A Closer Look at MOOC Accessibility: Comparing Local and Global Platforms with WCAG 3.0 in Mind

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***Abstract*—This paper aims to assess the accessibility of various Massive Open Online Course (MOOC) provider platforms on both national and international scales and compare their adherence to the World Wide Web Content Accessibility Guidelines (WCAG) 3.0, as of the draft version released on June 8, 2021. The methodology involved the use of four automated tools for data collection and contrast: WAVE, LERA, ARC Toolkit, and A11Y. These automated processes were complemented by manual validation and the filtering of duplicated results. Furthermore, manual data collection was employed in instances where tools were insufficient, enhancing the comprehensiveness of the evaluation. Subsequently, a new quantitative scoring system was applied to the gathered data. The assessment focused on four critical activities: searching for a course, creating an account, enrolling in a course, and reviewing course content pages. These activities are deemed fundamental for accessing knowledge on the four platforms under scrutiny, encompassing two international providers (Coursera and edX) and two national platforms (CEC-EPN and MOOC UTPL). Results indicate that the international platforms chosen exhibit better accessibility than the national platforms. This comprehensive evaluation provides insights into the accessibility status of MOOC platforms and highlights areas for improvement in aligning with WCAG 3.0. The integration of automated evaluations with manual contributions proved essential for comprehensive results. Further research is necessary to advance web accessibility and ensure MOOCs positively impact education.**

***Keywords*—web accessibility, Web Content Accessibility Guidelines (WCAG) 3.0, Massive Open Online Courses (MOOCs), automatic tools**

I. Introduction

Since the late 1980s, the global population growth rate has steadily decreased stabilizing at 1%. The population was expected to reach the milestone of 8 billion by 2023 [1]. In contrast, the rapid expansion of internet accessibility has been remarkable. As of 2019, over half of the world's population has embraced the internet as users [2]. Concurrently, the closing months of that same year marked the beginning of a struggle against the COVID-19 pandemic, even though its formal declaration occurred in March of the subsequent year.

Alongside the adoption of masks, social distancing, and other precautionary measures, quarantine emerged as a recommended strategy, introducing challenges that required universal adaptation. The ensuing transformation in our lifestyle unfolded rapidly over a matter of months. Amid many disruptions resulting from an unprepared shift, education stood out as a sector poised to derive advantages from widespread internet access, compelled to undergo a comprehensive transition to a fully virtual mode.

With the traditional face-to-face education system facing uncertainties, the integration of web-based learning materials, encompassing audio and video resources, has played a pivotal role in assisting teachers and students in acclimating to a virtual environment. Amid the array of virtual options available globally, Massive Open Online Courses (MOOCs) witnessed a surge in popularity during the pandemic. Illustratively, Coursera, a leading MOOC provider, observed a remarkable 248% growth in enrolments from September 2019 to September 2020 [3]. Likewise, edX conducted a survey, revealing a staggering 110 million new enrolments in its courses [4].

These platforms host courses provided by higher education institutions and experts in their fields, facilitating the dissemination of knowledge as web content. The effectiveness and efficiency of this distribution hinge upon the quality of the platform, specifically the quality of its software, which is subject to evaluation. This quality is defined as the degree or ability of the software to meet or conform to its stated and implicit needs [5], encompassing a diverse range of characteristics. Certain aspects, such as maintainability and compatibility, necessitate an internal examination of the software, or in this instance, the platform.

However, usability, defined in the current context as the user's perception of satisfaction when using the provided MOOCs, is externally assessable and comprises various sub-characteristics. Considering this, one of the primary advantages of MOOCs is the concept of "open", denoting the free usage of them, aimed at making knowledge widely available and accessible. Yet, it's acknowledged that this accessibility differs from that required for universal access, and it's recognized that most websites do not comply with this standard, serving as a barrier for those seeking content access [6].

Accessibility, as a sub-characteristic within usability, provides insight into the extent to which individuals with diverse characteristics and abilities can effectively use specific software [5]. It constitutes a research domain addressing challenges encountered by users under varying circumstances, leading to temporary or permanent disabilities, including conditions like hearing loss, colour blindness, finger fractures, etc. A more specific subset of this field is web accessibility.

The World Wide Web Consortium, known as W3C, has established open standards on this subject, with the most pertinent being the Web Content Accessibility Guidelines (WCAG). These guidelines are designed to clarify the process of enhancing web pages and web applications, making them more accessible to individuals with disabilities [7]. However, this standard is undergoing an update to version 3.0, and its

nomenclature has evolved to W3C Accessibility Guidelines, reflecting its expanded scope beyond web content. The updated version encompasses additional tests, incorporates a distinct scoring mechanism, and is founded on more recent research. Moreover, it aspires to enhance accessibility for a broader range of digital products, including ePub, PDF, mobile applications, and other emerging technologies, by dynamically adapting to their specific requirements.

Alongside these improvements, the guidelines incorporate details regarding the functional categories of disability that receive support through their implementation and adherence. This support draws upon documents like the United States government's Section 508 Functional Performance Criteria [8] and the European Telecommunications Standards Institute's Accessibility Requirements for Public Procurement of Information and Communication Technology Products and Services in Europe [9]. Within these documents, careful attention is devoted to offering alternative methods of operation tailored for individuals with disabilities, such as those with vision impairment or diminished hearing. This is summarised in the enumeration of functional categories.

