A Study on the Standards Related to Learning Objects

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Summary. This article presents a study on the standards that address the accessibility of a virtual learning environment. Firstly, the standard ISO/IEC 24751 describes the process of generating a virtual learning environment customized according to the preferences of the students, taking into consideration the metadata of learning objects as a key element to the search and selection of the learning object that satisfies these preferences. Secondly, the standard ISO/IEC 40500 addresses the recommendation for selecting the success criteria which can be applied to learning objects. Thus, based on the above mentioned standards, both requirements how to be realized in an online learning system to meet accessibility levels or A, AA, or AAA and the way to follow to implement technical requirements are discussed.

Keywords: accessibility, adaptability, access for all, standard ISO/IEC, e-learning, guideline, checkpoint, learning object.

1 Introduction

The standard ISO 9241-171:2008 is called “Ergonomics of human-system interaction [1]”. It defines accessibility as the ease of use based on efficient, effective, and satisfying form of a product, service, environment or facilities by people who possess different capacities. Based on this definition it can be inferred that an online educational environment is accessible as long as any person, regardless of their personal capabilities, can access and exploit the information and published applications efficiently. Over almost two decades of research in the field of e-learning, numerous definitions of learning object (LO) have been provided; for example, the definition produced by Willey [2] stands for realism, simplicity and extensive scope of application:

> *"Learning object is any digital resource that can be reused to support learning"*

The base on an e-learning environment lies in their LOs allowing both the presentation and control of information by the student, and in educational activities and evaluation of learning provided by the activities. This gives a rise to numerous advantages in learning among which the following ones are the most obvious

- It promotes communication, cooperation, and individual and group responsibility.
- It increases motivation and self-esteem.
- It creates synergy and encourages the development of critical thinking.
- It is possible to connect to the course content from everywhere and any time.
- The student can review the comments in the forum and the answers of the teacher as many times as necessary, because they are saved in the platform. In addition, all the students can learn from the answers given to other students.

In order for everybody to achieve these benefits, the LOs published in this type of learning environment must be accessible and meet the requirements and recommendations set for this purpose in the standards. This paper focuses on the study and explanation of the standards that concern LOs, understanding them as Web content on a platform for online learning.

2 Data Models

The objective of the standard ISO/IEC 24751 - called "Individualized adaptability and accessibility in e-learning, education and training" - is to present data model so that the product will satisfy the needs of any person in a context of deficiency, either personal or environment-related (such as a room with poor lightning or too much noise), which allows an individual user to choose the desired digital resource if it is available [3].

To achieve such a goal, it is necessary that the content authors produce alternative LOs in addition to the original, they must submit the same cognitive content, but provide different type of sensory perceptions (sight, hearing, touch, etc.), for example a video as an original resource but providing subtitles (textual perception) and hearing aid (auditory perception) as adapted resources. That is to say the students specify their preferences and needs in their user profiles, which will allow them to search the online platform for available LOs and to select one that matches their preferences without difficulty.

In this respect, the standard ISO/IEC 24751 defines two patterns of information: one for the Digital Resources Description (DRD), based on the accessibility metadata, that should be added to the LOs to facilitate an efficient search [4], and the other, for the configuration of the Personal Needs and Preferences (PNP) of the student, based on an interactive form, whose answers give a rise to PNP [5]. Moreover, once generated, the PNP must be subject to changes by the user, for example due to enhancement, replacement or removal of the description, creating multiple PNP sets for different contents, or transfer of the description to a new system for reuse.

To obtain a correct DRD, the standard establishes the need for the observance of the basic accessibility guidelines defined in the World Wide Web Consortium's Web content Accessibility Guidelines. In particular the priorities 1 (level A) and 2 (level AA) of the WCAG ensure the presentation and control of the text as adjustable. In order to facilitate this task, a study of these guidelines was carried out to identify the success criteria directly related to LOs (showed later in table 2).

