r. Prawo o szkolnictwie wyższym. Dz. U. 2005 Nr 164 poz. 1365).

[9] Ministerio de Educación (2009). Resolución de 8 de junio de 2009, de la Secretaría General de Universidades, por la que se da publicidad al Acuerdo del Consejo de Universidades, por el que se establecen recomendaciones para la propuesta por las universidades de memorias de solicitud de títulos oficiales en los ámbitos de la Ingeniería Informática, Ingeniería Técnica Informática e Ingeniería Química. Boletín Oficial del Estado n° 187, 4 de agosto de 2009.