Furthermore, from a research standpoint, a literature review on MOOC accessibility was conducted by Sanchez-Gordon and Luján-Mora [10]. The findings revealed that despite the valuable insights generated by these studies, there is insufficient impact within the research community. Nevertheless, the outcomes of these investigations contribute to shaping an initial roadmap for further exploration.

Considering the aforementioned context, the objective of this research paper is to conduct a comprehensive assessment and comparison of international and local MOOCs against the working draft of WCAG 3.0, dated 8th June 2021, even though its latest version was released on July 24, 2023. This evaluation is facilitated by automated tools designed to pinpoint potential accessibility issues, with the goal of identifying prominent distinctions in their web accessibility. These variations may be hindering individuals seeking knowledge independently. The paper presents the outcomes of the evaluation carried out on international platforms, namely Coursera and edX, and on local platforms, MOOC UTPL and CEC-EPN.

II. Literature Review

When discussing quality characteristics, the ISO/IEC 25010 standard frequently emerges, encompassing eight key attributes. Several of these can only be assessed by accessing the code, yielding a comprehensive and meaningful evaluation in terms of metrics. Notably, usability takes precedence among these characteristics, offering insights into the software product's ease of use, comprehensibility, and appeal to the user [5]. This encompasses sub-characteristics, including the aesthetics of the user interface, which becomes secondary if the user, for any reason, cannot perceive this aesthetic aspect. Consequently, another sub-characteristic assumes the role of evaluating whether a software product accommodates individuals with varying capacities. Accessibility, as a sub-characteristic, serves as the foundational element for the analysis of MOOCs in this context.

MOOCs are succinctly characterized by their acronym:

- Massive: Signifying their engagement with millions of participants;
- Open: Emphasizing the inclusivity, allowing anyone to share and contribute to knowledge;
- Online: Reflecting their mode of accessibility through the Internet; and
- Courses: Describing their structured, learning-oriented format, incorporating assessments for learning evaluation [11].

Given our focus on web content, it's imperative to delve into the realm of web accessibility. In this domain, W3C emerges as a preeminent organization dedicated to crafting open standards that underpin the sustained evolution and enhancement of the web [12]. Notably, within this framework, the WCAGs take centre stage. These guidelines are designed to furnish a diverse array of recommendations, ensuring content accessibility for users with disabilities across various devices when adhered to.

The current iteration, albeit still in draft form, extends its coverage to static, interactive, and multimedia content, encompassing audio, video, augmented reality, and virtual reality. Anticipated as an evolving document, this version is expected to undergo continuous updates to align with emerging technologies. Positioned as a successor to WCAG 2.2, its adoption is encouraged to enhance applicability in future contexts [7].

The aforementioned parameters were duly considered while conducting the literature review. The decision was made to restrict the search to articles published within the last six years, available in English or Spanish for enhanced comprehension. Seven databases and search engines were explored using keywords such as "MOOC", "accessibility", "web", "education", "WCAG", and "W3C".

The outcomes of the search are succinctly presented in Table 1, with Filtering 1 denoting articles featuring non-obsolete links, no duplications identified within the same database or search engine, and access to the complete articles is readily available. Filtering 2 pertains to articles that were singularly identified in the specific database or search engine where they were initially queried. Conclusively, Filtering 3 designates articles for which the abstracts were perused and deemed pertinent to the ongoing analysis.

Table 1. Literature review summary

Databases	Articles	Filtering 1	Filtering 2	Filtering 3
Google Scholar	164	138	138	20
ACM Digital Library	15	15	6	1
IEEE Computer Society Digital Library	2	2	0	0
IEEE Xplore	0	0	0	0
Microsoft Academic Search	41	38	29	3
Science Direct	3	3	1	1
Springer Link	5	5	1	0

The identified publications delve into various analyses and evaluations of MOOCs across specific content domains. For instance, there are studies examining the efficacy of educational videos [13], as well as assessments of mobile device accessibility for users with visual impairments [14], and the provision of accessibility for elderly individuals [15].

However, it's noteworthy that these scientific publications predominantly reference standards predating WCAG 3.0.

Furthermore, there are works that served as inspirations for this research, drawing from local contexts. For instance, research conducted in the Kingdom of Bahrain scrutinises the accessibility of university websites in relation to WCAG 2.0 [16]. Similarly, an analogous study analyses local MOOCs in Turkey, probing into internal challenges [17]. Likewise, a study conducted in the United Arab Emirates integrated multiple automated tools and interviews with educational website managers, employing previous versions of the WCAG standard [18]. On a separate note, a pivotal factor motivating this research endeavour was the significant influence of MOOCs during the pandemic, a topic extensively explored in a publication assessing user emotions concerning distance education experiences [19].

This paper aims to fill a gap in existing analyses by evaluating adherence to the new accessibility standard and providing a comparative analysis between local and global contexts, an aspect that has not been addressed in previous literature. Moreover, drawing from insights gleaned during the literature review, we identified the potential utility of automated tools in expediting the collection of accessibility data across selected platforms. Among these tools, WAVE stands out as a valuable complement to manual analysis, facilitating the categorisation of obtained data in relation to compliance criteria [20]. Available online, WAVE specialises in accessibility assessments, displaying symbols within the website alongside corresponding legends to pinpoint identified issues. However, it is advised to critically review the findings generated by the WAVE tool, considering factors that may influence the determination of whether reported issues constitute errors or not.

Furthermore, during research into these tools, it was discovered that the ARC Toolkit not only assesses accessibility but also validates and evaluates HTML code. By adhering to established best practices or standards, this feature contributes to enhancing overall quality and, consequently, accessibility [21]. However, it's worth noting that the ARC Toolkit may pose challenges for new users due to its integration into the browser and its results being displayed within one of the developer tools tabs.

