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ORIGINAL ARTICLE

Learning technologies for people with disabilities

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Abstract Nowadays learning technologies transformed educational systems with impressive progress of Information and Communication Technologies (ICT). Furthermore, when these technologies are available, affordable and accessible, they represent more than a transformation for people with disabilities. They represent real opportunities with access to an inclusive education and help to overcome the obstacles they met in classical educational systems. In this paper, we will cover basic concepts of e-accessibility, universal design and assistive technologies, with a special focus on accessible e-learning systems. Then, we will present recent research works conducted in our research Laboratory LaTICE toward the development of an accessible online learning environment for persons with disabilities from the design and specification step to the implementation. We will present, in particular, the accessible version "Moodle^{Acc+}" of the well known e-learning platform Moodle as well as new elaborated generic models and a range of tools for authoring and evaluating accessible educational content.

1. Introduction

The world report on disability affirms that over one billion people in the world live with some disabilities and there are about 150 million school-aged children with disabilities. Many of these children are excluded from educational opportunities and do not complete primary education. At the same line, recent UNESCO Global report (UNESCO Global Report, 2013) indicates that people with disabilities face a wide range of barriers, including access to information, education and a lack of job opportunities. However Information and Communication Technologies (ICT) can be a powerful tool in supporting education and inclusion for persons with disabilities. Technological development can enable people with disabilities to improve their quality of life (Arrigo, 2005). The successful application of such technologies can make classrooms more inclusive, physical environments more accessible, teaching and learning content and techniques more in tune with learners' needs (UNESCO Global Report, 2013).

In fact, the continuous progress of ICT raised the need to move toward improving the learning quality applied in education and training systems by addressing new perspectives and opportunities. e-Learning emerges as the answer to fulfill that need (Ben Brahim et al., 2013) and vouches to attend the

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learning needs of the students in a personalized and inclusive way. Actually, there is no shortage of optimism about the potential of e-Learning to reduce barriers to education and improve the lives of individuals with disabilities (Klomp, 2004). Therefore, developing accessible online educational environments appears as a principal solution to address this issue and to remove the barriers that people with disabilities may meet when they access these learning technologies. An appropriate technology has to provide people with disabilities with adaptive and personalized learning experiences that are tailored to their particular educational needs and personal characteristics. It should also improve their satisfaction, learning speed and learning effectiveness.

In this paper, we propose a conceptual abstract view of an accessible learning environment and we describe a new process allowing the translation of a conceptual model into a specific code adapted to the user's individual learning context. The translation process corresponds to a personalization process which supports people with disabilities learning by accommodating and adapting the learning process to their needs.

In this context, many researchers developed specific tools dealing with specific needs for people with disabilities (Seale and Cooper, 2010; Jemni and Elghoul, 2007; Elghoul and Jemni 2009). However, these tools do not allow the user to adapt the contents to other needs. In fact, when we want to update, we have to modify existing codes. The new codes can be validated only by tests which make it difficult to guarantee the soundness of the result and the preservation of previous properties. For these reasons, we should consider accessibility from an early stage of the systems lifecycle by giving generic models which could be considered as a reference for the following steps of development. By this way, any tool is an instance of such a model and any modification could give an updated content generated by this generic model as a new instance which refines the previous one.

This paper starts by introducing the scope of our work. Section 2 reviews the state of the art related to accessible e-Learning with a special focus on e-accessibility and its related initiatives. Then, in Section 3, we describe our approach covering the different steps carried out to build an accessible e-Learning environment starting from the abstract model and reaching the code generation and evaluation phase. We will also underline the particularity of the accessibility evaluation process we conducted within the e-Learning environment. This section ends through presenting our accessible e-Learning environment Moodle^{Acc+}. The paper is concluded in Section 4.

2. Background

In this section we give an overview of the need of accessibility for people with disabilities. We focus on web accessibility and assistive technologies which offer new designs and tools satisfying the requirements of people with disabilities. Then we present basic concepts of accessible e-learning and its state of the art.

2.1. e-Accessibility

2.1.1. People with disabilities

Disabilities can be grouped according to the type of impairment; generally there are four groups (Kavcic, 2005):

- Mobility impairments (restricted movement or control of arms, hands and fingers): refer to physical disabilities that affect the ability to move, to manipulate objects, and to interact with the physical world
- Visual impairments (blindness, partial sight and color blindness): include the range from low vision to full blindness, where the user cannot use the visual display at all. Although people with visual impairments have the greatest problem with information displayed on the screen (especially graphics and pictorial information), the use of a pointing device, which requires eye-hand coordination (such a mouse), may also pose an issue for them.
- Hearing impairments (deafness and hearing loss): have difficulties detecting sounds or distinguishing auditory information from the background noise. Deaf individuals cannot receive any auditory information at all. Many of them communicate through the Sign Language that differs significantly from the spoken language. Cognitive impairments (including cognitive, language and learning disabilities like attention deficit disorder, dyslexia, dementia, etc.): there are a wide range of cognitive impairments, including impairments of thinking, memory, language, learning and perception.

2.1.2. Assistive technologies

Assistive or enabling technology includes devices, tools, hardware, or software, which enable, partially, people with disabilities to use the computer. It presents an alternative way to access the content on screen, command the computer or process data. Specific adjustment software or devices for manipulating the computer include (Arrigo, 2005).

- Screen reading software (speaks displayed text and allows simulating mouse actions with the keyboard),
- Screen magnification software (for enlarging the content of the screen),
- Braille display (for displaying Braille characters),
- Alternate input devices (e. g. Screen keyboard) and special keyboard (to make data entry easier),
- Keyboard enhancements and accelerators (like StickKeys, Mousekeys, repeatKeys, SlowKeys, BounceKeys, or ToggleKeys), mnemonics and shortcut keys,
- Alternative pointing devices (e. g. Foot operated mice, head mounted pointing device, or eye tracking systems),

These aiding technologies can be either devices or equipments (hardware) e.g. Braille, or software applications e.g. screen reading software. However, these technologies do not seem sufficient for providing full support to people with disabilities. Web content providers should also participate in the inclusion process by making arrangements that allow particularities of people with disabilities to be taken into account when creating web content. Several efforts were conducted toward addressing this issue.

2.1.3. The Web Accessibility Initiative (WAI)

Being conscious of the constraints witnessed by people with disabilities in everyday life especially with web based applications, the W3C carried out a key solution promoting people with disabilities in accessing, using and interacting with the web through the Web Accessibility Initiative (WAI).