HOW TO INTERWEAVE ACCESSIBILITY WITH DIDACTIC AND TECHNOLOGICAL QUALITY OF DIGITAL EDUCATIONAL MATERIALS

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Abstract: Accessibility is a quality requirement for digital educational materials (or contents) in interactive learning environments. It ensures that students with disabilities do not face barriers when using such content. However, guaranteeing the accessibility of these materials is no easy task, at least for a significant part of the producers, authors, evaluators, and users of educational materials, such as teachers. Proof of this can be found in the

results of the case studies on the usability and reliability of technological accessibility evaluation standards conducted by Spanish Association for Standardisation (UNE) during the development of the Spanish Standard for the Quality of Digital Educational Materials UNE 71362. The results obtained show the difficulty of ensuring a good level of accessibility to digital educational materials, concluding that most creators and evaluators did not apply the guidelines due to either inexperience or difficulties. In order to minimise this problem, a new research approach has been taken based on unifying and abstracting the technology accessibility indicators from the regulations in force and integrating them, according to their applicability, transversally in the teaching and technological criteria of the new standard. This paper presents, explains and justifies this new approach in which the accessibility criteria are not isolated.

Keywords: accessibility, disability, digital educational materials, digital learning resources, quality models

Introduction

The use of Digital Educational Materials (hereinafter DEM) either integrated into e-learning platforms or as standalone is rapidly increasing. A Digital Educational Material is, according to UNE 71362, the Spanish standard of Quality of Digital Educational Materials, "any digital entity which has defined at least one teaching goal in order to be used in learning, teaching, and training" (UNE 71362, 2017). Other related terms, with more specific meanings, are learning object and educational software system (UNE 71361:2010). Electronic books, educational software, multimedia content, web pages, video classes, streaming video and audio recordings are examples of the wide variety of DEM's. Educational materials constitute one of the basic pillars of the quality of an institution's entire educational process (EQL, 2008; UNIQUE, 2011; OpenECBCheck Quality Criteria, 2012). For this reason, since the beginning of e-learning in the mid-1990s, several models for evaluation of DEM quality, based mainly on criteria have been developed.

These models all regard quality as including three fundamental aspects, in addition to others: the educational aspect, the technological aspects, and accessibility. The educational aspect pertains to the criteria which establish that material will be effective in terms of teaching, that is, in other words, that helps the student to learn and the teacher to teach. The technological aspect comprises the criteria ensuring that material is technologically effective, which means that it can be used with no problems on any computer system. Moreover, these criteria guarantee that it is portable, interoperable, and can be easily scaled.

Finally, accessibility pertains to the criteria that ensure that the DEMs can be used by individuals with the broadest range of skills possible (UNE-ISO/IEC 24751-1:2012; UNE 139803:2012). In order to establish the essential aspects and criteria for the quality of digital educational materials with the largest possible agreement, and in the most usable, effective, and reliable way possible, Working Group 12[1] (hereinafter WG12) was created in September 2013 as part of the National Technical Committee 71, Subcommittee 36 on "E-learning" of the Spanish Standardization Association (UNE). The group was multidisciplinary with agents coming both from the public and private sector: ministerial offices, universities, editorial and private educational

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[1] The work group 12 (AEN/CTN71/SC36/WG12) on "Quality of digital teaching materials" has the following members: Arturo de Porras Guardo, Consejería de Consejería de Educación y Empleo; Ángel Luis González Serrano, Pearson Educación; Julián García Villalobos, Organización Nacional de Ciegos Españoles (ONCE); Pilar Fernández Prieto, Asociación Española para la Calidad; Pedro Luis Iglesias Vázquez, Clara María Vizoso Martín, Institución Educativa SEK; Daniel Pons Betrián; Luis de Castro Soriano; Juan Pedro Cabanilles Gomar; Yolanda González Maroto; Patricia Camacho Fernández; Covadonga Rodrigo y Jose Luis Delgado Leal, Universidad Nacional de Educación a Distancia; Lourdes Moreno López, Universidad Carlos III de Madrid; Elena Domínguez Romero, Isabel de Armas, Antonio Sarasa Cabezuelo, Jose Luis Sierra Rodríguez, Jorge Arús Hita and Ana Fernández-Pampillón Cesteros, Universidad Complutense de Madrid.