Additionally, the W3C maintains a comprehensive list that includes these two automatic tools and many others, such as LERA. LERA enables users to generate reports in spreadsheet format, containing details like the evaluated URL, recommendations, and the applicable standard [22].

While these tools assess most accessibility criteria, some are tailored for specific purposes. For instance, the A11Y accessibility colour contrast validator scrutinises colour pairs within webpage content, including background and text, to determine if their contrast meets sufficient standards.

III. Materials and Methods

The methodology employed in this study adopts a quantitative approach, anchored in the WCAG 3.0 guidelines, while considering both international and local contexts. The primary outcome involves a comparative analysis of data collected predominantly through automated means, facilitated by specialized software, with subsequent manual filtering of results. Additionally, a smaller portion of data was gathered manually and meticulously documented for integration into the analysis. The methodology comprises nine distinct phases, outlined in detail in Fig. 1.

In the initial Phase 1, the relevant characteristics of MOOC provider platforms were identified to facilitate objective filtering and comparison. These characteristics include cost, student support, technology integration, instructional quality, course diversity, total courses available, student population, and course enrolment figures. Among these, the most pertinent for our study are the total number of students and course enrolments.

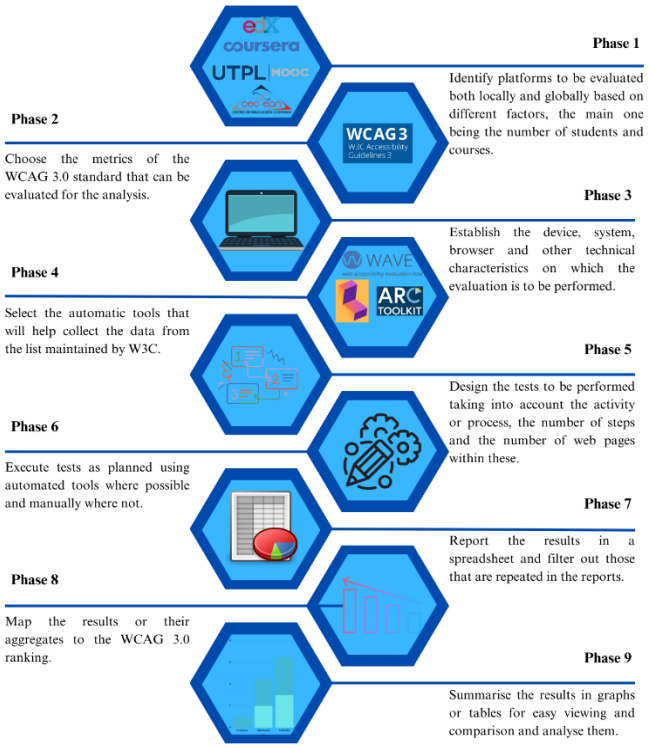

Fig. 1. Methodology process.

Based on reported figures from 2021, the most popular platforms were Coursera, edX, FutureLearn, and Swayam, as illustrated in Table 2 [23].

Table 2. Number of students per platform

Platform	Number of students
Coursera	97 million
edX	42 million
Swayan	22 million
FutureLearn	17 million

Indeed, the trend of Coursera's popularity appears to have continued, as indicated by its own report, which highlights a 60% increase in the number of students and a remarkable 248% surge in course enrolments [3]. Similarly, edX has reported significant enrolment figures, with over 110 million enrolments in courses, along with more than 400 thousand enrolments in its online campus and over 300 thousand in its business version [4]. These trends can be attributed to several factors. Firstly, there's a growing demand for online education due to its inherent flexibility and accessibility compared to traditional methods. Additionally, the expansion of course offerings and advancements in learning technologies contribute to making online education more appealing and effective for students.

In the local context, our review of specific literature did not yield a detailed report comparing these parameters to ascertain the popularity of MOOC platforms offered by Ecuadorian universities. However, we encountered an article that emphasises several characteristics of these platforms, highlighting qualities such as their overall quality, certification options, and economic accessibility. Notably, CEC-EPN is singled out as a pioneer in this regard, particularly for its provision of Self-Study Courses [24]. Similarly, an investigation focused exclusively on the national sphere conducted an extensive examination of courses offered. This study revealed that just over ten percent of Ecuadorian universities offer at least one MOOC. Noticeably, MOOC UTPL emerges prominently, boasting the largest number of courses available among local providers [25]. The Secretariat of Higher Education, Science, Technology and Innovation is recognized for its commitment to maintaining a MOOC that undergoes regular updates. Moreover, it is noted that the Science and Technology domain boasts the highest number of courses offered.

In light of these considerations, our study has selected edX and Coursera for the international context, while focusing on CEC-EPN and MOOC UTPL for the local context. These platforms were chosen based on their prominence and relevance within their respective spheres.

In Phase 2, there are five guidelines outlined in the new WCAG 3.0 standard:

- Alternative text: Ensuring alternative text is provided for all non-text content;
- Clear words: Utilizing familiar and easily understandable language;
- Subtitles: Providing subtitles and relevant meta-information for audio content;
- Structured content: Organizing content using sections, headings, and subheadings;
- Visual contrast of text: Guarantying sufficient contrast between foreground text and its background.

Among these, three guidelines were evaluated. However, the assessment scope was limited excluding the Clear Words guideline. This limitation arises from the subjectivity involved, as it depends on the language proficiency of the evaluator. Since the platforms in the international context are predominantly in English and the national ones in Spanish, there is a risk of introducing bias regarding what constitutes "familiar words" in the content taught.

