Including Design for All in Computing and Telecommunication Engineering Studies in Spain

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***Abstract*— This paper discusses a number of key issues related to teaching Design for All to undergraduate students and presents an assessment report requested by the *Initiative for Design for All in Spain*, in collaboration with the *Institute for the Elderly and Social Services* (IMSERSO), and the ONCE *Foundation for the Cooperation and Social Inclusion of People with Disabilities*. The objective was to study, discuss and propose the inclusion of Design for All methods and practices in the curricula of undergraduate degrees related to Computer and Telecommunication Engineering, in order to train future professionals able to apply Universal Accessibility principles in their practice of the profession. The flexible and modular structure of the proposed curriculum is described, including the included mandatory and optional modules. The resulting report was presented to the Spanish University Quality Assessment Agency, involved in the updating of the Bachelor degrees in Spain. These recommendations were adopted by several Spanish Universities for their renewed Computer and Telecommunication engineering degrees.**

Keywords—curricula in University; Design for All;

I. FROM AD-HOC DESIGN TO DESIGN FOR ALL

With the appearance of the first personal computers there were various initiatives to use these to assist people with different disabilities in order to enhance their opportunities to communicate and to control their environment. Most of the devices, applications and services developed at that time were single-user designs devoted to meeting the needs, and taking advantage of the remaining abilities, of specific users.

These pioneer works demonstrated the validity of personal computing to enhance the autonomy and the quality of life of people with disabilities. Nevertheless, *ad-hoc* designs were expensive and rigid, that is, difficult to adapt to other people with different physical, sensory or cognitive characteristics. In addition the rapid evolution of the technology available in the market soon rendered them obsolete. Moreover, people with disabilities preferred to use mainstream applications rather than the specific ones designed for them [1].

Designers soon discovered that making mainstream technology broadly accessible was better than adapting commercial devices and applications, or producing particular solutions for specific people. This idea fostered diverse but similar approaches, such as Design for All, Universal Design, Universal Accessibility, etc. All of them have in common the objective of producing devices, applications and services that can be used by most people without the need to adapt or modify them. This is compatible with, and can include, the need for specific devices or applications to access regular technology in specific cases (e.g. some blind people may require a Braille line in order to read text output).

This design philosophy has innumerable advantages as well as that of including people with disabilities. It is more user friendly for all the users including people who speak a non-official language, illiterate people, etc., and it covers situations where people without disabilities have restrictions to access common technology. Therefore, it can reach a larger market, making solutions cheaper.

The main difficulty of the Design for All approach is that, to be valid, it must be applied by all designers for all of the mainstream technology. This requires that future engineers are sufficiently trained to apply it. For this reason, promoters of the Universal Design and Design for All have surveyed, discussed and proposed diverse ways to include Design for All methodologies in the curriculum of future designers.

II. OUR PROPOSAL TO INTRODUCE DESIGN FOR ALL IN ENGINEERING CURRICULA

In this paper we present the results of an assessment requested by the Initiative for Design for All in Spain, in collaboration with the Institute for the Elderly and Social Services (IMSERSO) and the ONCE Foundation for the Cooperation and Social Inclusion of People with Disabilities, to propose the inclusion of Design for All methods and practices in the curricula of university degrees related to Computer and Telecommunication Engineering. Its main goal was to promote a basic foundation in Universal Accessibility among the future professionals working on the design, development, production and the maintenance of Information and Communication Technology (ICT), with the objective of enabling them able to apply these principles in the practice of their profession.

A broad overview of the Design for All concept was undertaken. This approach subsumes accessibility, and also entails promoting equal opportunity to access, use and

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understand any part of the information and communication technology. Therefore, the resulting proposal was oriented to train engineers to be able to design ICT products and services so that they can be used by all people, regardless of age, gender, (dis-)abilities or cultural background.

