Assessing the accessibility components in the Moodle platform architecture to propose improvements based on WCAG guidelines.

Amanda Paulina Bermudez Mendez, Gerardo Adolfo Salas Montoya
Master's degree in software engineering with emphasis on software architecture and design
Universidad Cenfotec
San Jose, Costa Rica
Email: {gsalasm, abermudezm}@ucenfotec.ac.cr

***Abstract*—In the wake of the global pandemic, the shift towards virtualization has presented significant challenges, particularly for individuals with disabilities in the educational sector. This study aims to evaluate the accessibility components of the Moodle e-learning platform at Universidad Cenfotec, a tool that has transitioned from being a sparingly used resource to the primary channel of interaction between students and educators. The evaluation is based on the application of Web Content Accessibility Guidelines (WCAG 2.2), with a focus on ensuring that all users, regardless of their abilities, can fully access the services and resources available. The study provides an initial diagnosis of the situation, compares the principles and accessibility criteria established in WCAG 2.2, and develops recommendations to address the most critical accessibility issues. The findings of this study will contribute to making e-learning more inclusive and accessible to all.**

***Index Terms*—E-learning Accessibility WCAG 2.2 Virtualization Educational platforms Web accessibility requirements Disability Online learning**

I. Introduction

Following the pandemic, we have experienced significant changes in various aspects of our lives, such as access to information, social interaction, educational methods, and work environments. Virtualization has become a reality in nearly all fields, presenting a considerable challenge for the general population and especially for individuals with disabilities in the educational sector.

In numerous institutions, educational platforms have undergone a notable transition: from being a sparingly used resource to becoming the primary channel of interaction between students and educators. However, due to the sudden context of this digitalization, many institutions were not fully prepared and were forced to implement accelerated changes. Unfortunately, these changes do not always meet basic accessibility standards, which may exclude certain groups of people with disabilities.

Depending on the ease of accessing information on the main webpage, users typically decide whether to continue navigating those websites or not [1](Acosta-Vargas, Luján-Mora, & Salvador-Ullauri, 2016). In the case of institutional platforms, users do not have the freedom to decide whether to continue navigating as it becomes essentially obligatory since it becomes an indispensable tool for their educational process.

According to OMS, one in every six people has some form of disability, totaling approximately 1.3 billion people worldwide [2](World Health Organization, 2023). In Costa Rica, according to the National Disability Survey (ENADIS), in 2018, there were over 670,000 individuals over 18 years old with some form of disability [3](National Institute of Statistics and Census of Costa Rica [INEC] and National Council for Persons with Disabilities [CONAPDIS], 2018, p.60). In this context, this survey is the first of its kind and aims to measure the prevalence of disability for the formulation, monitoring, and evaluation of public policies, which is a clear example that although we have taken the first steps on this important path, we still have a long way to go to ensure that all people, regardless of their abilities, can fully access the services and resources available in our society.

In 2019, Directive (051-MTSS-MICITT) includes compliance with the accessibility criteria established by the Web Content Accessibility Guidelines (WCAG) in its version 2.1 for the Costa Rican public sector at the first level, with the exception of the Legislative and Judicial Powers. It excludes some public institutions and provides a grace period of 3 years [4](Costa Rican Executive Branch, 2019).

Despite regulatory efforts, through an evaluation conducted by the Ministry of Science, Innovation, Technology, and Telecommunications of 388 websites of evaluated institutions, it was evidenced that "86.60% do not comply with the minimum accessibility standards to achieve basic accessibility (A) rating" (quoted in PROSIC, 2022, p.42).

Notably, private institutions currently have no obligation to adhere to the WCAG guidelines within their websites. In the context of education, this lack of obligation poses a significant challenge. Therefore, this project aims to consolidate a proposal for improving the institutional webpage of Universidad Cenfotec.

Conforming to the Goal-Question-Metric (GQM) paradigm [5], the goal of this research can be stated as follows:

> ***Apply:*** An evaluation to the accessibility components of the Moodle e-learning plataform.
> ***for the purpose of:*** provide improvements and recommendations.
> ***With respect to:*** WCAG version 2.2 guidelines.

From the point of view of: researchers and software engineering practitioners
In the context of: suggests and provide recommendations to inprove accessibility for education platforms.