The issue of potential bias in the evaluation process, particularly regarding the Clear Words and Structured Content guidelines, has indeed been previously identified in accessibility evaluations. It was acknowledged that such biases could impact the validity and reliability of the results. However, it's worth noting that in previous instances, this identification was based on data from user testing rather than expert evaluation [26]. Nonetheless, there is no evidence to suggest that this situation differs in the current context. Similarly, the Structured Content guideline was not evaluated due to its requirement that headings be both relevant and conducive to easier navigation and location of information. This criterion introduces subjectivity, particularly in the context of language differences, where relevance becomes a subjective judgement, potentially impacting the assessment process. Correspondingly, it's essential to acknowledge that the Structured Content guideline assesses the provision of a semantic structure that effectively communicates the hierarchy of content. Given that MOOC courses involve pedagogical considerations, it would be more appropriate for this aspect to be reviewed by someone knowledgeable in pedagogy.

Moving forward, the technical configuration for evaluating the platforms in Phase 3 has been established. The evaluation was conducted using a Dell XPS 15 9560 laptop running Microsoft Windows 10 Home as the operating system. Microsoft Edge served as the browser for conducting tests, with relevant plugins for the selected tools installed. Tests were carried out under these specific conditions to ensure consistency and facilitate the replication of results.

During Phase 4, a selection of four automatic evaluation tools was made, including LERA, WAVE, ARC Toolkit, and A11Y. The first three tools are primarily focused on accessibility evaluation, allowing identified issues to be classified according to different guidelines and filtered based on the applicable standard. WCAG, in its previous versions, serves as the closest reference to version 3.0. Among the chosen guidelines, the Alternative Text guideline stands out as particularly beneficial and facilitated by these tools. This guideline is well-suited for evaluation by these tools, as they can review content such as images, logos, and other multimedia elements to ensure appropriate alternative text is provided. The A11Y tool played a crucial role in gathering background and foreground colours for assessing the visual contrast of text. However, it should be noted that this tool faced limitations in accessing all the content assessed. Furthermore, its colour comparison mechanism was based on previous versions, necessitating manual extraction and processing of colour pairs.

Moving on to Phase 5, four essential activities were defined to be conducted on the platforms, which are fundamental for accessing a MOOC. These activities include searching for a course, creating an account, enrolling in a course, and reviewing a page of the course content. These activities were selected to comprehensively evaluate the user experience and accessibility of the platforms. The selection of these activities stemmed from the identification of commonalities in the mandatory processes required to access and study a MOOC as a user. While there may have been variations in the number of screens or steps involved, the fundamental objectives and functionalities remained largely consistent across platforms.

Phase 6 was executed with careful consideration of the aforementioned factors. Further details regarding this phase are elaborated upon in the results section, where the specific definitions of activities for all platforms are provided. This comprehensive approach ensures that a clear roadmap is available for repeating the evaluation process and confirming the results.

Phase 7 was conducted almost concurrently with phase six, involving the recording and filtering of data collected during evaluations. This process entailed validating the results obtained from automated tools while eliminating any instances of repetition or inaccuracies.

Once all pertinent data were compiled, the next step, outlined in Phase 8, involved applying the quantifications established in WCAG 3.0 to provide corresponding

assessments. Further elaboration on the use of these quantifications is provided in the results section.

To enhance accessibility and comprehension, Phase 9 focused on summarising and presenting the findings in a user-friendly manner. This phase culminated in the development of comparative graphs illustrating the outcomes of the evaluations, thereby concluding the quantitative methodology outlined for this research.

IV. Results and Discussion

A. Results

A summary of the number of steps and content analysed per activity has been compiled in Table 3. Subsequently, based on this plan, the tests were conducted to evaluate the accessibility and usability of the platforms.

Table 3. Summary of the test plan

Platform	Activity	Steps	Web pages
Coursera	Searching for a course	4	2
	Creating an account	5	2
	Enrolling on a course	2	2
	Reviewing the course content	1	1
edX	Searching for a course	4	2
	Creating an account	5	2
	Enrolling on a course	2	2
	Reviewing the course content	1	1
MOOC UTPL	Searching for a course	3	1
	Creating an account	5	3
	Enrolling on a course	2	2
	Reviewing the course content	1	1
CEC-EPN	Searching for a course	4	1
	Creating an account	7	3
	Enrolling on a course	4	3
	Reviewing the course content	4	1

The tests were executed meticulously, and their outcomes were recorded per guideline and per tool. For instance, in the case of evaluating alternative text, tables such as Table 4 were utilized.

This table presents details such as the platform name, the total number of images identified, errors reported by automatic tools, repeated errors subtracted from the total count, and the resulting score based on WCAG 3.0 guidelines. It's worth noting that the score depends on the set of images identified and the percentage of these images that have appropriate alternative text.

Table 4. Alternative text evaluation results in platform of edX to search for a course

Steps	Details	Value
Step 1: Web page 1	Number of images in the page	69
	Errors found by WAVE	4
	Errors found by LERA	5
	Errors found by ARC Toolkit	5
	Duplicated errors WAVE & LERA	2
	Duplicated errors LERA & ARC Toolkit	5
Step 4: Web page 2	Number of images in the page	43
	Errors found by WAVE	4
	Errors found by LERA	6
	Errors found by ARC Toolkit	7
	Duplicated errors WAVE & LERA	2
	Duplicated errors LERA & ARC Toolkit	5
Summary	Total number of images	112
	Total number of errors	17
	Images with alternative text	95
	Percentage of images with alternative text	84%
Rating		**3**

This score ranges from 0 to 4 in the following way [7]:

- Rating 0: Fewer than 60% of the images have appropriate alternative text;
- Rating 1: 60% to 69% of the images have appropriate alternative text;
- Rating 2: 70% to 79% of the images have appropriate alternative text;
- Rating 3: 80% to 94% of the images have appropriate alternative text;
- Rating 4: 95% to 100% of the images have appropriate alternative text.

