Raising awareness of the accessibility challenges in mathematics MOOCs

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ABSTRACT

MOOCs provide learning environments that make it easier for learners to study from anywhere, at their own pace and with open access to content. This has revolutionised the field of eLearning, but accessibility continues to be a problem, even more so if we include the complexity of the STEM disciplines which have their own specific characteristics. This work presents an analysis of the accessibility of several MOOC platforms which provide courses in mathematics. We attempt to visualise the main web accessibility problems and challenges that disabled learners could face in taking these types of courses, both in general and specifically in the context of the subject of mathematics.

CCS CONCEPTS

• **Information Systems** → User/Machine Systems; *human factors; human information processing* • **Information Interfaces and Presentation** → User Interfaces; *standardization; prototyping; user-centered design* • **Computers and Education** → Computer Uses in Education: *Collaborative learning; Distance learning* • **Computers and Society Issues** → Social Uses; a*ssistive technologies for persons with disabilities; handicapped persons/special needs*

KEYWORDS

Accessibility, MOOC, mathematics, standards

1 INTRODUCTION

Massive open online courses (MOOCs) may be of particular benefit to disabled learners by offering academic opportunities at low cost and without the need to travel [1]. However, it does not appear that this new educational paradigm has developed with a built-in capability to offer accessible education to disabled learners [2] who have been discriminated against by traditional educational systems, and who unfortunately still face numerous and problems as users of open educational resources (OERs). It has not been common practice for disabilities to be taken into consideration by those who analyse the persistence and performance of learners in MOOCs [3], by those who study the demographics of MOOCs in order to know in more detail key elements such as disengagement [4], those who propose models for digital practice [5] or even those who propose generative models for social learning [6]. Fortunately, some rankings that evaluate the qualities of these courses begin to consider the levels of accessibility required for both the platform and the content [7] and some studies present accessibility requirements that need to be considered in the design, implementation and evaluation of MOOCs to ensure they are inclusive [8 - 10]. The process towards quality must be based on the observation of good practices, both by the institution and by individual courses [11, 12], recognising accessibility as being one of the added values of the quality level of the virtual educational projects [13] that can be taken into account in the different processes of the development life cycle [14]. Within the context of mathematics, computer studies and other Science, Technology, Engineering and Mathematics (STEM) disciplines, achieving accessibility standards is much more complicated because of the specific requirements of the discipline: the interactive presentation of visual images, annotation rich in symbols, complex calculations, be they by hand or by means of software packages, scientific experiments [15] or designing innovative science assessments that are accessible for learners [16]. These added difficulties must be considered when analysing accessibility and developing guidelines that allow accessible content to be created for the user from its conception.

The structure of the article first presents the context of teaching mathematics by means of MOOCs. It goes on to the evaluation methodologies for accessibility to the study, an analysis of the results, and finalising with the main conclusions.

2 MATHEMATICS AND MOOCS

The precursor to the intensive use of mathematics in open learning is Khan Academy[1] [17], a non-profit making organisation created in 2006 by Salman Khan, who initially began to give short lessons recorded on video in which he explained the exercise procedures or problems mainly in the field of mathematics. The videos made by Khan Academy and openly available from his website on

[1] Khan Academy, https://www.khanacademy.org/

YouTube have allowed millions of learners to revise lessons on specific mathematical problems as many times as they want. For this reason, in 2010 the organisation received specific funding from both the Gates Foundation and Google. Khan Academy currently has more than 8000 videos in different areas (sciences, finance, the humanities, etc.), all of which are available in open access. In this way, the learners are able to make use of the wide-ranging library of content including interactive challenges, evaluations and videos from any computer with access to the Internet [18].

On the other hand, in mathematics, there are introductory courses in calculus, algebra and statistics given mainly on edX[2], Coursera[3], Udacity[4] and MiriadaX[5] platforms. In 2016 Coursera had 82 courses related to some area of mathematics available in both English and Spanish, which represents 4.2% of the courses on offer; edX offers 70 courses related to mathematics in four different languages, which represents 8% of the courses available from this provider; Udacity with 5 courses available all in English, for 5%; MiriadaX makes 14 courses available all in Spanish, which represents 8.6% of the courses. In 2013 the MOOC-ED[6] site was launched in which courses for the education of teachers in several areas were incorporated. In 2015, two courses in mathematics were included for the first time: the fundaments of fractions and statistics for research. Additionally, in 2014 and 2015, 12 training courses were created for mathematics teachers given by the *Proyecto Reforma de la Educación en Costa Rica* (Project for the Reform of Education in Costa Rica) [19].

