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Model for Profiling Users With Disabilities on e-Learning Platforms

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ABSTRACT There are millions of people worldwide using e-Learning platforms. However, people with disabilities still have problems using these platforms due to a lack of accessibility. In the present study, a model for the generation of the profiles of users with disabilities is proposed. This model enables e-Learning platforms to have information on users' accessibility needs as input for automated adaptation of its interfaces. This would enable equal access for all learners with and without disabilities. In this context, different studies related to the profiling of users on e-Learning platforms were identified and analyzed. The model presented considers the Web Content Accessibility Guidelines (WCAG) that can be implemented in the interfaces of the e-Learning platforms and the metadata that represent the accessibility needs of users based on Schema.org. The researchers used Unified Modelling Language diagrams to design the model and define a description of the interaction between users, user interfaces, WCAG, Schema.org., and the eXtensible Markup Language (XML) profile generated. The testing of the prototype was carried out using WAVE and ARC Toolkit. The validation with the support of forty-four users was conducted using the System Usability Scale (SUS). The most outstanding results of this study are the identification of WCAG success criteria that are automatically implementable, the inclusion of two special categories for combined accessibility needs related to the elderly and linguistics, and the automatic generation of the profile as an XML file containing the metadata needed to enable the adaptation of e-Learning platform interfaces.

INDEX TERMS Web accessibility, WCAG, e-learning accessibility profiling, student profiling, Schema.org, disabilities, accessibility needs.

I. INTRODUCTION

Due to an increase in the use of the Internet, the Web has become one of the most important elements in several aspects of everyday life, such as health, education, work, commerce, and entertainment. Inclusive education aims to ensure equal access to education and professional training for vulnerable people, including people with disabilities, to guarantee this right without discrimination and based on equal opportunities [1].

The general concept of web accessibility is "…Web accessibility means that websites, tools, and technologies are designed and developed so that people with disabilities can use them" [2]. In the last decades, there has been growing attention towards web accessibility [3]. This has forced web developers to address the accessibility needs of a wide variety of users. Therefore, web accessibility is an essential requirement when developing applications for the web environment, including in the context of learning [2], [3].

As can be seen, all content found on the Web must be accessible. Therefore, any software solution must consider accessibility aspects in all the stages of the software development life cycle.

Currently, there are millions of people conducting studies using e-Learning platforms, this is a trend that has been aggravated by the global health crisis caused by the COVID-19 virus pandemic that, since March 2020, has forced students from all over the world to switch to an emerging online mode. For example, around a third of the users enrolled in a Massive Open Online Course (MOOC) platform corresponds to students who joined in 2020 [4].

MOOC are e-Learning platforms for academic and professional training that are popular due to their massive character and open access. For an e-Learning platform to be considered

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an effective learning tool, it must consider the abilities of each of its students, their learning objectives, the devices they use, and the learning environment. In this context, the accessibility needs of the students, identified through the generation of a profile, are important characteristics to consider in these platforms.

For developing countries, MOOCs can offer important educational opportunities, allowing students to learn at their place and benefiting people with disabilities by improving their level of employability and social inclusion [5]. MOOCs are cataloged as "…an evolution of e-Learning towards a new scenario based on computers and mobile devices together with social technologies that lead to the appearance of new types of learning" [6]. Nevertheless, current e-Learning platforms do not consider the creation of user profiles. Most of the published studies do not address the accessibility needs of users, on the contrary, they focus on improving the accessibility of platform resources and, in some cases, considering the technical characteristics of the hardware and software of the devices [7].

Web accessibility means that users with disabilities will be able to make better use of web applications. The problems regarding web accessibility can be overcome by using the guidelines such as the Web Content Accessibility Guidelines WCAG [2].

In this context, this study proposes a model that contributes to improving the situation concerning the lack of profiling of students with disabilities within e-Learning platforms. The output of the proposed model is an XML file that contains the necessary metadata so that e-Learning platforms can adapt their interfaces and match profiled educational resources with the needs of students with disabilities.

The rest of this study is organized as follows: Section II presents the theoretical background, Section III summarizes the related work, Section IV presents the research method, Section V includes the results and discussion. Finally, Section VI presents conclusions and future work.

II. THEORETICAL BACKGROUND

In this section, the theoretical concepts used in this study are presented, including the description of WCAG and the metadata of Schema.org as the building blocks for the proposed model. The metadata includes the vocabulary subset for accessibility and the alternative metaformats.

A. WEB CONTENT ACCESSIBILITY GUIDELINES

The Web Accessibility Initiative, created by the World Wide Web Consortium (W3C), oversees the existence of Web accessibility, for which it has developed and published technical specifications, guidelines, techniques, and resources. Specifically, the WCAG explains what needs to be done to make web content accessible to people with disabilities [8].

In 2008, W3C published WCAG 2.0. In late 2020, a WCAG 2.2 version was published which contains new guidelines and eighteen additional success criteria that improve accessibility for three groups of users: those with learning disabilities, low vision, and disabilities in terms of mobile devices [9], [10]. Levels of compliance are established according to the user's needs, where A is the lowest level, AA the intermediate level, and AAA is the highest level of compliance [8]. The WCAG 2.2 version makes use of the same compliance model as the WCAG 2.0 version. This allows compatibility among websites that comply with the WCAG 2.0, 2.1, and 2.2 versions. Also, the Accessibility Guidelines Working Group is developing another version in parallel, following a user-centered and research-focused methodology to produce a more effective and flexible outcome [10]. This new version - WCAG 3.0 - was released in January 2021, in the form of an editor's draft. However, WCAG 3.0 "…is not backwards compatible with WCAG 2.x. WCAG 3.0 does not supersede WCAG 2.2 and previous versions; rather, it is an alternative set of guidelines" [11].

The goal of organizations and individuals around the world is to create a single standard for web content accessibility that benefits individuals, organizations, and governments internationally. Thanks to the WCAG, they can make websites and web applications accessible to people with disabilities, including those with "…blindness and low vision, deafness and hearing loss, learning disabilities, cognitive limitations, limited movement, speech disabilities, photosensitivity, and combinations of these" [8].

Nevertheless, the WCAG also has some drawbacks: even content that conforms to AAA may not be sufficient to ensure accessibility for people who have several types, degrees, or combinations of disabilities; and are difficult to apply to websites or web applications that contain thousands of pages or that are constantly updated with new content because human participation is required to test and verify compliance with various criteria [12].

B. METADATA SCHEMA

A relevant aspect of online educational systems is the availability of a description of the resources and services offered to users. The tendency is to write this information using metadata [13]. Metadata are defined as data about data, but the term is typically understood as referring to structured data about resources that can be used to help support a wide range of operations [14]. The implementation of an appropriate metadata scheme will allow the efficient management of educational resources in terms of search, reuse, interoperability, and accessibility. This last point is a key feature in promoting inclusive education and professional training in e-Learning environments where there is a great diversity in terms of the students' needs concerning accessibility [15]. If the educational resource has been described using accessibility metadata, and the student has a profile of their personal accessibility needs, the platform can identify the most appropriate educational resources for the student, allowing them to access these resources easily [16], [17].

In e-Learning platforms such as MOOC, the education of students with disabilities can be greatly facilitated. However, educational resources must be made available in accessible formats, and metadata mechanisms must be in place to identify resources that are both accessible and appropriate.

The metaformats schema allows enrichment of the information about web content so that the search engines or the e-Learning platforms can classify and show the content in terms of the accessibility characteristics needed by the user. Once defined, metadata can be shared and reused. Metadata sets designed for a specific purpose - also known as metadata schemas - help a resource to be described by a specific type of information; the values provided to metadata elements are its content. Terms may come from a specific controlled vocabulary, or there may also be syntax rules about the coding of the elements and their content.

To locate and identify web pages and resources on the web, the Dublin Core Metadata Initiative (DCMI) was proposed, which had its beginnings in 1995. DCMI is one of the first initiatives to consider the definition of a vocabulary for the description of metadata [18]. In mid-2000, the Friend of a Friend (FOAF) vocabulary emerged, which is used to define metadata about people, their interests, their relationships, and their activities. With FOAF each person can have a profile with their personal information [19].

In 2004, the Access for All Metadata Specification was developed to work on metadata, creating the approach known as the Instructional Management System Access for All (IMS AfA). IMF AfA became the standard ISO/IEC 24751 ''Adaptability and individualized accessibility in e-Learning, education, and training''. The standard ISO/IEC 24751 is divided into three parts [20]:

- Part one is the framework of definitions and rules, allowing a clear definition of the accessibility needs that users may have. Also, the mechanisms of the computer applications that help and guide the user are described.
- Part two is Access for All Personal Needs and Preferences (PNP). This section shows a model for the definition of the needs and preferences of a person.
- Part three is Access for All Digital Resource Description (DRD), whose objective is to facilitate the search for the most suitable resources for the user.

