

Accessibility in E-learning: From Inclusive Choice to Universal Training

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Abstract - This article discusses the topic of digital accessibility as the ability of information systems to deliver usable services and provide usable information, avoiding any form of discrimination, including that oriented toward those who require assistive technologies or special computer configurations due to disabilities or unsuitable environmental conditions. In this paper, the experience of the Piazza Copernico's development team is explained in regarding the implementation of an accessible and usable course. The paper shows the complexity of this topic and the main solutions implemented in a real example to guarantee an effective inclusive learning environment.

Keywords—Accessibility; Usability; Disability; Inclusion; E-learning; Universal design

I. INTRODUCTION

The topic of accessibility has recently come into the spotlight because, thanks to current regulatory and societal changes globally, more and more people with disabilities can access opportunities that they were previously denied.

The official definition of disability was provided by the World Health Organization (WHO), which defines it as: "any restriction or deficiency (resulting from an impairment) in the ability to perform an activity in the manner and within the limits considered normal for a human being" [1]. However, it is important to emphasize that disabilities should not be regarded as a disease or defect, but a natural part of human diversity. Therefore, individuals with disabilities have the right to take full part in the society that, for a long time, has been structured on standards commonly considered "normal." Disabilities can be of different types and degrees and may be present from birth or acquired as a result of illness, accident, or aging. Sensory disabilities, such as blindness and deafness, limit the ability to see or hear and consequently may limit the ability to learn and interact. In addition to sense organ impairment, physical, mental, and intellectual limitations are also to be considered.

Respect for and inclusion of all is a social responsibility and, as such, must be made explicit in all contexts of an individual's life. One of the areas to work on to achieve this goal concerns training and, more specifically, e-learning. This area requires special attention to design and develop accessible e-learning training, it is necessary to take into account the many difficulties that any individual may face. For example, those with visual impairments often find themselves in the condition of not being able to enjoy effective learning, either because of the traditional use of images and graphics that are significant for the achievement of training objectives, or because of

instructions to be displayed in the interface employed to facilitate navigability in the course. From this and other needs we are seeing a proliferation of accessibility technology regulations and guidelines, which increasingly promote the design of accessible online platforms and content for all users. So, for Piazza Copernico it rapidly became a topic to be studied to promote correct solutions to manage learning and promote inclusive learning digital materials and courses, accordingly to D&I policy in company itself and clients' requirements.

II. ITALIAN REGULATION

The increasingly imminent need to make digital environments accessible is regulated in Italy by Law No. 4 of January 9, 2004 (Stanca Law) [2], which establishes provisions to facilitate and simplify access to digital tools for users in general and people with disabilities in particular. The constitutional framework on which this law is based is Article 3 of the Italian Constitution, as it is based on the principle of equality and social dignity. In Art. 3 of Law 4/2004, moreover, the addressees are specified, namely:

- public administrations.
- public economic entities.
- private companies that are concessionaires of public services.
- public welfare and rehabilitation institutions.
- transport and telecommunications companies with majority public capital participation.
- regional municipal utilities and IT service contractor companies.

Thanks to Law 4/2004, it is possible to obtain a more objective framework regarding definitions, particularly of "accessibility," understood as: "the ability of information systems, in the forms and to the extent permitted by technological knowledge, to deliver services and provide information usable, without discrimination, even by those who due to disabilities require assistive technologies or special configurations" (Law 4/2004) [2]. The law also provides an accurate definition of "assistive technologies" in terms of: "technical tools and solutions, hardware and software, that allow the disabled person, overcoming or reducing the conditions of disadvantage, to access information and services provided by information systems" (Law 4/2004) [2].

III.WEB CONTENT ACCESSIBILITY GUIDELINES (WCAG) AND E-LEARNING STANDARD

The spread of the offer in services and courses delivered largely via the Web and aimed at post-secondary or vocational training rose the need for authorities to adopt recognized standards to enable their quality certification [3][4]. The International Standard Organization (ISO) with the International Electrotechnical Commission (IEC) created an international standard, ISO/IEC 24751 (2008) [5], which considers the accessibility characteristics that "the new training context" must have to be considered accessible [9].