On analysing the overall supply of MOOCs in 2016, the number of courses related to mathematics has not exceeded 3.8 % in total [20]. In spite of this, efforts are being made which are centred on the development of courses solely within this area of study, which implies an additional challenge resulting from the use of mathematical language and the complexity arising from teaching in a virtual and massive medium. Previous research [21, 22] suggests that there are a series of common difficulties and common errors in the learning and teaching of mathematics, related to the mathematical method: abstraction, logical-deductive development and concretion or applicability. Basically, the difficulties arise according to the higher or lower level of understanding that the learner has of this method [23], some authors are using traces of self-regulated learning in self-paced mathematics MOOCs to predict learner success or failure [24].

Together with the aforementioned, it is necessary to discuss the usual beliefs and attitudes that the learners have towards mathematics, in which it is evidenced that those learners with a positive attitude towards this discipline perceive the subject with greater usefulness and motivation, giving rise to a greater confidence towards their learning [25]. Additionally, the first steps in the inclusion of Information and Communications Technologies (ITC) in mathematical education were given with the Computer Algebra System (CAS), which consisted of computational systems whose aim is to carry out complex symbolic calculations. These systems were developed at the end of the 1970s, and since then they have evolved into more advanced systems such as *Máxima, Derive, Mathematica*, among others. Artigue [26] highlights the quandary that some of these tools have, which the author has called classic (such as CAS, spreadsheets and software for the study of dynamic geometry), the teaching and learning of mathematics, which are within the reach of everybody and easy to use but which have a great potential associated with the teaching strategies appropriate the teaching of mathematics. Although the use of ITC for the teaching and learning of mathematics has demonstrated a successful impact on the performance of the learners [27], in other cases, what it offers is the facility and adaptation of the teaching methods directed at learners for a digital generation or digital natives [28]. There are also studies which are looking into an integrated and critical use of the technologies in the teaching of this discipline [29, 30], in which an improvement in performance is linked to a series of conditions and parameters, which make it clear that the mere use of ICT in education does not mean greater efficiency in teaching and learning. What does predominate in studies into ICT and mathematical education is the clear evolution which has taken place in recent years, in which it has gone on from the use of conventional computer programs [31], learning in virtual environments [32], proposed the use of augmented reality [33], to the recent creation of complementary virtual courses and those of the MOOC type, which has allowed the knowledge of this discipline to become diversified and democratised.

Many authors have demonstrated their scepticism about the introduction of MOOCs to mathematics teaching. The fact is that many of the mathematics MOOCs have been developed by computer science teachers rather than mathematicians [34]. For instance, Robert Ghrist [35] (University of Pennsylvania), emphasizes that he was motivated by the opportunity to present the subject from his own point of view, to give a proof-of-concept for a different approach to calculus and calculus education starting with Taylor series. Petra Bonfert-Taylor (Wesleyan University) created a course in complex analysis, an upper-level mathematics course, minimizing course pre requisites and trying to “spark a lasting interest and curiosity in a beautiful corner of mathematics” [36]. MOOCs might be a tool that will help at least some learners, whether in conjunction with a traditional course or as a substitute for it.

3 METHODOLOGY OF THE STUDY

Although there is a large amount of research work into accessibility to the web, previous works carried out on accessibility assessment to platforms and MOOCs have been selected [37, 38]. This research was born from the hypothesis that MOOCs, on being designed for a very heterogeneous group of users, in general present greater problems of accessibility than if they had been designed for a more specific group of learners, especially taking into account, in this case, the high content of mathematical notation.

We, therefore, proposed to carry out specific research to evaluate the degree of accessibility of several MOOCs in the area of mathematics, offered by means of different platforms and

[2] edX, https://www.edx.org/
[3] Coursera, https://www.coursera.org/
[4] Udacity, https://www.udacity.com/
[5] MiriadaX, https://miriadax.net/
[6] MOOC-ED, http://www.mooc-ed.org

providers. With the objective of carrying out a more integrated evaluation, it is proposed to carry out trials of conventional web accessibility on the pages of each course, using both manual and automatic techniques. After that, the evaluation of the accessibility of the teaching content is carried out in order to finally go on to evaluating the specific accessibility to the mathematical content.

