

Integrating Universal Design and Accessibility into Computer Science Curricula – A Review of Literature and Practices in Europe

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Abstract. The absence of accessibility in many ICT systems and products indicates insufficient accessibility competence among designers, developers and project managers. Higher education institutions play an important role in raising awareness and competence and in preparing universal design and digital accessibility specialists. Although many universities are teaching accessibility as part of the biomedical, special education and disability studies programmes, few provide accessibility education in technical specialisations such as computer science. By combining literature review and manual search and inspection we aim at investigating the state of the art in integrating universal design and digital accessibility into the curricula of computer sciences-related programmes.

Keywords. Universal design, accessibility, computer science, curricula

1. Introduction

The demand for digital accessibility has increased continuously over the last two decades. In the U.S., section 508 of the Rehabilitation Act requires that information and communication technologies (ICT) developed, procured, maintained or used by federal agencies be accessible. These include computers, telecommunications equipment, multifunction office machines (e.g. copiers that also function as printers), software, websites, information kiosks and transaction machines and electronic documents. The European Web and Mobile Accessibility Directive [1] requires that *accessibility* be understood as the principles and techniques observed while designing, constructing, maintaining and updating websites and mobile applications to make them more accessible to users, particularly to persons with disabilities.

The absence of accessibility in many ICT systems and products indicates a low accessibility competence among designers, developers and project managers. Although certification in digital accessibility has gained attention in the past few years, there are still insufficient numbers of accessibility specialists who can meet the increasing demand from the job market.

The design and development of accessible ICT products both require certain skill sets and a deep understanding of the subject [2]. Many researchers have highlighted the

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responsibility of higher education institutions to prepare the specialists in the digital accessibility area [2-8]. For example, Keates [2] stated that “education plays an important role in helping designers acquire the knowledge and skills necessary to find the relevant information about the users and then apply it to produce a genuinely inclusive design”.

Although many universities are teaching accessibility as part of the biomedical, special education and disability studies programmes, few provide accessibility education in technical specialisations such as computer science (CS) [3]. In 2005 Cohen et al. [5] found only few CS programmes that integrated software accessibility into the curricula. Ten years later, Keates [2] concluded that it was still rare to find accessibility concepts taught within the programmes/courses related to computer science: “Often they are taught within modules such as Interaction Design, if at all, and usually only make up a few hours of the teaching material being delivered.” Several other researchers have also emphasised the importance of integrating accessibility knowledge and skills into the curricula of CS-related programmes [3, 4].

Our goal is to investigate the state of the art in integrating universal design (UD) and digital accessibility into the curricula of CS-related programmes. Through this project, we hope to collect best practices and give input to policy makers, faculty members and course designers in universities on how to best integrate universal design and digital accessibility principles into CS curricula.

2. Methods

To collect state of the art in integrating UD and digital accessibility into CS curricula, we have combined a literature review and research network with a manual search and an inspection of degree programmes.

2.1. Literature review

The literature search was conducted by using the search engine Oria and the ACM Digital Library. A range of keywords was used in different combinations, including: *digital accessibility*, *accessibility*, *universal design*, *inclusive*, *design for all*, *course*, *university*, *curricula*, *curriculum* and *computer science*. The search included publications from 2003 to 2018. All the publications were reviewed and categorised. Papers that were not directly related to the integration of UD and digital accessibility into CS-related curricula were excluded. For example, there were several publications that investigated UD and digital accessibility education from different perspectives. Some studies focussed on making higher education more accessible for diverse students [9-11]. They investigated the current state of higher education accessibility, including the accessibility of campuses, universities' websites and different kinds of online education. Some studies also investigated the accessibility of universities' courses and provided guidelines and examples for making courses' curriculum more accessible. Publications that described the practices of including accessibility and UD concepts into CS-related courses and curricula were selected for qualitative synthesis. The screening process is presented as a PRISMA diagram in Figure 1.