However, due to the complexity of the data models presented in the standard ISO/IEC 24751 (especially in the PNP data model) and the difficulties experienced in previous research projects, as it was the case of the EU4ALL project [6], IMS Global Learning Consortium (institution dedicated to the development of open specifications for facilitating online learning activities) has prepared a draft of basic specification, IMS AFA (Access For All) v3.0. This specification contains the main norms of the ISO/IEC 24751 standard, so that the primary needs of users are covered, and it allows a faster and more efficient operation.

IMS AFA v3.0 specification information model [7] helps to establish accessibility metadata to be associated with both the original and adapted LOs and the model defines a set of value space that makes it possible to define each one of them. Accessibility metadata contain information describing the accessibility features of an LO, for example the sensory mode of access (auditory, tactile, textual, etc.), LO control mode (keyboard or mouse), identification of the adaptations associated with it or potential risk of hazard behavior. Different hazard type elements of LOs may be flashes or sound, etc. For adapted resources it is necessary to include all original metadata of the resource, adding further specific metadata adaptation, as for example the identity of adapted resource, type of adaptation (subtitles, long description, and alternative text) or language of adaptation among others.

Table 1 shows an example of the metadata and the values for a video, as original resource, and associated captions, as adapted resource.

Table1. Example of IMS AFA 3.0 accessibility metadata for a video and its captions.

Learning objects: video, captions (deaf or different languages)		
Metadata	**Value (video, ID_1)**	**Value (captions, ID_1.1)**
AccessMode	Visual, auditory	Textual
HasAdaptation	ID_1.1	--
ControlFlexibility	FullMouseControl	--
DisplayTransformability	--	--
Hazard	--	--
IsAdaptationOf	--	ID_1
• IsPartialAdaptationOf	--	ID_1
• IsFullAdaptationOf	--	--
AdaptationType	--	Captions
AccessModeAdapted	--	Auditory
AdaptationDetail	--	Verbatim
AdaptationMediaType	--	--
LanguageOfAdaptation	Spa	Spa
EducationalComplexityOfAdaptation	--	
• EducationalLevelOfAdaptation	4	
AtInteroperable	False	
• ApiInteroperable	--	

Interoperability has particular importance in the process in two ways: (1) from the viewpoint of the requirement of assistive technologies which are external to the system and (2) from the viewpoint of the process of searching for right resource through communication between the different subsystems. Figure 1 shows the entire process.