entities. Moreover, members of the potential user's associations were invited to join. The final goal of WG12 was to develop the National Project for Spanish Standard 71362, PNE 71362, in order to define a quality standard for digital educational materials (Fernández-Pampillón 2014). The standard was approved and published in July 2017. The methodology used to develop the standard was based on evaluating (through case studies) and correcting the successive quality models, generated from an initial model, similar to what occurs in a prototyping process (Sommerville 2005). From the very outset, this methodology made it possible to detect a problem in the applicability of the accessibility criteria of the standard. In all evaluations, we discovered that the evaluators of the educational material either did not apply the accessibility criteria at all or only applied it partially and with no basis. To solve this problem, a team of accessibility experts was created in the WG12 who worked jointly with DEM creators. This team designed a new approach to explain and ensure DEM accessibility adding to the standard a new group of indicators related to specific learning and cognitive aspects that affects users with disabilities. Understanding how people with disabilities access DEMs is essential to define the criteria for accessibility quality. Access to DEM depends on the specific needs and preferences of people with disabilities.

The said approach is presented and justified in this paper. The paper is structured into six sections. Section 1 has introduced the evaluation of DEM quality. Section 2 presents state of the art developments in DEM accessibility; and the models of quality assessment in Section 3. Section 4 describes the methodology followed during the development of the PNE 71362 quality model. Section 5 presents the final standard DEM quality model developed. Finally, Section 6 presents the conclusion and lines of work.

Overview of accessibility

Providing Universal Access to DEM in interactive learning environments involves making every piece of information accessible to everyone. Difficulties accessing digital content can affect not only students with disabilities but also students without disabilities. Whenever possible, the accessibility needs of different user profiles should be taken into account. There is a vast range of ways to access electronic resources on the Internet, depending on users' characteristics of access as well as their context. Some people have difficulties processing information or are people with visual, auditory, physical, cognitive or neurological impairment. However, it is not only people with disabilities who find accessibility barriers involving access to content. For instance, digital contents can be offered as text, image, audio or video depending on the preferences or needs of every student, so the plat-forms should provide accessible content to the resources.

Types of access to DEM by students with disabilities

Understanding how people with disabilities access DEMs is essential to define the criteria for accessibility quality. Access to DEM depends on the specific needs and preferences of people with disabilities. In this regard, two distinct types of access to DEMs can be established: direct access and compatible access (NCAM 2009).

A disabled person uses direct access to a DEM when he or she can operate it without the need to depend on assistive technology. One example is a software or a website that provides features such as on-screen text or high contrast colours, to allow individuals with impaired vision to read the content. Other examples are a keyboard interface with audio output for blind people. The second type of DEM access is non-direct compatible access. Compatible access entails the use of assistive technology (screen reader, a screen magnifier, and an alternative input device) to access the DEM.

Accessibility Standards and Guidelines

Legally, there are several accessibility standards, nationally and internationally, which are mandatory. The ISO/IEC 40500:2012 standard (Information technology -- W3C Web Content Accessibility Guidelines (WCAG 2.0) (ISO, 2012) establishes the criteria for accessibility to online resources (W3C 2008). This standard must be taken into account when the DEM is web content or browsable format. ISO/IEC 40500:2012 (ISO 2012) was created from the Web Content Accessibility Guidelines (WCAG) promoted by the WAI (W3C 2004). In the Spanish regulatory framework, there is a regulation equivalent to WCAG and ISO/IEC 40500:2012 that is mandatory for the E-Government websites. This Spanish standard is the UNE 139803:2012, "Web content accessibility requirements" (UNE 139803:2012). UNE 71362 includes, as the minimum accessibility level, Compliance level AA of WCAG 2.0.

To evaluate the accessibility of educational software DEMs, in addition to standard ISO/IEC 24751-1/WCAG 2.0, software accessibility standard ISO 9241-171: 2008 has been taken into account in this research work. This standard provides ergonomics guidance and specifications for the design of accessible software for use both at work and at home as well as in education and the public State administration. This international standard has a corresponding Spanish standard too, UNE 139802:2009, "Guidance on software accessibility" (UNE 139802:2009).

In addition to technological accessibility, UNE 71362 pertains to accessibility as regards teaching and cognitive aspects. This is because of their impact on the teaching and learning of students with disabilities. These aspects have been studied and published in the Guidelines for the Design of Accessible Educational Environments for People with Visual Disabilities by ONCE - the Spanish National Organization for the Blind (ONCE, 2005). They target direct application DEMs (direct access to a DEM), and compatible application DEMs (no-direct or compatible access to a DEM.). These guidelines have been taken into account in this research work too.

Related work

In order to study works related to the development of the standard UNE 71362, fifty-two works on the evaluation of DEM quality, published between 1996 and 2013, were reviewed. In the following paragraphs, a discussion regarding these is provided.