Table 1 summarises the courses selected to carry out the study, all of which focus on the learning of some specific area of mathematics (calculus, basic mathematics, statistics, etc.) and presented in each one of the three most popular MOOC platforms in the world: edX, Coursera and Udacity [39].

Table 1: Courses selected for the study

Code	Name of course	Institution	Provider
EXA	Pre-University Calculus	Delft University of Technology	edX
EXB	Mathematical basis: Integrals	Universidad Politécnica de Valencia	edX
CRA	Basic algebra	Universidad Nacional Autónoma de México	Coursera
CRB	Calculus Two: Sequences and Series	The Ohio State University	Coursera
UYA	College Algebra	San Jose State University	Udacity
UYB	Intro to Descriptive Statistics	San Jose State University	Udacity

Six pages were selected from each course to be evaluated by means of the tests which are described below. The types of pages chosen are as follows:

- The homepage of the course.
- The description page of the course.
- The communication page or consultation forums.
- The content of the course page (structure of the course).
- A page with a lesson of the course (video lesson).
- A page with a peer to peer activity.

Different tests for manual and automatic accessibility were carried out on each page of each selected course. The automatic tests, although of great help, are not always sufficient or exhaustive enough to evaluate the accessibility to a web page, therefore in order to carry out a more integrated evaluation it has been decided to combine the potentialities of both types of accessibility trial. Additionally, an evaluation of the teaching content of the course is carried out (multimedia and digital content) based on [40, 41] and an evaluation of the accessibility of the mathematical content according to the template proposed for this work.

Before carrying out the evaluation into the accessibility of the mathematical content in the courses, it is important to check its degree of general accessibility. In order to do so, a manual and automatic accessibility test is carried out, which will allow the criteria for the evaluation of the mathematical content to be supported. The guidelines to be followed to carry out the corresponding accessibility tests are as follows:

Manual accessibility test:

1. **Font size**. To validate whether the page has an option to increase and/or decrease the font size of the template. The Chrome (version 49) browser for OS X was used for this test.
2. **Sound**. If the page depends on any sound, it must be validated that it can be heard well as regards quality and volume. The Chrome (version 49) browser for OS X was used for this test.
3. **Screen resolution**. The resolution of the screen can be changed using the Web developer tool from Chrome (version 49) for OS X. It is validated whether the page retains its structure and legibility for each resolution.
4. **The use of the keyboard.** The search for the basic options of the page is validated by using just the keyboard. By means of the Chrome browser (version 49) for OS X.
5. **The use of different conventional browsers** [7]**.** The visualisation options from the web page of most popular conventional web browsers are validated (Chrome, Firefox and Internet Explorer). Chrome (version 49) for OS X, Firefox (version 45) for OS X and Internet Explorer 8 for Windows 7.
6. **The use of an alternative accessibility browser**. The search for the elements of the page with the use of Lynx browser is validated.
7. **Screen contrast.** The contrast ratio of the elements of each page is determined using the WCAG[8] Contrast checker in Firefox for OS X. The minimum recommended contrast for WCAC 2 level AA must be 4.5:1 for normal text and 3:1 for large text.
8. **Mobiles optimisation.** The Developer Tools extension for the Chrome browser (version 49) OS X is used to validate the pages of the courses at different resolutions, of mobile devices (Galaxy S5, Nexus 5X, iPhone 5, iPhone 6 and iPad).

Automatic accessibility test:

9. **SortSite Test.** The SortSite tool for verifying the accessibility to each page in accordance with the WCAG guidelines is used. Furthermore, this tool offers additional information on usability, broken links, the structure of the page (HTML, CSS, etc.) and positioning in search engines (SEO).

The evaluation of the teaching content:

10. **Evaluation of multimedia material.** The evaluation of the multimedia material is carried out in accordance with the guidelines defined in [40].
11. **Evaluation of digital documents.** The evaluation of the digital documents (where it corresponds) is validated using the template and alignment defined in [40, 41].

The evaluation of mathematical content:

12. **Evaluation of the mathematical content with the support of the screen reader.** The template proposed in Table 2 is used to determine the way in which the mathematical content is represented in the selected pages together with their degree of accessibility. This evaluation is supported in the manual accessibility tests, the previously carried out teaching content tests, and furthermore, it is supported by the ChromeVox reader incorporated in the Chrome search engine (version 49) OS X to carry out the reading of the screen of the pages with mathematical content and to verify accessibility by means of this tool.