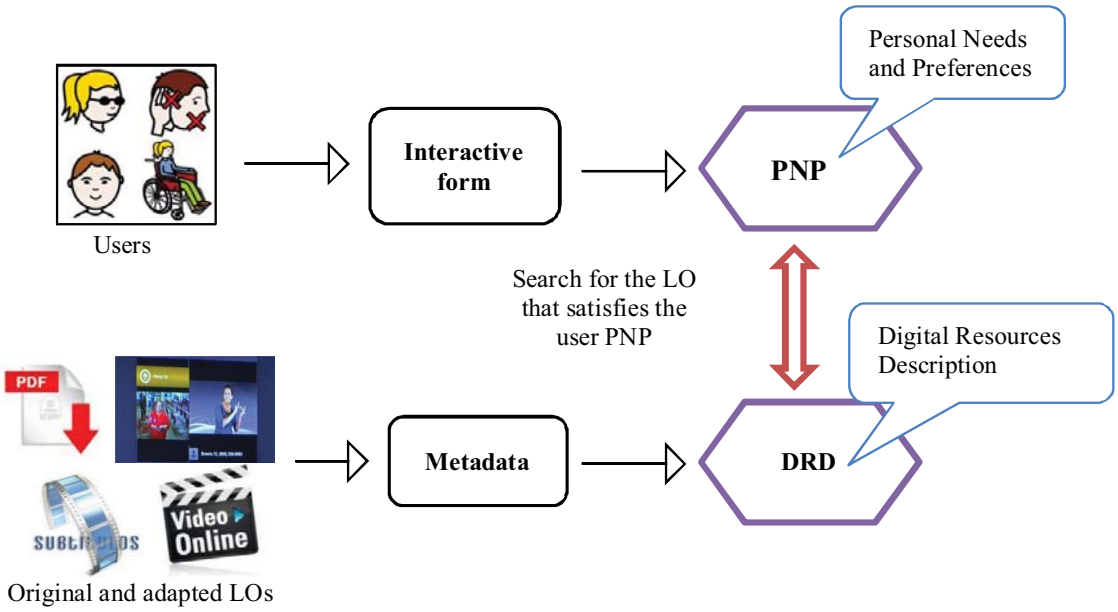

Figure 1. Relationship between the processes taking place in the selection of a resource.

Based on the data model of the user preferences and taking into consideration the answers to the interactive form, the PNP of the user is generated. On the other hand, based on the data model for the description of the resources and taking into consideration the LO metadata, the DRD is generated. The next step consists of the execution of a communication process between both parties (PNP and DRD) for searching and selecting the LO that satisfies the user PNP.

Use case

To give an example, Airline maintenance staff receives regular training sessions, but there is always a possibility of the need for "ad hoc" instruction. Available airplane resource materials include video instructions on aircraft engine maintenance that addresses the methods for repairing various engine problems. Usually, the material is used in a noisy hangar in which workers are required to wear hearing protection. There may also be multiple information systems connected to their ear-phones for safety reasons. In this environment, workers use portable computers to view the reference materials as they carry out the repair actions.

When workers log in, they indicate the hangar as the context and a PNP file is selected by the system. This profile requires text transcripts or animated diagrams to replace audio content. When viewing the training videos, the system automatically retrieves the available text captions or alternative visual content and supplements the video with them while synchronizing it to the original audio. As a result, the workers are able to reference videos as they work in the hangar.

3 Web Content Guidelines

The standard ISO/IEC 40500, “Information Technology W3C Web Content Accessibility Guidelines (WCAG) 2.0”, [8] accurately reflects the guidelines published in the WCAG (Web Content Accessibility Guidelines), version 2.0 in 2008 for the crea-

tion of accessible Web content, being raised to the category of standard. Since then the guidelines have been widely consolidated by users.

The standard is organized into 12 guidelines or recommendations concerning the Web page content and navigation as well as the user interface [9]. Success criteria are established to develop and specify the meaning of each guideline. In total there are 61 success criteria that moreover are useful for checking the correct implementation of the recommendations.

The guidelines are based on four fundamental principles that should cover Web content development, so that the Web content is considered accessible. They are the following:

1. **Perceivable**: according to this principle both the user interface and the Web content must be received and appreciated properly by all users.
2. **Operable**: this principle establishes that both the user interface and navigation must be operable or controllable by all the users.
3. **Understandable**: through this principle a need for a correct interpretation of the content and user interface is declared.
4. **Robust:** this principle requires the Web content to be compatible with current and future technologies.

In turn, the verification points that are shaping the guidelines are classified in a hierarchy according to their accessibility level at 3 different levels, known as A, double A or AA and triple A or AAA, with priorities low (or priority 1), middle (or priority 2) and high (or priority 3) respectively.

1. **Level of accessibility A**: indicates the success criteria required to be fulfilled by the Web developer so that certain groups of users **can access** the content of the Web page.
2. **Level of accessibility AA**: indicates the success criteria required to be fulfilled by the Web developer so that certain groups of users **do not have serious difficulties to access** the content of the Web page.
3. **Level of accessibility AAA**: indicates the success criteria required to be fulfilled by the Web developer so that certain groups of **users do not have difficulties to access** the content of the Web page.