Regarding the inclusion of accessibility as an aspect of DEM quality, works presenting DEM quality models were found in which accessibility was not taken into consideration. One example of this is Schoner, Buzza, Harrigan & Strampel (2005) which consider five criteria that include usability, but not accessibility.

Other works indicate that the DEM in question must be accessible by people with special needs (Lin et al. 2006). However, they do not include specific information regarding what accessibility elements need to be included in the DEMs. The project (DESIRE 2000) and the guide LORI (Nesbit et al. 2003) define guidelines for the creation of collections of digital materials. The quality criteria include taking into account the special needs that users of the materials might have. Along these lines, Becta (2007) presents a set of quality criteria that include accessibility, understood as making sure that any student, regardless of their physical abilities, is able to access the contents.

Some of the works found understand accessibility to be the adaptation of content according to different student profiles and their learning needs (Del Moral 2005), (LOAM 2005), but not as complying with accessibility standards such as the WCAG 2.0

On the other hand, quality models exist which do take accessibility into consideration. Although they do not reference accessibility standards. One example is the work of Buzzeto (2006) that contains a rubric in which some aspects of accessibility, such as the presentation of information and the type of multimedia used, are presented. Morales (2008) presents a model for the evaluation of learning objects. They include aspects related to accessibility,

such as interface design and navigation design. Obizor (2010) discusses the need to take accessibility for people with disabilities into account when developing educational materials. More specifically, a review of accessible devices is given.

Works that do indeed consider accessibility as compliance with WCAG standards have also been found. This is the case of SREB-SCORE (2007), that describes a questionnaire for evaluating learning objects which include the accessibility criterion. To do this, it poses two questions regarding compliance with WCAG 1.0 Level A standards. Another work along these same lines is the MELT project (MELT 2007), which provides digital educational materials for schools. The project's products include quality guides for the re-sources created, which consider accessibility is complying with the WCAG 1.0 Level AA. Nevertheless, applying the WCAG is not something trivial, and none of these models provides any guidance as to how to implement it.

Others do, on the other hand, offer a guide and support on how to apply them. One example is the ECBCheck Initiative (OpenEC-BCheck 2012) which seeks to improve the quality of teaching programs based on e-learning and has a questionnaire evaluating quality that takes the accessibility and usability of materials into account. However, it only partially takes accessibility into consideration as it does not cover all the aspects which must be considered when complying with the accessibility standards.

To conclude, the models reviewed include accessibility as an aspect of quality, but the distinction between accessibility, adaptability, and usability is not clear in some of them. Very few models are found that include help guides to evaluate accessibility. They use technological standards to verify the accessibility criterion without providing support. In order to provide a solution for this situation in which there is a lack of support when accessibility is taken into consideration, a proposal for an accessibility sub-model was defined and presented in this work.

Methodology

The development of the DEM quality standard of the PNE71362 was carried out using an iterative process with a methodology involving successive refinements based on evaluating, analysing results, and correcting.

The initial DEM quality model was composed of the following criteria: objectives and didactical coherence, content quality, capacity to generate learning, adaptability and interactivity, motivation, format and design, usability, reusability, interoperability and accessibility (Fernández-Pampillón 2014).

In this initial model, the accessibility criteria indicated that it had to assess if the DEM could be accessed and managed by people with special needs. With this model, we carried out experimental studies in order to evaluate and correct the accessibility evaluation model following a specific methodology. These studies are presented in this section. As a result, a final quality model is presented in section 5 for the accessibility of DEMs, which is the proposal of this article.

Method and Measures

The empirical method followed by the WG12 to evaluate and correct the accessibility evaluation model is based on the Case Study Method. The goal was to measure the usability and reliability of the model. To do so, an evaluation panel was asked to assess qualitatively and quantitatively the quality of a set of DEMs using that quality model.

Usability was evaluated using surveys, while reliability was statistically evaluated by calculating the degree of agreement between evaluators using the Intraclass Correlation Coefficient (ICC).

In the evaluation of the DEM, the ICC should be understood as the percentage of the total variability in measures which can be attributed to the actual differences between the materials evaluated. Its value ranges

between 0 and 1. The framework for the quality of digital educational materials considers ICC values following the scale put forward in Fleiss (1986) (see Table 2). To calculate the ICC the ICC(2) rate was used, which employs a bifactor ANOVA model with two random factors, as described in Shrout et al. (1979).

The procedure for the evaluation of DEM quality has a significant influence on the reliability of the evaluation measures (Nesbit et al. 2003). In this regard, in all case studies performed, a scheme for DEM evaluation by moderate reliability and average cost pairs was used.

