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## Considerations on Barriers to Effective E-learning toward Accessible Virtual Campuses

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Additional information is available at the end of the chapter

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### Abstract

Nowadays, the implementation of virtual campuses is a reality, both in academic settings and in the workplace. However, there are several challenges associated with the implementation of effective learning outcomes via e-learning. In this chapter in particular, the use of e-learning to reach students with disabilities and the barriers that they may have will be presented. In this sense, e-learning solutions adopted by several institutions are encouraged to validate and promote accessibility in a virtual campus. A large myriad of research related to accessibility in distance education systems is available in literature, and the most relevant studies and standards are presented in this chapter as a starting point for education institutions looking at improving the accessibility in their own virtual campuses. This work is intended to be relevant both to teachers and lecturers who use e-learning for their courses, and to those involved in the design, setup, and maintenance of e-learning systems, whether from a pedagogical or technical perspective to take into account the accessibility for students with disabilities. This work will explore on the accessibility of the basic stone of the e-learning process, the learning objects. An analysis of the IMS AfA v3.0 specification will be presented as a starting point to develop an accessible and adaptable online course, based on the student's preferences, within an accessible virtual campus.

**Keywords:** accessibility, learning objects, adaptability, disability, e-inclusion

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## 1. Introduction

A virtual campus is an environment based on a web technology that provides facilities for the development, management, and publication of content that contributes to the process of teaching and learning. The process of teaching and learning enhanced by technology is

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commonly known as e-learning. The virtual campus is the fundamental element on which a virtual education project is based. If it is an accessible virtual campus, it must be ensured that all functionality can be used by any user, including users with disabilities.

There are several challenges associated with the implementation of effective learning outcomes via e-learning within a virtual campus. In this chapter in particular, the considerations on the use of e-learning to reach students with disabilities and the barriers [1–5] that they may have will be analyzed, providing the basic knowledge to prepare an accessible virtual campus.

This chapter is structured as follows: A state of the art on accessibility related to virtual campuses, highlighting studies related to the application of accessibility standards to improve the e-learning systems is presented in the first section. The first section explores on the main accessibility requirements for an e-learning campus. Then a review on the basic knowledge that the stakeholders involved in e-learning education should have in order to preserve and promote accessibility is presented. In particular, the authors propose an evaluation guideline on accessibility for virtual campus administrators. Finally, the considerations on the accessibility requirements of learning objects (LOs) are presented using the IMS Access for all v3.0 specification, the main objective of which is to simplify the definition of the accessibility metadata for learning objects and the preferences and needs of the users of these objects tracing them to students' related disabilities.

## 2. State of the art on accessibility related to virtual campuses

A virtual campus is an environment based on a web technology that provides facilities for the development, management, and publication of content that contribute to the process of teaching and learning. In this work, a virtual campus will be also referred as e-learning system and learning management system (LMS). In terms on legislation related to students with disabilities in e-learning, Edmonds [6] explored the different laws available and highlights the legal and technical concerns for education institutions. International legislation in terms of technological evolution related to e-learning is reflected on the Convention on the Rights of Persons with Disabilities (CRPD) in Article 9 (points 2.g and 2.h) [7]. The CRPD highlights the importance of promoting access to information and communications technology (ICT) for people with disabilities (PWD) and specially producing accessible content in early stages at minimum costs. Related to education, the (CRPD) in Article 24 recognizes the right to education. Countries that signed the CRPD must make sure that students with disabilities are able to get access not only to general education but also to tertiary education, vocational training, adult education, and lifelong learning without discrimination and on an equal basis with others.

In terms of accessibility, the International Organization for Standardization (ISO) defines accessibility as “the usability of a product, service, environment or facility by people with the widest range of capabilities” [8]. The World Wide Web Consortium (W3C), the organization in charge of developing web standards, created the Web Accessibility Initiative (WAI) with the aim of studying the problems of accessibility and propose solutions. One of its most known

results is the Web Content Accessibility Guidelines (WCAG) 2.0 that establishes four principles that give the foundation of web accessibility: web content must be perceivable, understandable, operable, and robust [8].

In terms on learning objects accessibility, it is important to take into consideration the standard ISO/IEC 24751 [9–11] to describe the process of using an accessible online educational system, which takes into account the needs and preferences of the student and contains accessibility metadata of the learning objects. This chapter will explore also on the metadata for the learning objects using the IMS Access for All v3.0 specification [12], the main objective of which is to simplify the definition of the accessibility metadata for learning objects and the preferences and needs of the users of these objects.

## **2.1. General requirements for accessibility of learning management systems (LMS)**

Learning management systems (LMS) are mainly based on web technologies through a client–server model, with an interface prepared to work base on HTML markup and presented in a web browser. For this type of systems, accessibility requirements should be followed, especially guidelines provided by the Web Accessibility Initiative (WAI) [13] part of the World Wide Web Consortium (W3C). These guidelines are summarized as follows:

- Authoring Tool Accessibility Guidelines (ATAG) [14]—guidelines intended to software used to create web sites and content
- User Agent Accessibility Guidelines (UAAG) [15]—addresses web browsers and media players, and especially related to assistive technologies interaction
- Web Content Accessibility Guidelines (WCAG) [8]—guidelines intended to improve information on a web site, including text, images, videos, etc.
- Accessible Rich Internet Applications (WAI-ARIA) [16]—defines a way to make dynamic web content and web applications based on new interactive technologies as Ajax, HTML5 more accessible

## **2.2. Accessibility requirements for content and user interfaces**

Learning management systems (LMS) work with web technology, so their user interfaces can be evaluated based on the basic principles for creating accessible web content as presented in WCAG 2.0. The universality of these guidelines is evidenced by the fact that it was approved in 2012 as an international standard: ISO/IEC DIS 40500 [8]. WCAG 2.0 identifies twelve guidelines and numerous compliance criteria (“*success criteria*”). WCAG 2.0 is based around four main principles, which provide the necessary basis for anyone to access and use a system. The four principles are described as follows:

- Perceivable: This principle is related to how information and user interface components must be presentable to users in ways they can perceive without limitations. This means that users must be able to perceive the content and information available in a web, the information presented in any part of the web must be visible to all of their senses.