The structure of the rest of the article is as follows. Section II presents research questions. Section III discusses related and state-of-the-art works. Background is described in IV. The research methodology is explained in Section V and the objectives are presented in Section VI and VII. Section VIII describes the tool uses for this analysis "IBM EQUAL ACCESSIBILITY CHECKER". Section IX addresses the description of the e-learning tool that is been evaluated.Section X describes the WCAG guidelines.And, Finally, Section XI and XII discusses the results, conclusions and presents future work.

II. Research Questions.

This section lists the main research questions that we set out to answer.

- Is the Moodle platform of University Cenfotec meeting the principles of accessibility outlined in WCAG 2.2?
- How can we improve the web accessibility of Universidad Cenfotec's Moodle by incorporating the main needs identified by the WCAG 2.2 guidelines to promote greater inclusion in the web ecosystem of Universidad Cenfotec?

III. Related Work

The following research has been conducted focusing on web accessibility within the context of e-learning software architecture:

In 2018, [6] published an article titled "An analysis through experiences in scientific literature and a case study," where the focus is on analyzing the accessibility of the Moodle online learning platform, reviewing previous studies and evaluating the accessibility of specific Moodle installations.

[7] in 2016 conducted a comparative study of three Learning Management Systems (LMS), Moodle, Sakai, and the system called ABC, developed in Ecuador to evaluate the levels of accessibility according to users' needs. They analyzed and compared the selected LMSs based on accessibility criteria, considering functional tasks on a scale with 6 levels of accessibility that can be used for decision-making and LMS selection from the perspective of teachers and students.

[8] published the research "Analysis of Accessibility of the e-Learning Platforms According to the WCAG 2.0 Standard Compliance," which aims to analyze the accessibility of the latest public versions of several Learning Management Systems (LMS), such as Moodle, Eliademy, Docebo, Sakai, and ATutor, for people with disabilities. The analysis will evaluate compliance with different levels of criteria established in the Web Content Accessibility Guidelines (WCAG).

The web accessibility project of the University of Costa Rica focuses on the application of international web accessibility standards, specifically on the WCAG 2.1 standard. Throughout the document, there is a reference to the importance of complying with these standards to ensure that websites are accessible to all users, including people with disabilities [9].

We also find the publication "AccGuideLiner: Towards a Modelling Approach of Web Accessibility Requirements following WCAG 2.2," which describes a detailed model for describing accessibility requirements by integrating expert knowledge and domain knowledge to simplify its implementation in tools. The document is aimed at web developers, designers, accessibility engineers, and researchers who wish to understand the guidelines and accessible requirements from the technical perspective to the code phase.

The main source of information is the guidelines established by WCAG 2.2 developed by the World Wide Web Consortium (W3C), which set technical standards and guidelines for creating more accessible web content for a wide range of users, including those with disabilities. These guidelines address key aspects such as perception, operability, and understanding of web content, ensuring it is accessible for both assistive technologies and users without disabilities.

IV. Background

Many authors consider LMSs and their accessibility from different points of view. When the accessibility in context of e-learning is considered, many authors highlighted that there is a need to define criteria for instructors, authors of the contents and e-learning specialist that create and run activities on the web (Bocevska et al,2018).

Given that this research is conducted within the legal context of Costa Rica, we will adopt the definition of accessibility provided in Directive 051-MTSS-MICITT (Costa Rican Executive Branch, 2019). This directive defines accessibility as "the measures adopted by public and private institutions to ensure that persons with disabilities have access, on equal terms with others, to the physical environment, transportation, information and communications, including information and communication technologies and systems, and to other services and facilities open to the public or for public use. These measures also include the identification and removal of such barriers."

V. Research Methodology

The research method employed in the proposal involves several key steps. Initially, the chosen topic is clearly defined, followed by an extensive search for relevant literature addressing the research problem. Databases such as Google Scholar, EBSCO, and ResearchGate are utilized for this purpose [10]. Additionally, web searches are conducted to gather information on learning management systems (LMS), WCAG compliance, and tools available for evaluating web accessibility. During this process, detailed notes are taken to capture essential insights related to the research problem, and specific evaluation tools are selected. Citations are diligently recorded to facilitate the compilation of the references list later on. The gathered information is then analyzed and integrated into the project proposal, with key findings being summarized and thoroughly discussed this process follow Biolchini Technique.[11].