III. State of the Art and Related Work

A. Inclusion of Design for All in undergraduate courses

The European financed Thematic Network IDCnet: Inclusive Design Curriculum Network [2] had an important role in the promotion of the inclusion of the Design for All in undergraduate curricula. Its main objective was "to integrate information and identify core knowledge sets and skills for model curricula in Design for All for Information and Communication Products, Systems and Services". IDCnet collected and elaborated extremely useful materials that can be found on its webpage. After its conclusion, its activities were continued under the umbrella of the European Design for All e-Accessibility Network.

The European Design for All e-Accessibility Network (EDeAN) [3] is composed of 160 organizations in European Union member states. Its goal is to support all citizens' access to the Information Society. Among other services, EDeAN provides online resources on Design for All. Specifically it has a section on Design for All Education and Training [4] aiming "to introduce newcomers to key concepts, examples and design/research methods, and to support practitioners in building up their own collection of tools and techniques". It is devoted to "design students and their tutors, professional designers, design managers and policy makers across Europe.

The diverse curricula proposed by ACM and IEEE have had worldwide influence in the design of Curricula in the computing field. Nevertheless, the "Curriculum Guidelines for Undergraduate Degree Programs in Information Systems. Computer Science" [5], published in 2013 by the Joint ACM/IEEE task force on Computing Curricula, contains scarce mention of Accessibility: "HCI/Foundations" does include a section on "Accessibility, e.g., interfaces for differently-abled populations (e.g., blind, motion-impaired)" and "SP/Social Context" includes "Accessibility issues, including legal requirements") but there is no mention of Universal Design or Design for All in the proposal.

B. Experiences and good practice examples

Experiences on teaching Design for All are required to guide and encourage lecturers wanting to start teaching these topics. Some few examples have been published. Among them, Keates (2005) presents in [6] an MSc Course on "Usability and Accessibility" used to teach Universal Access. He provides useful details, including content and structure of the course, methodology, and a critical review of the course including feedback from the students.

Hand Kramer (2014) also provides interesting examples of teaching Universal Design in the courses described in [7, 8].

C. Accessibility to Design for All courses

In parallel with the tendency to include Design for All abilities in engineering curricula, the question of making their own classes accessible to all students arises. In fact, it would seem incoherent to teach Design for All to audiences in which people with restrictions are excluded.

In this way, Burgstahler (2013) "summarizes the history and development of applications of Universal Design (UD) in educational settings, references research and practice that supports the UD approach, and recommends topics for future research. She also shares specific strategies that apply a UD to course syllabi, Web resources, teaching methods, presentation materials, labs, and assessment instruments" [9].

Chambel et al. (2009) [10], describe in detail their experience in teaching Human-Computer Interacting to blind students integrated in group of sighted students. Due to the mostly visual nature of the majority of user interfaces, this challenging experience provides excellent considerations for people wanting to teach accessible Design for All.

D. Inclusion of Design for All in general design courses vs. Universal Design standalone courses

Two principal approaches to teach Universal design in Engineering are possible. To teach Design for All methodologies and techniques in specific courses or to include these methodologies in general design courses. The former allows going more thorough into specific topics related to disability, user needs gathering, evaluation, etc. Nevertheless, it can reinforce the idea that design for all is a separate branch of general design, only used when people with disabilities are involved. The latter integrates accessibility into the whole design process. In this case, the Universal Design concept can lose prominence, but the need to apply Design for All in all designs is effectively reflected. Therefore a combination of both approaches appears to be an optimal strategy.

For instance, Burgstahler (2011) suggests a strategy for including Universal Design (UD) as a Computing Curriculum Topic: "Computing instructors should therefore consider how their courses might increase in quality by infusing the UD philosophy within their curricula. For example, if the creation of application software is part of an assignment in a computing course, the instructor could require that students apply UD principles as they develop their software interfaces so that they are usable by all potential users, including those with disabilities" [9].

IV. Building an Inclusive Curriculum

This work started from our contribution to the first workshop organized by IDCnet in Helsinki, from February 14 to 15, 2003. The topic of the workshop was: "Design for All Curriculum: Towards a synergy of the needs of ICT industry and education". Later we were invited to a seminar held in Barcelona, on November 24, 2003, organized by the Coordinator of Design for All in Spain. The results were published in 2006 the "White book of Design for All in the University" [11].