Finally, the sequence of two cases to study the usability and reliability of the evaluation model was organised as follows:

1. The first study was aimed at evaluating the usability of the quality model. At this point, and in parallel to this study case, an expert panel in the development of digital educational materials evaluated accessibility in order to compare its results with those of empirical evaluation of the study case.

2. The goal of the second case study was to verify the usability and reliability of the corrected quality model again, but now trying to compare the usability and reliability of the quality model with and without the accessibility aspect. The goal was to check whether the evaluation of accessibility still posed difficulties to evaluators, in which case the usability and reliability results should be significantly different, or whether on the contrary, they would be similar.

The following subsection presents in detail each of the studies, its results, and the corrective actions applied to the model for the evaluation of accessibility until the final model presented in section 5.

Results and discussion

Case study 1

Criteria in quality model: (1) Objectives and Didactical Coherence, (2) Content Quality, (3) Capacity to Generate Learning, (4) Adaptability and Interactivity, (5) Motivation, (6) Format and Design, (7) Usability, (8) Accessibility, (9) Reusability and (10) Interoperability.

Goals: Evaluation of the usability of the quality model.

Design: a teacher training workshop on "Quality of digital materials" was held. The goal of the workshop was to evaluate the quality of a piece of material and propose improvement. Four teachers (one from pre-school education and three from primary education) with user knowledge of computers took part. A piece of preschool education material created by the participating pre-school teacher was used. The workshop was held in two sessions.

Development: in the first session, the piece of educational material was jointly evaluated with the support of a member of the GT12 workgroup. In the second session, improvements were proposed, and it was re-evaluated.

Data collected: 8 evaluations.

Results of the analysis of the survey regarding accessibility: the accessibility criterion is hard to understand and apply.

Evaluation by experts in the development of DEM of a publishing house. In parallel to case 1, an expert panel evaluated the quality model. A report was generated, the conclusions of which did not mention accessibility as a problem of the model.

Discussion of results and corrective actions: Case study 1 showed difficulties in understanding and how to apply the accessibility sub-model. However, the expert panel did not mention the usability of accessibility as a

problem in the quality model, probably due to their familiarity with the evaluation of accessibility. To solve this problem, a team of accessibility experts was created within the WG12 aiming two goals: (1) developing an accessibility sub-model, and (2) integrating it in the global quality model. The strategy was to bring together the existing technological accessibility criteria from standards ISO/IEC 24751-1 and WCAG 2.0 as a verification list or checklist and incorporate as a novelty, the study (Guidelines for the Design of Accessible Educational Environments for People with Visual Disabilities) on the cognitive accessibility of the DEM. The verification list is composed of criteria. Every criterion of Verification list was defined by a list of items of checkpoints.

The new accessibility sub-model was organised into two parts: the accessibility of the container elements (interface) and the accessibility of their contents. These two parts were added to the global criteria model as two additional criteria (criteria 10 and 11).

Case study 2

Criteria in the quality model: (1) Educational description, (2) Content quality, (3) Capacity to generate learning, (4) Adaptability, (5) Interactivity, (6) Motivation, (7) Format and design, (8) Reusability, (9) Portability. Additionally, the accessibility criteria:

- (10) Interface Accessibility: (10.1) Navigation, (10.2) Predictable changes in context, (10.3) Operability, (10.4) Use scenarios, and (10.5) Cognitive aspects.

- (11) Content Accessibility: (11.1) Images, (11.2) Video and audio, (11.3) Text, (11.4) Forms, (11.5) Tables, (11.6) Lists.

Goal: Comparative evaluation of the usability and reliability of the quality model with and without the accessibility aspect.

Design: Three studies were conducted:

1) a statistical reliability study taking the 9 first criteria in the model into account (excluding accessibility)

2) a statistical reliability study taking tall the 10 and 11 criteria into account (including accessibility)

3) a qualitative study of validity through opinion surveys among the evaluators.

For the study of the two first questions, 1) and 2) an experiment based on case type 1 documented in (Shrout & Fleiss 1979) was used. This type 1 is aimed at evaluating the consistency of the measurements obtained without taking into account the agreement or disagreement factor. In this way, deviations in the measurements caused by the evaluators' possible subjectivity are not taken in account. The experiment was designed with the stimuli and participants as follows:

- 2 pieces of educational material were randomly selected from a sample of 11 pieces of material from different educational levels and fields of knowledge. These materials were evaluated by 3 evaluators also randomly selected from a sample of 17 evaluators belonging to WG12 with different profiles: teachers, developers, editors, academic and administrative officers. The evaluators had no knowledge of the accessibility evaluation sub-model.