Regarding the Subtitles guideline, the valuation is different, as there are only three applicable values [7]:

- Rating 0: An average score from 0 to 0.7 to one decimal place;
- Rating 1: Not applicable;
- Rating 2: An average score of 0.8 to 1.5 to one decimal place;
- Rating 3: Not applicable;
- Rating 4: An average score of 1.6 to 2 to one decimal place.

This score refers to the methods defined by WCAG 3.0, which states that text equivalents must be provided for speech and audio [27]:

- Each video without subtitles will have a score of 0;
- Each video with captions that are always visible will have a score of 1;
- Each video with captions that the user controls (visible/hidden) will have a score of 2.

And due to the limitations of the chosen tools in evaluating this parameter, manual evaluation was conducted based on the aforementioned methods. The results of this manual evaluation are presented in tables similar to Table 5.

Table 5. Subtitles evaluation results in platform of MOOC UTPL to enrolling on a course

Steps	Details	Value
Step 1: Web page 1	Content requiring subtitles	1
	Content without subtitles	1
Step 4: Web page 2	Content requiring subtitles	8
	Content without subtitles	8
Summary	Content requiring subtitles	9
	Content without subtitles	9
	Content with subtitles	0
Rating		**0**

The final guideline concerns the visual contrast of the text, which is assessed using the Accessible Perceptual Contrast Algorithm (APCA). This algorithm compares pairs of colours and other text characteristics against their background to determine accessibility.

The A11Y tool facilitated the extraction of details such as text colour, background colour, font size, and font weight from most of the web pages evaluated. With this data, we were able to derive values for comparison using the search table provided by Myndex Technologies [28].

However, for certain web pages, these characteristics had to be extracted manually, as illustrated in Table 6. This manual extraction process was necessary to ensure accurate evaluation of visual contrast in instances where the A11Y tool faced limitations.

The values obtained were transferred to a new table to calculate the score for each analysed colour pair, from which

their WCAG 3.0 rating was determined [7].

Table 6. Manually extracted contrast characteristics in platform of edX to creating an account

Reference	Background	Font	Size (px)	Weight
Start	0e3639	FFFFFF	78	700
with	0e3639	03c7e8	78	700
Register	FFFFFF	00262b	18	500
I agree that edX	FFFFFF	454545	12	400
By creating an account,	FFFFFF	707070	11.008	400
Create	d23228	FFFFFF	18	500
register	FFFFFF	00262b	18	700
Apple	000000	FFFFFF	16	400
Microsoft	2f2f2f	FFFFFF	14	400
Facebook	1877f2	FFFFFF	14	400
Google	4285f4	FFFFFF	14	400

According to this rating:

- Rating 0: Any failure concerning the APCA lookup table or the lowest APCA value is 15% below the APCA lookup table value;
- Rating 1: The lowest value is 10 to 15% below the APCA lookup table value;
- Rating 2: The lowest value is 5 to 9% below the value of that table;
- Rating 3: The lowest value is 1 to 4% below the value in that table;
- Rating 4: All values meet or exceed the values in the table.

However, upon considering this rating system, it was observed that all screens on all platforms would receive a score of 0. This is because they all exhibit at least one colour pair or other text contrast feature with an APCA value at least 15% below that provided in the lookup table. As a result, it was deemed appropriate to adopt the atomic test scoring approach. This approach allows for the averaging of individual results to report an overall score for the search result [7]. The scores were calculated for each colour pair, and subsequently, these scores were averaged over the individual colours, as demonstrated in Table 7. As depicted in the tables, comprehensive data are provided, and assessments are made according to the rankings outlined in WCAG 3.0. This recording process for the results was conducted for each of the activities and screens outlined in the test plan. Subsequently, summaries for each of the guidelines were extracted from these results, as illustrated in Tables 8–10.

Table 7. Visual contrast of text evaluation results in platform of CEC-EPN to searching for a course (Step 1: Web page 1)

Background	Font	Size (px)	Weight	APCA	Rating
00acc8	ffffff	16	300	700	0
972d33	ffffff33	22	700	700	4
ffffff	808080	18	400	500	0
003B6D	ffffff	20	700	400	4
ffffff99	333333	32	600	400	4
fffffe6	000000	14	700	500	3
972d33	fffffe6	22	700	700	4
ffffff	333333	18	300	400	4
c1272d	ffffff	14	300	400	0
		Average			2.555556

Table 8. Alternative text evaluations summary

Platform	Activity	Rating
Coursera	Searching for a course	2
	Creating an account	3
	Enrolling on a course	3
	Reviewing the course content	3
edX	Searching for a course	3
	Creating an account	1
	Enrolling on a course	2
	Reviewing the course content	2
MOOC UTPL	Searching for a course	2
	Creating an account	0
	Enrolling on a course	3
	Reviewing the course content	0
CEC-EPN	Searching for a course	3
	Creating an account	0
	Enrolling on a course	No images
	Reviewing the course content	0

Table 9. Subtitles evaluations summary

Platform	Activity	Rating
Coursera	Searching for a course	Does not require
	Creating an account	Does not require
	Enrolling on a course	Does not require
	Reviewing the course content	4
edX	Searching for a course	Does not require
	Creating an account	Does not require
	Enrolling on a course	Does not require
	Reviewing the course content	4
MOOC UTPL	Searching for a course	Does not require
	Creating an account	Does not require
	Enrolling on a course	0
	Reviewing the course content	Does not require
CEC-EPN	Searching for a course	Does not require
	Creating an account	Does not require
	Enrolling on a course	Does not require
	Reviewing the course content	0

Table 10. Visual contrast of text evaluations summary.