In both cases we contributed with the experience accumulated teaching a Design for All module within the optional subject "Advanced Interactive Systems" of the Informatics degree in the University of the Basque Country/Euskal Herriko Unibertsitatea. In addition, we

included Design for All lessons in several doctorate courses in the Human-Computer Interaction area from 1996/1997.

In 2008 we were invited to participate in the scientific and redaction committees of the Second White Book of Design for All in the University. The rationale for a second version of the book was that the Spanish universities would be soon involved in the process of adaptation of their degrees to the European Higher Education Area agreed in Bologna. This was an unbeatable opportunity to include Design for All content in the adapted degrees. The first meeting was held in Madrid in April 28, 2008. In that meeting we received the assignment of redacting a proposal for the Computing and Telecommunication Engineering grades.

After compiling, analyzing and discussing the published material and curricula we created a draft proposal that was discussed and completed with the contributions from other Spanish experts in Accessibility. To this end, we organized a seminar on Design for All in Information Systems and Telecommunications degree programs, held on September 8th 2009 as part of the 10th Conference on HCI-*Interacción* 2009 in Barcelona.

The proposed curriculum was completed with recent references and materials, and was sent to the editors. The book was delayed until all the different Curricula proposals for diverse studies were put together. It was finally published in 2011. In the meantime, the scientific committee held meetings with the National Agency for Quality Assessment and Accreditation of Spain (ANECA) and the Conference of Rectors of Spanish Universities (CRUE) that made policy makers aware of the curricula proposals even before the book was published.

V. Description of the Proposed Curriculum

The structure of the courses follows general recommendations such as the European Qualifications Framework for Lifelong Learning [12], the European Credit system for Vocational Education and Training [13] and similar recommendations of the Board of Education and Training in the European Community.

In addition, relevant standards and recommendations were considered in order to be able to train future professionals to develop robust technology which can be used in different platforms, use contexts and users with different abilities.

The proposed curriculum has a modular structure where content and acquired skills are organized in thematic mandatory and optional modules.

A. Structure

The proposal framework includes three parts:

1) Fundamental matters: cross-disciplinary topics that can be included in the basic training of the various qualifications for professionals that have responsibilities at any level in the design and building of ICT (accounting for approximately 15 % of the total European Credit Transfer and Accumulation System - ECTS).

2) Specialization: specific techniques that can be accommodated in the teaching of diverse ICT matters, accounting for approximately 50% of the total ECTS.

3) Practical training: work on realistic projects applied to real cases, which will make up around 35% of the total ECTS.

B. Modules

These topics are complementary and may be taught at different levels of depth and granularity, depending on the particular characteristics of each degree and the configuration of the studies. The proposed general structure provides sufficient flexibility to introduce Universal Accessibility concepts and practices in existing modules and/or to create specific modules devoted to accessible design. For the later choice, three tracks are proposed:

- Design for All and user-based evaluation (which will include Modules 1 to 3).
- User Interfaces, Technology Support and Web Applications (which includes Modules 4 to 6).
- Advanced Knowledge of Design for All and its implementation (composed of Modules 7 to 10).

Module 1: Design for All and target user groups

Type: Mandatory

Knowing the target users and their characteristics (abilities, expectations and needs) is a necessary prerequisite for understanding the requirements of an application. Students' knowledge about the characteristics of users with various requirements, disabilities or limited resources must be expanded. This knowledge underpins a basic motivation for the Design for All approach. This module can be set as a prerequisite for all of the other modules.

Objectives:

- To motivate and introduce demographics, a diversity of user preferences and needs, and the benefits of the approach based on Design for All.
- To provide a vision of the diversity of target groups and the issues to be borne in mind regarding people with different characteristics and requirements when using ICT, as well as the principles of Design for All and cooperation with user groups.
- To learn techniques and methods for cooperating with consumers and their organizations throughout the life cycle of products and services.