Furthermore, accessibility testing and evaluation are performed on the latest public version of relevant LMS platforms, such as Moodle. The data collection process involves utilizing the IBM Equal Accessibility Checker plugin, which is installed in Google Chrome, to ensure comprehensive evaluation of web accessibility standards. This methodical approach ensures that the research is thorough and systematic, laying a solid foundation for the project proposal and its objectives.

VI. Objective

The main objective of this study is to evaluate the accessibility components of the Moodle e-learning platform and provide improvement recommendations based on the application of WCAG guidelines (version 2.2).

VII. Specific Objectives

1) Analyze the current accessibility components of the Moodle platform at Universidad Cenfotec using tools developed as plugins to analyze the entire accessibility infrastructure of a specific URL.
2) Compare the principles and accessibility criteria established in WCAG 2.2 to determine their relevance and effectiveness for improving Moodle's accessibility.
3) Develop recommendations based on the conducted research to address the most critical accessibility issues of Moodle at Universidad Cenfotec.

VIII. IBM equal accessibility checker

To collect the WCAG 2.2 ratings on the analyzed pages, we used the "IBM Equal Accessibility Checker 7.3," which is an open-source tool (https://github.com/IBMa/equal-access) and available for free. It integrates into the browser's development tools and provides a comprehensive analysis environment through the auditor's or developer's browser, allowing for automatic accessibility evaluation of the visited page.This study is conducted using Google Chrome, and therefore, the tool is obtained through the official Google Chrome extension store.[12]

We will use version 7.3, which includes six new success criteria from the Web Content Accessibility Guidelines (WCAG) 2.2 Level A and AA, as well as criteria that were already included in previous versions.

The rule set applied in this tool is grouped as follows:

- Non-text content
- Keyboard content
- Language Parsing

The technique used for analysis relies on the tool's functionality, which checks various aspects of web accessibility in accordance with WCAG 2.2 guidelines, as mentioned earlier. It scans the pages to be analyzed, pinpointing potential accessibility issues and offering insights into elements that don't meet specified standards, such as exporting results in Excel format, among other functionalities.

Key features to note include:

- Automatic scanning: The tool automatically analyzes the webpage, identifying areas of concern regarding accessibility.
- Comprehensive reports: Following the analysis, we thoroughly examine the detailed reports provided by the tool to draw conclusions and formulate recommendations aimed at improving accessibility.

This tools offers integrated accessibility testing through plug-ins and modules for Node JS and Karma [13] The URL that will be covered in the scope of the investigation are in the taxonomy of the page in next image

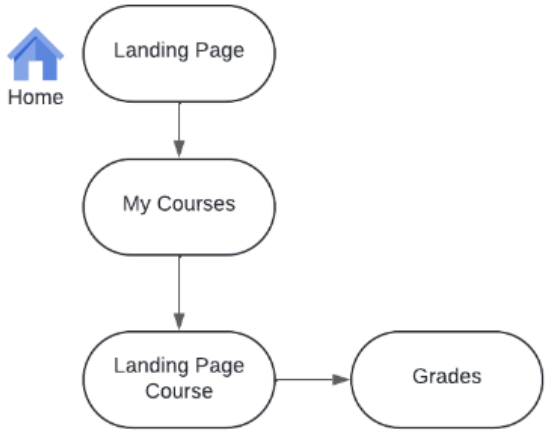

Fig. 1. Moodle page taxonomy

IX. MOODLE

Moodle is one of the most popular open source LMS options available today. It features dashboards, learner tracking, and multimedia support. This open source Learning Management System also gives the ability to create mobile-friendly online courses integrating third party add-ons. One of the standouts of this tool is the user community [14].

E-Learning has a series of conditions to have a successful learning process. The student's motivation and his/her level of responsibility and autonomy are crucial to achieve it. It is also important the quality of the digital materials and their design, as well as the appropriate learning situations and methodologies provided by the teacher to carry out learning, an accurate, quick and efficient tutoring are also fundamental elements [15].

X. WCAG

The Web Content Accessibility Guidelines 2.2 [16] was issued by the world's leading organization - The World Wide Web Consortium (W3C) on October 5, 2023. In the following image are the differences between the tree version.

