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Giuseppe Di Bucchianico
Pete Kercher *Editors*

Advances in Design for Inclusion

Proceedings of the AHFE 2016 International Conference on Design for Inclusion, July 27–31, 2016, Walt Disney World®, Florida, USA

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Janusz Kacprzyk, Polish Academy of Sciences, Warsaw, Poland
e-mail: kacprzyk@ibspan.waw.pl

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Editors
Giuseppe Di Bucchianico
University of Chieti-Pescara
Chieti, Pescara
Italy

Pete Kercher
EIDD—Design for All Europe
Oliveto Lario, Lecco
Italy

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Proceedings of the AHFE 2016 International Conference on Design for Inclusion, July 27–31, 2016, Walt Disney World®, Florida, USA

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Improving Learning Technologies and Social Inclusion Through Human Centred Design and Universal Design Approaches: Novel Designing Scenarios

Alessia Brischetto and Francesca Tosi

Abstract In contemporary society, technology is increasingly the main tool for producing and promoting information and well-being. With special regards to the framework of ICT for learning, assistive and adaptive technologies as well as e-learning and m-learning platforms, are usually employed to provide equal access to knowledge regardless of any impairment or disabilities. However, due to several limitations of technology, people can be socially excluded. In the present work, to deeply understand such limitation, the most relevant learning theories in the creation of instructional environments were investigated. On the basis of this preliminary research, the work was aimed at analyzing the inclusive potential of current ICT and related standards of web accessibility, platforms and content format in order to assess what may be the contribution of Ergonomics for design and Universal Design for improving learning environments and social inclusion for the widest number of person.

Keywords Universal design · Human centered design · ICT · Social inclusion · Web accessibility · Learning

1 Introduction

Within a based-knowledge society, personal devices, social networks and most widely, all the emerging web technologies may be increasingly considered as the main tools for producing and promoting information and well-being. Consequently, the accessibility to technologies becomes the basic requirement in the way of living, working and sharing experiences. To date, the Information and Communication

A. Brischetto (✉) · F. Tosi
Department of Architecture, Laboratory of Ergonomics and Design,
Via Sandro Pertini 93, 50041 Calenzano, Firenze, Italy
e-mail: alessia.brischetto@unifi.it

F. Tosi
e-mail: francesca.tosi@unifi.it

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Technology (ICT), commonly in use every day in routine activities, play a primary role in improving and speeding up the above described processes, since they are seen suitable and powerful means able to enhance also the residual skills of the weakest people, especially elderly and most in general, all the disabled carriers [1].

Within the framework of ICT for learning, the assistive and adaptive technologies, which include a broad range of devices (hardware, furniture, computer screens, software and so on), are usually employed to enable anyone to interact with more easily and effectively, regardless of any impairment or disabilities. Similarly, e-learning and m-learning platforms, born as electronic educational technologies, are largely used nowadays as networking environments to promote the integration and guide learning through flexible architectures based on current standards of web accessibility, platforms and content format [2]. However, due to several limitations, mainly ascribed to the lacking of accessibility, people with different types of impairments may not have easy access to information and hence, very often, are socially excluded.

At the same time, it is worth to note that the free market laws are mostly oriented towards groups of users considered "normal," thus excluding all those persons who have special needs and that hardly manage the technology. Facing with the development of so-called "digital highways," it should be avoided also that the continuous spread of technologies is dictated by methods purely economics, not only for reasons of social equity but also to avoid of having high social and economic costs to sustain. It is therefore clear the need to implement specific politics based on a strong sense of social responsibility and targeted mainly to enable people with disabilities to live independently in all aspects of life [3]. In this respect, for instance, the European Community policies, through the i2020 initiative related to the Lisbon Strategy, are actively engaged towards the creation of a unique information space. In particular, with the aim of building up an inclusive information-based society (e-inclusion, e-accessibility, European Action Plan, the diffusion of ICT policies), several funds in research and development of the ICT's sector have been planned [4–6].