Currently, Schema.org is the most relevant metadata initiative, in that it has integrated four previous initiatives: LRMI Accessibility, IMS AfA v3.0, AMP v6.0, and EPUB v1.0. Schema.org was endorsed by W3C in 2015, and its most recent version was published in 2019. Also, three search engine providers, Google, Yahoo, and Microsoft Bing, and the search company Yandex, have joined this initiative. The key concept of Schema.org is the use of metadata. Schema.org is not specific to educational resources but relates to semantic extraction. Different types of web content are considered to define the accessibility metadata in Schema.org and can be classified using metadata schemes [21].

The accessibility metadata defined by Schema.org are based on those specified for the IMS AfA 3.0 version, which consists of two data models, PNP and DRD. These two models will be considered in this work, especially the first. As its name indicates, the PNP model is based on descriptions of the needs and preferences of users regarding accessing or interacting with resources on the web.

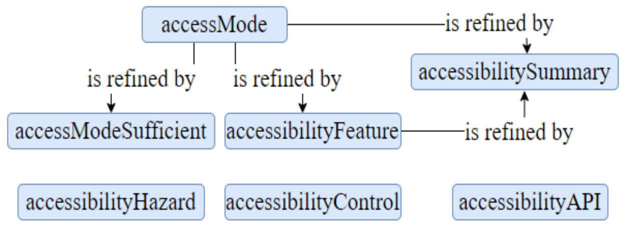

FIGURE 1. Accessibility metadata schema [21].

Each of these metadata models can have possible values that are defined in the specification, with these values being given when the user completes their profile. In this way, it is possible to determine the accessibility and preference characteristics that students reveal through their given profiles [21].

1) VOCABULARY SUBSET FOR ACCESSIBILITY

Metadata schemas help search engines understand the context and meaning of digital objects by organizing content and libraries. Metadata schemas are aggregates of classes. The CreativeWork class is relevant for this study and includes a set of properties that are used to identify accessible qualities of publications such as books, movies, and videos [22]. Figure 1 shows an example of accessibility metadata [21], [22], where:

- ''accessMode'' details sensory ways in which content can be understood. ''accessMode'' is refined by ''accessModeSufficient'', ''accessibilityFeature'', and ''accessibilitySummary''. This allows a consistent maintenance of the accessibility metadata generated by the three characteristics.
- ''accessModeSufficient'' specifies the combination of forms necessary to understand all the content.
- ''accessibilityFeature'' describes more detailed accessibility features (such as including subtitles in a video).
- Also, the general accessibility characteristics ''accessibilityHazard'', ''accessibilityControl'' and ''accessibilityAPI'' are included.

Within Schema.org, there are already established definitions and properties, where values focused on accessibility are considered, and can be reused. Table 1 describes the accessibility metadata for the CreativeWork class proposed by Schema.org [22]. The attributes included in Table 1 are property, description, and values.

The accessibility metadata of the CreativeWork class focuses on the descriptions of digital resources. Also, there is the Person class focused on user metadata [23]. The present study proposes to expand the metadata for the Person type of Schema.org. This extended Person type can include descriptions of accessibility needs of users with disabilities, particularly students accessing e-Learning platforms such as MOOC.

TABLE 1. Accessibility Metadata for CreativeWork [22].

Property	Description	Values
accessMode	The human sensory perceptual system or cognitive faculty through which a person can process or perceive information.	auditory, chartOnVisual, chemOnVisual, colorDependent, diagramOnVisual, mathOnVisual, musicOnVisual, tactile, textOnVisual, textual, visual
accessMode Sufficient	A list of unique or combined accessModes that are sufficient to understand all the intellectual content of a resource.	auditory, tactile, textual, visual
accessibility Summary	A human-readable summary of specific accessibility features or deficiencies, consistent with the other accessibility metadata, but expressing subtleties such as "Short descriptions are present, but long descriptions will be needed for non-visual users" or "Short descriptions are present, no long descriptions are needed".	Legible summary of features and accessibility deficiencies.
accessibility Feature	The content characteristics of the resource, such as accessible multimedia content, supported enhancements for accessibility, and alternatives.	alternativeText, annotations, audioDescription, bookmarks, braille, captions, ChemML, describedMath, displayTransformability, highContrastAudio, highContrastDisplay, index, largePrint, latex, longDescription, MathML, none, printPageNumbers, readingOrder, rubyAnnotations, signLanguage, structuralNavigation, synchronizedAudioText, tableOfContents, taggedPDF, tactileGraphic, tactileObject, timingControl, transcript, ttsMarkup, unlocked
accessibilityHazard	A feature of the described resource that is physiologically dangerous for some users. Related to WCAG 2.0 guideline 2.3. All three negative properties must be established if none of the hazards are known. If the content has danger(s), include positive assertions for the dangers it has and negative statements for others. If the property is not set to positive or negative or is specifically defined as unknown, the status of the hazards is not known.	flashing, noFlashingHazard, motionSimulation, noMotionSimulationHazard, sound, noSoundHazard, unknown
accessibilityControl	Identifies one or more input methods that allow access to all application functionalities.	fullKeyboardControl, fullMouseControl, fullSwitchControl, fullTouchControl, fullVideoControl, fullVoiceControl
accessibilityAPI	Indicates that the resource is compatible with the referenced accessibility Application Program Interface (API).	androidAccessibility, ARIA, ATK, AT-SPI, BlackberryAccessibility, iAccessible2, iOSAccessibility, JavaAccessibility, MacOSXAccessibility, MSAA, UIAutomation

2) METAFORMAT

The metadata can be encoded in a definable syntax such as XML, JSON, or Resource Description Framework (RDF) [24], [25]. These three types of encoding can be used to define the Schema.org vocabulary.

Table 2 shows properties of XML, JSON, and RDF including release year, extension, format type, orientation, based on, structure, and schema archive.

Once the syntax of the three types was analyzed, the researchers selected XML as the most suitable for the proposed model. An XML file allows an efficient storage and transportation of user profiling information to be analyzed by any platforms or systems that support this type of format. Additionally, XML allows the independence of tools or platforms. Due to its structure, XML is the most suitable implementation syntax for this proposal. Specifically, XML will allow the generation of the user profiles.

III. RELATED WORK

Looking for solutions to the lack of models that consider the profiling of users with accessibility needs in e-Learning platforms, a review of the existing scientific literature has been carried out as part of this study. Figure 2 shows the search process.

Search engines of scholarly literature such as IEEEXplore and Google Scholar were used. In the initial search, a total of fifty studies were identified, which were then entered into a selection process. In the selection process, studies published in 2006 or later were considered. In this search, the studies containing the keywords: web accessibility, profiling, and e-Learning were filtered. Once the search strings

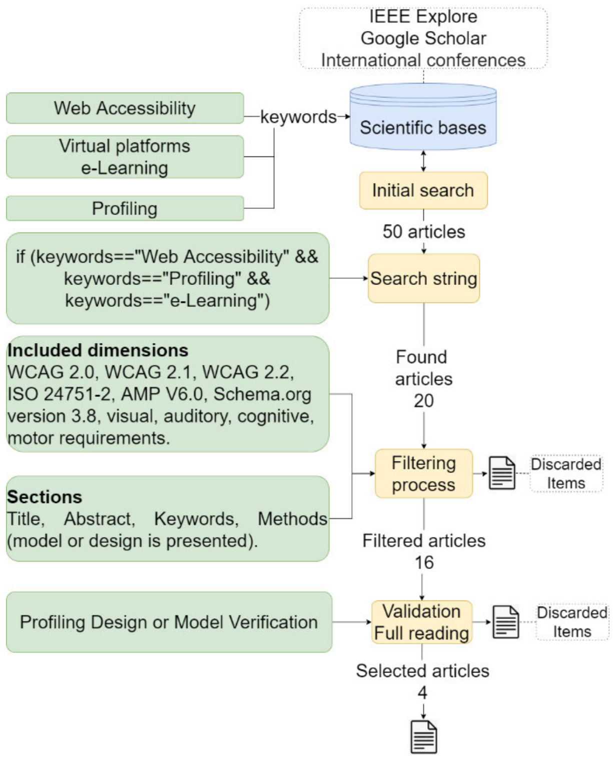

FIGURE 2. Literature review search process.

TABLE 2. Metaformats [24] [25].

Property	XML	JSON	RDF
Release year	1995	2019	2014
Extension	xml	json	rdf
Format type	Markup language	Markup language	Structural interoperability
Orientation	Document-oriented	Data-oriented	Object-oriented
Based on	Tags	{key: value}	XML
Structure	Tree-like levels of depth	Levels of depth (tree structure)	Triplet model
Schema archive	Yes	No	Yes

were applied, twenty studies were found that were entered into a second filtering process. This second process considered the dimensions WCAG 2.0, 2.1, and 2.2 versions, ISO/IEC 24751-2, and Schema.org 3.8 version. Visual, auditory, cognitive, and motor disability requirements were also considered. Elements such as Title, Abstract, Keywords, and Method were reviewed to verify if a model or design had been provided. This second filter resulted in a total of sixteen studies that were read in full text. Subsequently, the studies were categorized into high and medium priority, according to the models or profile designs presented. Finally, the four studies most relevant regarding the proposed model were identified. Those studies consider e-Learning environments, disabilities, accessibility, profiling, and specifications to create profiling models. These four studies are summarized below.