- **Operable:** This principle is based on the fact that user interface components and navigation through a web must be operable. This is important so that users must be able to operate the interface, avoiding to ask the user some interaction that she cannot perform.
- **Understandable:** This means that users must be able to understand the information as well as the operation of the user interface without more details provided.
- **Robust:** Content presented in a web must be really robust, in a way that it can be interpreted easily by a wide variety of user agents, especially software and hardware prepared as assistive technologies. This means in other words that users must be able to access the content independently as technologies advance and evolve.

Under each of the four principles, there is a list of guidelines that address the principle. There are a total of 12 guidelines. One of the key objectives of the guidelines is to ensure that content is directly accessible to as many people as possible. There are success criteria related to each guideline, which describe specifically what must be achieved in order to conform to the WCAG 2.0 standard [8]. Each success criterion is written as a statement that will be either true or false when specific web content is tested against it. Table 1 presents the 12-guideline part of the standard.

Principles	Guidelines
Perceivable	1.1 Provide text alternatives for any non-text content so that it can be changed into other forms people need, such as large print, Braille, speech or simpler language. 1.2 Provide alternatives for time-based media. 1.3 Create content that can be presented in different ways (for example, simpler layout) without losing information or structure. 1.4 Make it easier for users to see and hear content, including separating foreground from background.
Operable	2.1 Make all functionality available from a keyboard. 2.2 Provide users enough time to read and use content. 2.3 Do not design content in a way that is known to cause seizures. 2.4 Provide ways to help users navigate, find content, and determine where they are.
Understandable	3.1 Make text content readable and understandable. 3.2 Make web pages appear and operate in predictable ways. 3.3 Help users avoid and correct mistakes.
Robust	4.1 Maximize compatibility with current and future user agents, including assistive technologies.

**Table 1.** Accessibility guidelines for web content WCAG 2.0

The group of principles, guidelines, and success criteria based on WCAG 2.0 [8] are applicable to any web pages and digital content. In the case of e-learning systems (e.g., LMS), these systems are a group of web pages and educational digital content so WCAG 2.0 can be applied to each element. As a summary, the following six basic accessibility principles should be included in every e-learning system [17]:

1. Allow users to customize their portal based on their preferences.
2. Provide equivalents to every time-based media and visual elements.
3. Use different ways to present information in an interface.
4. Provide information appropriate compatible with assistive technologies.
5. Allow access to all functionalities via keyboard.
6. Provide background information and status and location information to the user at all times.

From WCAG 2.0 [8] guidelines and different accessibility related laws, in terms of basic functionality, e-learning systems (learning content management systems) should have the following basic characteristics:

1. Structure
  - a. Absence of markup code errors in pages (HTML, CSS)
  - b. Setting of accessibility preferences as default configuration, available for user personalization
  - c. Accessibility check for content creators (HTML editors) and images selectors (e.g., alternative texts for each image)
  - d. Summary of last activity within the system
2. Keyboard navigation
  - a. Definition of a logical order to display tab indicators, provide a visual place mark to identify where the user is in a particular moment
  - b. Provide links to jump to main content
  - c. Functionality to simplify configuration to minimize secondary content pages and menus
  - d. Functionality to select options using a simple combination of keys
  - e. Provide complete access to all functionality via keyword, including HTML editors, controls in multimedia viewers, and Web 2.0 functionalities (e.g., Drag and drop")
  - f. Enable keyboard shortcuts (hotkeys) and provide a definition page with all combinations
  - g. Provide a complete sitemap structure for navigation in all systems
  - h. If a key is pressed by mistake, provide the ability to undo and return to previous state
3. Magnification of screen size and functionality to change colors contrast
  - a. Provide a standard design of the interface through all systems in order to find similar functionality on all tools



- b. Provide integration for assistive technologies
  - c. Provide a selector to change style sheets for user personalization
  - d. Avoid the communication of system information based on colors (e.g., buttons with a specific color and meaning)
  - e. Provide the ability to change user preferences to change font size and style
  - f. Maximize compatibility with assistive technologies
  - g. Compliance-oriented design to improve interoperability with assistive technologies
  - h. Consistent and unique design of headings, links, buttons and images description
  - i. Provide descriptive forms including support for errors correction. Identification of the location of the users when filling a form
  - j. Minimal use of frames, appropriate use of title in frames, provide adoption of ARIA standard attributes and navigational marks ("role landmarks"), structural tags, and alerts
4. Multimedia (audio) functionalities

### 2.3. Accessibility requirements for content authoring tools

Authoring tools are software and services included in e-learning systems (LMS), used for teachers and students to produce web content as educational material. Authoring tools related to LMS include desktop applications, multimedia authoring tools, and mainly HTML editors (e.g., what-you-see-is-what-you-get WYSIWIG editors). These tools should follow the Authoring Tool Accessibility Guidelines (ATAG) 2.0 [14].

The Authoring Tool Accessibility Guidelines (ATAG) explain to developers how to make and adapt the authoring tools to be accessible so that people with disabilities can access and create educational content. The guidelines explain how to help authors (teachers and students) to create more accessible web content (learning material) with inline validators, forms with hints and reminders.

Accessibility, from the perspective of authoring tools, is related to content creators and then for final users (especially people with disabilities). Thus, ATAG [14] is divided into two parts, each reflecting a key aspect of accessibility with respect to authoring tools. Part A "Make the authoring tool user interface accessible" relates to the accessibility of authoring tool user interfaces to authors with disabilities. Part B "Support the production of accessible content" relates to support by authoring tools for the creation, by any author (teachers and students, not just those with disabilities), of web content that is more accessible to end users with disabilities.