Besides, the UN convention on the Rights of Persons with Disabilities, whose the main purpose is to promote, defend and reinforce the human rights of all persons with disabilities, highlights the importance of sustaining the research and development in this field through dedicated projects including the Universal design (UD). The latter is clearly defined as the design of products, environments, programs and services to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design. Additionally, UD shall not exclude assistive devices for particular groups of persons with disabilities where this is needed and underlines the importance of adopting a human-centered design approach in this field [7]. Thus, UD becomes an indispensable element by which, in a systematic and proactive way, can be provided accessible solutions to all persons in a perspective, therefore, inclusive.

In this scenario, the present work is mainly aimed at analyzing the inclusive potential of current ICT and assessing what may be the contribution of Ergonomics for design and UD in improving learning environments and social inclusion for the widest number of persons.

2 Methodological Approach

On the basis of the abovementioned framework, the work was focused in the first stage to examining the accessibility features that ICTs have in contemporary society. This was carried out by analyzing the major European strategies and Italian national policies[1] aimed at the development and integration of inclusive learning practices. To get a complete picture of European policies, reference to the Eurydice database was done [8]. In the mentioned database recommendations regarding the use of ICT for promoting equity in educational environments are described.

For understanding the psychological and cognitive aspects involved in human-machine interaction and related learning practices mediated by technologies, *behaviorism, cognitivism and constructivism* theories along with their respective learning models (i.e. transmission model, learner-centered model, participatory model) were explored and analyzed. The latter were developed during the evolution of the so-called "learning machines" and belong nowadays to Educational Technology field. These principles, even if theorized in the second mid of 20th century, are the focus of the international debate and still used for designing the most advanced technological solutions. In particular, these three models, moving the main focus from teaching to learning, allowed to develop new educational models and learning practices. The most recent theory of *connectivism* was also taken into account [9].

On the basis of such models, the types of technologies developed until now in the field of interest, including application examples, were also analyzed. Aspects related to the effectiveness and inclusive potential of these technologies were subsequently investigated for assessing the contribution of a combined approach between UD and Universal Design for Learning (UDL) and how and when assistive technologies (AT) should be used. At the same time, the existing web accessibility standards (WCAG) and standards ISO[2] were analyzed and possible integrations with UD-UDL approach evaluated.

[1]The main projects and initiative promoted are the EU "*Action Plan e-Learning*" and Scuola Digitale—*Cl@ssi 2.0*, *Nuove Tecnologie e Disabilità* (NTD) on Italian scale.

[2]ISO 9241-171:2008 provides ergonomics guidance and specifications for the design of accessible software for use at work, in the home, in education and in public places. It covers issues associated with designing accessible software for people with the widest range of physical, sensory and cognitive abilities, including those who are temporarily disabled, and the elderly. It addresses software considerations for accessibility that complement general design for usability (see also ISO 9241-110, ISO 9241-11 to ISO 9241-17, ISO 14915 and ISO 13407). Regarding AT: ISO/IEC TR 13066-3:2012 Information technology—Interoperability with assistive technology (AT)—Part 3: accessibility application programming interface (API).

3 Results and Discussion

3.1 ICT and Web Accessibility Standards

To define the factors that can promote social inclusion through the use of ICT, it is strictly necessary to overcome both the vision of computer as a set of hardware and software and the information technologies for the disabled as functional prostheses to allow its use [10]. The access to ICT is the result of the combination of a plurality of aspects not only physical, but also social and relational. With respect to the problems of persons with disabilities, it is possible to identify four different simplified visions of the computer science, which correspond to different ways of thinking about new technologies. They are summarized in the following as follows [7].

- calculator as a physical machine—the hardware;
- calculator as a virtual machine—the software;
- calculator as an information dissemination system—the Web;
- calculator as a two-way communication—Web 2.0.