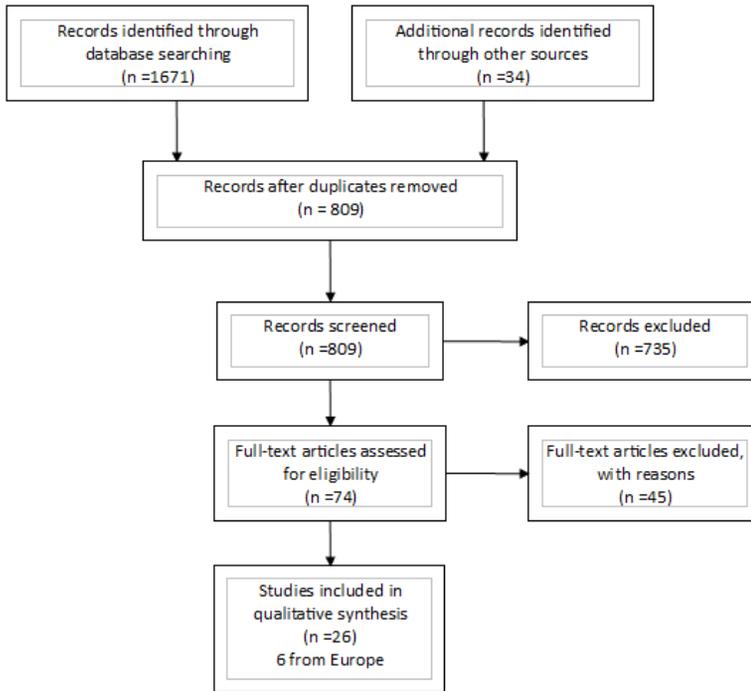


Figure 1. Process of the literature review.

2.2. Manual search and inspection of degree programmes

In this step, we took advantage of the International Association of Universities' unique online reference tool that provides comprehensive and detailed information on Higher Education Systems and Credentials (in 186 countries) and Institutions (more than 18500) around the world. After careful consideration, we decided to start with universities in Norway.

We manually searched the websites of all universities and inspected their CS-related programmes, courses or modules and identified those that included accessibility and/or UD content in their curricula. The search was conducted in the bachelors' and masters' courses using keywords such as *accessibility*, *universal design*, *inclusive design*, *design for all* and *Web Content Accessibility Guidelines (WCAG)*, both in English and in Norwegian. Only the courses related to CS and ICT programmes were included, although we also found courses related to product design, medicine, welfare, special education and architecture that included universal design and accessibility.

3. Results

In this section, we present the findings from the literature review and manual search and inspection.

3.1. Findings from the literature review

The data analysis of the literature review showed that most of the publications that described the practices of integrating accessibility into CS courses' curricula were from universities in the USA and Canada (20 out of 26). Only six publications were from EU universities, and their courses and programmes are described in Table 1.

The results showed that UD and accessibility are mostly integrated into other courses (e.g. computing, human-computer interaction, Web programming) rather than being fully dedicated courses (for example, a Digital Accessibility course). Most of the courses included basic UD principles [2, 8, 12, 13], and one focussed on Web accessibility [14]. Also, in one of the courses, the instructors included people with disabilities into the teaching process [15].

3.2. Findings through research networks

Through professional research networks, especially the Erasmus+ project Massive Open Online Courses (MOOCs) for Accessibility Partnership², we had previously collected courses and programmes related to CS that integrated UD and accessibility. During the research, all the data were reviewed to find detailed information about the courses and programmes. They are presented in Tables 2 and 3.

Table 2 shows the collection of individual courses that are fully dedicated to UD and/or accessibility, for example, the “Accessible Design in ICT” course at Stuttgart Media University and “Designing Usable and Accessible Technologies” from the University of Southampton. Only a few universities had full programmes dedicated to UD and digital accessibility (see Table 3).