Among the most comprehensive and important guidelines for accessibility, WCAG is a set of international guidelines related to accessibility and usability provided by the World Wide Web Consortium (W3C), an international no-governmental association that has been working for years to further the web. Web Content Accessibility Guidelines (WCAG) 2.1 is the most recent version and was released on June 5, 2018. It is based on four core principles:

1. *Principle of perceptibility, states that all interface elements should be able to be perceived by the user;*
2. *Principle of operability, states that the user must be enabled to effectively use the interface;*
3. *Principle of understandability, states that the content of the interface must be presented clearly and unambiguously;*
4. *Principle of robustness, states the relative importance of an interface's ability to be accessible regardless of the technology used by the user.*

Thirteen criteria are also provided within the Web Content Accessibility Guidelines (WCAG) to determine the level of accessibility of an interface. Depending on the fulfillment of these criteria, the interface can be classified through three levels of accessibility: A, AA and AAA. These levels are progressive, so as accessibility increases as the level advances. It is important to emphasize that the thirteen criteria in no way represent a regulation with normative value, but rather a set of practical and useful guidelines for those involved in making digital environments accessible.

IV.MAIN EXISTING METHODOLOGIES AND THEORIES

Considering the theoretical models and methodologies employed in e-learning, a major contribution to the topic of accessibility comes from Universal Design for Learning (UDL), an approach based on modern neuroscience. Specifically, Universal Design for Learning (UDL) is a framework that addresses the main training difficulties present within still rigid, one-way learning environments, which raise significant barriers in the process of knowledge acquisition by users, not only those with disabilities [6].

The underlying principle is that there is no one type of learner, but everyone learns differently based on multiple factors, from physical to sociocultural, and based, therefore, on different needs [6].

Universal Design for Learning (UDL) aims to help anyone planning lessons or learning units understand how

to implement learning pathways. A learning program must be able to meet the needs of all students from the outset, encouraging the creation of flexible, inclusive and customizable designs. In this regard, Universal Design for Learning (UDL) has drafted Guidelines to reduce the obstacles associated with traditional training and to try to reach an increasingly broad range of learners.

The guidelines drafted by UDL are based on the following principle: provide multiple means of representation. This principle is indispensable in the absence of a single, optimal tool for all users. In fact, learning is impossible if the information is not perceivable by the learner, or is perceivable with difficulty (for example, if it is presented in ways that require great effort or extraordinary help). For information to be equally perceivable by all individuals, the Guidelines suggest, for example, providing the same information through different perceptual modalities such as: sight, hearing, or touch.

In addition to multiple representations, another strategy to try to break down barriers in learning is to offer the user information in an adjustable format, such as enlarged text and augmented sound. It is especially important to remark the role of multiple representations of information in learning, as they are useful not only in conveying accessible information to users with particular sensory and perceptual disabilities, but also in facilitating understanding for many other users.

V. CURRENT STATUS OF TECHNOLOGIES

Currently there are many technological achievements to overcome obstacles to the accessibility of e-learning paths, among them we consider:

- the use of special keyboards.
- the presence of a video with a translator who expresses himself through sign language.
- the adoption of joysticks.

In more detail, mainly used technologies for visually impaired people are audio description and image magnification using specific software. A tool that can implement both mentioned solutions for visually impaired people is the multipurpose interface. On the other hand, a tool very useful for trainers is the multi-subject database [8], which makes it possible to shorten the distance between trainers and people with disabilities through a virtual repository that can trace the progress of special education.

Technologies to support the blind are called "assistive technologies" and are based on the use of hearing and touch. Among the various developed solutions, it is important to consider screen-reading software that can convert content in written form present in an interface into audio. Other assistive technologies include alternative keyboards (keyguards, adjustable keyboards, miniature keyboards, programmable keyboards) and Braille displays.

To identify the most promising technologies for people with hearing impairments, Martinsa and al. [8] pointed out that the efforts of industry companies have focused on three key aspects:

- comprehension, as the ability of technological tools to recognize gestures, body movements and facial expressions in order to grasp the message.
- representation, as the ability to create a virtual image that corresponds to the user's communications.
- translation, as the ability of software to convert a message expressed through sign language into written form.

Regarding the first aspect, i.e., understanding, there are two solutions adopted until today:

- the use of cameras that can record movements.
- the use of gloves that analyze the movement of the hand and forearm.

Several difficulties are currently evident with both above-mentioned solutions; on the one hand, the gloves fail to capture the message in its entirety because they exclude important aspects, such as facial expressions and body language; on the other hand, although extremely accurate cameras are available, it is difficult to succeed in developing software that can process and understand all the necessary visual stimuli.

For sign language representation, on the other hand, a tool that has been successful in various areas of communication is adopted: the virtual avatar. However, much research on the subject shown that there are several difficulties [8]. Indeed, making animations capable of reproducing specific and complex movements with high levels of accuracy and fidelity proved to be a more arduous task than expected.

Finally in the case of translation, the greatest difficulty doesn't involve software, but regards hardware; in fact, it is really difficult for modern systems to be able to process hundreds of spoken gestures in a few minutes, understand them, and translate them into a written format. Software based on particularly powerful hardware actually cannot process more than eight signs per minute, certainly not enough considering the communication speed of a possible user.