The first 2 points include AT such as keyboards, braille printers, screen readers, screen magnifiers, special devices (pointers, expanded or reduced keyboards etc.), speech synthesis programs and speech recognition. They are therefore means allowing access to the computer merely as a tool. On the contrary, in step 3, all those systems useful for the dissemination of accessible information, as web sites, are included. The latter have become the main resource to access information and the network can enable disability carriers to break down the mobility constraints, allowing them to use the services not only through the physical way, but also through the virtual one. Web 2.0, associated to point 4, is the new frontier of communication exchanges in the network. Web 2.0 comprises the services based on directional communication "one to many" and provides the fruition and sharing of information through circular interaction between users and platforms, and among user groups [11].

In parallel to the evolution of software and hardware components, and more generally of ICT, grew up gradually issues concerning the use of such technologies, mainly related to accessibility of the information content, to interaction with system, as well as to access interfaces, systems and services for communication between people [12].

As regards the information content, guidelines for how the Web pages of information presentation to be built, were developed by the W3C-WAI [13]. Presented in a first version (WCAG 1.0) in 1999, the WAI guidelines were refined and republished in 2008 as WCAG 2.0 [14]. In this version they were accepted as an ISO standard and supported also by the European Commission. WCAG, although developed with specific reference to the accessibility of Web pages contents, have a sufficient general form as to be applicable also in different application environments.

Concerning with the interaction with the system and API, there are guidelines for the creation and implementation of *browsers* [15]. Current operating systems make also available, directly or through third parties, the support and functionalities to access the system and to manipulate it in appropriate ways for different types of users.

In the case of access to information, the use of the guidelines, although designed to provide the usability of information, is often not completely followed. An additional constraint is related to the fact that the guidelines require computer skills and are therefore directed mainly to professionals. In the Web 2.0 era, it is assumed that the production of information and publishing on the network is no longer just an asset in the hands of experts, but to all connected individuals who typically do not know and are not able to apply these guidelines. Thus, the use of guidelines such as those WAI can be limiting.

3.2 Learning Models Mediated by ICT

The use of ICT for disability carriers in educational environments simultaneously affects educational-methodological and technical issues regarding the selection of devices to be used. ICT, for its characteristics, would seem to have strength for at least three aspects including "motivation, strictness, adaptability." The use of computer, thanks to its flexibility, allows the customization of specific training processes, playing a key role on learning styles and abilities of each individual. The educational and training potential of using technologies as information transmission systems are a vast field of research and widely debated. For this reason, it was considered necessary to revise the theoretical foundations that have addressed the issue of cognitive development related to the use of technology, especially computer. Through the analysis of learning theories (behaviorism, cognitivism, and constructivism) and their respective models, which are transmission model, learner-centered model and the participatory model, specific hardware and software technologies (see LOGO-MicroWorlds, V2: E-learning platform for primary schools, Vle Platform, Tabula Fabula) have been individuated.

Briefly, the computer systems CAI (Computer Assisted Instruction) and CBT (Computer Based Training) refer to the transmission model, while the ICAI (Intelligent Computer Assisted Instruction), ITS (Intelligent Tutoring System), MCL (Multimedia Computer Assisted Learning) and CACT (Computer Assisted Cognitive Training), defined as "Intelligent Software" exploiting the capacity of systems to formulate hypotheses and propose routes, to the learner-centered models. To the third model belong CSCL (Computer Supported Collaborative Learning) environments and the so-called web 2.0 tools including e-learning and mobile-learning.

It is precisely to the latter systems, based on the participatory models, which are attributed the ability to generate inclusive condition through the collaborative learning (Activy Theory, Situated action models, Distributed knowledge).

The latter has the potential to provide added value compared to the process of learning developed individually, especially for people with disabilities who are often disadvantaged and excluded in the individual learning practices [2]. In fact, with respect to specific disabilities, within educational contexts are traditionally used compensatory and dispensatory technologies that result in part ineffective, since they generate conditions of inequality.

The learning and development of each individual originates in everyday social practices, where the mediation of cultural artifacts plays a decisive role. On the other hand, it was demonstrated that the learning process stimulates the zone of proximal development (ZPD),[3] by activating a variety of evolutionary pathways which can only operate when the subject interacts and cooperates with his peers and with others present in the environment [16].