3.3. Online courses

Online courses are becoming an increasingly important source for knowledge and education. We searched for courses related to UD of ICT and digital accessibility on some popular MOOC platforms such as Udacity, edX, Udemy, Coursera and Future Learn. The results are presented in Table 4.

3.4. Courses in Norwegian universities

The search among Norwegian universities revealed only a few courses or programmes that were fully dedicated to UD or digital accessibility, such as the master's programme “Universal design of ICT” at Oslo Metropolitan University. There were, however, several CS-related courses that integrated UD and accessibility into their curricula. Some of them covered only particular topics, for example, testing or legislation, and some covered general concepts, such as UD principles, Web accessibility guidelines, diversity, usability and so on. The courses and programmes are presented in Table 5.

² <https://moocap.gpii.eu/>

Table 1. Courses/programmes found through the literature review

	Course/Programme	Department	Topics covered	University	Country	Article	Notes
	Usability and Accessibility (later: Usability and User Experience—Methods and Communication)	Computer Science	Graduado en Ingeniería Informática /seminars	Master's in Software and Systems, module: Challenges of Accessible Computing for People with Functional Diversity	Computing Courses	Human-Centred Interactive Technologies	Localisation and Project Management course
	MSc degree within the Design and Digital Communication (DDK) programme	Dept. of Computer Science	Computer Science School	Computer Science School	School of Computing	Dept. of Computer Science	IM/FTI
	Principles of designing for Universal Access by practice	Including people with disabilities in the learning process	Content related to accessibility and Design for All, requested by the Spanish legislation	Basic concepts of ICT accessibility, functional diversity, Design for All legislation, technical standards and ICT product and service accessibility conformance assessment	Diversity and inclusivity, foundation in accessibility, guidelines	Diversity, disability, understanding disabled users, aging, disability-related legislation, principles of universal design and universal access, assistive technologies	Web accessibility + WCAG 2.0
	IT Univ. of Copenhagen	Univ. Politehnica of Bucharest	Technical Univ. of Madrid	Technical Univ. of Madrid	Univ. of Dundee	University of York	Univ. of Geneva & Univ. Salamanca
	Denmark	Romania	Spain	Spain	UK	UK	Switzerland & Spain
	Keates (2015)	Rughinis & Rughinis (2014)	Fuertes, González & Martínez (2012)	Fuertes, González & Martínez (2012)	Waller, Hanson & Sloan (2009)	Petrie & Edwards (2006)	Vázquez (2014)
		Interaction sandbox	The paper describes the experiences since 1995	The paper describes the experiences since 1995	Accessibility content integrated into several computing courses as an integral part of design and development		Seminars for localisation students

Table 2. Courses found through research network

Country (city)	Republic of Ireland (Dublin)	Germany (Dresden)	Austria (Linz)	Germany (Stuttgart)	England (Southampton)	Greece (Mytilene)	Greece (Mytilene)
University	Dublin Institute of Technology (DIT)	Technical University in Dresden (TUD)	Johannes Kepler University Linz	The Stuttgart Media University	University of Southampton	University of the Aegean	University of the Aegean
Programme	Master of Science and Computing	Informatik/ Informations systemtechnik/ Medieninformatik	Master's program in Computer Science	Master's program in Computer Science and Media	MSc Computer Science, MSc Web Technology, MSc Software Engineering	MSc Design of Interactive and Industrial Products and Systems	Product and Systems Design Engineering
Course	Universal Design (module)	Barrierefreie Dokumente (Accessible documents)	Assistive Technologies and Accessibility	Accessible Design in ICT	Designing Usable and Accessible Technologies	Ergonomics and Design for All	Design for All
Topics covered	Principles of designing for Universal Access by practice	Including people with disabilities into learning process	Content related to accessibility and Design for All, requested by the Spanish legislation	Basic concepts of ICT accessibility, functional diversity, Design for All legislation, technical standards and ICT product and service accessibility conformance assessment	Diversity and inclusivity, foundation in accessibility, guidelines	Diversity, disability, understanding disabled users, aging, disability-related legislation, principles of universal design and universal access, assistive technologies	Web accessibility + WCAG 2.0
Language	English	German	English	German and English	English	Greek (English if necessary)	Greek