- The different types of materials and evaluators, their random pairing, and the use of the evaluation method by pairing simulates the most unfavourable general case regarding the usability and reliability of the evaluation model: a panel of evaluators who might not be specialists in the disciplines of the materials, who had not previously used the evaluation model.

A survey rating the usefulness, clarity, completeness, precision, and usability of each criterion was designed for the study of the usability of the accessibility sub-model (see Figure 1).

Figure 1. Item of the survey to assess the validity of the criteria

Data collected: 30 evaluations and 15 surveys.

Results of the data analysis and discussion: Table 1 shows the results of the quantitative reliability study. Table 2, the score and concordance mapping. In turn, Table 3 shows a summary of the qualitative study of usability.

• The average scores for the quality of the assessed materials are very similar to each other - an average 0.66 and a confidence interval of [0.59, 0.85]. This means that the materials used have a quality degree ranging between Moderate and Good.

• The score variation coefficient is on average 21%, which means that 79% of scores are homogeneous (or 21% are heterogeneous), which indicates an acceptable degree of reliability.

• As regards the ICC values obtained, it can be seen that the average ICC is Moderate both for the first 9 criteria (excluding accessibility), which is 0.6326, and for the 10 and 11 criteria, which is 0.5489. This

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means that the accessibility model can be regarded as acceptable as regards reliability.

- Criteria 10 and 11 (accessibility) slightly penalise reliability (-8.3% on average).

Table 1. Analysis Factor ANOVA model with two random factors for evaluations of the reliability

Id DEM	LEVEL	No. Evaluators	Average Scores Material	Deviation Standard	variation coefficient	9_Alpha Cronbach (*)	9_ICC unique measures	10_11_AlphaCronbach	10_11_ICC unique measures
18	University	3	0.67	0.17	0.253	0.675	0.409	0.706	0.445
28	University	3	0.59	0.13	0.220	0.844	0.643	0.88	0.71
2291	University	3	0.62	0.15	0.241	0.886	0.721	0.791	0.558
2293	Vocational training	3	0.66	0.12	0.181	0.809	0.585	0.75	0.5
2305	Vocational training	3	0.57	0.11	0.192	0.609	0.342	0.607	0.34
2306	Vocational training	3	0.68	0.19	0.279	0.772	0.53	0.726	0.469
2283	University	2	0.8	0.19	0.237	0.987	0.987	0.927	0.864
2298	Special Education	2	0.57	0.1	0.175	0.749	0.598	0.905	0.827
2300	Special Education	2	0.85	0.18	0.211	0.764	0.619	0.575	0.404
2302	Special Education	2	0.59	0.05	0.084	0.943	0.892	0.543	0.372
Averages			0.66	0.139	0.207	0.803	0.632	0.741	0.548
EDeviations			0.096	0.045	0.054	0.116	0.197	0.137	0.188

(*) the prefix 9 or 11 specifies whether the 9 or 11 first criteria are taken into account, respectively.

Table 2. Score and concordance mapping

CCI Value	Strength of concordance
>0.90	Very good
0.71-0.90	Good
0.51-0.70	Moderate
0.31-0.50	Mediocre
<0.30	Bad or none

- The scoring scale [0,1] seems to be reliable (Cronbach's Alpha between 0.74 and 0.80]. Regarding the usability of accessibility, Table 3 shows that accessibility criteria 10 and 11 are scored above average, that is, can be regarded as usable. However, the user remarks indicate that the format selected to include the accessibility sub-model in the general model was unfortunate, as it did not correspond to the structure of the rest of the model.

Table 3. Summary of the analysis of surveys on the usability of accessibility

INDICATOR	Average evaluation (out of 5)	Standard deviation	Summary of remarks
Criterion 10	3.89	0.32	Format is hard to use; need to accessibility knowledge (training), text revision suggested
Criterion 11	3.86	0.24	Same as criterion 10

Conclusions on accessibility: (1) it seems that the reliability of the quality model could be improved by at least 8% by improving the reliability of the accessibility criteria; (2) the quality model seems more reliable than the previous model if the results of the average ICC of the model of case 1 (0.57) is compared to the corrected model of case 2 (0.63), even though the accessibility sub-model has been included; (3) the format of the accessibility criteria should be redefined to improve usability.

Corrective actions: Even though the sub-model for the evaluation of accessibility displayed acceptable usability and reliability values, the WG12 decided to correct the format of criteria 10 and 11. To this end, the quality model was redesigned to integrate and abstract the accessibility items in criteria 10 and 11 with the other criteria in the quality model.