The hierarchy presented by these requirements determines the legal obligation of compliance by all contents published on the Web. In this regard, different countries have adapted their legislation according to the publication of the standards by ISO. For example, the Spanish law establishes Royal Decree 1494/2007 as mandatory minimum level of accessibility, compliance regarding priorities 1 and 2 of the standard UNE 139803:2004, “Computer applications for people with disabilities. Requirements of the Web content accessibility” [10]. However, the State Legal Service of the Ministry of Health, Social Services and Equality determines the legal application of the norm UNE 139803:2012: "Web content accessibility requirements" that replaces the previous one, without requiring their incorporation in a Ministerial Order [11].

In Finland the requirements are declared in the Constitution about the equality of all citizens. Immediate band on discrimination means that no person may be discriminated against on the basis of disability [12]. Moreover, Ministry of Interior has determined the Instructions for the Web site design of public administration [13].

According to the definition, the LOs are part of the Web content. Table 2 shows such success criteria that relate directly to the Web content and such that can be controlled by the metadata of LOs. Such success criteria are removed if they are not controlled by the metadata and are related with the user interface and navigation between pages.

Table 2. Applicable ISO/IEC 40500 success criteria to LOs [14].

Principle	Guideline	Accessibility level	Checkpoint
1. PERCEIVABLE	1.1: Text Alternatives	A	*1.1.1 Non-text Content*
	1.2:Time-based Media	A	*1.2.1 Audio-only and Video-only (Prerecorded)* *1.2.2 Captions (Prerecorded)* *1.2.3 Audio Description or Media Alternative (Prerecorded)*
		AA	*1.2.5 Audio Description (Prerecorded)*
		AAA	*1.2.6 Sign Language (Prerecorded)* *1.2.7 Extended Audio Description (Prerecorded)* *1.2.8 Media Alternative (Prerecorded)* *1.2.9 Audio-only (Live)*
	1.3: Adaptable	A	*1.3.1 Info and Relationships* *1.3.2 Meaningful Sequence* *1.3.3 Sensory Characteristics*
	1.4: Distinguishable	A	*1.4.1 Use of Color* *1.4.2 Audio Control*
		AA	*1.4.3 Contrast (Minimum)* *1.4.4 Resize text* *1.4.5 Images of Text*
		AAA	*1.4.6 Contrast (Enhanced)* *1.4.8 Visual Presentation*
2. OPERABLE	2.1: Keyboard Accessible	A	*2.1.1 Keyboard*
		AA	*2.1.2 No Keyboard Trap*
		AAA	*2.1.3 Keyboard (No Exception)*
	2.3: Seizures	A	*2.3.1 Three Flashes or Below Threshold*
		AAA	*2.3.2 Three Flashes*
3. UNDERSTANDABLE	3.1: Readable	A	*3.1.2 Language of Page*
		AAA	*3.1.5 Reading Level*

Based on Table 2, which serves as an example, the operation from the checkpoint *Reading Level*, accessibility level AAA, belonging to the guideline *Readable* and grouped under the principle *Understandable*, means that if the content is of higher educational level (higher than secondary education level), then an additional content of the secondary education level must be provided.

4 Conclusions

The standard ISO/IEC 40500 has been consolidated through the recommendations of WCAG 2.0 and is the base of the Web technology both in terms of content and user interface.

All in all, the analysis has shown that 27 success criteria out of the total of 61 refer to Web content while the rest are related to the user interface and navigability.

The standards ISO/IEC 40500 and ISO/IEC 24751 are presented as complementary. On the one hand the first one defines a set of recommendations for developing accessible Web content, and on the other hand, the second specifies the implementation procedure to be followed in order to meet these recommendations.

The ISO/IEC 24751 standard is presented as a starting point for an accessible e-learning; however, it needs a restructuring that simplifies and makes it more efficient and aligned with reality.

Interoperability is particularly relevant in the process in two ways, from the viewpoint of requirements of assistive technologies which are external to the system and from the viewpoint of the process of searching for the right resource by the communication between the different subsystems.

The shortage of adapted LOs becomes the biggest challenge to be taken up by institutions and governments in coming years because it paralyses the whole process.

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