[7] ATAG, https://www.w3.org/TR/ATAG20/
[8] WCAG, https://www.w3.org/TR/WCAG/

Table 2: Mathematical accessibility criteria

Criteria for accessibility
How is the mathematical content on the page represented? ( ) Images ( ) MathML ( ) Latex ( ) Video
Are the search mechanisms able to use the information of the text? ( ) Yes ( ) No
Is there a description of the text of the mathematical content represented in the images provided? ( ) Yes ( ) No ( ) NA
Can the mathematical content font be increased or decreased? ( ) Yes ( ) No
Is the mathematical content adapted to the different screen resolutions and are they correctly visible? ( ) Yes ( ) No
Do the videos with mathematical content have an appropriate transcription of the formulas? ( ) Yes ( ) No ( ) NA
Can the mathematical content be interpreted as speech with the screen reader? ( ) Yes ( ) No
Does the reading of the mathematical content with the screen reader correspond to natural language which allows its meaning to be understood? ( ) Yes ( ) No
Is it possible with just the transcription of the subtitles to correctly interpret the explanation of the videos (without visual elements)? ( ) Yes ( ) No
Is there additional material offered which allows the content of the videos to be interpreted? ( ) Yes ( ) No

4 ANALYSIS OF THE RESULTS

An analysis of the results obtained from the range of accessibility tests applied to the selected courses is presented in this section. These results are summarised according to the type of test (manual, automatic, teaching content and mathematical content).

Table 3 details the percentage and number of pages that comply, do not comply or do not apply to the manual accessibility criteria indicated. Of the 8 criteria evaluated, only 3 of them do not comply 100% with any of the courses, that is, no page contained any element for changing the font size (although it is possible to zoom in and zoom out with the browser). Furthermore, none of the courses could be accessed by means of the Lynx browser, nor was it possible to advance from the home page in any of the 6 courses. Likewise, all the 36 pages evaluated had contrast problems between the visual elements, mainly in the case of white backgrounds or grey or sky-blue fonts.

About the robustness criteria, 100% of the pages evaluated could be visualised correctly with the 4 most commonly used desktop screen resolutions, and all the content of the pages were also accessible and visible with the 3 most popular conventional browsers (Chrome, Firefox and Internet Explorer). It only took longer to download one of the pages in the courses on the Coursera platform when using Internet Explorer. Furthermore, the content (menu options, action buttons, video players, etc.) of 94.5% of the pages could be accessed by means of just the use of the keyboard.

Moreover, although the courses are visualised correctly with the usual screen resolutions used on the desktop, this is not the case for mobile devices, in which only 44.5% of the pages had optimisation for mobile devices. The remaining 55.5% were not optimised. This causes problems for visualising the content and accessing the options of the menu.

Table 3: Percentage of the pages evaluated that comply with the manual accessibility criteria indicated

Manual accessibility criteria	Yes	No	N\A
Did the page have any device to increase and/or decrease the font size?	0%	100% (36)	0%
Was the reproduction of the sounds of the page suitable and was it possible to regulate the volume?	30,5% (11)	0%	69,5% (25)
Did the page conserve its structure and legibility in the given resolution?	100% (36)	0%	0%
Was it possible to access all of the options of the page with just the use of the keyboard?	94,5% (34)	5,5% (2)	0%
Was it possible to access all of the content of the page in every browser?	100%	0%	0%
Was it possible to access all of the content of the page with the use of the Lynx browser?	0%	100%	0%
Did the page have an appropriate contrast?	0%	100%	0%
Did the page adapt to the resolution of the given mobile device?	44,5% (16)	55,5% (20)	0%

On the other hand, 24 different accessibility problems were encountered with the application of the automatic test, which was catalogued at 3 levels: level A, those users with accessibility requirements will find it impossible to use some of the pages; level AA, those users with accessibility requirements will find it difficult to use some of the pages; and level AAA, those users with accessibility requirements might may find some difficulty in using some pages. It is important to highlight that 94.4% of the pages have small markup problems and 58.3% have big markup problems, which could give rise to the screen readers missing some of the content. Furthermore, of level A, it was found that 58.3% of the pages did not use the LANG attribute to identify the language of the page, while in level AA 61.1% of the pages must avoid the option of opening the links in a new window. Likewise, in level AAA the most recurrent problem was that 44.4% of the pages had some element with the contrast between the foreground and the background of less than that recommended.