Platform	Activity	Average rating
Coursera	Searching for a course	2.857142857
	Creating an account	2.90625
	Enrolling on a course	3.4
	Reviewing the course content	2.75
edX	Searching for a course	2.285714286
	Creating an account	3.157894737
	Enrolling on a course	3.04
	Reviewing the course content	3.294117647
MOOC UTPL	Searching for a course	1.571428571
	Creating an account	3.421052632
	Enrolling on a course	3.307692308
	Reviewing the course content	3.545454545
CEC-EPN	Searching for a course	2.555555556
	Creating an account	2.611111111
	Enrolling on a course	2.072727273
	Reviewing the course content	1.818181818

Based on the information provided, it can be concluded that the Alternative Text guideline was initially assessed using automated tools. Subsequently, each result was meticulously verified to ensure its validity. Additionally, repeated results between the tools were identified and filtered out, enhancing the reliability of the data. This approach enabled the presentation of objective discussions and conclusions supported by demonstrable data.

Conversely, the Subtitles guideline underwent a fully manual evaluation process. Each piece of content was individually assessed, and the corresponding score was assigned without the aid of any tools during the execution

phase of the tests. For the last guideline, Visual Contrast of Text, a combined approach was adopted. Due to the inability of the tool to extract colour pairs from numerous screens, manual extraction was carried out for these instances. Furthermore, the data extracted by the tool underwent prior verification before being amalgamated with the manually recorded results. With all the records and test summaries now available, we are poised to present the results in a more dynamic manner. Utilising graphs will enable us to clearly and concisely visualise the comparisons, aligning with the primary objective of this work.

Regarding the guideline of visual contrast of text as depicted in Fig. 2, it is evident that only the Reviewing the course content process of a MOOC UTPL course barely meets the threshold of conformity with a rating just above 3.5. This is followed closely by the process of creating an account on the same platform, as well as the process of enrolling in a course on the Coursera platform.

Conversely, the platform with the highest rating has the lowest score for the Searching for a course process, with CEC-EPN's Reviewing the content process being the closest to this.

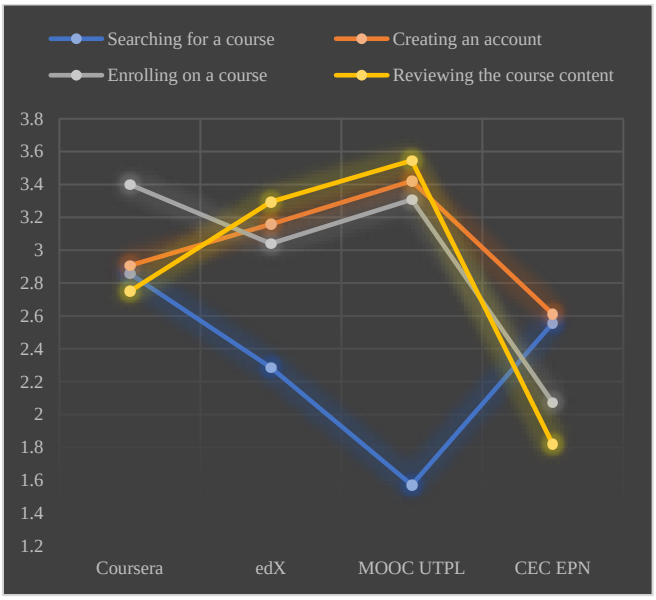

Fig. 2. Rating by platform and process—Visual contrast of text.

In the graphical representation of the alternative text guideline depicted in Fig. 3, it is apparent that no activity or platform met the minimum required for compliance. However, it is noteworthy that the process of Enrolling on a course in CEC-EPN is not featured in the graph, as it does not entail any content necessitating this feature. Nevertheless, processes that are depicted and have the lowest rating actually received a score of zero. Additionally, it is evident that the national platforms have the lowest scores, each with two instances of zero.

For the Subtitles guideline, a process was identified for each platform requiring the implementation of this feature, primarily in the Reviewing the course content process. Additionally, in the UTPL MOOC platform, subtitles were necessary for the enrolling on a course process.

This guideline highlights the disparity between national and international platforms, with edX and Coursera achieving conformity and a perfect score, whereas the opposite is observed in both MOOC UTPL and CEC-EPN.