Besides general authoring tools, which are referred by ATAG, it is important to keep in mind that in the field of e-Learning, educational resources are usually packaged in containers for interoperability and reusability. Following ATAG [14] recommendations, tools used to prepare educational containers should take into account the accessibility requirements.

The format most commonly used is Sharable Content Object Reference Model (SCORM). This is a set of standards and specifications for creating structured teaching objects [18]. With SCORM, it is possible to create content that can be imported into different learning management systems providing SCORM compatibility. Based on the original definition of SCORM (ADL) [18], it is important to mention the six motivations of the standards: accessibility, adaptability, affordability, durability, interoperability, and reusability. In this chapter, Section 4 will elaborate on two aspects: accessibility and adaptability for the learning objects, building blocks for this standard.

#### **2.4. Accessibility requirements for multimedia tools**

The users of an e-learning campus use different tools as media players, web browsers, and assistive technologies to be part of the educational process. These tools are known as user agents. The User Agent Accessibility Guidelines (UAAG) [15] explain how to make user agents accessible to people with disabilities, particularly to increase accessibility to web content, a basic building block for educational material in a virtual campus. As described in the working draft of UAAG Guidelines, in addition to helping developers of browsers and media players, UAAG 2.0 benefits developers of assistive technologies because it explains what types of information and control an assistive technology may expect from a user agent that follows UAAG 2.0. Assistive technologies not addressed directly by UAAG 2.0 [15] (e.g., Braille rendering) are still essential to ensuring web access for some users with disabilities.

UAAG is organized in guidelines, principles, and success criteria elements. There are five principles: “perceivable, operable, understandable, programmatic access, and specification and conventions.” Following the principles, there are 27 guidelines [15].

#### **2.5. Accessibility requirements of dynamic content and rich user interfaces**

Nowadays, web applications, in our work the case of virtual campuses based on learning management systems, are increasingly using more advanced and complex user interface controls such as tree controls for site navigation, drag-and-drop functionality, or technologies developed with Ajax or DHTML. To prevent accessibility issues, the Web Accessibility Initiative (WAI) [13] proposed a recommendation called “Accessible Rich Internet Applications,” usually known as WAI-ARIA [16]. This suite of recommendations defines a way to make web content and web applications more accessible to people with disabilities. It especially helps with dynamic content and advanced user interface controls developed with Ajax, HTML, JavaScript, and related technologies.

More specifically, WAI-ARIA provides a framework for adding attributes to identify features for user interaction, giving hints on how they relate to each other, and their current state. The WAI-ARIA framework [16] identifies innovative navigation techniques to mark regions and common web structures as menus, primary content, secondary content, banner information, and other types of web structures. As a working example for developers, with WAI-ARIA, it is possible to identify regions of pages and enable keyboard users to easily move among regions rather than having to press the tab key many times.



WAI-ARIA also includes technologies to map controls, Ajax live regions, and events to accessibility application programming interfaces (APIs), including custom controls used for rich Internet applications. WAI-ARIA [16] techniques apply to widgets such as buttons, drop-down lists, calendar functions, tree controls (for example, expandable menus), and others usually available in virtual campuses so it is important that LMS administrators.

### **3. Knowledge required for users related to an accessible virtual campus**

Once a virtual campus reaches an acceptable level of accessibility, this accessibility must be constantly maintained. The content and learning material published by the teachers and administrators will be periodically updated, and it is important to teach stakeholders on how to create and adapt learning content to be accessible following most used guidelines. Among the actions to be carried out periodically to maintain accessibility in a virtual campus are the following:

- Training for teachers and students in techniques for creating accessible digital contents
- Training for teachers in Universal Learning Design techniques
- Providing in the virtual campus the functionality of online accessibility checkers when final users work with basic actions such as uploading images and alternative text, providing context information for links, validating information in content editors, etc.

#### **3.1. Techniques for creating accessible documents**

It is important to take into consideration that when digital content is created by teachers or students in any type of format (textual, graphic, audio, or multimedia), it is necessary to keep in mind that final users of such content may be people with physical, sensory, or cognitive limitations, who could find barriers to access the information. In fact, at some point in our lives, we all probably will have limitations that can affect our access to digital content. Among the difficulties that teachers are facing when preparing learning content in digital format is the diversity of authoring tools available to create the content. In [19], a collection of the basic considerations to create accessible digital content are presented and for diversity, the Accessible Digital Office Document (ADOD) initiative [20] prepared different recommendations based on the content creator used.

The Accessible Digital Office Documents (ADOD) Project [20] is an initiative created to provide guidelines on the accessibility of office documents, office document formats, and office applications independent of the tool used to create the content. ADOD provides both an “ADOD Assessment Framework” and a suite of practical guidance documents that are intended to help stakeholders in the educational process to make decisions about office applications. Currently, ADOD is based primarily on the WCAG and ATAG recommendations presented in Section 2.

The recommendations provided for office tools are also applicable to PDF documents. Among the recommendations to create accessible PDF documents with learning content, based on WCAG 2.0 guidelines [21], are the following:

1. Check that all nontext elements should include alternative text.
2. Check for background color and foreground contrast.
3. Specify the text language in all documents to help assistive technologies.
4. Check if hyperlinks are correctly formatted and functional.
5. Provide labeling of elements and correct use of styles.
6. Provide alternative texts and contextual information for hyperlinks.
7. Provide information for abbreviations and acronyms.
8. Check for language changes in the text if more than one language is used.
9. Identify decorative elements in headers and footers.
10. Add markers (bookmarks) that allow the user to jump to a specific part of the document.
11. Verify that the default reading order, according to the structure of tags, makes sense and is consistent.
12. Check for the proper security settings, avoiding sharing a document with password.
13. If the PDF contains an image from a scanned document, an OCR process has to be prepared to provide the text as background alternative for assistive technologies.
14. In case the PDF contains a form, the fields properties should have a detailed description to help the user to fill in the requested information.

Besides the ADOD project and the recent book [19], other initiatives and guidelines for creating electronic documents accessible are found in [22–24].