As a new development, the accessibility criteria and items ceased to be separated from the quality criteria 10 and 11 and joined them, constituting a model in which, for the first time, accessibility and quality are indistinguishable and inseparable. The result was a new grouping and a more consistent text of the items and the definition of new criteria. The result of

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integrating the accessibility aspect with the educational and technological aspects is a UNE 71361 quality model with fifteen criteria.

Accessibility is included in seven of these fifteen criteria in two ways. The first is to include quality indicators into certain criteria of the previous model such as (2) Content quality, (7) Format and design, (11) the structure of the learning scenario, (12) navigation and (13) operability. Secondly, it includes criteria only with regards to accessibility items such as (14) accessibility of the audio-visual content and (15) accessibility of the text content.

Standard DEM Quality Model

The final standard DEM Quality Model integrates the accessibility indicators and criteria as shown in figure 2.

Figure 2. UNE standard quality model. Integration of accessibility requirements

The UNE 71362 standard quality model is made up of fifteen criteria. The first six criteria evaluate didactic quality. Criteria seven to ten evaluate technological quality. Finally, criteria eleven to fifteen describe how to evaluate accessibility. As can be seen in figure 2, criteria 2 (didactic) and 7 (technological) also include accessibility indicators. The following subsections detail each of these accessibility indicators and criteria,

indicating, in addition, their correspondence with the accessibility standards and principles WCAG 2.0, ISO 9241-171 and ONCE Guidelines (Guidelines for the Design of Accessible Educational Environments for People with Visual Disabilities by the Spanish National Organization for the Blind, ONCE).

Accessibility indicators in Criterion 2 and in Criterion 7

Criterion 2 focuses on assessing digital educational material content. Compliance with this criterion is measured by assessing compliance with seven indicators, the second of which is an accessibility indicator: "2.2. Contents are presented in a clear and understandable way. Key ideas are highlighted, and clear instructions on the activities are given."

This indicator corresponds to Principle 3 of WCAG 2.0, which states that the information and the operation of the user interface should be understandable. The accessibility requirements that state that navigation and interactive elements should be consistent, resulting in a clear and intuitive presentation of the learning scenario interface, have been integrated into Criterion 7, Format and Design. These requirements have been extended to include that users (students or teachers) can configure characteristics of the interface of the learning scenario according to their characteristics and preferences. Compliance with criterion 7 is measured by assessing compliance with eight indicators four of which are accessibility (7.1, 7.5, 7.7. and 7.8):

- 7.1. The DEM design is well-organised and is clear, concise, and intuitive (mapping with Principle 3 of WCAG 2.0, ONCE Guidelines)

- 7.5. Use of the interface is intuitive (e.g. the contents and instructions are easily located), and otherwise the instructions for use are clear (mapping with Principle 3 of WCAG 2.0, ONCE Guidelines)

- 7.7. The appearance of the functional elements (icons, buttons, so forth) is consistent with the rest of design elements throughout the

DEM (mapping with the Success Criteria (SC) 3.2.3., 3.2.4 of the WCAG 2.0, ONCE Guide-lines).

- 7.8. There is a "preferences" option that makes it possible to personalise the interface, and these are kept for later sessions (mapping with SC 1.4.8 of WCAG 2.0, ONCE Guidelines).

Accessibility indicators in Criterion 11 and Criterion 12

Aspects such as structure and navigation are linked concepts, as the structure describes how to define and distinguish between learning scenarios, and how they are interrelated through navigation. Structure and navigation requirements are numerous and important, not only to ensure didactic effectiveness, but also to ensure usability and accessibility of the DEM. These accessibility indicators have been integrated through Criterion 11, The structure of the Learning Scenario, and Criterion 12, Navigation. The term Learning Scenario is used metaphorically to denote where the student is working. For example, a screen in an educational video game, a page in an e-book, a browser window displaying web content, etc. The indicators in Criterion 11, Learning Scenario Structure, are the following:

- 11.1. Each learning scenario has a single and meaningful title and can be accessed visually, through direct access or compatible access (mapping with SC 2.4.2 of WCAG 2.0, 10.5.1-1 of ISO 9241-171).

- 11.2. The semantic structure and information relationships in a learning scenario are made explicit in the presentation and can be accessed through direct access or compatible access (mapping with SC 1.3.1, 2.4.6 and 2.4.10 of WCAG 2.0).