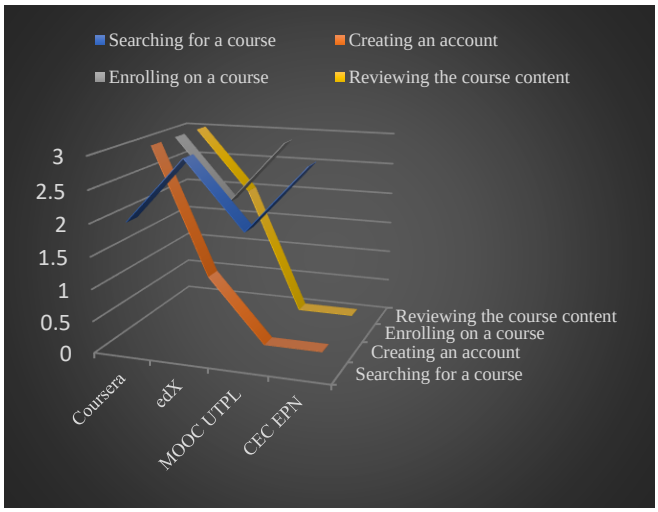

Fig. 3. Rating by platform and process—Alternative text.

Since the comparison is conducted per platform, individual values of each process are taken as a reference and averaged for comparison purposes.

Considering the first guideline, Visual contrast of text, all platforms except CEC-EPN are averaging close to 3 points, which is not significantly distant from the minimum required for conformity. However, as illustrated in Fig. 4, a notable disparity is evident in the CEC-EPN platform, scoring below 2.5 points on average.

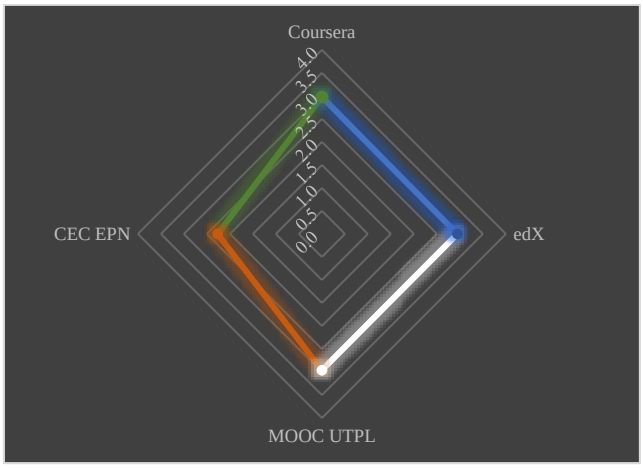

Fig. 4. Rating by platform—Visual contrast of text.

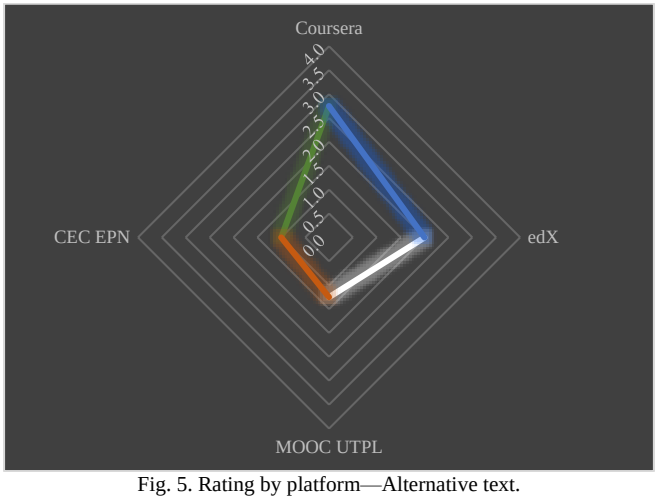

Fig. 5. Rating by platform—Alternative text.

In contrast, the Alternative text guideline reveals a disparity, with better implementation clearly evident in international platforms, as depicted in Fig. 5. However, they are slightly moving further away from compliance since their rating is below 3.

And finally, as shown in Fig. 6, the Subtitles guideline presents a clear and explanatory picture, demonstrating implementation only on international platforms.

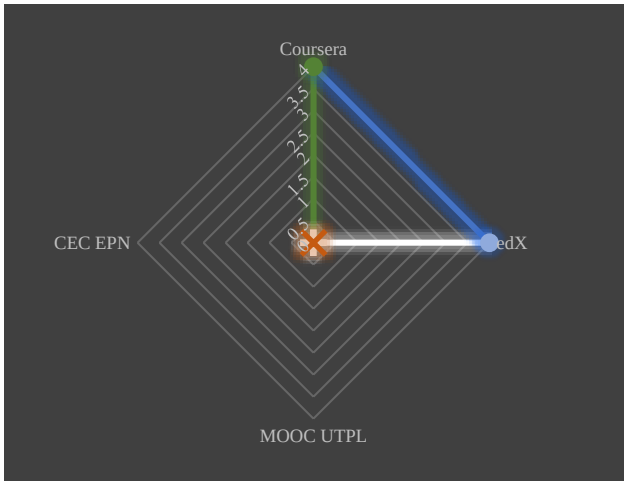

Fig. 6. Rating by platform—Subtitles.

In Fig. 7, a conceptual model succinctly encapsulates the procedural journey and ultimate outcomes of the study. It illustrates the involvement of three guidelines, four platforms, and four activities throughout the process. Importantly, the model unequivocally demonstrates that none of the results obtained across platforms and guidelines meet conformity standards.

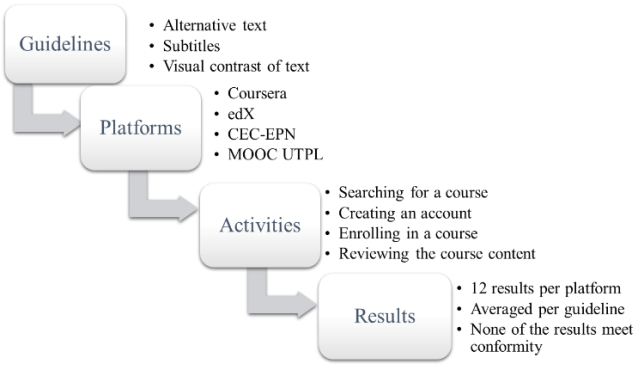

Fig. 7. Conceptual model.