As an alternative, authors can export a document in DAISY format, which is a good way to ensure that a document is accessible. DAISY is a multimedia format that maintains and promotes a system of Access to standard printed documents for blind, low vision or other problems. The format was developed by the DAISY consortium in 1996 and is currently based on the definition of ANSI/NISO Z39.86-2005 standard [25].

The text content can be exported in DAISY format with plug-ins for Word processors as Microsoft Office Word and LibreOffice Writer. This format can be tested with a DAISY complaint software, for example, the AMIS software (<http://www.daisy.org/amis>). Exporting content to DAISY [25] format allows authors to check the accessibility of a document to a person with vision problems because the software prepares an audio book based on the content.

Administrators for a virtual campus based on learning management systems (LMS) should not assume that the users (e.g., teacher, instructor, tutor, student, etc.) have all the knowledge concerning WCAG guidelines or principles of Universal Learning Design. It is important to

incorporate and provide descriptive aid in the different interfaces and provide validators to allow users to know whether the content is accessible based on the minimal requirements established by the educational institution.

Examples of basic functionality to be included to help final users creating contents are as follows:

- Basic code validator (HTML) included in WYSIWYG content editors usually used in application for discussion forums, wikis, information box, etc. (e.g., AChecker plug-in ([www.achecker.ca](http://www.achecker.ca)) for ATutor LMS)
- Validator for images and alternative text aids for users editing content
- Validator for accessibility in equation writer editors

### 3.2. Automatic analysis using validation tools

The evaluation of the accessibility of a virtual campus and its contents is performed in two main phases.

1. Automatic analysis with validation tools
2. Manual analysis/heuristic evaluation by experts and end users

The first phase is proposed to use an online automatic validator based on the WCAG guidelines. Some of the identified tools available online are as follows:

- Examiner (based on WCAG 2.0 guidelines) ([www.examinator.ws](http://www.examinator.ws))
- AChecker (based on WCAG 2.0, HTML y CSS) ([www.achecker.ca](http://www.achecker.ca))
- TAW (based on WCAG 2.0) ([www.tawdis.net](http://www.tawdis.net))
- CynthiaSays (based on WCAG 2.0) ([www.cynthia-says.com](http://www.cynthia-says.com))
- Tingtun (based on WCAG 2.0) ([accessibility.tingtun.no](http://accessibility.tingtun.no))
- HERA (based on WCAG 1.0) ([www.sidar.com/hera](http://www.sidar.com/hera))
- WebAim (Web Accessibility Evaluation Tool) (<http://wave.webaim.org>)
- HTML validator (<http://validator.w3.org/>)
- CSS validator (<http://jigsaw.w3.org/css-validator/>)

The assessment of accessibility should identify a simple of pages related to the main actions from users within the virtual campus. The main actions to be evaluated are as follows:

1. Start using the virtual campus.
  - a. Visit the homepage of the educational institution.
  - b. Visit the accessibility information for the educational institution.
  - c. Pages that the user needs to visit to reach the virtual campus login pages.

- d. Registration, enrollment, and log into the virtual campus.
  - e. Change the personal settings and preferences for the user.
  - f. Follow the steps to visit a course page.
2. Use basic functionality for students.
- a. Find and review content within a course, including multimedia content.
  - b. Contribute to course content assigned to the student (wiki tool or upload a file form).
  - c. Find, check, and submit and assessment.
  - d. Find a questionnaire, read the instructions, answer all questions, and send the completed questionnaire (quiz).
  - e. Find and check the gradebook.
  - f. Read news and announcements published by the teacher.
  - g. Find, publish, and interact in a course blog.
  - h. Find the discussion forums application and be part of a conversation.
3. Use basic functionality for teachers.
- a. Create and publish content in a course page.
  - b. Create content on the course with conditional availability (hide and enable content).
  - c. Create a task assignment.
  - d. Create a questionnaire with different types of questions.
  - e. Reorganize and sort items in the course menu.
  - f. Copy items from one section of the course to another section.
  - g. Login and manage the student gradebook.
  - h. Evaluate and comment a student assignment.

The pages included in the virtual campus (dynamic content and login required pages) usually cannot be verified easily by automatic analysis tools. To perform this analysis, it is possible to use installed tools as plug-ins (e.g., WAVE tool) or download the pages to be evaluated as static content.

The second phase of the evaluation is the heuristic evaluation by experts and end users. Automatic validation tools offer a partial view on the accessibility, but it is important to have a group of accessibility experts and final users with disabilities to test the main functions and have a contrasted opinion and recommendations to improve the accessibility of the virtual campus.

## 4. Requirements to create accessible learning objects

Learning objects (LOs) are the minimum unit in which educational content is organized so that it can be easily published for a better understanding. One of the most popular definitions of LO is that offered by Wiley “as any digital resource that can be reused to support learning” [26].

The main goal of an LO is their reuse in more than one training activity. To do this, it is necessary that the LO can be found in a simple manner. To achieve this, we need to describe the LO's characteristics, including their metadata, which are a set of fields that provide information about the LO such as, for example, its title, its description, the language in which it is written, or its scope. There are some specifications and standards commonly used to define the LO metadata for their correct description. The most popular are Dublin Core [27] and LOM [28].

LOs, besides regular metadata, must have associated accessibility metadata that describe their accessibility characteristics and that make them accessible to all people. These metadata are the fields used for searching accessible LOs.

Repositories are used to store LOs and to facilitate their search and therefore their reuse. Search operations are performed based on their metadata, hence the importance of clearly and correctly describing the resources, which provides more precise searches. One of the most known repositories is Merlot [29], which have an interesting advanced search function.

When users need to perform a training activity, they use these repositories to find the learning objects that better adapt to that training, thus drawing up a new course from the learning objects found in the repository or repositories to they can access.

Metadata should be inserted in an XML (extensible markup language) file [30], composed of each of the fields (each field corresponds to a metadata) described following one of the standards published for this purpose, such as, for example, learning object metadata (LOM) [28]. This work is provided by metadata editors such as, for example, LomPad, known for being one of the most used [31].