- 11.3. Learning scenarios allow "always forward" use, simultaneously keeping prior scenarios if necessary, and "returning to previous scenarios" if they do not have to be simultaneously kept (mapping with requirements 10.5.4-5-6 of ISO 9241-171, ONCE Guidelines).

- 11.4. If overlapping learning scenarios are allowed, they can be minimised, maximised, resized, restored, and closed (mapping with requirements 10.5.7-8-9 of ISO 9241-171).

Criterion 12, Navigation, indicates that navigation between the DEM learning scenarios is correct, clear, and consistent. The result of integrating these accessibility requirements is materialised in the following indicators of Criterion 12, Navigation:

- 12.1. The name of each link is descriptive, clear, and different from the rest of the links. The links leading to the same location use the same descriptive text (mapping with SC 2.4.4-9 of WCAG 2.0, ONCE Guidelines).

- 12.2. The links work properly. No broken links

- 12.3. At least two mechanisms are provided to locate each learning scenario in the interface. For example, in the case of a web DEM, a web map and a search engine should be provided (mapping with SC 2.4.1-5-8 of WCAG 2.0, ONCE Guidelines)

- 12.4. The logical order of navigation and the location of the presentation navigation mechanisms are maintained in the compatible access unless the user changes them (mapping with SC 3.2.3 of WCAG 2.0, ONCE Guidelines).

- 12.5. Users are given information about where they are into the DEM (mapping with SC 2.4.5-8 of WCAG 2.0, ONCE Guidelines).

- 12.6. Users are aware of their progress in the execution of the DEM task (ONCE Guidelines).

- 12.7. The interface provides unlimited or enough time to read and use the contents. In any case, the reading time and use of the contents can be adjusted (mapping with SC 2.2.1-2-3-4 of WCAG 2.0, requirements 8.2.7, 10.1.2 of ISO 9241-171).

- 12.8. Mandatory passage through repetitive content elements is avoided (mapping with SC 2.4.1 of WCAG 2.0). For examples, there are links to go directly to the main content.

- 12.9. At the start of each session, the contents return to their initial configuration (mapping with requirement 9.2.3 of ISO 9241-171).

- 12.10. The DEM informs users about their status (active/inactive) in the task (mapping with the ONCE Guidelines).

- 12.11 It is possible to exit the DEM at any point (mapping with the ONCE Guidelines).

Accessibility indicators in Criterion 13

As was explained in Section 2.1, people with disabilities can sometimes only access the DEM via a keyboard only, mouse only, or using assistive technology. Criterion 13 of the Standard, Operability, indicates that the complete DEM functionality should be operable through the standard input devices (keyboard, mouse) and Assistive Technology. The indicators in Criterion 13, Operability, are the following:

- 13.1. The DEM should be operable through compatible or direct access (mapping with SC 4.1.2 of WCAG 2.0, requirements 9.1.2-3, 9.4 of ISO 9241-171).

- 13.2. Operability is complete with key, mouse, and any other input device provided, such as emulators, voice activation or tactile interaction (mapping with SC 2.1.1 of WCAG 2.0, requirements 9.1.1.2-3, 9.3, 9.4, 10.2.4 of ISO 9241-171, ONCE Guidelines).

- 13.3. A visible keyboard focus (or another alternative device) is provided, and there are no traps for the keyboard focus (mapping with SC 2.1.2, 2.4.7 of WCAG 2.0, requirements 9.2.1-2, 10.5.10 of ISO 9241-171).

- 13.4. Users should be allowed to click the keys, the mouse, or other input devices at speed adapted to their needs (mapping with SC 2.1.3 of WCAG 2.0, requirements 9.3.4-5-6-7 of ISO 9241-171).

- 13.5. Keyboard shortcuts or speed keys are provided for main links and essential form controls (mapping with SC 1.3.2, 2.4.3, 3.2.1-2-4-5 of WCAG 2.0, requirement 9.3.10-12 of ISO 9241-171).

- 13.6. The interface learning scenarios appear and operate in a predictable way. Users are previously warned if changes of context take place (mapping with SC 1.3.2, 2.4.3, 3.2.1-2-4-5 of WCAG 2.0, ONCE Guidelines).

Accessibility indicators in Criterion 14

There are many specific accessibility requirements for audio-visual content. For this reason, a specific criterion was kept in UNE 71362. It is essential that, together with audiovisual contents, alternative contents are provided, such as subtitles for deaf users, audio description for blind users, Sign Language for signing blind users or good contrast with low-vision users. These requirements are essential and affect practically all the DEMs used in education. All these requirements have been defined in the following indicators of Criterion 14 on audio-visual content accessibility:

- 14.1 There is enough contrast between the colour of the images and the background colour for the images to be properly seen (mapping with SC 1.4.3-6 of WCAG 2.0, requirement10.4.5 of ISO 9241-171, ONCE Guidelines).