Systems that are based on the participatory model, typically turn their attention to learning processes involving scaffolding and tutoring. The learner is motivated through participatory practices to produce something on his own, sharing the project and making practice in problem solving [17, 18]. In this model, the computer is seen both as mean and learning environment where the learner may develop knowledge in an open and cooperative way. In doing so, the knowledge results well distributed and shared with other peers, thus stimulating different ways of thinking and supporting different learning modes. Within this framework, hypertext and multimedia play a very important role, as they allow to rethink and reorganize knowledge and the learner, throughout them, is able to produce new meanings [19].

3.3 UD and Access to Knowledge

Considering the participatory model and web 2.0 tools as able to generate and foster inclusive learning processes, the work was focused at this stage to assess what can be the contribution of Universal Design (UD) in education.

As known, the Universal Design philosophy is based on the idea of a design oriented to satisfy the widest possible range of end user requirements (abilities, disabilities, and other characteristics-such as age, reading ability, learning style, language, culture, and others) during the entire development cycle of a product or service. The UD approach has been adopted in different sectors with the common goal of making fair the access and the fruition towards products, environments and services [20]. In the field of instructional design and related areas (educational sciences, neuroscience, cognitive psychology), UD was applied using the same approach. In particular, within the teaching-learning contexts, where UD is used for the development of teaching practices mediated by technology, it is properly called

[3]ZPD has been defined as: "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers" [17].

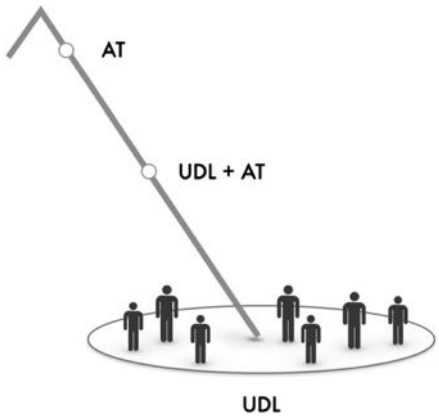

Fig. 1 Pyramid-based approach of universal design for learning

Universal Design for Learning (UDL). This educational framework was born in the United States around the years two thousand thanks to the Center for Applied Special Technology (CAST), a research and development center which since 1984 operates in the field of assistive technologies for learning. The researchers' work of CAST has focused from the beginning on the accessibility of the text and reading books holders, realizing in advance that the instruments made available by IT companies (i.e. GUI text-to-speech systems, management media), would be useful to make transversal the use of teaching materials. Since that time, it was demonstrated that the technology could meet the needs of all, and that the difficulties of each individual should be read as access barriers to learning. Accordingly, AT are not replaced, but exploited as a means to reduce the barriers to learning. To express the coexistence between UDL and AT a pyramid-based sketch is shown in Fig. 1.

Starting from the base are respectively shown UDL interventions involving a larger number of subjects, UDL intervention supported by AT when needed, and in the top level, interventions with the exclusive use of AT [21].

The UDL by unifying the principles of inclusive design derived from UD along with research in neuroscience about learning sector outlines the following principles:

- To support learning recognition, provide multiple, flexible methods of presentation;
- To support strategic learning, provide multiple, flexible methods of expression and apprenticeship;
- To support affective learning, provide multiple, flexible options for engagement.

Specifically, flexible curriculum, shows how the inclusive universal design provides accessibility and flexibility of the learning paths. To enable effective use of the content, in line with the learning styles of each learner, means using tools (Multiple Means of Presentation) that support different languages and communication methods (Simple and Intuitive Instruction). Main objective of these principles is to break down the barriers of access to learning through the use of diversified and flexible teaching strategies. This is not to offer special educational solutions,

but teaching practices employing diversified ways and media to represent the contents, in order to make them accessible and usable to all students. The main features that technologies have (thanks to binary encoding), and which are best suited to the application of UDL principles are[4]: variability, transcoding, convergence, multimedia and hypertext. These are shown below:

- Variability: the information on digital media are treated to never stand as definitive, they are changeable over time. At educational level, they allow customization of modes of presentation and use of materials;
- Transcoding: ability to convert one format to another (e.g. to translate the analog to digital etc.), to have the ability to manage and transmit information through diversified codes;
- Convergence: the digital allows you to transfer on a single support, information from different media. For us, to make convergent more media, it means having in hand different languages, integrated so as to involve the largest number of recipients;
- Multimedia: using different channels and media can enhance learning and diversify ways of content delivery;
- Hypertext. in addition to offering non-sequential reading experiences, it allows to organize the content to levels of depth and, therefore, of difficulty.