Table 3. Programmes found through research network

Country (city)	United Kingdom (York)	France (Paris)	Norway (Oslo)
University	University of York	Université Paris 8-Vincennes-Saint-Denis (UP8)	Oslo Metropolitan University (OsloMet) prev. Oslo and Akershus University College of Applied Sciences (HiOA)
Department	Department of Computer Science	Domaine: Sciences, technologies, santé, Mention: Mathématiques et Informatique Appliquées aux Sciences. Humaines et Sociales ngénierie, Cognition, Handicap (ICH)	Faculty of Technology, Art and Design; Department of Computer Science
Programme	Human-Centred Interactive Technologies	Géomatique, applications et accessibilité, Technologie et handicap (HANDI)	Universal Design of ICT
Language	English	French	English

Table 4. Massive open online courses (MOOCs)

Platform	Udacity	edX	Udemy	Udemy	Future Learn
Developed by	Google	Microsoft	U1 Group	Peachpit Press	University of Southampton; MOOCAP
Course	Web Accessibility	Web Design Best Practices: An Inclusive Approach	Web Accessibility: Learn Best Practices, Tools & Techniques	Designing Web Accessibility for a Beautiful Web	Digital Accessibility: Enabling Participation in the Information Society
Cost	Free	Free, add a Verified Certificate for 99 USD	Full price 2110 NOK	Full price 610 NOK	Free
Timeline	Approx. 2 weeks	5 weeks (3–4 hours per week)	2.5 hours on-demand video	2 hours on-demand video	5 weeks (3 hours per week)

Table 5. Courses and programmes found in Norwegian Universities

University	Course/programme	Topics covered	Level of study	Language
Norwegian University of Science and Technology	Mobile Media and Social Interaction	Accessibility and universal design in a mobile context, fundamentals of UI-design on a small screen	Intermediate course	English
	Web Technologies	Web accessibility	Foundation courses	Norwegian
	Usability and Human Factors in Interaction Design	Core concepts in usability, usability heuristics, Web Content Accessibility Guidelines (WCAG 2.0) and accessible web	Second-degree level	English

	Web Design	Universal design principles	Third-year course	Norwegian
	IT, Environment and Society	Universal design principles	Third-year course	Norwegian
Oslo Metropolitan University (OsloMet) /prev. Oslo and Akershus University College of Applied Sciences	Universal Design of ICT	National and international legislation and guidelines related to universal design of ICT; universally designed documents; evaluation and development of universally designed in user interfaces, web pages and web applications	5th semester	Norwegian and / or English
	Web Programming	Development of dynamic web pages using PHP and JavaScript by keeping user-friendliness and high-level accessibility	Bachelor's	Norwegian and / or English
	Universal Design of Interactive Systems	Technologies and techniques relevant to universal design, research within universal design, evaluating the prototypes using various forms of user testing with diverse users	Master's (3rd semester)	English
	Interaction Styles and Technologies for Accessibility	Knowledge of interaction technology to address new problems in universal design of ICT; analysing issues related to accessibility in public spaces, mobility problems and the user's affective state; multimodal user interfaces; multimodal user interfaces	Master's (2nd semester)	English
	User Diversity and ICT Barriers	Diversity among users, equipment and user situations; demography and age structure of society, trends and tendencies and their implications for universal design of ICT; sensory, motor and cognitive disabilities; concept of disability and the Gap model; disabling barriers in ICT solutions	Master's (1st semester)	English
University of Bergen	Web Design	Usability and user testing (how to make the use efficient and effective), accessibility (how to cater to e.g. blind users), responsivity (how to design a website so that it can be flexibly viewed on different devices)	Bachelor's	English
University of Oslo	Software Testing	Usability testing, accessibility testing	Master's	Norwegian Group work is in English. Students who don't speak Norwegian can join a group that has a teacher who speaks English.