Lancheros-Cuesta and Carrillo-Ramos [26] present a model for virtual learning environments. The model is referred to as the Adaptative Learning System (ALS). ALS considers the profiles of the student, the disability, the device, the context, and the learning style. The ALS model dynamically updates user profiles. However, the study lacks the use of accessibility guidelines and the identification of user needs.

Lancheros-Cuesta and Carrillo-Ramos [27] mention that there are several learning difficulties for students who wish to access virtual education, especially those with disabilities. Therefore, the study [27] analyzes systems and tools that do not characterize students or do not take their accessibility needs into account, which consequently causes students to abandon online courses. The study [27] generates an Adaptive Learning Disability Model System (MDALS) created to mitigate barriers. The model consists of a four-layer architecture: adaptation model, personalized educational services, educational services, and application.

Lancheros-Cuesta *et al.* [28] present Kamachiy-Idukay, an educational services platform adaptable to the needs of users. The platform of [28] considers two actors within the process: teachers and students. The process consists of tests that must be carried out the first time the user enters the platform. If the user has already carried out the tests, they will enter the course with their accessibility needs considered.

Iniesto [29] describes the situations that exist for individual students when using MOOC. The study in [29] mentions that is necessary to use a person-centered planning approach. The study in [29] proposes a combination of approaches that are designed to enable people with disabilities to make their own choices and decisions. The main idea is to facilitate expressions of interest by placing the individual in the planning process and, most importantly, to consider that the student is the true expert regarding their own needs. In this study, a systematic tool called MOOC Accessibility Audit was developed, based on the heuristic evaluation method in terms of person-computer interaction.

Other studies [30]–[32], [34]–[40] are considered important because of the attention they pay to the accessibility needs of e-Learning users or the improvement of the architecture of e-Learning platforms. These are summarized below.

The study [30] is based on the customization of any Open Educational Resource (OER) environment to provide an accessible user experience. To perform the personalization, a user's profile is defined, which includes a disability specification and the user's particular requirements. As part of the study, the Open Educational Resources for All (OERfAll) website is generated, which allows customization of the interface and content thanks to the self-selection of disability options and preferred language. The user selects a disability profile from the profile toolbar offered by OERfAll. The disabilities considered are blindness, deafness, motor skills, low vision, and dyslexia. Additionally, OERfAll has options such as text display, navigation aids, and design, allowing customization for users without disabilities. OERfAll uses a subset of descriptors from the Learning Object Metadata (LOM) specification. One limitation of this study is that a combination of disabilities is not considered.

In another study [31], the authors propose an architectural design that improves the accessibility and usability of an OER Website through a user's disability profile. The components of the design are accessibility, usability, information architecture, personalization of the OER environment, and adaptation of resources; the authors apply WCAG 2.1 and consider control with mouse and keyboard. For usability, the guidelines of the ISO 9241-151 standard are applied. Additionally, the design uses metadata descriptors that come from the LOM specification to identify the resources, and the user profile requirements are defined by using IMS AfA PNP and some attributes from Schema.org. The user selects a disability profile and optionally configures advanced options and language. For the tests, sixteen users with disabilities were considered, who answered a questionnaire. Accessibility based on the selected disability profile had a higher score than the other characteristics surveyed. As for the disadvantages of the design, there is a lack of a definition for elderly users and that the profile data is saved in HTTP cookies, which implies that, if the user uses another device, they will have to choose the characteristics of their profile again.

Camino Fernández *et al.* [32] propose a project aimed to develop a learning program on the use of information technology for the elderly. The University of León created a MOOC in which older people, aged between 60 and 85 years, are taught to use devices with iOS and Android operating systems. For this specific group of people, it is necessary to carry out learning actions that are oriented to their needs and their reality. In this respect, according to the World Health Organization "…between 2000 and 2050, the proportion of the planet's inhabitants over 60 years of age will double, going from 11.0% to 22.0%, this age group will go from 605 million to 2000 million in the course of half a century" [33].

Sanchez-Gordon and Luján-Mora [34] propose a personalized presentation of the content that is delivered to users to improve accessibility and usability. The study [34] proposes a three-layer architecture that allows the Open edX MOOC platform to be expanded, where the users must be able to access any of the available formats, thanks to the use of questionnaires that allow combining users' accessibility needs with automatic adaptations.

The study [35] proposes a design that allows developers to improve the accessibility of MOOC with the use of a user-side component with four layers and an accessible API. The students interact with the first layer where the assistive technology is located, or with the second which is the browser. The two layers must be compatible with the User Agent Accessibility Guidelines. The design allows the content to be adapted to the user's needs, with the support of the Authoring Tool Accessibility Guidelines.

In another study, Sanchez-Gordon and Luján-Mora [36] propose a design that will help students with language problems in online learning platforms. In a survey, 17.5% of the respondents stated that they will not register for a MOOC due to a lack of language proficiency. The design incorporates three actors: non-native speakers, local instructors, and the authors of the MOOC.

Rodriguez-Ascaso *et al.* [37] present an evaluation of users of virtual classrooms about their accessibility needs. One hundred and fifteen participants were surveyed, of whom fifty-three were students and sixty-two were professionals, where the presence of visual, auditory, or physical disabilities could be evidenced. The evaluation carried out was produced to collect evidence of user experience when establishing the different accessibility needs within an e-learning system.

Klemes *et al.* [38] considered people with disabilities who study at a distance, unlike students who attend academic institutions that are oriented towards face-to-face teaching. The study was carried out over two months involving a group of students with attention disorders and dyslexia. Using tests at the end of the modules were possible to identify problems related to the time it takes for them to complete tasks without a computerized environment. It was found that, by using a computerized environment, their learning time was reduced, and their satisfaction improved.

Also, the Flexible Learning for Open Education (FLOE) Project [39] provides open technical tools that allow the creation of personalized digital interfaces. FLOE seeks to incorporate a one-size-fits-all learning design for the total diversity of students, supporting students, educators, and producers. Thanks to the user interface options, students can select and configure their accessibility needs, allowing them to personalize their learning experience. FLOE considers educational materials freely and legally available on the Internet so that they can be reused, revised, mixed, and redistributed by users.

In the same line, the Inclusive Global Public Infrastructure (GPII) [40] seeks to ensure that anyone who faces accessibility barriers can access, use the Internet and all its information, considering their disability, literacy, digital literacy, or aging, regardless of economic resources. To achieve this, GPII finds any solution that contains information on assistive technology. The GPII considers the needs of users to generate automatic personalization of digital interfaces. This infrastructure houses a DeveloperSpace where information can be found. There are around seven hundred and seventy-eight components and tools that allow the development of solutions that consider the accessibility needs and disabilities of users. DeveloperSpace also allows communication with experts or consumers who can help develop a better design. "…The auto-personalization is currently in a build-and-pilot-test phase on personal computers. It is supported by IBM, Microsoft, Adobe Foundation, Consumer Technology Association Foundation, Mozilla, Serotek, and individual contributors, such as FLOE Project. Later, it will extend to mobile and other technologies with digital interfaces" [39].

The studies and initiatives presented above are related to the profiling of users with disabilities in e-Learning platforms. The evaluation performed aimed to determine the

TABLE 3. Comparison of related work and proposal.

Study	Profi-ling	Accessibility guidelines	Consideration of e-Learning environments	Use of Meta-data	Score
[26]	H	N	H	N	10
[27]	H	N	H	N	10
[28]	H	N	H	N	10
[29]	H	N	H	N	10
[30]	H	M	H	N	13
[31]	H	M	H	M	16
[37]	H	M	H	M	16
[38]	L	N	L	N	6
Proposal	H	H	H	H	20

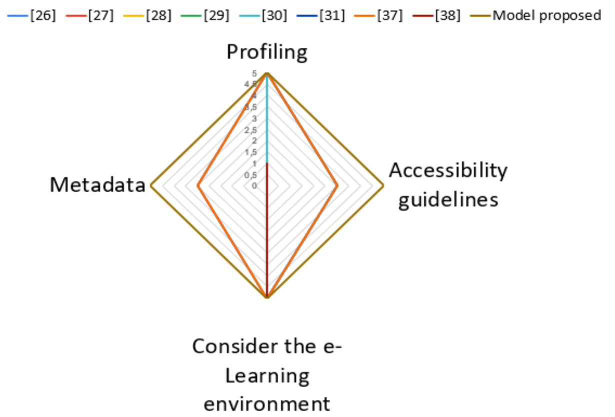

FIGURE 3. Comparison results of related studies.

current state of the problem and obtain inputs for the model proposed in this research.

Table 3 presents a comparison made between the relevant studies and the proposed model. A qualitative scale is considered with four levels (N = None, L = Low, M = Medium, and H = High). Additionally, scores have been assigned to each qualitative characteristic. The values are 0, 1, 3, and 5 respectively, where the maximum total score of 20. The chosen criteria for comparison are profiling, accessibility guidelines, consideration of e-Learning environments, and use of metadata.