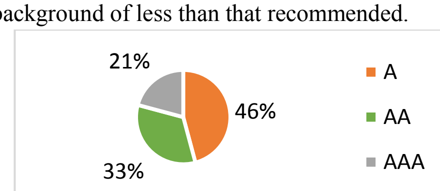


Figure 1: Percentage of accessibility problems encountered in accordance with its level

According to the description of the accessibility levels and Fig. 1, it is seen that 46% (equivalent to 11 problems) corresponds to a level A problem, 33% to problems at level AA and only 21% of problems with lesser priority. This demonstrates that 79% of the accessibility problems encountered could make the content of some pages impossible or very difficult for users with accessibility requirements.

Also, as shown in Fig. 2, 94.4% (equivalent to 34) of the pages had some level A accessibility problem and 97.2% (equivalent to 35) had level AA problems. For its part, 50% had level AAA problem, in which it is highlighted that those courses available on the Coursera platform had no problem at this level; in contrast, 100% of the pages of both courses on this platform had problems at both A and AA levels.

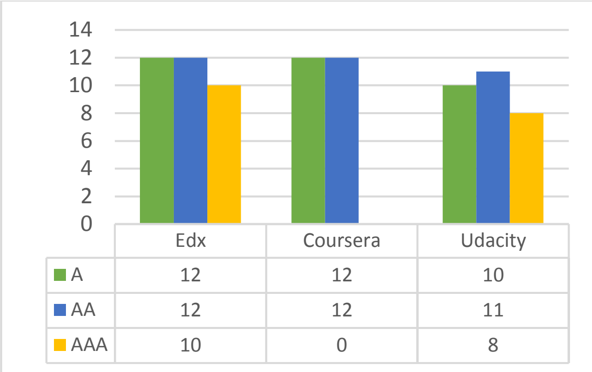


Figure 2: Number of pages with accessibility problems categorised by level and platform

It is worth highlighting that the pages evaluated of the courses available on the edX platform had the highest number of accessibility problems (see Fig. 3), all the pages had some problem at A and AA levels, and 10 of the 12 pages had problems at AAA level. In general, the 3 platforms have problems at A and AA levels in all or almost all the pages evaluated. Additionally, of the 11 level A accessibility problems found, 4 of them are in the edX courses evaluated. Of the 8 AA level problems, 5 were found in the edX courses. It is worth highlighting that there were no AAA level problems in the courses on the Coursera platform. In comparison, the courses which had the highest number of problems were EXA with 14 problems, UYB also with 14 and UYA with 12.

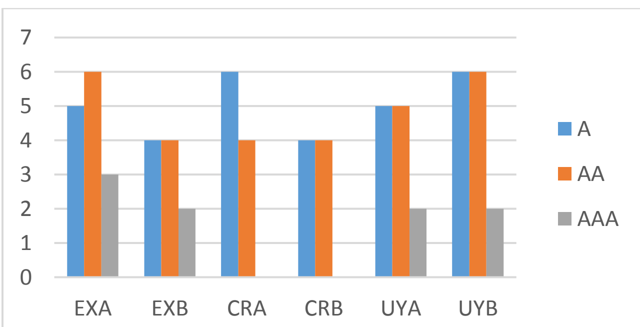


Figure 3: Number of accessibility problems detected categorised by level and course

Table 4 details the degree of compliance with the accessibility requirements for the multimedia content of each of the courses. It is highlighted that all of the courses include subtitles in the videos. Also, all of the courses include a transcription of the video in text format, which is either visible simultaneously in the video or may be downloaded in text format. Furthermore, none of the courses included audio descriptions, in the same way, none of the courses evaluated included sign language interpretations.

It is concluded that the multimedia content can be accessed from within the website (learning platform) about the use of keyboard and mouse. However, they are not accessible to learners with visual or hearing impairment, as the transcriptions and subtitles are not faithfully reproduced in the content presented and have errors in their interpretation.

Table 4: Compliance with the accessibility requirements for the multimedia content

Requisites for accessibility	EXA	EXB	CRA	CRB	UYA	UYB
The media player allows subtitles.						
Transcription in text format.						
There are subtitles						
Sign language interpretation.						
The user can control the volume.						
The media player can be controlled using the keyboard.						
The buttons or controls of the media player can be controlled without difficulty by learners with reduced mobility.						
The media player allows the audio description.						
The media player is compatible with support products such as screen readers.						
The embedded videos have alternative text.						
There is an audio description.						