In conclusion, significant examples of web platforms (platforms UDL Editions, Learning Landscape and UDIO: The Universal Literacy Network) adopting the UDL principles for defining the design and procedural requirements useful for the development of inclusive solutions were evaluated. The main features are displayed in the Fig. 2.

Within this initiative, prototypes of online environments for making easy reading and the information more accessible to a wider number of users as possible were developed. The platform is structured as a series of functions to guide learning (Fig. 3) through a support function to build reading strategies and help readers understand the content of a "Texthelp" toolbar to promote accessibility and the search for language functions in the text, multimedia glossaries and enrichment activities of the specific context and multimedia resources.

Numerous scientific studies have shown that this model can also be transferred to higher levels of education and applied to any information environment (on-line newspapers, Wiki, etc.). An example, it is represented by the research presented in 2010 at the 71ST IDA Annual Conference.[5] Later, it was developed a digital version of the article "2020s Learning Landscape: A Retrospective on Dyslexia", where they were incorporated inside the supports of the UDL for learning developed by CAST.

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[4]To make more solid the UDL approach, CAST developed, according to the three above described principles, further indications articulated in guidelines and operating checkpoints UDL Guidelines (http://www.udlcenter.org/aboutudl/udlguidelines).

[5]It refers to the following publication: Rose, David, Ge Vue, "2020s Learning landscape: a retrospective on dyslexia," (http://www.cast.org/w/page/2020learning/l3).