Additionally, Figure 3 shows the level of fulfillment of the comparison criteria of the works related to the one carried out in this study. According to the score achieved, the proposed model is the most complete.

IV. METHOD

In this section, the method followed to build the model is presented. Figure 4 shows the following five development phases:

- Phase 1. Studies relating to the profiling of students with disabilities were identified and analyzed.
- Phase 2. A categorization of the disabilities addressed in this study was carried out.
- Phase 3. WCAG 2.2 success criteria were identified as implementable or not by the interfaces on the e-Learning platforms.

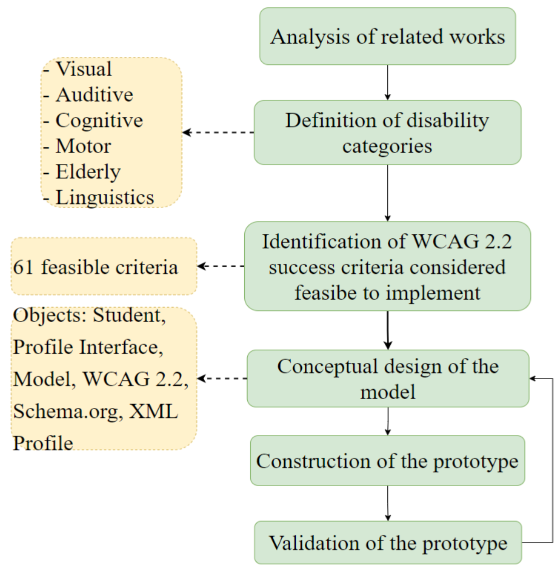

FIGURE 4. Phases of the present study.

- Phase 4. A set of Unified Model Language (UML) diagrams were designed. These diagrams show the interaction and messaging between the components of the model. A sequence diagram was generated for each of the categorized disabilities. Also, a class diagram of the proposed model was designed.
- Phase 5. Finally, the authors proceeded to develop, evaluate, and improve the prototype that implements the model.

A. MODEL DESIGN

The model presents the categorization of disabilities that were considered for the elaboration of the UML diagrams. The categories used are listed below, with their respective disabilities identified within the scope of this study:

- Visual category with its subcategories: low vision, blindness, and color blindness.
- Auditory category with its subcategories: deafness and low hearing.
- Cognitive category with its subcategories: reading difficulties and difficulties in understanding.
- Motor category with its subcategories: insufficient dexterity to operate a keyboard, and insufficient dexterity to operate a mouse.
- Elderly category with a combination of visual, auditory, cognitive, and motor subcategories.
- Finally, the linguistic category with the second language subcategory.

Elderly people are considered users having combined disabilities. There is a global growing trend in terms of users over 65 years of age who access and participate in lifelong learning online [21], [32]. Additionally, in this study, limitations in terms of the language proficiency of students in e-Learning platforms who are non-native speakers are also considered as

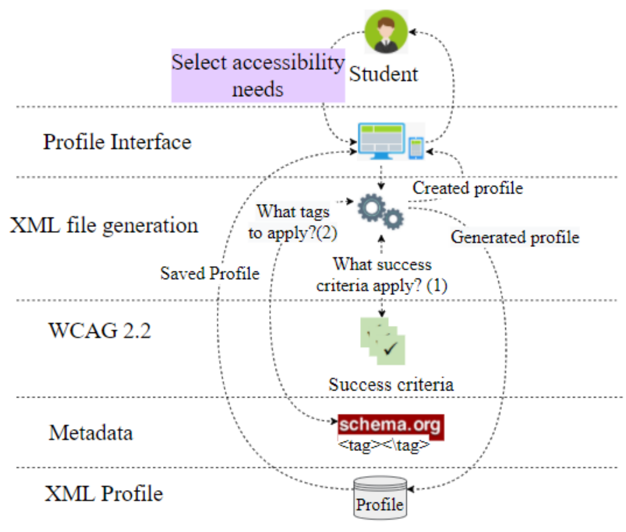

FIGURE 5. Architecture of the proposed model.

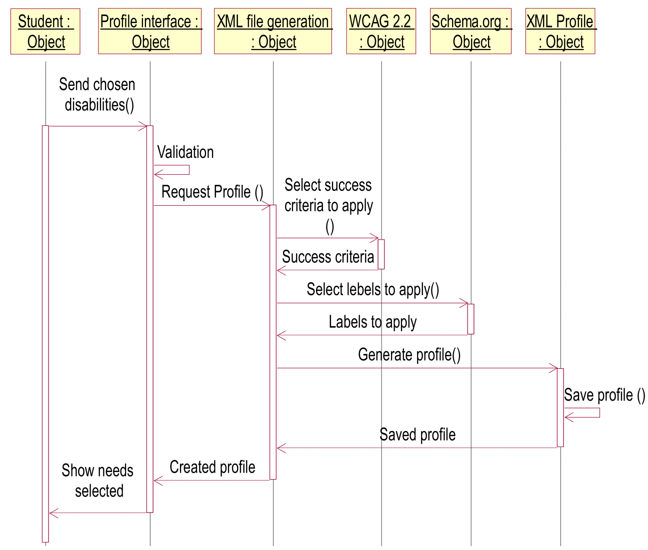

FIGURE 6. Proposed model for profiling users with disabilities.

a disability due to the additional cognitive load of studying in a second language [36].

B. ARCHITECTURE

The architecture of the model to address accessibility in e-Learning platforms using user profiling is depicted in Figure 5. The accessibility needs of users with disabilities are entered through the profile interface. Later, the necessary WCAG 2.2 success criteria and Schema.org labels are selected, and the profile is created. This metadata is stored as an XML file that contains the information necessary for any e-Learning platform to adapt its interfaces and educational resources according to the accessibility needs selected by each user.

1) IMPLEMENTABLE SUCCESS CRITERIA

The detailed design implies the identification of those WCAG 2.2 success criteria feasible to implement, as well as the definition of the interaction of the different objects of the proposed model.

As an example of the identification of implementable success criteria, Table 4 presents the first principle of WCAG 2.2, named Perceivable, with its four guidelines: 1.1 Text Alternatives, 1.2 Time-based Media, 1.3 Adaptable, and 1.4 Distinguishable; each with its success criteria, giving a total of twenty-nine. The Implementable column identifies those success criteria considered to be implementable in the e-Learning platforms. For the Perceivable principle, a total of twenty-four implementable success criteria were identified.

In total, sixty-one implementable success criteria were found within the four WCAG principles. On the other hand, thirty-three success criteria were discarded because those should be implemented by default in e-Learning platforms for the benefit of all users instead of being profiled by each user.

2) GENERAL DESIGN

After identifying the implementable success criteria, the authors elaborated a general UML interaction diagram that visualizes the information and messaging that flows between the components of the model.

Figure 6 shows the interaction of the objects that participate in the creation of the student profile. The schema presents the following objects: student, profile interface, XML file generation, WCAG 2.2, Schema.org, and XML Profile. These objects communicate with each other to generate a file that contains the student's profile metadata, according to the success criteria and correspondent labels assigned, based on the selections made by the student through the profile interface.

3) DESIGN OF COMPONENT INTERACTION

After defining the conceptual design of the model in terms of the interaction of its components, a set of UML sequence diagrams were generated, one for each of the six disability categories identified in this study. The object called XML File Generation receives the success criteria sent from the WCAG 2.2 object and requests the labels from the Schema.org object. Upon receiving the labels, the XML File Generation object sends a request to the XML Profile object to produce the corresponding metadata for the student's profile. The XML Profile object saves the profile and confirms that the student's profile has been created. In turn, the XML File Generation object sends an acknowledgment to the user interface so that the student will be notified that their profile has been saved.

Table 5 shows the WCAG success criteria for the principle Perceivable which can be implemented for the blind and the elderly.

Success criteria identified as implementable are matched to the labels provided by the extended vocabulary of Schema.org. For example, the success criterion "1.1.1 Non-textual content" matches with the label "AlternativeText"

TABLE 4. Success criteria for principle perceivable.