	Systems, Requirements and Consequences	Core laws and regulations for the development of digital systems, including universal design, privacy and user involvement	Bachelor	Norwegian
	Administrative Informatics	Digital divisions, universal design of ICT, etc.	Master's	Norwegian
	Information Architecture and Content Management	Concepts, tools and standards commonly used in the areas of information architecture and universal accessibility	Master's	Norwegian

4. Discussion and related research

Previous research has focussed on teaching accessibility and UD and has provided guidelines on how to integrate these topics into CS-related curricula [5, 16]. For example, Nicolle et al. [17] provided a list of 10 recommendations developed by the Inclusive Design Curriculum Network (IDCnet) project of accessibility and UD integration and promotion. Lewthwaite and Sloan [7] investigated the pedagogical aspects and challenges of teaching accessibility in CS-related programmes.

Some publications described the practical experiences of integrating UD and accessibility into CS-related courses. For example, Cohen et al. [5] described the integration of software accessibility into CS courses based on Java programming language. The paper provided some simple guidelines on teaching accessibility with descriptions of programming projects. Freire et al. [18] presented an approach for Web accessibility education based on short introductory courses with the use of screen readers during the classes. Rosmaita [19] described the concept of teaching accessibility at the beginning of students' educations in universities to better promote accessibility principles and affect more students.

Very few similar studies have been conducted to investigate the state of the art in integrating UD and digital accessibility into CS-related curricula. Keith, Whitney and Petz [20] collected data on accessibility teaching in EU through the European Design for All eAccessibility Network (EdeAN), which represented 23 countries within Europe. They gathered information through emails and found 50 courses that had some content related to Design for All. They did not provide the data on the courses they found, but they presented an analysis of teaching accessibility best practices in their paper. Keates [2] investigated existing courses that had integrated universal access into their curricula by randomly choosing 20 universities from the Guardian Subject League Tables 2014 and looked for topics related to accessibility and UD. He concluded that there were still too few CS-related courses that include UD or accessibility content. Most recently, Putnam et al. [21] gathered information on CS-related courses that have integrated accessibility and UD into their curricula in US universities.

5. Conclusion and future work

In this paper, we have investigated the state of the art in integrating UD and accessibility principles and concepts into CS-related curricula. By combining literature

review and manual search and inspection, we have found that there is a limited but increasing effort in this area.

This study only included universities, not institutions such as university colleges of applied sciences and institutes of technology. In our literature review, we used *computer science* as a keyword, and during the manual search and inspection, we looked at programmes and courses in departments of computer science, computer engineering, informatics, information science, information technology, information systems, software engineering and information and communication technology. We also included courses and programmes in other departments, such as design and communication, when they were related to digital technology and development.

We experienced challenges while searching through the universities' websites. In the beginning, we tried to use a Web crawler to look for CS courses and programmes in universities. However, the websites have different structures and categories, which made the searching process difficult and less effective. Language also posed a big challenge for our research. Even though most of the European universities have English versions of their websites, the information on the English versions is often much more limited than the original websites. Some of the courses have descriptions only in the original language of the website. We also tried to use email to contact different universities to ask them to point us to the related courses and programmes. However, this effort did not give us any useful results. Most of the emails did not receive responses.

Despite these challenges, we managed to gather some literature and practices in integrating UD and accessibility into CS-related courses and programmes. During our research, we also found that some CS departments have project work, summer courses and master thesis topics related to UD and accessibility. These data could be investigated in future work. In addition, we plan to look further into web crawlers and find a more efficient approach for searching and gathering information through university websites. Another research direction is to conduct in-depth interviews with faculty members in CS-related courses who have already integrated UD and accessibility into their teaching.

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