B. Discussion

In this study, we aimed to compare the web accessibility compliance of MOOC platforms based on the WCAG 3.0 guidelines draft, contrasting the international and national contexts. We evaluated several guidelines objectively, leveraging various automatic tools to differentiate and aggregate results.

Our findings revealed a notable disparity between international and national MOOC platforms, particularly in the Subtitles guideline. International platforms like Coursera and edX achieved perfect ratings, whereas CEC-EPN and UTPL MOOCs lacked implementation of subtitles in multimedia content. Overall, accessibility appears to be higher on international platforms, although improvements are still necessary to align with the new WCAG standard. This reaffirms the need for continued efforts to enhance accessibility, as even minor adjustments could significantly improve user experience, a notion previously emphasized by Lazar [29].

While the automated tools proved valuable for data extraction, manual contributions were essential for data validation and identifying accessibility issues not captured by the tools. We encountered challenges with the automated assessment of certain guidelines, such as the visual contrast of text, due to discrepancies between WCAG 3.0 guidelines and the tools' capabilities.

We underscore the significance of employing multiple assessment tools to evaluate the same platforms and processes, thereby enhancing the reliability of the results. As empirically demonstrated by Vigo, Brown and Conway [30], relying solely on a single automatic assessment tool can yield unreliable outcomes, potentially assessing only the minimum level of compliance. Thus, recommends aggregating results from multiple assessments, emphasizing that this should not overshadow evaluations conducted by experts. This approach is also advocated by Akgül [31], particularly in the local context of Turkey, suggesting its applicability for future research endeavours, particularly within the realm of MOOCs catering to older individuals.

It is evident that the accessibility challenges observed cannot be solely attributed to course creators or platform administrators, as noted by Kurt [32]. However, a perceived lack of commitment to ensuring equitable access is apparent. Previous evaluations on international platforms by Park, So, and Hyunjin [14], Akgül [17], and Sanchez-Gordon and Luján-Mora [33, 34] have highlighted similar issues, particularly regarding the Alternative Text guideline. These recurring challenges highlight the need for concerted efforts to address accessibility shortcomings across the board.

As WCAG 3.0 serves as a standard reference point, it's essential to gauge conformity based on the analysis conducted. Upon reviewing the results tables, it's evident that none of the platforms meet the minimum conformity level, even at the bronze level. Without meeting this baseline, achieving higher levels of conformity such as silver or gold is not feasible, as these require fulfilment of preceding levels.

Additionally, as previously mentioned, attaining a minimum conformity score of at least 3.5 is necessary. However, none of the platforms reach this threshold comprehensively. Only three partial results exceed this value, notably in activities such as Reviewing the course content within the Subtitles guideline on international platforms like Coursera and edX. Similarly, in the Visual Contrast of Text guideline, the MOOC UTPL platform shows a slightly higher score in the previously mentioned activity. Nonetheless, these isolated instances fall short of sufficient conformity across all evaluated parameters.

The scope of our study was constrained by the limited number of guidelines evaluated. This limitation stemmed from the potential introduction of bias at subjective junctures necessary for assessing aspects like localization ease, navigation, and content relevance. The absence of pedagogical expertise in both languages used on the platforms under examination led us to focus solely on guidelines that could be objectively evaluated using the

criteria outlined in the standards draft.

Due to these limitations, we couldn't provide a holistic judgment of the platforms, but we were able to gain a general understanding of their accessibility status. In future studies, we recommend engaging experts in the field to conduct a comprehensive assessment of both the general processes for accessing courses and the provided content. This approach would help to address the nuanced aspects of accessibility and provide a more thorough evaluation of MOOC platform.

V. Conclusion

In conclusion, our evaluation of web accessibility compliance among national and international MOOC platforms against WCAG 3.0 guidelines revealed significant disparities. While improvements have been made, they are insufficient for users seeking knowledge, highlighting persistent barriers that require attention.

The study highlighted the neglect of web accessibility despite its insertion into legislation in several countries. Accessibility problems extend beyond technical implementation, reflecting varying levels of commitment to equitable access to educational resources. A notable finding was the marked disparity in subtitle implementation between national and international platforms. International platforms demonstrated full compliance, prioritising access to a wider audience, including the hearing impaired. In contrast, national platforms lagged significantly behind, necessitating urgent improvement to align with international standards.

Our methodology underscored the importance of balancing automated evaluations with manual contributions for comprehensive and reliable results. Future research should integrate pedagogical expertise and user engagement to address accessibility issues comprehensively and ensure user-centred design principles guide MOOC development. While international platforms outperformed those in Ecuador, the complete lack of subtitles in national platforms' multimedia content is a critical issue. Continued research and awareness efforts are vital for advancing web accessibility and ensuring MOOCs contribute positively to education.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Jonathan Quespaz and Tania Calle contributed collaboratively to the conception, planning, and execution of the research presented in this paper. Jonathan Quespaz was primarily responsible for the data collection, analysis, and interpretation, under the supervision of Tania Calle. Jonathan played a key role in drafting the manuscript and addressing reviewer comments. Tania Calle provided critical guidance throughout the entire research process, offering valuable insights into the study design, methodology, and data analysis. Both authors have read and approved the final manuscript, acknowledging their respective roles in, and contributions to, this collaborative research effort.

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