Credits: 2 credits

Contents:

- The national and international legislative context.
- Basic information on the type and numbers of people with a need for e-Inclusion.
- Introduction to the limitations experienced by people with some sort of functional deficiency in terms of

their participation in society (sight, hearing and mobility-related disabilities, etc.) and the identification of potential solutions.

- Introduction to the problems caused by usage context (disabling situations).
- Introduction to Design for All. Relationship between usability and accessibility.
- Cooperation with users and organizations, oriented towards User-Centred Design. Methods for collecting data from users.
- Application of the methods throughout the life cycle of products and services to achieve their improvement iteratively.

Module 2: User-Centred Design

Type: Mandatory

The principles of User-Centred Design can be used to identify valid requirements when developing technology so as to end up with a useful, accepted system that has a chance of success in the market. Similarly, more accessible systems can be achieved when the intended user groups include people with disabilities, senior citizens or people with a low level of education.

Objectives:

- To motivate and introduce principles and methods of User-Centred Design methodology. Broadening it to include the principles of Design for All also considering users with different needs and characteristics.
- To learn methods to support the activities in a User-Centred Design and Design for All process.

Credits: 2 credits

Contents:

- The process of User-Centred Design (ISO-13407). Benefits.
- Design for All in a User-Centred Design process. Identification of requirements. Creation of design solutions.
- The current state of the art of the methods which support User-Centred Design.
- Methods of evaluation: participation by users, inter-disciplinary groups and iterative design solutions.

Module 3: Evaluation methods

Type: Mandatory

Evaluation is a crucial step in achieving accessible systems. This includes evaluation by experts, evaluation by users and technical evaluation using validation tools. The selection of the evaluation methods to be used in order to achieve valid and verifiable results is a key issue to obtain universally accessible and usable results.

Objectives:

- To become familiar with the evaluation of systems in terms of Design for All qualities as perceived by users, such as utility, usability and accessibility.
- To become familiar with the methods for evaluating systems, considering Design for All from the perspective of the characteristics perceived by users.

Credits: 2 credits

Contents:

- Analyzing when and why to perform an evaluation.
- Evaluation criteria involving Design for All.
- Methods of evaluation by experts
- Methods for evaluation by users
- Automatic evaluation methods and tools.
- Formative vs. normative evaluation. Comparative evaluation.
- Suitable selection of evaluation methods.

Module 4: Accessible user interfaces

Type: Mandatory

The interface between a system and its users is the point at which the user interacts with the system and uses its functionality. The interface is closely related to user experience and is more or less flexible. The accessibility of new interfaces will be achieved through research, though new paradigms may offer new solutions to the accessibility problems existing in current interfaces.

Objectives:

- To motivate and introduce the design of interfaces for a broad spectrum of users and usage situations, including new user paradigms.
- To provide a perspective of the current state of the art, innovative user interface design methods and options for Design for All.

Credits: 2 credits

Contents:

- Defining User Interfaces and Human-Computer Interaction (HCI). HCI hardware and software components.
- The role of Supporting Technologies in Design for All. Accessible APIs.
- Information architecture, displaying information and browsing.
- Adaptable and adaptive user interfaces.

- Ambient Intelligence.
- Examples of designs for exclusive and inclusive user interfaces.
- Methods for achieving Design for All (prototyping, screen design, interaction design, the use of guidelines and style guides, etc.).

Module 5: Assistive Technologies

Type: Mandatory

Some people need Assistive Technologies (AT) in order to be able to access common ICT products and services. ATs may be specialized hardware or software. AT must avoid any interference with the functionalities of the accessed services or technologies.

Objectives:

- To motivate and introduce the role of Assistive Technologies as a tool and mechanism for ensuring the inclusion and participation of people with specific characteristics.
- To provide a vision of Assistive Technologies and how to use them in common real-life situations.
- To learn how to select the most appropriate technology in specific environments for people with certain needs.
- To achieve an in-depth understanding of the interoperability between Assistive Technologies and ICTs.

Credits: 2 credits

Contents:

- Assistive Technologies. Use cases.
- Interoperability of Assistive Technologies and common ICTs.
- Contexts for using Assistive Technologies and their relationship with other ICTs.
- Ethics in the design and use of Assistive Technologies.
- Alternative hardware and software.