As shown in Figure 1, the LomPad editor allows completing the LOM metadata fields. Once all data have been inserted, an XML file containing all information is generated.

The process for sharing content and distributing it among different information systems is to pack it in a compressed file composed of the content and metadata that describe it. In this scope, there are two specifications widely used, such as Sharable Content Object Reference Model (SCORM) [18] and IMS Common Cartridge [32]. Just as there are editors to help content authors to describe the metadata, there are also editors that help to pack this content along with metadata. One of the most known editors is Reload Editor [33].

Reload not only allows packing content based on SCORM specification but also allows to describe resources with metadata (analogously to LomPad) and to organize the sequencing of these resources.

The screenshot shows the LomPad editor window titled "LomPad - intro\_java\_lom.xml". The interface includes a menu bar (File, Language, Profiles, Help) and a tabbed interface for the IEEE LOM profile. The "1 - General" tab is active, displaying various metadata fields:

- 1.1 - Identifier:** Catalog URI and Entry <http://www.cursos.es/introjava/>
- 1.2 - Title:** Introducción a Java
- 1.3 - Language:** es
- 1.4 - Description:** Two entries are shown: "Curso de introducción al lenguaje de programación Java." (language: es) and "Introductory course in Java programming language." (language: en).
- 1.5 - Keyword:** Two entries: "Java" (language: es) and "programación" (language: es).
- 1.6 - Coverage:** Universal (language: es)
- 1.7 - Structure:** collection
- 1.8 - Aggregation level:** 2

Figure 1. LomPad editor.

#### 4.1. IMS Access for All (AfA) V3.0

IMS AfA v3.0 specification [12] is a way to add accessible metadata to a learning object. Using this, we can describe what is the best sensory form to access the learning object. The specification is created with the aim of simplifying the ISO/IEC 24751 standard [9–11] due to the difficulties encountered when putting it into practice. Both standard and specification in version 3.0 cover the entire process from reading the user needs to the search mechanism needed to find the LO that meets those needs or preferences. The main objectives of IMS AfA v3.0 specification are as follows [12]:

- Being simple and easy to understand
- Facilitating its modification to suit the needs of the organizations requiring some parts of the model
- Facilitating integration with other metadata and specifications
- Allowing integration with devices' properties standards for accessibility
- Allowing integration with user agents, accessibility APIs, and productivity-oriented accessibility standards



- Allowing inclusion in accessibility frameworks and tools

It has two metadata models to describe the following:

- Personal needs and preferences (PNP): description model of the users' needs and preferences to access and interact with the digital resources
- Digital resource description (DRD): description model of the accessibility metadata for the digital training resources

With the AfA DRD, the accessible metadata of the learning objects are described and with the AfA PNP the students can provide their personal needs (or those due to disability environments). The goal is to find the learning objects that best match user needs and preferences in an automated way, solving the metadata similarities between PNP and DRD.

#### 4.1.1. Digital resource description (DRD)

AfA DRD defines the accessibility metadata of a resource that will be used for searching and using the most adequate learning resource to each user according to his or her PNPs.

The adaptation of a learning object occurs when we produce one with the same training content but with a different form of access. To achieve this, two types of LOs must exist: original and adapted. An original resource corresponds to a primary resource, while an adapted resource presents the same educational information than the original resource, for example, a PDF format file as the original resource and an audio description of its content as an adapted resource. The first one presents textual access, while the adaptation presents auditory access to the same educational content.

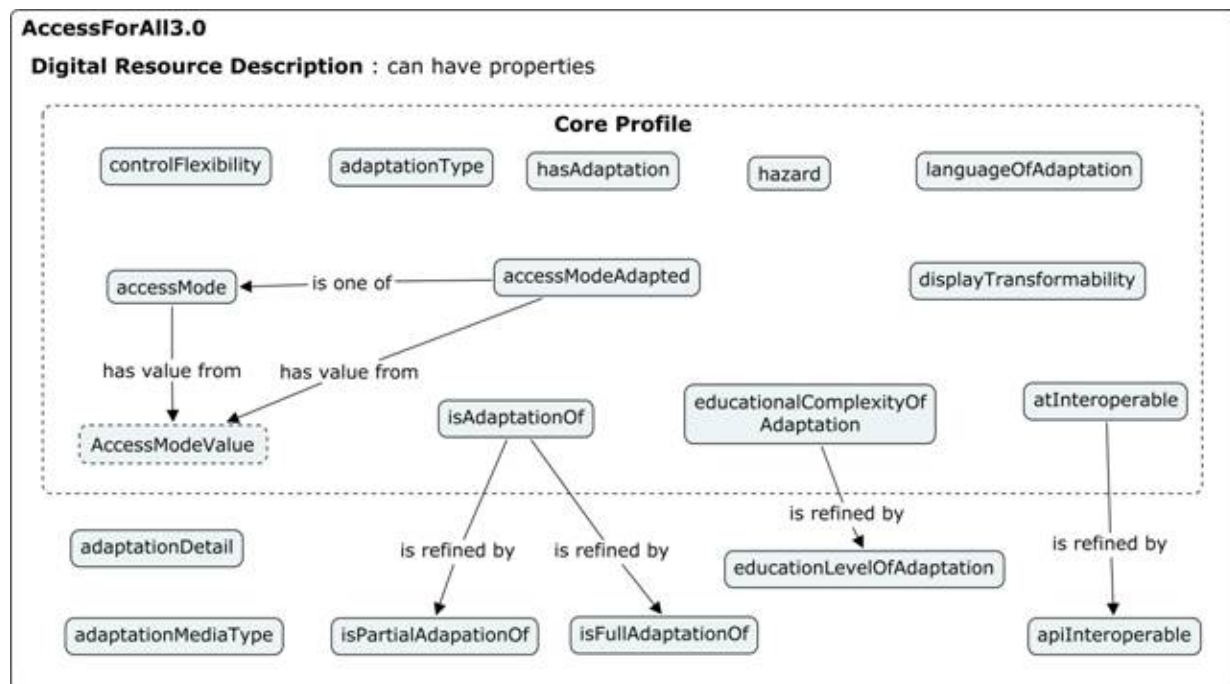
Original resources may have any number of adaptations, which may be total or partial, i.e., or they are adaptations of the whole educational content or they are just a part of this.