Fig. 4 details the different mathematical content formats present in the courses evaluated. As a result of its character, all of the courses have mathematical content in the video lessons, which makes it crucial for the multimedia material to be analysed. It is worth highlighting that only the courses developed on the edX platform have their mathematical content available in MathML (recommendation of the W3C), which means that it would be the most accessible format, but as we will see later on it is not necessary like that. Furthermore, it can be evidenced that on every platform the courses show examples of the 3 formats (images, Latex and MathML) to include mathematical content on the web. This allows us to evaluate which of the 3 has been the best used, what errors appear and the recommendations pertinent to each one of them.

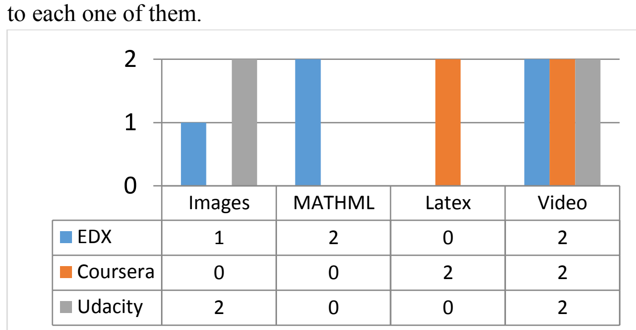
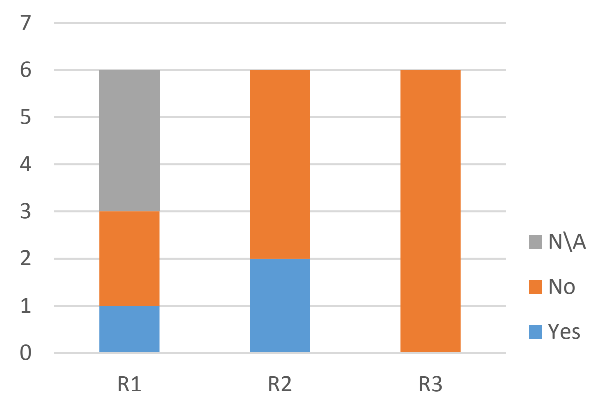


Figure 4: Formats of the mathematical content present in the courses of each platform

Fig. 5 shows the number of courses which comply with some of the 3 accessibility requirements suggested for mathematical content on the web. Only one course of the 3 that have mathematical content represented in images, includes alternative text. Furthermore, only 2 of the courses permit the interpretation of the mathematical content by means of the screen reader, although this was only partially so and there were serious errors in the interpretation.



R1: A text description of the mathematical content included in images is provided
R2: Mathematical content can be interpreted as by the screen reader.
R3: The screen reader produces comprehensible natural language

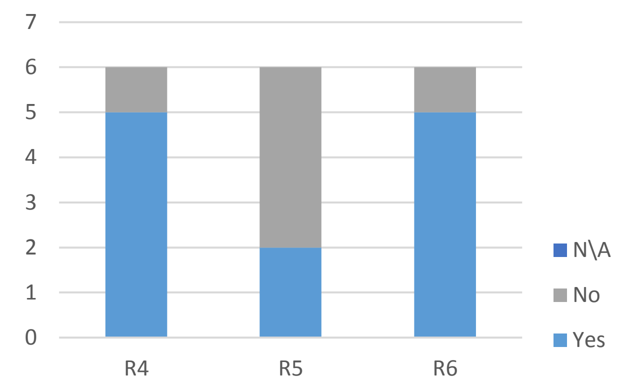
Figure 5: Number of courses which comply with some of the accessibility requisites of mathematical content available on the web pages

For learners with hearing impairments, the correct inclusion of subtitles and transcriptions of the mathematical content represented in the video is crucial. Fig. 6 shows the courses that comply or not with the requisites catalogued for multimedia content, and 5 of the 6 courses have a suitable transcription of the mathematical content available on the video. Leaving to one side the visual elements, correct subtitles should describe the contextual elements that appear in the video, something which was not complied with in 2 of the courses. Finally, 5 of the courses include additional material which could facilitate the interpretation of the content represented in the videos.