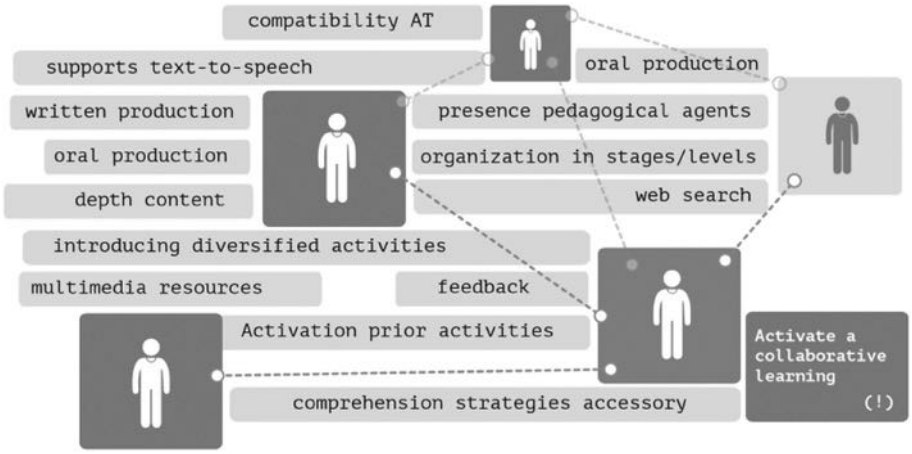

Fig. 2 Synthesis of requirements for the definition of an UDL platform

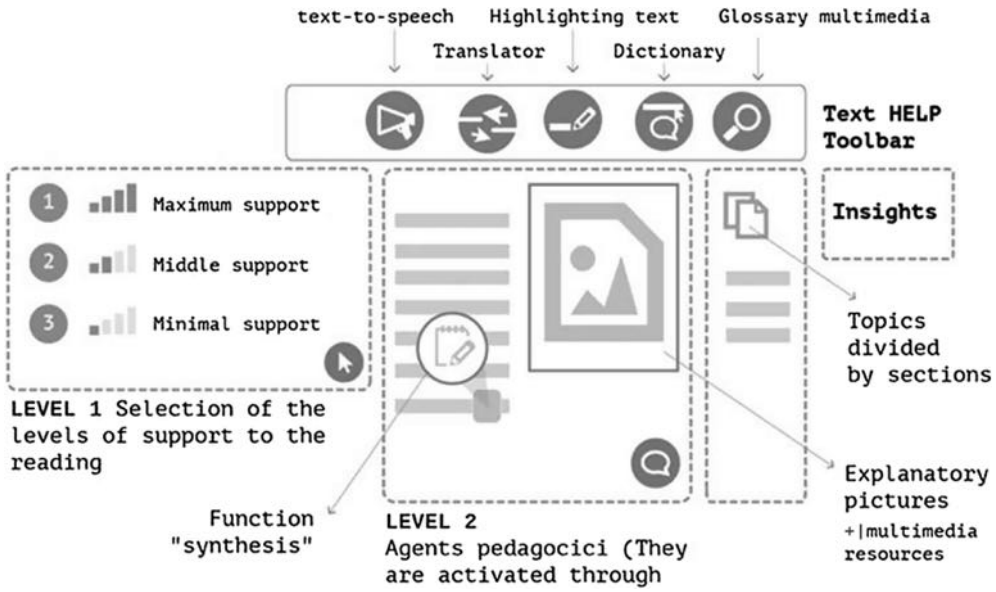

Fig. 3 Schematic representation of an UDL web platform

It should be noted in conclusion that the UDL guidelines do not enter into the merits of the design of online activities, nor are intended as standards for the design of systems. They have to be understood rather as guidelines to make inclusive learning practices in specific contexts, through the diversified use of multimedia languages thanks to the digital medium. Ultimately, they provide an interesting perspective and a solid foundation allowing to state that it is possible to pass from the concept of "special adaptation" focused on disability to universal design (for all), by valorizing individual differences and taking advantage of the potential of inclusive technologies.

Table 1 Comparative assessment between accessibility standards and UD-UDL guidelines

Quality attributes of usability[a]	UD principles[b]	UDL principles[c]	WCAG 2.0[d]
Effective	Principle 3: simple and intuitive use	Multiple means of presentation	Perceivable
	Principle 4: perceptible information	Multiple means of presentation	
Efficiency	Principle 2: flexibility in use	Flexible curriculum	Understandable
Satisfaction	Principle 1: equitable use	Equitable curriculum	Robust
	Principle 6: low physical effort	Appropriate level of student effort	
Learnability	Principle 3: simple and intuitive use	Simple and intuitive instruction	
Memorability	Principle 3: simple and intuitive use	Simple and intuitive instruction	
Errors	Principle 5: tolerance for error	Success oriented curriculum	Operable

[a]Ref. [22], [b]Ref. [23], [c]Ref. [24], [d]Ref. [14]

Identified in the UDL a viable base of operations to define strategies for planning and structuring learning in accessible way, the similarities and potential synergies between UD, UDL, WCAG 2.0 and the quality attributes of Usability (ISO 9241-11) are listed herein in Table 1.

Although in Table 1 are evidenced similarities between the different approaches and standards of accessibility, their integration looks like as an interesting future perspective but not easy to apply. It is noteworthy that WCAG and UDL have in common the attention to customize how to display the information, the availability of alternatives to the audio and visual content through the use of different media (even in support of understanding), the readability and comprehensibility of texts and compatibility with assistive technologies.

4 Conclusion

In this work, an overview on the inclusive potential of current ICT and related standards of web accessibility, platforms and content format is reported. Within the frame-work of ICT for learning, the UDL approach, if supported by human-centered design philosophy and the use of accessible ICTs, provides an interesting perspective and a solid basis, either theoretical and practical, to valorize individual differences.

In addition, the parameters and standards for accessibility provide valuable indications, but it is necessary to adopt a broader perspective and consider the standards as a starting point and not an end one. Finally, it is noteworthy that the

research conducted in recent years related to the Educational Technology sector can significantly contribute to implement the existing standards, in terms of accessibility and usability, thus enhancing design practices.

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