- 14.2 All the audio-visual content (such as images, graphics and figures) should have an alternative text description which can be accessed either through direct access or else through compatible access (mapping with SC 1.1.1, 1.4.5-9 of WCAG 2.0, requirement 10.2.3 of ISO 9241-171, ONCE Guidelines)

- 14.3 Audio-visual contents (video, audio, animations) have synchronized alternatives, such as subtitles (for people with auditory disabilities or with aural comprehension difficulties), audio description, full transcription, or sign language (SL) (mapping with SC 1.2.1-2-3-5 of WCAG 2.0, requirements 10.6.5-8, 10.7 of ISO 9241-171, ONCE Guidelines).

- 14.4 In audio-visual contents, users have control over their display and their text alternatives through direct access or compatible access (mapping with requirements 10.6.2, 10.8 of ISO 9241-171, ONCE Guidelines).

- 14.5 If the DEM has unexpected sounds, users should be able to control them (such as turn them off or lower the volume) (mapping with SC 1.4.2, 2.2.2 of WCAG 2.0).

- 14.6. The contents do not include flashes effects with a threshold that may cause seizures, spasms, or convulsions (mapping with SC 2.3.1-2 of WCAG 2.0, requirement 10.1.1 of ISO 9241-171).

- 14.7. If there are visual or sound warnings, they should have their respective alternatives (sound alternatives for visual warnings, visual alter-natives for sound warnings) (mapping with SC 1.3.3, 1.4.1 of WCAG 2.0).

Accessibility indicators in Criterion 15

Use of text DEMs (or text combined with other formats) is fundamental in education. When these contents are printed, it is often impossible to make them available. However, the digital format makes it possible to make them accessible, facilitating education for all. The accessibility requirements for text contents have been integrated into the quality model through the following indicators of Criterion 15:

- 15.1. The text is legible, or its size can be adjusted (mapping with SC 1.4.4-8 of WCAG 2.0).

- 15.2. There is enough contrast between the colour of the text and the background colour for the text to be read clearly and with no effort (mapping with SC 1.4.3-6 of WCAG 2.0, requirement10.4.5 of ISO 9241-171, ONCE Guidelines).

- 15.3. Information is not provided exclusively through sensory characteristics (mapping with SC 1.3.3, 1.4.1 of WCAG 2.0, requirements 10.3.1, 10.4.1, 10.6.7 of ISO 9241-171).

- 15.4. If there are any forms, they are accessible if they can be filled in with no problems using the keyboard (mapping with SC 1.3.1, 3.3.1-2-3-5, 4.1.1 of WCAG 2.0).

- 15.5. If there are any tables, they should be correctly used, be properly structured and described, and be programmed in such a way as to allow compatible access (mapping with SC 1.3.1-2, 4.1.1 of WCAG 2.0, ONCE Guidelines).

- 15.6. If there are any tables, they should be simple, avoiding combined, divided, and nested cells as much as possible.

- 15.7. If there are any lists, they should be correctly used, and be programmed in such a way as to allow compatible access (mapping with SC 1.3.1, 44.1 WCAG 2.0).

Conclusions and future research

The primary goal of the standard developed in UNE 71362 is to include accessibility in the quality model. The aim is that any user (expert or not) who needs to evaluate accessibility aspects of the quality of a DEM, knows how to do it.

To do so, two lines of work were followed: (1) trying to make the indicators of accessibility compliance as understandable as possible and, therefore, as usable as possible and (2) reorganising the presentation of the accessibility indicators so that, rather than being isolated, they are logically integrated into the corresponding educational and technological criteria of the quality model of DEMs. Usability and reliability have been evaluated empirically. A moderate degree of reliability was verified by calculating the degree of agreement in the quantitative evaluations carried out by a sample of evaluators on a sample of materials. The conclusion of the WG12 work on DEM accessibility assessment is that, for the first time, accessibility and quality are indistinguishable and inseparable. Accessibility is part of the educational and technological quality of the DEMs, regardless of whether users have disabilities or not. The main research to be carried out in the future is to monitor the application of the standard in order to do the following: (i) verify its usefulness in measuring DEM accessibility, (ii) identify its weaknesses and strengths in order to correct or support it with new solutions, and (iii) define effective and efficient procedures for DEM evaluation with the standard. These three lines of work define key issues needed to ensure that accessible DEM is truly realised.

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