It is important to consider access to the platform from the user registration process, which was possible with the use of different conventional browsers, also by means of mobile devices and with the use of just the keyboard. As has already commented on before, access by means of an only text browser (Lynx) was impossible in all cases, since it was not possible to go on to the registration form in any of the three platforms evaluated.

As a result of the nature of the MOOCs, all of the courses have multiple embedded videos and pages in HTML, but not documents in WORD or PDF format. For this reason, the elements which presented the greatest problems were the pages in HTML, from mistakes in the markup language, lack of alternative text labels, and lack of language definition of the page, among others. This aspect is of great importance since it is the responsibility of the platform on which the courses are hosted and not on the design of the course. The lack of the language gives rise to an inappropriate functioning of the screen readers, for example. In this sense, it would be recommendable to suggest improvements and guidelines avoid design problems in the HTML material and videos.

Summarising, of the 26 most recurring accessibility problems in the courses, 9 of them are associated with the platform in which they are housed, 8 related to the design of the course or the educational material, 5 with the mathematical content and the remaining 5 are less important and can be easily fixed to improve the experience of the users. This allows a fast separation to be made of the problems to be corrected from the design of the courses and others that are the responsibility of the developers in which they are housed. It is also worth highlighting that in general, they are flaws which are considered serious for accessibility to the mathematical content given the high relevance of the courses and that they play an important role in the success or failure of the learning process.



R4: Videos with mathematical content present appropriate transcription of the formulas.
R5: It is possible with only the transcription or subtitles to correctly interpret the explanation of the videos (without visual or auditory elements).
R6: Additional material is provided to interpret the content of the videos.

Figure 6: Number of courses that comply with some of the accessibility requirements of mathematical content for learners with hearing impairments

Those flaws related to accessibility to the mathematical content available on the MOOCs could be resolved with specific recommendations and guidelines for its design, taking into account the different representations available: HTML (MathML, Latex or images) and Video.

5 CONCLUSIONS AND FUTURE WORK

We shall now present some of the main conclusions related to the different sections of access accessibility defined in the methodology.

General accessibility:

- None of the courses evaluated had any functionality with which to change the font size of the text on the pages.
- It was not possible to access the MOOCs by means of the Lynx browser.
- Although the platforms in which the MOOCs are held have home pages which are adaptable to mobile devices, not all of the internal pages of the courses are adaptable.
- A high number of the pages had problems catalogued as level A. Some users with accessibility requirements will find it impossible to use these pages.
- The absence of the LANG label means that screen readers are unable to identify the language used, in order to carry out the interpretation through speech.

- The largest number of accessibility problems detected are associated with the platform in which the MOOCs are hosted.

Accessibility to the multimedia content:

- No interpretation of the videos is provided by means of sign language or audio description in any of the courses evaluated.
- The transcriptions and subtitles are not faithfully reproduced in the content presented and there are mistakes in their interpretation.
- If the speech is not descriptive, then this aspect should be supported by subtitles, however, this is not considered in the evaluated courses.
- There are no specific accessibility recommendations for MOOCs.

Accessibility to mathematics content:

- In spite of the use of MathML and that the visual interpretation was correct, it was not possible to interpret the mathematical content by means of a screen reader.
- The flaws in accessibility to the mathematical content is evidenced in all of the representations available (images, MathML, Latex and video).
- The general guidelines of the W3C to include mathematical content on the web, in which the use of MathML is recommended, are only for the HTML content, no other formats are contemplated.
- There is a lack of regulations or guidelines which allow courses to be designed with the mathematical content accessible to all users.

Therefore the following recommendations are offered which should be followed:

- Access by means of any device should be guaranteed (computer or mobile device).
- The use of a template for multimedia content should be considered. This could allow the minimum accessibility to the contents set out in it to be guaranteed.
- The inclusion of sign language and audio description in the videos is recommended.
- A faithful and suitable transcription of the multimedia material.
- Attention to be paid to the visual details, type and size of the font, the images and their resolution and their position and sound (music, introduction, speech) of the videos.

Limitations and future work include the need for broader discussion in relation to the issues between the various existing platforms. As MOOCs are viewed worldwide on many different devices, operating system and browsers, more differentiation between accessibility and usability is needed for further analysis. It should also be fruitful to review the processes followed by universities, as authors may not provide precise information about the way they want the mathematics to be captioned or represented in audio descriptions and transcriptions.

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