Despite great efforts by institutions, the world of research, information technology, and new technologies, there are still many steps to take to achieve high-impact inclusive goals and so accessibility can become an established principle in e-learning education. However, future of accessible e-learning is very promising. There are several emerging technologies that are making e-learning increasingly accessible for people with disabilities. One of the most important emerging technologies is artificial intelligence (AI). AI can be used to create personalized and adaptable learning systems to real learner's needs and learning abilities. In this way, it become possible to receive personalized education tailored to each specific need. In addition, there are also emerging technologies, such as portable devices and sensors, that can help interact with e-learning in more intuitive ways. For example, handheld devices such as smartwatches can help students with visual impairments receive haptic feedback to navigate learning content. Then, virtual and augmented reality technologies are becoming more accessible and could be used to create immersive and immersive learning experiences.

VI. PIAZZA COPERNICO'S EXPERIENCE

A. Accessibility vs. Usability

The adoption of Web Content Accessibility Guidelines (WCAG) became increasingly important as more and more people use technology to access information, services and products. In addition, accessibility has also become legally mandated in many countries, especially for public service-providing organizations.

Creating e-learning courses that comply with WCAG means creating content that is accessible, but also that is easy to use and navigate. However, the two do not always coincide. With these considerations in mind, the Piazza Copernico's production team started from the question, "Will following the WCAG guidelines allow our products to be truly usable by anyone?" Indeed, accessibility and usability are two different concepts, although they are often confused or considered as synonymous. Accessibility refers to "a person's ability to access online content regardless of his or her physical, sensory, or cognitive abilities.

On the other hand, Usability refers to the ease with which a person can use a website or application, that is, its efficiency, effectiveness, and satisfaction during use. According to the ISO 9241-11 (1998) standard [9], the purpose of usability is to study the interaction between the user and the site, or between the user and the online course, with the aim of highlighting obstacles that prevent effective use of information and services. [10] For example, an online course may be accessible, because it has text alternatives for images and support keyboard navigation, but it may not be very usable if the navigation is confusing and unclear, with menus and submenus that are not well organized and difficult to find. On the other hand, an online course could be very usable, that is, easy to navigate and use, but not be accessible if it does not support assistive technologies or offer text alternatives for images. In the goals of accessibility and usability there is an overlap in some cases, but the differences between the two areas become clearer when considering the entities involved.

To verify that the accessibility requirements of the WCAG guidelines are met, automatic validation of the page code using special software and a series of technical tests are required. The focus of usability, on the other hand, is on the relationship between the product and the end user, and the preferred method of validation is a test conducted directly with human users.

In summary, accessibility and usability are both important for ensuring a positive and inclusive user experience for all users, but they are different concepts and require different design and validation approaches. Therefore, the appropriate test of whether an online course is accessible is whether people with disabilities can use it, not just whether it complies with WCAG or other guidelines. In fact, Thatcher [11] states that accessibility is experiential and environmental and depends on the interaction of the content with the user agent, the assistive technology, and the user. Obviously, one would hope that there would be a high correlation between user performance and usability measures on the one hand and

WCAG compliance on the other. So far, however, there are few studies that have produced evidence underlying this relationship [12].

In the light of these considerations and in response to the specific need expressed by the company Enel Spa to provide training that would consider the obligations of Legislative Decree 2020/76, the production group in Piazza Copernico began to think about how to make its products accessible and usable, developing an e-learning environment suitable for this purpose. The first project to be tested for accessibility was "Being Antifragile": a course consisting of four episodes built on the stories of various characters in different environments; in each episode a typical situation of chaos, stress, risk, error is staged, in which the "antifragile" attitude can make a difference in improving, learning, evolving. The group worked in parallel on the content front and the interface front to produce an easily navigable environment for people with visual and hearing disabilities and normals with suboptimal conditions; the goal was to achieve level AA according to the WCAG guidelines. To do this, several measures were taken.

B. Taken measures on the web application

The development of a web application capable of presenting accessible and usable multimedia content required a set of best practices to be followed.

The principles used at this stage followed the guidelines outlined by the W3C on WCAG, which state that for content to be accessible it must be perceivable, usable, understandable, and robust [13]. The robustness of the code and the use of semantic tags [13] enabled assistive technologies for the blind (*screen readers*) to convey the right information according to the order set in the HTML code. The proper use of semantic tags has enabled *screen readers*, for example, to recognize text as a title regardless of how it looks on the screen. The inclusion of detailed instructions for each button and the implementation of keyboard-only interface navigability allowed users with screen readers to operate with the application controls and know what will happen after each button is selected (see Figure 1).