Module 6: Accessible Web applications

Type: Mandatory

Web applications can be accessed through a Web browser using the Internet. As a large number of ICT applications are used in private and professional contexts, Design for All must deal with them explicitly.

Objectives:

- To motivate and provide an introduction to principles and methods for building Web applications for All, including different users who have a wide range of needs.
- To become familiar with user-friendly, accessible Web application design methods and guidelines.

Credits: 2 credits

Contents:

- Web design for e-Inclusion.
- Web technologies and their use to create accessible Web applications.
- The role of standards and guidelines for accessible Web applications.
- Accessible solutions for typical Web applications.

Module 7: Ethics, legislation and privacy

Type: Optional

The relationship between the ICT industry and users must adhere to ethical principles and take into account privacy issues. Privacy and ethics are important during the development and use of ICT systems and services. Privacy must be strengthened, and dangers and data loss prevented. To achieve this, legal regulations on accessibility and ICT technologies must be known by all the stakeholders.

Objectives:

- To become familiar with ethics, legislation and privacy issues involved in ICTs for all users, including users with different needs.
- To be able to select solutions based on good practices with regard to legal matters, ethics and privacy issues for specific technologies or application domains.

Credits: 1 credit

Contents:

- Relevant aspects of ethics involved in Design for All.
- National and international policies and legislation.
- Principles of privacy in national and international legislation. Privacy vs. security.
- Identification of ethical, legal and privacy-related issues in an ITC project.
- Recommendation of solutions.

Module 8: Social integration and labour

Type: Optional

The Design for All approach usually has a positive effect on the industry, because it affects the accessibility and security of jobs. Improving accessibility may be mandatory due to legal requirements or because it can lead to increasing the number of customers.

Objectives:

- To motivate and introduce the implementation of Design for All policies within companies.

- To understand the concepts of Corporate Social Responsibility.
- To learn applicable techniques and methods for developing business models made successful by implementing Design for All within companies.

Credits: 2 credits

Contents:

- Inclusion of Design for All as a part of the business and marketing strategy within companies. Case studies.
- The difference between Design for All and Corporate Social Responsibility.
- Implementation of means for including policies which benefit people with disabilities with regard to Corporate Social Responsibility policies.
- Procedures for achieving accessible products and services.
- The potential of products and the market since the advent of Design for All.

Module 9: Accessibility to consumer electronics and games

Type: Optional

Consumer electronics and games play an important role in the lives of people in a similar way as Web applications do. They involve aspects of recreation and social interaction which must be usable by all people. Although the accessibility of websites is a very widely studied topic and now has mature guidelines, the same cannot be said of the accessibility of consumer electronics and games.

Objectives:

- To introduce Design for All in consumer electronics and games.
- To learn methods and techniques for implementing Design for All and Universal Accessibility in consumer electronics and games.

Credits: 2 credits

Contents:

- The role of consumer electronics and games in people's lives, above all people at risk of exclusion.
- State of the art in consumer electronics and games and their interfaces.
- Examples of good and bad practices in the development of consumer electronics and games. Processes and methods for implementing Design for All.
- Standards and guidelines for the development of consumer electronics and games. New paradigms.
- Methods for identifying questions about the accessibility and usability of this technology.
- Prototyping and user evaluation in an iterative manner.

Module 10: Back-end technologies

Type: Optional

Systems based on back-end technologies, such as servers, databases, networks, interfaces, services, content management systems and service delivery platforms may have an impact on the usability and accessibility of systems depending upon what choices are made even if back-end technology is not visible to users.

Objectives:

- To emphasize the importance of back-end technologies in terms of usability and the accessibility of ICT services for end users.
- To understand the responsibility of Design for All in several scenarios of content development along with instructions for ensuring usability and accessibility.

Credits: 1 credit

Contents:

- The relationship between back-end technologies and Design for All for ICTs.
- A review of back-end technologies in ICTs.
- Critical points of Design for All in back-end technologies.
- Achieving requirements for Design for All in back-end technologies.