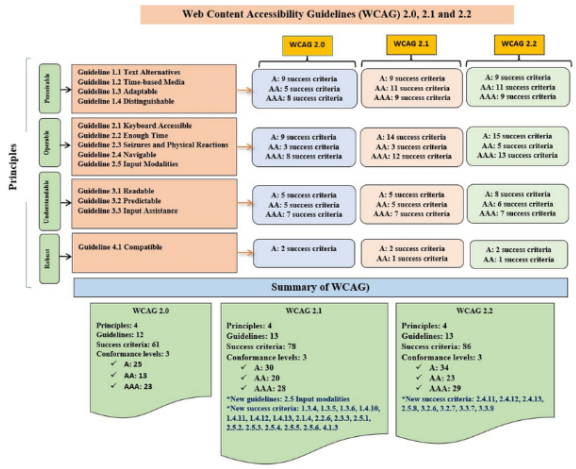

Fig. 2. Web Content Accessibility Guidelines 2.0 / 2.1 / 2.2

Accessibility, usability, and inclusion are three important factors to be considered while developing a website usable by people with disabilities [17]. The WAI suggests a set of WCAG guidelines to be followed by developers of any website. Thus, each tool is checked if it follows at least one version of WCAG standards like WCAG 2.0, WCAG 2.1 and WCAG 2.2.

Success criteria WCAG guidelines available at the W3C have a testable success criterion [18] that can be categorized into three levels of conformance namely A, AA and AAA respectively. Each conformance level creates a better user experience for a wider audience. Thus, we ensured to select tools that follow at least two levels of conformance to evaluate a webpage no less than sufficiently accessible. The conformance levels are as follows:

- Level A (Lowest Level): This holds the lowest level of accessibility success criterion to be satisfied by any website to be classified as accessible. A few suggestions by this level include-provide text alternatives for all non-text content; provide equivalent information for time-based media; create content that may be presented in multiple ways; use of color; audio and keyboard controls.
- Level AA (Sufficient Level): This holds a higher level of accessibility success criterion than Level A. The website should meet all conditions mentioned in Level A. Additionally, it should include live audio caption; audio description; text contrast and resizing; text over images; appropriate labels/headings.
- Level AAA (Highest Level): This holds the highest level of accessibility success criterion. The website should successfully meet all the criteria mentioned in Level A and Level AA along with extended audio descriptions; sign languages; multimedia alternatives and interruptions; and content size.

XI. POUR FACTORS

Guidelines and success criteria defined by the W3C are organized around four principles called the POUR factors. These principles lay the foundation necessary for anyone to access and use Web content with ease [19]. POUR is the abbreviation of Perceivable, Operable, Understandable and Robust. Each of the web accessibility evaluation tool is checked to follow at least one of the four factors. Additionally, information available on the website should be:

- Perceivable: The user interface components and information on website must be presented in a way that can be perceived by users with ease.
- Operable: Navigation and user interface components must be operable. This is necessary for users to operate all components required for interaction.
- Understandable: Operation and information of the interface must be understandable by the user. This is necessary as users must be able to understand the information and operations offered by website.
- Robust: Contents of website should work across.

XII. RESULTS

The W3 Consortium provides a publicly available quick reference for objectively rating the integration of accessibility into a platform. The WCAG 2.2 guidelines have a list of categories that can be rated on three levels: A, AA, and AAA. The lowest category, A, indicates poor accessibility, while the AA category signifies meeting all criteria of the A rating plus additional criteria. The highest category, AAA, implies that the previous levels are met.

We have established tree levels to categorize the issue founded in the analysis.