Figure 1. Example of a message read by the screen reader

About course interface, each button, once selected, shows a clearly visible border, allowing users its immediate identification (see Figure 2).



Figure 2. Example of key highlighting

Adaptive (*responsive*) management of the interface allowed the visually impaired to be able to enlarge the tabs and wording present, without having to give up their functionality (see Figure 3 and 4).

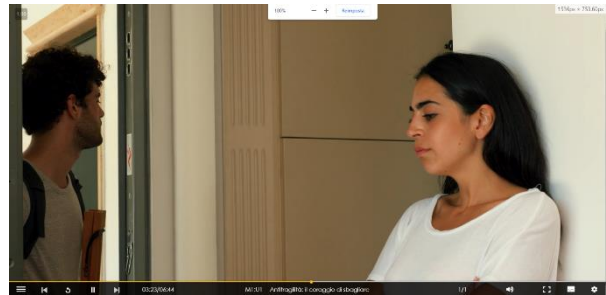


Figure 3. Example of focus on

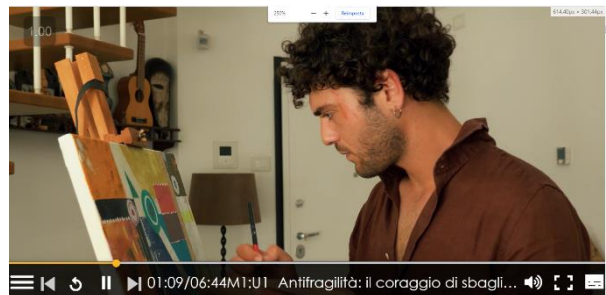


Figure 4. Example of focus on

C. Considerations on taken measures on the web application

The software and interface design must focus on the needs of users by providing tools that are pleasant and functional to use, in an effort to provide the best possible experience during use. Designing the commands to be made available and the information to be communicated at each stage of use, presupposes the task of stepping into the user's point of view to help them efficiently and comprehensively achieve their purposes: in our case, education on a given topic.

In the past, the target user of the graphic and functional design of our courses was quite similar in skills and possibilities to the people involved in making the course itself. Making a web application accessible means taking into consideration a multitude of viewpoints or use cases related to the different possibilities of fruition of the product applicable to users with different abilities and limitations. This is not an easy effort that requires specific training on the various usability needs and the use of assistive technologies to test and verify the validity of the solutions adopted. The immediate visual impact of texts and images is no longer the only parameter to be considered; the usability of what is shown after activating the browser's zoom tool or the use of a screen reader also become an integral part of the process of creating our courses.

D. Taken Measures on content

To make the media content accessible, synchronized subtitles are included that report, according to the choice:

- the spoken content only, i.e., subtitles for all audio content in real time in the form of synchronized media types.
- the spoken content and textual description of the noises.
- audio description, i.e., audio description provided for all pre-recorded video content in the form of synchronized media types. Such narration describes important visual details that cannot be understood through the main audio and includes information about actions, characters, scene changes, on-screen text, and other visual content (see Figure 5).

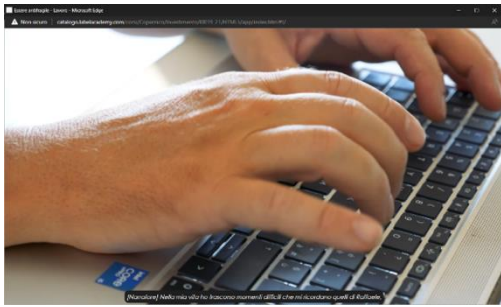


Figure 5. Example of audiodescription

Subtitles can be set in 4 different sizes (see Figure 6).

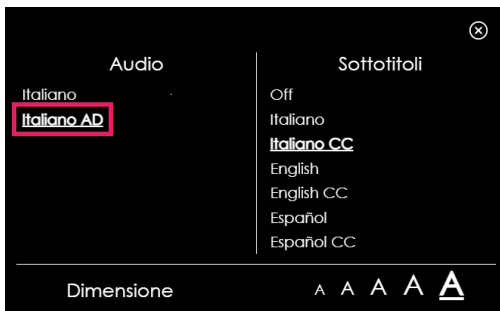


Figure 6. Audio/subtitle control panel

To further support the audience of hearing-impaired people, we have included, on a drag-and-drop panel, the ability to enjoy content through Italian Sign Language (LIS), a natural language conveyed through the visual-textual channel, relying on professional interpreters to literally translate the content of our videos (see Figure 7).