Figure 2 shows the accessibility properties or metadata of a resource and how they relate to each other, as IMS AfA v3.0 specification presents them. As seen in the figure, in order to simplify as much as possible the data model, the metadata have been organized in two clearly distinguished levels:

1. Those belonging to a basic core (Core Profile), containing the most important metadata, necessary for a proper description of the resource
2. Those belonging to the full specification, which extent and complement the basic core information

#### 4.1.2. Personal needs and preferences (PNP)

The specification shows a common information model to define and describe the student's or user's PNPs with a different sensory perception mode or who is in a disability context. The user's PNPs may be environmental (for example, "in the dark"), may be related to the communications technology or the available and specific information services (for example,



**Figure 2.** Digital resource description (DRD) properties.

“when a Braille device is available”), or may relate to social situations (for example, “when my nurse is present”) or other scenarios.

The recommended method to generate the student’s PNPs is the presentation of a form with various options (like aforementioned or preferred sensory mode). The PNPs will be generated from students’ responses to these questions.

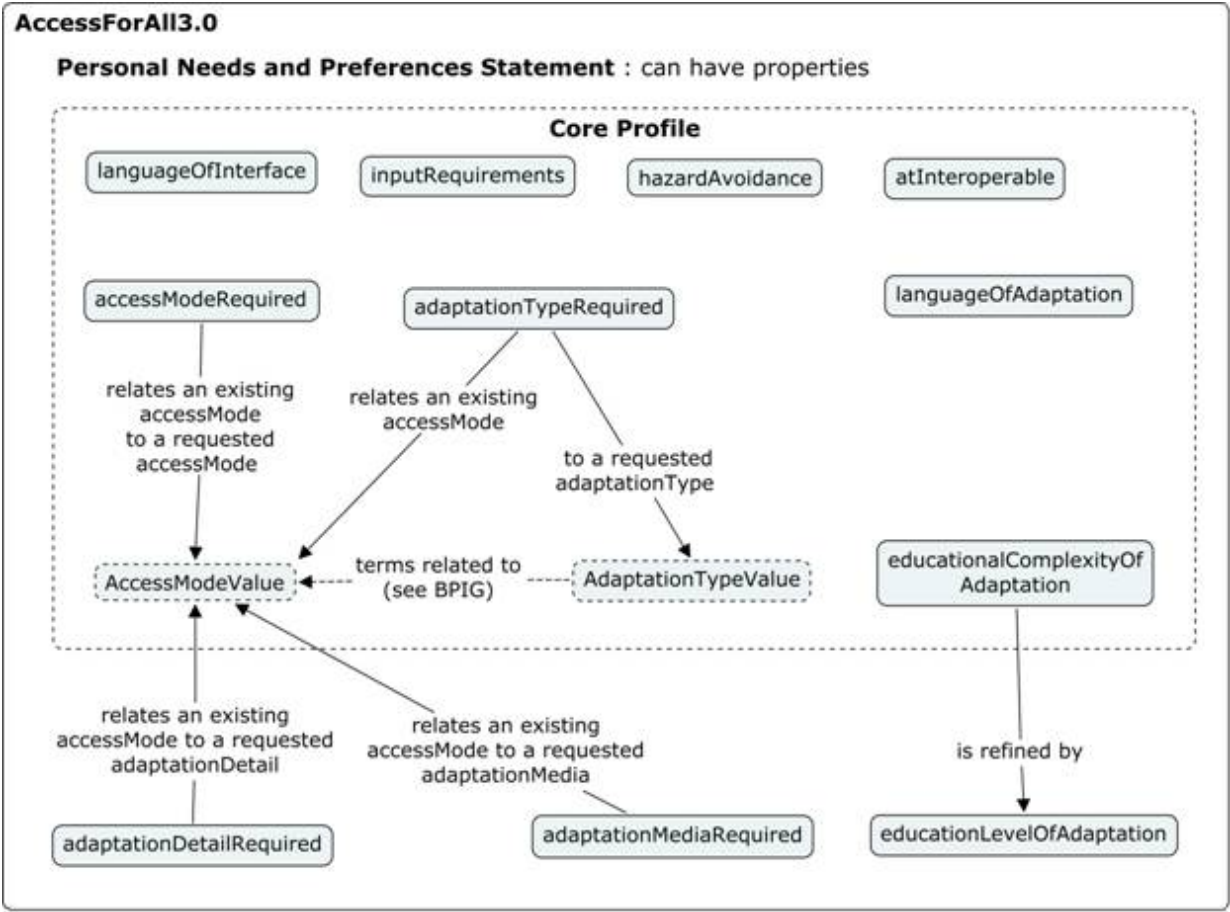
The declaration of PNPs is associated to one person. In turn, one person can generate several sets of PNPs for being used in the environment he or she is at each moment (for example, in the dark or in a noisy area). Like any software application, user’s PNPs should be easily modified by editing the user profile and by allowing its extension, replacement, or removal.

Figure 3 shows the user’s accessibility properties and how they relate to each other. In the same manner as specification AfA DRD, there are properties belonging to the basic profile (Core Profile) and those belonging to the full specification.

## 4.2. Application scenario

In this section, a scenario of use of IMS AfA v3.0 specification [12] is described in addition to other e-learning specifications and standards previously explained, describing all stages for getting an accessible learning object.

First, a content author plans to carry out a learning resource that contains a video tutorial (original resource) of an educational course. An alternative content (adapted resource) is created to provide access to this resource to the students with disabilities (especially those with



**Figure 3.** Personal needs and preferences (PNP) properties.

visual problems). This resource consists of an audio description (audio file that describes the images containing meaningful information).