Principle	Guidelines	Success Criteria	Level	Implementable
	1.1 Text Alternatives	1.1.1 Non-textual Content	A	✓
		1.2.1 Audio-only and Video-only (Prerecorded)	A	✓
		1.2.2 Captions (Prerecorded)	A	✓
		1.2.3 Audio Description or Media Alternative (Prerecorded)	A	✓
		1.2.4 Captions (Live)	AA	×
		1.2.5 Audio Description (Prerecorded)	AA	✓
	1.2 Time-based Media	1.2.6 Sign Language (Prerecorded)	AAA	✓
		1.2.7 Extended Audio Description (Prerecorded)	AAA	✓
		1.2.8 Media Alternative (Prerecorded)	AAA	✓
		1.2.9 Audio-only (Live)	AAA	×
		1.2.1 Audio-only and Video-only (Prerecorded)	A	✓
		1.2.2 Captions (Prerecorded)	A	✓
		1.2.3 Audio Description or Media Alternative (Prerecorded)	A	✓
		1.3.1 Info and Relationships	A	✓
		1.3.2 Meaningful Sequence	A	✓
		1.3.3 Sensory Characteristics	A	✓
1. Perceivable	1.3 Adaptable	1.3.4 Orientation	AA	✓
		1.3.5 Identify Input Purpose	AA	✓
		1.3.6 Identify Purpose	AAA	×
		1.3.1 Info and Relationships	A	✓
		1.4.1 Use of Color	A	✓
		1.4.2 Audio Control	A	✓
		1.4.3 Contrast (Minimum)	AA	✓
		1.4.4 Resize text	AA	✓
		1.4.5 Images of Text	AA	✓
		1.4.6 Contrast (Enhanced)	AAA	×
	1.4 Distinguishable	1.4.7 Low or No Background Audio	AAA	✓
		1.4.8 Visual Presentation	AAA	✓
		1.4.9 Images of Text (No Exception)	AAA	✓
		1.4.10 Reflow	AA	✓
		1.4.11 Non-text Contrast	AA	✓
		1.4.12 Text Spacing	AA	✓
		1.4.13 Content on Hover or Focus	AA	×

TABLE 5. Blindness and elderly success criteria- Principle Perceivable.

Blindness	Elderly
1.1.1, 1.2.1, 1.2.5, 1.2.7, 1.2.8, 1.3.1, 1.3.2, 1.3.3, 1.4.11	1.1.1, 1.2.1, 1.2.2, 1.2.5, 1.2.6, 1.2.7, 1.2.8, 1.3.1, 1.3.2, 1.3.3, 1.3.4, 1.3.6, 1.4.1, 1.4.2, 1.4.3, 1.4.4, 1.4.5, 1.4.7, 1.4.8, 1.4.9, 1.4.10, 1.4.11, 1.4.12

of Schema.org. This label is used for the formation of the XML profile. After identifying the success criteria for each disability, all success criteria have been related to Schema.org labels. A similar process was followed for the other WCAG principles.

Figure 7 shows, as an example, the interactions of the different objects within the UML sequence diagram, that was carried out for the elderly disability. Similar diagrams were developed for the other disabilities considered in this study.

Figure 8 shows the UML class diagram that depicts the proposed model. The class diagram includes seven classes.

- Class Person is associated with the Person Schema.org type [22]. Class Person instantiates a user that can be profiled.
- Class Student inherits from Class Person. Class Student instantiates users with disabilities who enter an e-Learning platform and who wish to select their accessibility needs at the time of registration.
- Class Category instantiates the set category of disabilities implemented in the model. In the present study, there are six categories considered: visual, auditive, cognitive, motor, the elderly, and linguistic (users that are non-native speakers). The model is designed to support and incorporate an unlimited number of categories. A student can select one or more disability categories to generate their profile.
- Class Disability instantiates disabilities associated with categories. For example, blindness is part of visual disabilities. In the present study, there are nine disabilities implemented.
- Class SuccessCriteria instantiates the WCAG 2.2 success criteria identified as implementable in the interfaces of the e-Learning platforms.
- Class DisabilityHasSuccessCriteria maps Shema.org labels to implementable success criteria corresponding to the selected disability or disabilities.
- Class XmlProfile instantiates students' profiles in a format that is readable by e-Learning platforms.

V. RESULTS AND DISCUSSION

This section presents an accessible prototype to implement the model in such a way as to overcome the weaknesses of current e-Learning platforms regarding accessibility.

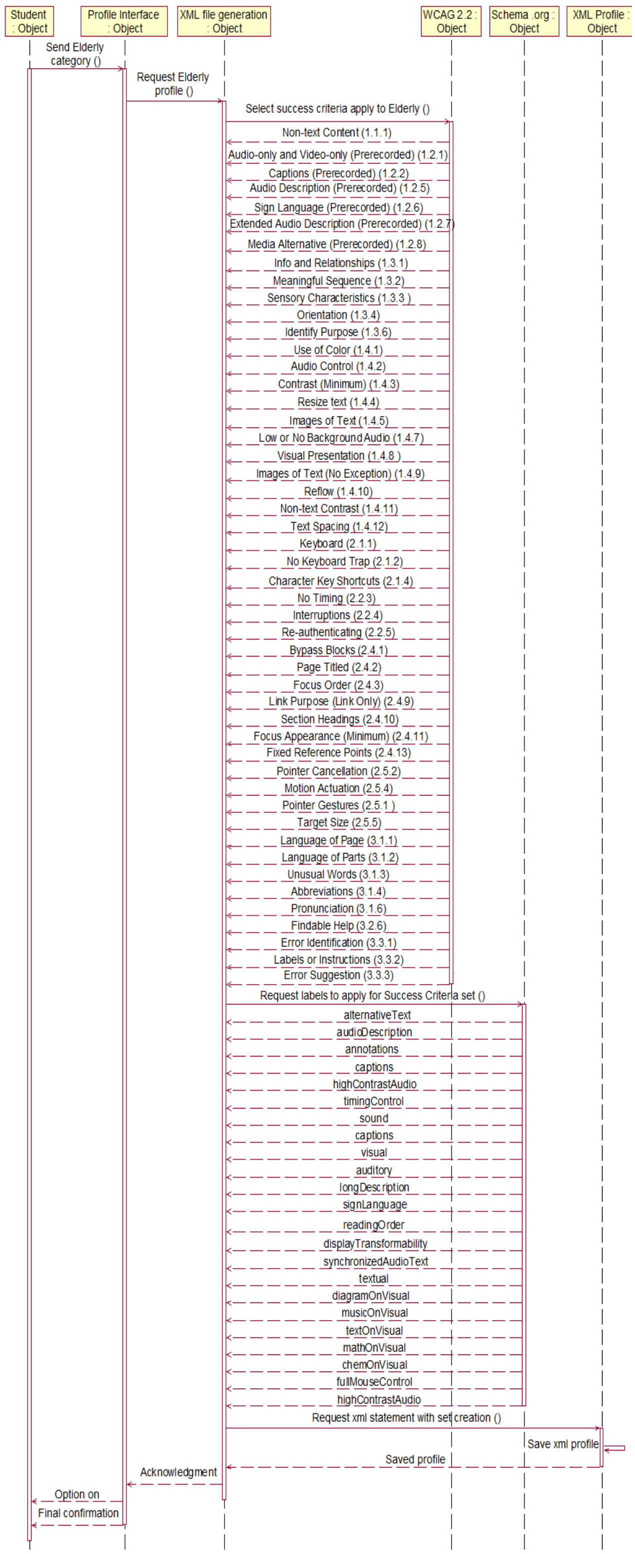

FIGURE 7. UML sequence diagram for the elderly.

The built prototype was subjected to automatic testing and improved accordingly. Additionally, tests with users were conducted to determine the accessibility or navigability limitations of the prototype and make improvements.

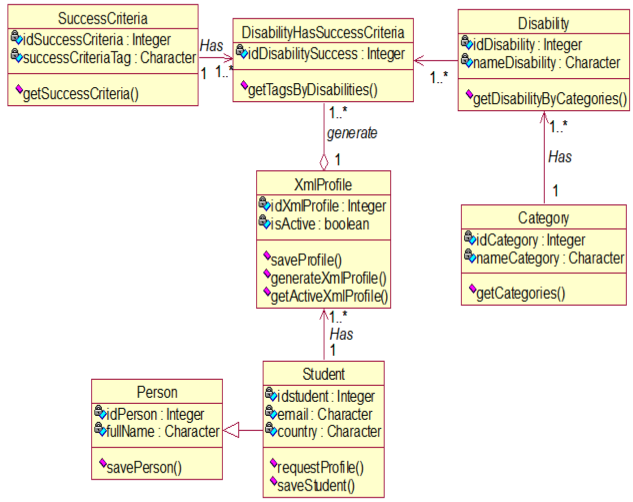

FIGURE 8. UML class diagram.

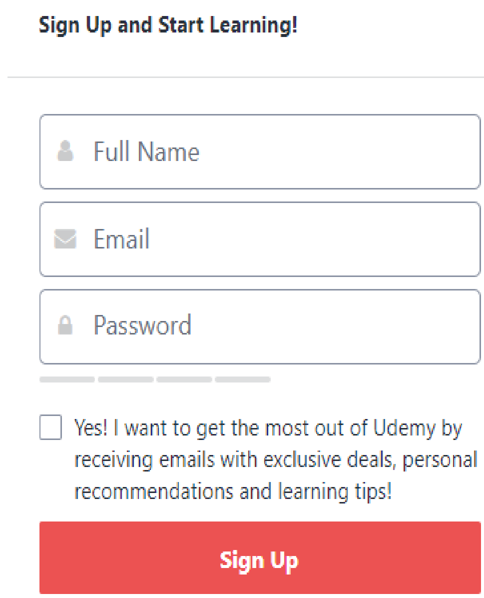

FIGURE 9. Udemy Sign Up interface.