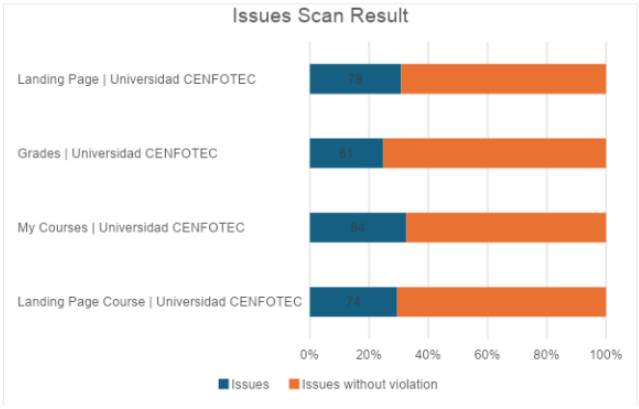

Fig. 3. Issues Scan Result

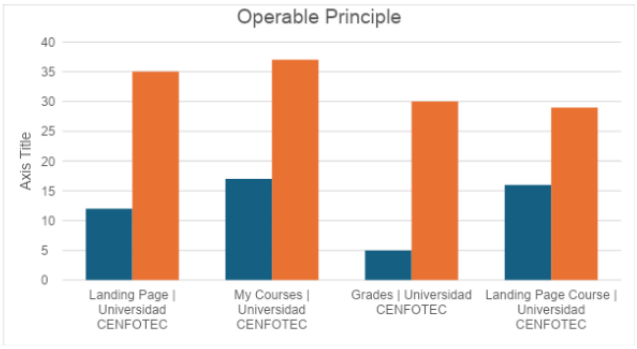

Fig. 4. Operable Principle

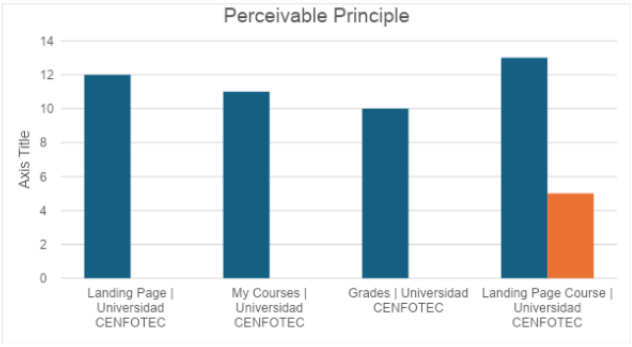

Fig. 5. Perceivable Principle

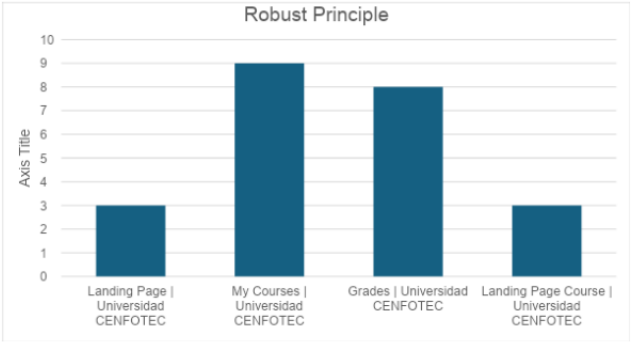

Fig. 6. Robust Principle

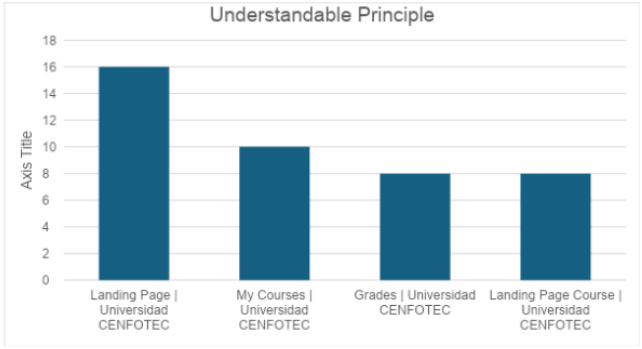

Fig. 7. Undestandable Principle

XIII. Solution Proposal

XIV. Conclusions and Future Work

- The importance of e-learning in the educational process is steadily increasing, necessitating that universities provide comprehensive facilities for both students and teachers to access knowledge through this medium. Ensuring accessibility across all aspects of the learning management system (LMS) platform is essential to enable seamless interaction with tools, modules, peers, and instructors.
- Moodle boasts commendable accessibility features, particularly in terms of customizable design elements, style options, selection editors, and alert configurations. However, there are notable gaps in accessibility considerations, particularly concerning session timeout protocols and default page settings.
- Moodle demonstrates strong adherence to accessibility criteria in various aspects such as page titles, breadcrumbs, navigation bars and menus, as well as link types and texts, ensuring visibility and navigational clarity for users with diverse needs.

Moodle has good accessibility features regarding customizing the design, style, selection editor, alert types, saving current state, but it does not consider accessibility criteria with respect to session timeout and default page. Moodle considered a good accessibility criteria with respect to page title, breadcrumbs, navigation bars and menu, link type and link text, visible.

TABLE I
Summary

Total issues	Violations	Needs review	Recomendations	Hidden
75	12	37	26	0

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