The content author uses LomPad [31] or Reload [33] to describe the LOM metadata of the video tutorial, thus describing the educational material so that it can be located and reused in different training activities.

Then it is necessary to include the accessibility metadata of the original resource; thus, the type of sensorial perception is described, which is needed to understand the training content. As this is a video, both the visual and the auditory senses are needed. For inserting the accessibility metadata by following IMS AfA specification, the author can use LomPad-AfA tool [34], as shown in Figure 4, whose ultimate goal is to generate the XML file, as shown in Figure 5. LomPad-AfA allows the content authors and the learning platform users to insert accessibility metadata of LOs (DRDs) and students' PNPs, respectively, generating both XML format files. This tool allows to complete the properties of DRDs and PNPs graphically and to generate the corresponding XML file following the IMS AfA v3.0 specification.

In the XML file generated, which is shown in Figure 5, it is described that the original resource has two access modes: visual and auditory. It has one adaptation: OR\_1\_A1, and it can be controlled using the keyboard and mouse.

The following step will be creating the description for the adapted resource, which contains the audio description. Using LomPad-AfA, the accessibility metadata are filled and the XML file is generated (Figure 6).

The screenshot displays the LomPad-AfA application window. The title bar reads 'LomPad-AfA'. The menu bar includes 'File', 'Language', 'Profiles', and 'Help'. Below the menu bar, the profile is identified as 'Profile : AfA v3.0 - DRD'. A series of tabs at the top represent different profiles: '1 - Gen', '2 - Lif', '3 - Met', '4 - Tec', '5 - Edu', '6 - Rig', '7 - Rel', '8 - Ann', '9 - Cla', '10 - DRD' (which is the active profile), and '11 - PN'. The main area of the window is divided into sections for each profile element. Each section has a red square icon indicating it is part of the 'Core profile'. The sections are: '10.1 - accessMode' with a dropdown set to 'textual'; '10.2 - accessModeAdapted' with two dropdowns, 'visual' and 'auditory'; '10.3 - adaptationType' with a dropdown set to 'longDescription'; '10.4 - hasAdaptation' with an empty text field; '10.5 - hazard' with an empty dropdown; '10.6 - languageOfAdaptation' with a dropdown set to 'en'; '10.7 - controlFlexibility' with two dropdowns, 'fullKeyboardControl' and 'fullMouseControl'; '10.8 - displayTransformability' with an empty dropdown; '10.9 - educationalComplexityOfAdaptation' with an empty dropdown; and '10.10 - educationalLevelOfAdaptation' with an empty text field. A legend at the bottom left shows a red square for 'Core profile' and a green square for 'Full profile'. The '10.10' section is marked with a green square, indicating it is part of the 'Full profile'.

**Figure 4.** Original resource's DRD XML (afadrdv3p0\_OR\_1.xml).



In the XML file generated, which is shown in Figure 6, it is described that the adapted resource has an auditory access mode, and it adapts a visual one. More details about the type of adaptation are given through property “adaptation type,” and it is specified that it is an audio description. It has full control by keyboard and mouse. It is an adaptation of the original resource OR\_1, and it is a partial adaptation. Finally, it states that the audio is recorded using a human voice.

Once the resources are created and the metadata are defined in their corresponding XML files, a package containing all information and following SCORM specification will be created. As shown in Figure 7, the SCORM package will be composed of two resources (the original and the adaptation) and their metadata files. The original resource will have associated two metadata files, one with its LOM metadata and another one with the IMS AfA metadata. Adapted resource only needs the IMS AfA metadata since the adapted resource contains the same learning information as the original.

```
<?xml version="1.0" encoding="UTF-8"?>
- <accessForAllResource xsi:schemaLocation="http://www.imsglobal.org/xsd/accessibility/afadrdv3p0/imsafav3p0drd_v1p0
  imsafav3p0drd_v1p0.xsd" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns="http://www.imsglobal.org/xsd/accessibility/afadrdv3p0/imsafav3p0drd_v1p0">
  <accessMode>afaterms-visual</accessMode>
  <accessMode>afaterms-auditory</accessMode>
  <hasAdaptation>OR_1_A1</hasAdaptation>
  <controlFlexibility>afaterms-fullKeyboardControl</controlFlexibility>
  <controlFlexibility>afaterms-fullMouseControl</controlFlexibility>
</accessForAllResource>
```

Figure 5. Adapted resource's A1 DRD XML (afadrdv3p0\_OR\_1\_A1.xml).

```
<?xml version="1.0" encoding="UTF-8"?>
- <accessForAllResource xsi:schemaLocation="http://www.imsglobal.org/xsd/accessibility/afadrdv3p0/imsafav3p0drd_v1p0
  imsafav3p0drd_v1p0.xsd" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns="http://www.imsglobal.org/xsd/accessibility/afadrdv3p0/imsafav3p0drd_v1p0">
  <accessMode>afaterms-auditory</accessMode>
  <accessModeAdapted>afaterms-visual</accessModeAdapted>
  <adaptationType>afaterms-audioDescription</adaptationType>
  <languageOfAdaptation>en</languageOfAdaptation>
  <controlFlexibility>afaterms-fullKeyboardControl</controlFlexibility>
  <controlFlexibility>afaterms-fullMouseControl</controlFlexibility>
  <isAdaptationOf>OR_1</isAdaptationOf>
  <isPartialAdaptationOf>OR_1</isPartialAdaptationOf>
  <adaptationDetail>afaterms-recorded</adaptationDetail>
</accessForAllResource>
```

Figure 6. LomPad-AfA resource DRD properties.