A. ACCESSIBLE PROTOTYPE

Through the accessible prototype created for the proposed model, the student can choose their accessibility needs when registering on an e-Learning platform. Before building the prototype, the user registration interfaces of three well-known MOOC platforms were considered for analysis: Udemy, Coursera, and edX. Figure 9 presents the characteristics of the Sign-Up interface of the Udemy platform, which requests full name, email, and password.

Figure 10 presents the characteristics of the Sign-Up interface of the Coursera platform that, as an alternative to providing full name, email, and password, allows the student to register using Google, Facebook, or Apple.

Figure 11 presents the characteristics of the Create Account interface of the edX platform, which requests email, full name, public username, password, and country; and,

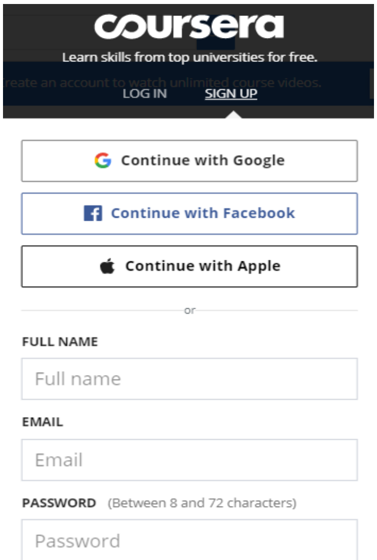

FIGURE 10. Coursera Sign Up interface.

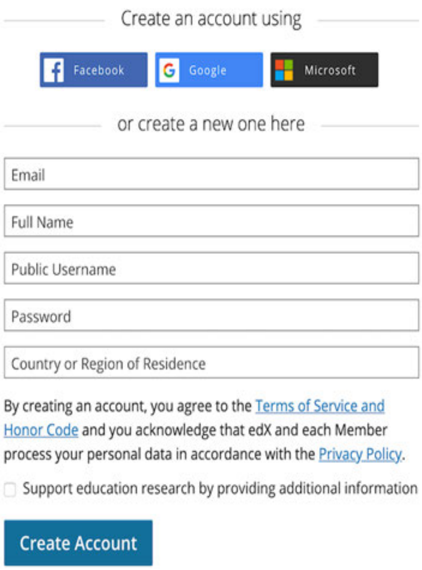

FIGURE 11. edX Create account interface.

alternatively, allows the student to register using Facebook, Google, or Microsoft.

The three platforms have similar characteristics in terms of their Registration interface. However, none of these e-Learning platforms request information regarding accessibility needs. For this reason, this study proposes the incorporation of this request and the generation of the correspondent profile.

The interfaces proposed were developed through a prototyping process. A prototype is "…a concrete representation of part or all of an interactive system. Designers, as well as managers, developers, customers, and end-users, can use these artifacts to envision and to reflect upon the final system" [41]. The Balsamiq tool was used for the initial design of the prototype. Figure 12 shows the main interface "Choose a Category of Accessibility".

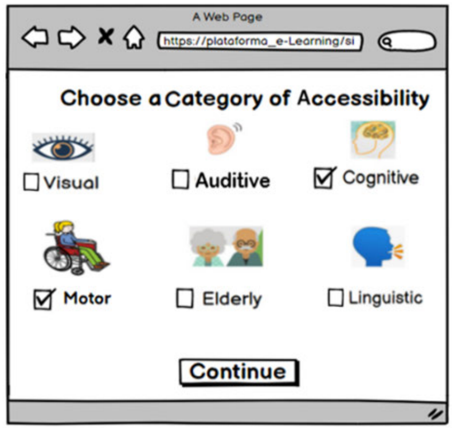

FIGURE 12. Main interface designed in Balsamiq.

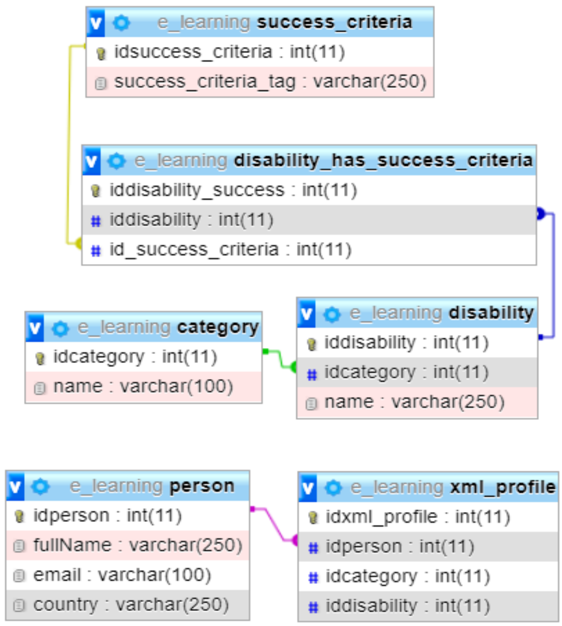

FIGURE 13. Database schema.

The mapping between categories of disabilities and WCAG success criteria necessary to generate the user's profile must be stored in a persistent repository. Therefore, a database schema was generated, as shown in Figure 13.

The database schema includes the following tables:

- Table person contains students' data, such as full name, email, and country.
- Table category stores six categories: visual, auditory, cognitive, motor, the elderly, and linguistic.
- Table disability contains the disabilities considered within the scope of the present study. These disabilities are low vision, blindness, color blindness, diminished hearing, deafness, reading difficulties, second language, insufficient dexterity to operate a mouse, and insufficient dexterity to operate a keyboard.
- Table success_criteria stores the Schema.org labels correspondent to the WCAG success criteria identified as implementable.

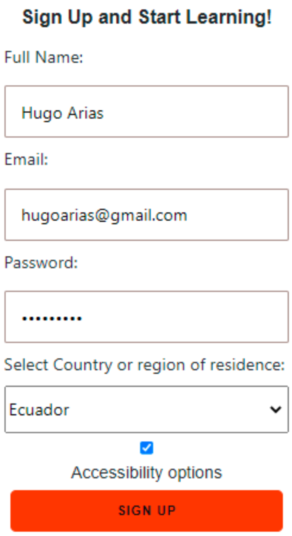

FIGURE 14. Sign Up interface of the accessible prototype.

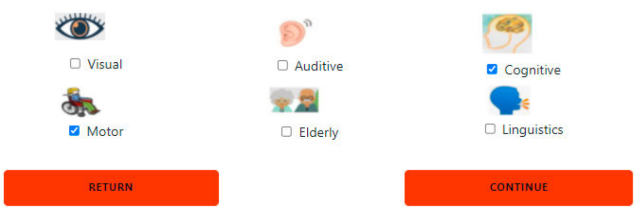

FIGURE 15. Choose accessibility categories interface.

- Table disability_has_success_criteria normalizes the relationship between disabilities and the WCAG success criteria.
- Table xml_profile stores the students' profiles automatically generated according to the chosen disability or disabilities.

The prototype was developed with accessibility characteristics so that students with disabilities do not face barriers when choosing their accessibility options. Figure 14 shows the implemented Sign-Up interface.

The student can select the checkbox with the description "Accessibility options". The next interface is "Choose an accessibility category". The student can select one or more accessibility categories. Figure 15 shows the categories that have been implemented in the prototype.

Figure16 presents the source code of a generated XML file for a user with a combination of motor and cognitive disabilities. The XML file contains the labels corresponding to the accessibility needs according to the categories and disabilities selected by the user, written with Schema.org nomenclature. These needs are set using the "on" feature and should be activated in the interfaces of the adaptive e-Learning platforms.

Figure 17 depicts the interaction of the eLearning platform and the adaptive motor that will process the metadata contained in the XML file with the student accessibility profile.

```
<?xml version="1.0" encoding="UTF-8"?>
<urlset xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"/>
<!--Category: Cognitive--><!--Category: Motor--><!-- 2021/3/10
<AccessibilityPreferences>
<alternativeText>on</alternativeText>
<annotations>on</annotations>
<audioDescription>on</audioDescription>
<captions>on</captions>
<highContrastAudio>on</highContrastAudio>
<longDescription>on</longDescription>
<readingOrder>on</readingOrder>
<syncronizedAudioText>on</syncronizedAudioText>
<timingControl>on</timingControl>
<fullMouseControl>on</fullMouseControl>
</AccessibilityPreferences>
```

FIGURE 16. XML file for a motor and cognitive profile.

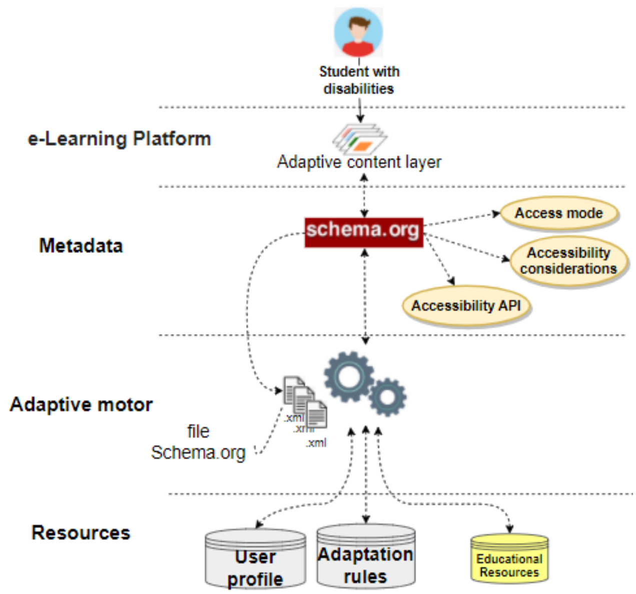

FIGURE 17. Interaction of the eLearning platform and the adaptive motor.