C. Reference materials

- Web Accessibility Initiative: http://www.w3.org/WAI/
- Preiser W. F. E., Smith K. H. (eds.). 2001. Universal Design Handbook, 2nd ed. McGraw-Hill.
- Cook A. M., Polgar J. M. Essentials of Assistive Technologies. Mosby, 2007.
- Cook A. M., Polgar J. M. Cook and Hussey's Assistive Technologies: Principles and Practice, 3rd Edition. Mosby, 2008.

D. Skills and Competencies

After taking these subjects, graduates should have acquired these skills and competencies:

1) Ability to apply Design for All in the development of new ICTs.
2) Ability to introduce Universal Accessibility in existing ICT devices and systems.
3) Ability to recognize the requirements Assistive Technology poses for Design for All in ICT.
4) Ability to apply mandatory rules on accessibility.

VI. Implementation of the Proposal

Taking advantage of the renewal of Spanish university degrees in order to adapt them to the European Higher Education Area agreed in Bologna, the Spanish University Quality Assessment Agency included within its verification protocols criteria and guidelines to ensure that professional activities are conducted with respect and fostering the promotion of human rights and the principles of universal accessibility and Design for All, therefore requesting the inclusion in the curricula of appropriate content related to those rights and principles was required.

On June 8, 2009 the Spanish General Secretariat of Universities agreed a resolution that established recommendations to the universities for the proposal of official grades in the Computer Engineering, Computer Engineering and Chemical Engineering fields [14]. Section 3, containing the "Objectives" for the Informatics Engineering, mentions among the skills that students should acquire: "3. Ability to design, develop, evaluate and ensure the accessibility, ergonomics, usability and security of the systems, services and applications and the information they manage". Similar recommendations appear in the description of the skills to be acquired in the 48-ETCS-module Specific software engineering technology: "Ability to design and evaluate human-computer interfaces that guarantee accessibility and usability of the systems, services and applications". In addition, the Degree Projects of the Information Technology specialization have to provide: "Ability to use user-centric methodologies and development organization, assessment and management based applications and information technology to ensure the accessibility, ergonomics and usability of the systems". These paragraphs are of extraordinary importance because all universities have to include topics that lead to these objectives. Therefore accessibility is mentioned in all the new Informatics Engineering Degrees, even if the implementations of these studies are extremely diverse.

As a result, several Spanish Universities included Design for All and Universal Accessibility in their engineering curricula, following differing approaches and with different levels of thoroughness. Among the diverse implementation of these recommendations, the one made by Universidad Carlos III de Madrid stands out. The general objectives of the degree include "The respect and promotion of human rights and the principles of universal accessibility and design for all (as required by Law 51/2003 of December 2, on equal opportunities, non-discrimination and universal accessibility for people with disability)". In addition, the specialization on Information Systems offers a 6-ECTS optional topic entitled "Accessibility and design for all software engineering" [15].

In the case of the University of the Basque Country (UPV/EHU) an optional 6-ECTS subject called "Intelligent and Accessible Interfaces" is taught in the fourth year of the degree. It covers topics oriented to natural interaction between humans and computing systems, which includes Design for All and multimodality, based on the diverse human communication modalities. As an example, Augmentative and Alternative Communication is used to design interfaces for people with oral communication restrictions.

On the other hand, a 60-ECTS Master degree on Assistive Technology for Independent Living provides specialization in accessibility issues. This degree proposes a multidisciplinary approach towards the design and maintenance of technology to achieving higher independent living for people with special needs.

VII. Challenges in Adopting Design for All in Engineering Curricula

From discussions in various workshops and seminars, we found two main barriers to the adoption of Design for All methodologies in engineering degrees.

A. Lack of awareness

Several university policy makers ignore the basic concepts of Universal Design or have a stereotypical opinion about it. They consider it fashion issue and reject modifying the traditional structure of the design topics to take into account specific population minorities. Fortunately, this kind of clichés is less and less frequent, but it is not easy to intervene when university policy makers are not in favour of including Universal Design at all. When strong arguments are required, Petrie and Edwards (2006) provide "a number of arguments, some radical, some more conventional, for including Inclusive Design and Assistive Technology as part of mainstream HCI courses" [16].