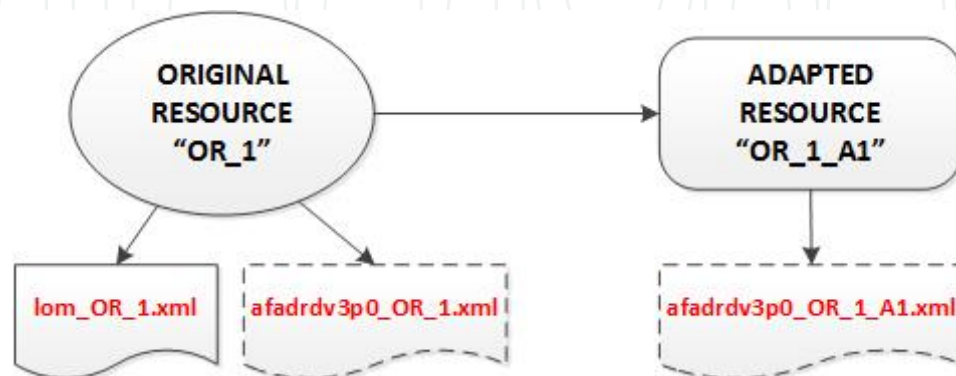


Figure 7. LomPad-AfA user PNP properties.

Furthermore, LomPad-AfA tool allows generating XML files containing the users' PNPs. For example, if a blind person or a person with visual problem wants to describe his or her preferences, he or she has to fill the metadata, as shown in Figure 8, and generate the XML file, as shown in Figure 9.

LomPad-AfA

File Language Profiles Help

Profile : AfA v3.0 - PNP

1 - Gen 2 - Lif 3 - Met 4 - Tec 5 - Edu 6 - Rig 7 - Rel 8 - Ann 9 - Cla 10 - DR 11 - PNP

11.1 - accessModeRequired

11.1.1 - existingAccessMode

visual

11.1.2 - adaptationRequest

textual

11.2 - adaptationTypeRequired

11.2.1 - existingAccessMode

visual

11.2.2 - adaptationRequest

longDescription

11.3 - hazardAvoidance

11.4 - atInteroperable

11.5 - languageOfAdaptation

en

11.6 - languageOfInterface

en

11.7 - inputRequirements

11.8 - educationalComplexityOfAdaptation

Legend : ■ Core profile ■ Full profile

**Figure 8.** SCORM content.

In the XML file generated, as shown in Figure 9, it is described that, for visual content, the user prefers adapted resources that have an auditory or textual access mode. By means of property “adaptation type required,” more details about the type of desired adaptation for visual



```

<?xml version="1.0" encoding="UTF-8"?>
- <accessForAllUser xsi:schemaLocation="http://www.imsglobal.org/xsd/accessibility/afapnpv3p0/imsafa3p0pnp_v1p0
imsafa3p0pnp_v1p0.xsd" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns="http://www.imsglobal.org/xsd/accessibility/afapnpv3p0/imsafa3p0pnp_v1p0">
- <accessModeRequired>
  <existingAccessMode>afaterms-visual</existingAccessMode>
  <adaptationRequest>afaterms-textual</adaptationRequest>
</accessModeRequired>
- <accessModeRequired>
  <existingAccessMode>afaterms-visual</existingAccessMode>
  <adaptationRequest>afaterms-auditory</adaptationRequest>
</accessModeRequired>
- <adaptationTypeRequired>
  <existingAccessMode>afaterms-visual</existingAccessMode>
  <adaptationRequest>afaterms-audioDescription</adaptationRequest>
</adaptationTypeRequired>
- <adaptationTypeRequired>
  <existingAccessMode>afaterms-visual</existingAccessMode>
  <adaptationRequest>afaterms-longDescription</adaptationRequest>
</adaptationTypeRequired>
<languageOfAdaptation>en</languageOfAdaptation>
<languageOfInterface>en</languageOfInterface>
- <adaptationDetailRequired>
  <existingAccessMode>afaterms-visual</existingAccessMode>
  <adaptationRequest>afaterms-enhanced</adaptationRequest>
</adaptationDetailRequired>
</accessForAllUser>

```

Figure 9. User PNP XML (afapnpv3p0\_USR1.xml).

content are given, and it is specified that they should contain audio description or long description. A learning system (educational platform, learning object repository, etc.) that is able to understand the PNP defined above and whose user is interested in learning the educational resource of the video tutorial, which represents the original resource, should show the adaptations that are associated with it.

## 5. Conclusions

The accessibility of a virtual campus should be ensured at two levels: (1) the accessibility of the learning management system (LMS) that supports the campus and (2) the accessibility of the learning materials published on the platform. A virtual campus with an LMS platform that meets the criteria under different guidelines as described in WCAG 2.0 will be accessible, but when new content is published, the accessibility could be lost, and students with disabilities could face barriers to achieve the learning objectives. Thus, it is important to maintain a continuous process of training for stakeholders involved in the virtual campus.

The main principles that an accessible virtual campus should provide are as follows: (1) allow users to customize their portal based on their preferences, (2) provide equivalents to every time-based media and visual elements, (3) use different ways to present information in an interface, (4) provide information appropriate compatible with assistive technologies, (5) allow access to all functionalities via keyboard, and (6) provide background information and status and location information to the user at all times.

Training for users of virtual campus, publishing learning content is an ongoing process that should primarily include the following components: (1) training teachers and students in

techniques for creating accessible documents, (2) training teachers on universal learning design techniques, and (3) training LMS administrators to maintain the accessibility and configure the LMS to provide validators of accessibility in content editors, to ease the process of learning objects publication.

IMS AfA v3.0 specification presents to the content authors and developers the technical way to follow for achieving an accessible online teaching. According to ISO/IEC 24751-2-3 standard and IMS AfA v3.0 specification, the basic steps in developing an accessible online course are as follows: creating accessible learning objects (LOs), both original and adapted, by means of inserting the accessibility metadata; reading the users' personal needs and preferences (PNP); and searching and presentation of LOs meeting those PNPs.

For an LO that can be used in an educational platform, it is necessary to pack all files shaping the LO with the files containing its metadata, including the accessibility ones, and following the standards established. There is a great lack of technical applications and human resources to provide assistance in developing accessible resources.

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