B. EVALUATION

The accessible prototype was subjected to two types of testing, firstly with automated accessibility tools and, secondly, testing with users with and without disabilities.

1) AUTOMATED TESTS

For the implemented prototype, accessibility tests were carried out using the WAVE tool and the ARC Toolkit. These two tools are aligned with WCAG 2.1 and can be installed in browsers using extensions.

WAVE is a web accessibility assessment tool developed by WebAIM.org [42]. WAVE provides visual information on the accessibility of web content by using icons and indicators on the webpage. The analysis is performed entirely within the browser, "allowing secure valuation of intranet, local, password-protected web pages and other sensitive web pages" [42]. For example, Figure 18 shows the WAVE initial results for the "Choose a Category of Accessibility" interface of the implemented prototype.

Table 6 summarizes errors, contrast errors, and alerts identified by WAVE on the "Choose a Category of Accessibility" interface. WAVE found six missing alternative texts, one

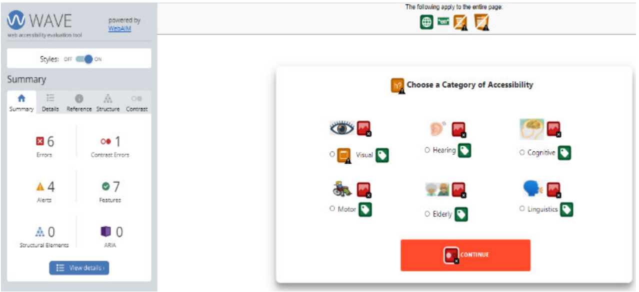

FIGURE 18. WAVE initial results.

TABLE 6. Summary of initial WAVE results.

Type	N°	Description
Errors	6	6 Missing alternative texts.
Contrast Errors	1	1 Very low contrast.
Alerts	4	1 Missing fieldset. 1 No heading structure. 1 No page regions. 1 Possible heading.
TOTAL	11	

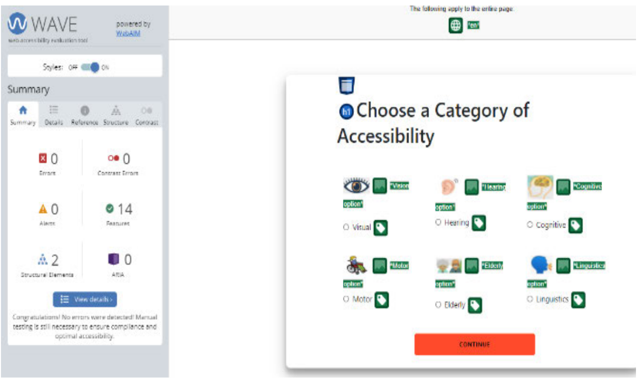

FIGURE 19. WAVE results after improvements.

problem of low color contrast, and four alerts that needed to be checked manually.

The errors identified and recommendations given by WAVE were implemented, and the test was executed again. Figure 19 shows the results of the "Choose a Category of Accessibility" interface.

ARC Toolkit shows the results in a table that includes the number of visible instances, errors, and warnings and then, the same for the hidden elements on the tested page. Figure 20 shows the initial results of the ARC Toolkit concerning the "Choose a Category of Accessibility" interface of the developed prototype.

Table 7 summarizes all the errors and warnings identified by the ARC Toolkit on the "Choose a Category of Accessibility" interface, with the categories and subcategories that the ARC Toolkit distinguished. Also, the ARC Toolkit indicates where errors and warnings were found.

The errors and warnings given by the ARC Toolkit were dealt with and the test was run again. Figure 21 shows the

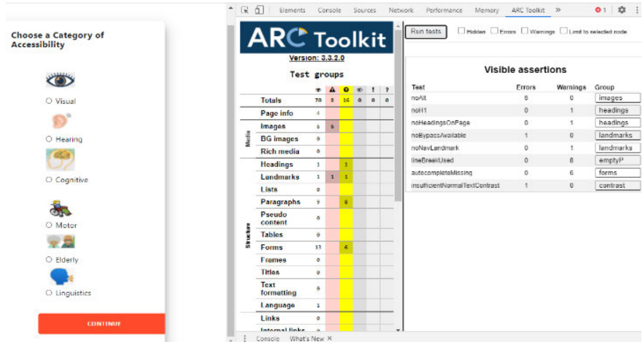

FIGURE 20. ARC Toolkit initial results.

TABLE 7. Summary of initial ARC Toolkit results.

Category	Subcategory	Errors	Warnings
Media	Images	6	0
Structure	Headings	0	1
	Landmarks	1	1
	Paragraphs	0	8
	Forms	0	6
Color	Color Contrast	1	0
	TOTAL	8	16

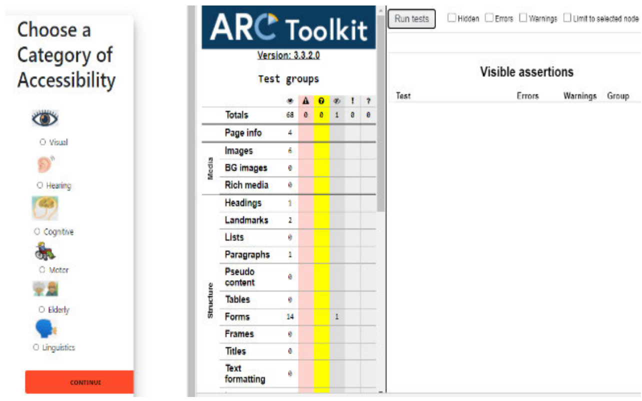

FIGURE 21. ARC Toolkit results after improvements.

results of the "Choose a Category of Accessibility" interface after the improvements.

The improvement process was carried out on all the prototype interfaces where the result obtained after rerunning WAVE was zero errors, zero contrast errors, and zero alerts; and after rerunning ARC Toolkit were zero errors and zero warnings. Once the corrections recommended by WAVE and the ARC Toolkit were implemented, the tests were carried out with the users.

2) TESTS WITH USERS

In the present study, forty-four users participated in the testing process. These participants formed a nonrandomized focus group including users with and without disabilities. Table 8 shows the distribution of users by age range and the total number of users with disabilities (B = Blindness, LV = Low vision, CB = Color Blindness, E = Elderly,

TABLE 8. Users.

Age range	No. (%)	B	LV	CB	E	DH	N
12-19	4 (9.1%)		1	1		1	1
20-27	5 (11.4%)		2				3
28-35	10 (22.7%)		4			1	5
36-43	3 (6.8%)					1	2
52-59	7 (15.9%)	1	2			1	3
60-67	5 (11.4%)				4	1	
68-75	7 (15.9%)				5		2
76-83	3 (6.8%)				3		
TOTAL	44 (100%)	1	9	1	12	5	16

DH = Diminished hearing) and without disabilities (N) in each age range. The complete dataset can be found at Mendeley Data (http://dx.doi.org/10.17632/nwcv33mvdf.2).

User tests were carried out through interviews. The authors asked open questions after observing the use of the prototype. After a process of analysis, this study summarizes the feedback from these end-users as follows:

- In the Accessibility Categories interface, a problem was found in using the checkbox as there were repeated labels, and the screen reader repeated the names of the disability.
- The option is not selected when pressing the enter key or the space bar.
- The Hearing category name should be changed to Auditory as it confuses the users.
- The name of the Motor category was not clear and should be changed to something more representative.
- There was no button or option to return to the previous interface in the event of a mistake.
- When using the Windows 10 screen narrator, the blind user could not select the country of residence. It only allowed selecting the option when the list was displayed.
- The prototype was built in English but the users who used it did not have the necessary knowledge of the language.

This feedback was used as input to improve the prototype. Additionally, the System Usability Scale (SUS) questionnaire was used [44]. This questionnaire consists of ten items that are evaluated using a five-point Likert scale. Table 9 shows the questions based on the SUS.

At the end of the use of the prototype, each user answered the questionnaire. Figure 22 shows the results in percentages per question.

As can be seen, in general, the responses are positive, because most users agreed or totally agreed with the different questions:

- Q01: 50.0% of the users totally agreed and 50.0% of the users agreed in their response to use the prototype frequently.
- Q02: 55.8% of the users totally agreed, 34.9% of the users totally agreed. However, in this question, 7.0% disagreed and 2.3% totally disagreed about the complexity of the prototype, due to the download options implemented to view the profile result.