B. Lack of teaching materials

Numerous people that might be inclined to include Design for All in their design topics cannot find materials, practices and examples ready to use in their lectures and have to create all the teaching materials themselves. Even if initiatives such as WAI/W3C, IDCnet, and ARIADNE provide useful material for the teaching of design for all, it is still insufficient for many specific topics. The way to collect, evaluate, select and share conveniently supported materials, and to give adequate formation to lecturers, throws down a challenge to the dissemination of Design for All teaching. International collaboration might lead to the availability of more and better teaching materials.

VIII. Conclusions

In this paper, we presented a curriculum proposal to include Design for All in the engineering studies related to computing and telecommunications in Spain. As a result, and due to the opportunity created by the need to update the degrees for the European Higher Education Area, numerous Spanish universities included Design for All modules in their engineering curricula.

In the process of carrying this out we have also been able to analyze the main difficulties facing the adoption of Design for All principles in engineering degrees: lack of awareness by the university policy makers and lack of teaching materials to help the lecturers to prepare their courses. For the latter, mechanisms to share quality teaching materials are proposed.

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References

[1] Abascal. J. Human-Computer Interaction in Assistive Technology: From "Patchwork" to "Universal Design". IEEE Int. Conf. on Systems, Man and Cybernetics, 2002, Vol. 3. DOI: 10.1109/ICSMC.2002.1176076:

[2] IDCnet: Inclusive Design Curriculum Network. http://www.idcnet.info

[3] ARIADNE. EDeAN Design for All virtual Resource Center. http://www.edean.org

[4] Design for All Education and Training http://www.education.edean.org

[5] ACM/IEEE. Curriculum Guidelines for Undergraduate Degree Programs in Information Systems. Computer Science Curricula 2013. Curriculum Guidelines for Undergraduate Degree Programs in Computer Science. December 20, 2013.The Joint Task Force on Computing Curricula Association for Computing Machinery (ACM) IEEE Computer Society.

[6] Keates S. A pedagogical example of teaching Universal Access. Universal Access in the Information Society 14(1), 2015., pp 97-110.Kramer H., Wahlbin K. Universal Design for Digital Media. 2013. http://accessinghigherground.org/udclass/

[7] Kramer H. Integrating Universal design into University Curriculum. 2014. http://www.slideshare.net/hkramer99/universal-design-content-in-curriculum-atia-2014

[8] Kramer H., Wahlbin K. Universal Design for Digital Media. 2013. http://accessinghigherground.org/udclass/

[9] Burgstahler S. Universal design: Implications for computing education. ACM Trans. Comput. Educ. 11(3), 2011. Article 19. http://doi.acm.org/10.1145/2037276.2037283

[10] Chambel T., Antunes P., Duarte C., Carriço L., Guimarães N. Reflections on Teaching Human-Computer Interaction to Blind Students. In Kotzè P. et al (eds.) Creativity and HCI: From experience to design in Education. Springer, 2009. Pp.: 123-142.

[11] CDTPE. White Book on Design for All in the University. 2006. http://media.designforall.org/publico/index.php?opc=articulo&article=1299&idioma_article=en. Coordinadora del Diseño para Todas las Personas en España.

[12] European Qualifications Framework for Lifelong Learning (EQF) http://ec.europa.eu/eqf

[13] European Credit system for Vocational Education and Training (ECVET) http://www.ecvet-team.eu

[14] BOE 4 de agosto de 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. http://www.boe.es/boe/dias/2009/08/04/pdfs/BOE-A-2009-12977.pdf

[15] UC3M: Grado en Ingeniería Informática. Accesibilidad y diseño para todos en ingeniería del software (218 - 15994) http://www3.uc3m.es/reina/Fichas/Idioma_1/218.15994.html

[16] Petrie H., Edwards A. Inclusive design and assistive technology as part of the HCI curriculum Procs. of {HCI} Educators Workshop, 2006.