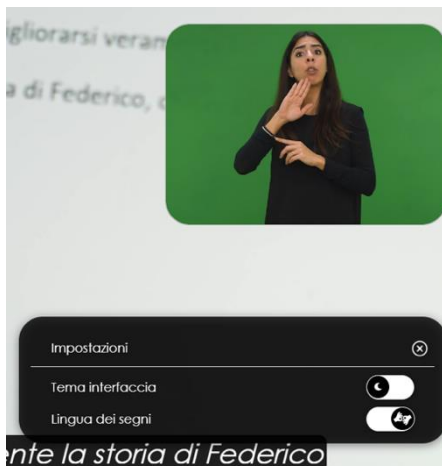


Figure 7. Example of LIS (Italian Sign Language)

E. Considerations on taken measures on content

For years now we focused on the use of video for our training courses, and working on accessibility necessarily means going to work on these as well. After all, we live in a world increasingly dominated by audiovisual content. And access to this content has been declared a fundamental human right by the 2006 United Nations Convention on the Rights of Persons with Disabilities (CRPD). [15] The first key step involved subtitles. Subtitles originated to be aimed at viewers who do not speak the language used in the video. Today the use of subtitles has changed; just look at the wide use of them on social and streaming platforms by all the people who enjoy videos in conditions where audio cannot be heard, such as in public. The use of Closed captioning (cc) or Subtitles for the Deaf and Hard of Hearing (SDH) has since evolved further. SDH includes oralists, as deaf oralists are people educated to speak, lip-read and understand spoken language to the exclusion of Sign Language

This type of subtitles carries over into the written text not only speech, but a whole range of additional information useful to people who are deaf and hard of hearing, such as:

- sound effects (gunshots, dogs barking, phones ringing, etc.).
- identification of the speaker (without a symbol or name identifying the speaker, lines of dialogue follow one another, leaving the viewer confused as to who said what and when, especially for off-screen interlocutors).
- music, the latter being a basic element in identifying the video's tone and atmosphere; it is useful, therefore, to make suggestions as to what type of music is in the field for the deaf.

To support users who have difficulty reading, subtitles are presented as white lettering on a dark background to ensure good contrast no matter what content they are displayed on. A further step toward accessibility is the translation of our videos into Italian Sign Language (LIS), which is increasingly used on TV and in live events to engage the signaling deaf community. If subtitles and LIS help those who have difficulty hearing, audio-descriptions are necessary for those who have difficulty seeing. Audio-descriptions consist of audio commentaries describing scenes that would not be understandable without visual support. The difficulty encountered lies in the fact that the training products produced are not feature films, which have more extended time frames and allow for full and detailed audio-descriptions, but short videos, usually at a fast pace, that require a specific study of best formula for effectively describing a scene.

F. Results

Once the "Being Antifragile" course was made accessible, with the described changes on the web application and content, it was sent to the client for consulting by Salvatore Scaldaferrì - Digital Accessibility Specialist of Global Digital Solutions of the Enel Group. This collaboration allowed us to test and verify the effectiveness of the measures undertaken in line with accessibility guidelines and to implement them in terms of

usability. The Digital Accessibility Specialist's main observations concerned:

- the correct reading sequence of on-screen elements.
- the overlap of the audio description with respect to the narrative voice of the video.
- the clarity of the instructions regarding the choice of subtitles.
- some redundancies in the functionality of the buttons.

The feedback allowed us to refine the functionality of the interface and calibrate content interventions according to the learning patterns of Enel users with disabilities. Changes were subsequently validated by the client, who confirmed that the course was usable according to his needs and that there were no anomalies that would affect compliance with WCAG level AA.

VII. CONCLUSIONS AND FUTURE WORK

What we have seen is confirmation that beyond the adoption of accessibility guidelines, only the human user is the true test of the usability of an e-learning course. Indeed, in this context, usability is important because students must be able to easily access learning materials, navigate between different sections of the course, and interact with the available tools and resources. Reflection should also be extended to the existing correlation between instructional design and usability since a well-designed e-learning course should also be easy to use. In fact, it is important to remember that when we talk about accessibility in e-learning we should not refer exclusively to the idea of making the platform and learning objects universally usable, but we should be aware that the content should also be conceived and designed in an accessible and usable way. In this regard, there is a lack of guidelines that give guidance on how to design in an accessible and inclusive way for all users, thus addressing the issue of accessibility from a methodological-didactic point of view. Next steps for producing highly and globally inclusive educational products involve new studies to identify standardizable design patterns to ensure full accessibility for all types of content while also taking into account the cognitive engagement required of the user.

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