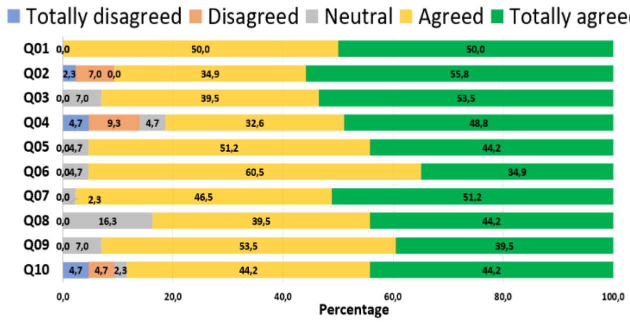

FIGURE 22. Results from the SUS questionnaire.

- Q03: 53.5% of the users totally agreed, 39.5% of the users totally agreed that the prototype was easy to use. However, on this issue, 7.0% of users remained neutral.
- Q04: 48.8% of the users totally agreed, 32.6% of the users agreed to use the prototype alone. However, 4.7% remained neutral and 9.3% disagreed and 4.7% totally disagreed, due to lack of knowledge about the use of a computer or the Internet.
- Q05: 44.2% of the users totally agreed, 51.2% of the users agreed to use the prototype alone. However, 4.7% remained neutral.
- Q06: 34.9% of the users totally agreed, 60.5% of the users agreed to use the prototype alone. However, 4.7% remained neutral.
- Q07: 51.2% of the users totally agreed, 46.5% of the users agreed to use the prototype alone. However, 2.3% remained neutral.
- Q08: 44.2% of the users totally agreed, 39.5% of the users agreed to use the prototype alone. However, 16.3% remained neutral.
- Q09: 39.5% of the users totally agreed, 53.5% of the users agreed to use the prototype alone. However, 7.0% remained neutral.
- Q10: 44.2% of the users totally agreed, 44.2% of the users agreed to use the prototype alone. However, 2.33% remained neutral and 4.7% disagreed and 4.7% totally disagreed. Users confirmed there was a need to know some aspects such as navigability and the purpose of the prototype before using it.

Additionally, Figure 23 shows the distribution of scores received in the SUS questionnaire, answered by the forty-four users who tested the prototype. In the lower limit, a score of 62.5 can be observed, in the upper limit a score of 100, these values represent the minimum and maximum values of the distribution. The median has a value of 84.3. The value of 52.5 is outside the range of values because a 78-year-old user could not use the prototype and assured that he would always need someone's help to complete the activities.

The SUS grade obtained by the prototype is B, as shown in Figure 24, giving the result of acceptable for the prototype with a usability rating of excellent.

Figure 25 shows the tendency of categories of disabilities chosen by the users when selecting their profiles, these being

TABLE 9. Questions based on SUS [44].

Code	Questions
Q01	I would like to use this prototype frequently.
Q02	The prototype is not complex.
Q03	I think the prototype is quite easy to use.
Q04	I could use this prototype alone.
Q05	The functions of the prototype are well integrated.
Q06	The prototype works as expected.
Q07	I think most people would learn to use this prototype very quickly.
Q08	I found the prototype lacking in difficulty when using it.
Q09	I felt confident using the prototype.
Q10	The prototype can be used with little knowledge of its functionality.

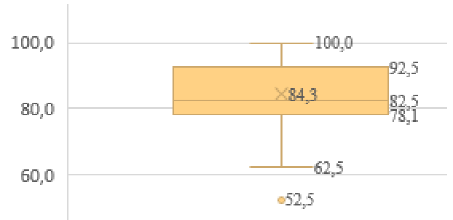

FIGURE 23. Achieved SUS score.

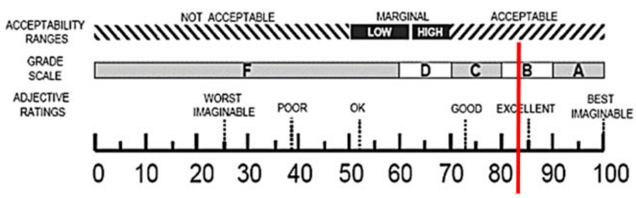

FIGURE 24. Grade rankings of SUS scores [41].

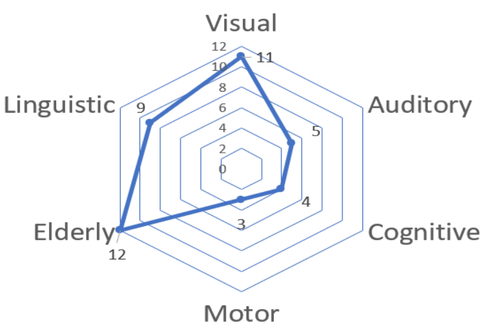

FIGURE 25. Trend by accessibility category.

the elderly, visual, and linguistic categories with the highest values.

Therefore, after the accessibility improvements, the prototype does not present major inconsistencies. Hence, the implemented prototype proved to have accessibility and usability. The prototype can be easily learned by new users, and when using it, users feel confident.

C. DISCUSSION

The solutions, proposed by the authors of previous studies, as presented in Section III, consider the accessibility needs of users. However, they lack the use of established guidelines that allow platforms on the Web to be homogeneous and offer equal access, as can be seen in the following summaries.

In [25], Lancheros-Cuesta and Carrillo-Ramos present a system that allows the adaptation of content to the needs of users. Similarly, the same authors in [27] propose a model that consists of a four-layer architecture, focused on the adaptation of educational services. In the first case, the system implemented is a personalized computer program where the characterization of the profile, medical records, and a history of user interaction within the system are considered. In the second case, the limitations of the model relate to the administration and the obtaining of information, as well as the amount of data necessary in the representation of knowledge, which allows characterizing disability and learning styles. Furthermore, in none of these cases is any reference made to guidelines such as WCAG or a metadata schema. Hence, two of the main differences compared with the present study were the WCAG 2.2 Accessibility Guidelines and the use of Schema.org metaformats.

Another study, which related to users' accessibility needs in a virtual environment, is [29] where a systematic tool called the MOOC Accessibility Audit was developed, incorporating changes resulting from user surveys. For implementation, the tool presented considers the WCAG 2.0. On the contrary, in the present study, the user will be able to select their accessibility needs when registering in the e-Learning platform. For this, the success criteria of the WCAG 2.2 and the metadata of Schema.org were considered.

Also, as was validated, current e-Learning platforms such as Udemy, Coursera, and edX, do not incorporate an initial request for accessibility needs during the registration process.

In a previous study, the authors of this research presented preliminary notions for the generation of profiles considering the answers to a set of questions in a questionnaire that specify the personal needs of a single user. The tests carried out in the previous study considered users with blindness, low vision, and color blindness [45].

In the proposed model, once the accessibility characteristics have been selected, an XML file will be generated which contains the metadata with Schema.org nomenclature and is based on the WCAG 2.2 success criteria. This XML file containing the user's profile can be read by any e-Learning platform, which will allow the platform to recognize and activate the characteristics that the user needs.

Additionally, the elderly and linguistics categories generate profiles that combine characteristics of two or more disabilities, such as difficulty in understanding and hearing impairment or low vision and insufficient dexterity to operate a mouse.

As limitations of the present study, while tests were conducted on individuals with and without disabilities and elderly users with a combination of disabilities in varying degrees, it is important to test the proposed solution with a larger number of users with disabilities.

VI. CONCLUSION

It is important to consider that more than one billion people live with some type of disability, which is approximately 15% of the world's population. For this reason, all software must be accessible, with accessibility being considered as a primary quality characteristic. Therefore, this aspect must be considered in the initial stages of the software development life cycle.

Despite the existence of studies aimed at identifying the problems faced by students with disabilities who use e-Learning platforms, these studies aim to improve the accessibility of educational resources or to interview students to find out the barriers that exist when studying through e-Learning platforms. There are few studies aimed at profiling and the main problem found in this study was that aspects, such as updating the profiles once created, are not considered, or the accessibility guidelines approved by the W3C are not considered.

Thanks to the UML, it was possible to establish the interaction of the different objects clearly and easily within the sequence diagrams, both in terms of the general model proposed, and in terms of the specific diagrams of each of the disabilities considered in this study.

One of the main advantages of the proposed model is that it can be used and adapted to future versions of the WCAG guidelines. The result is an XML file that can be optimized to other formats, depending on the needs of the platform concerned.

Thanks to the accessibility tests carried out using WAVE and the ARC Toolkit and the modifications made according to the results of these tests, the prototype was easily accessed and used by users with disabilities and elderly users.

As for future work, the authors plan to propose the profiling of instructors of e-Learning platforms, considering their accessibility needs as well. Also, the design of the model will be extended to any web platform, not just e-Learning platforms, but to any software that is available on the Internet and which must be accessible to everyone. Finally, the model will be extended to incorporate future versions of WCAG and additional guidelines, such as the US Federal Section 508 standards.

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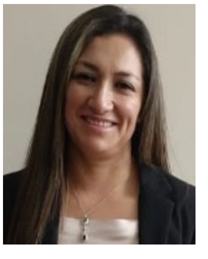

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