Media Accessibility in E-Learning: Analyzing Learning Management Systems

Muhammet Berigel ⓘ **, Duygu Solak Berigel** ⓘ **, Carlos Duarte** ⓘ **,
Christos Mettouris** ⓘ **, Evangelia Vanezi** ⓘ **, Alexandros Yeratziotis** ⓘ **,
and George A. Papadopoulos** ⓘ

Abstract Distance education and online learning gained significant importance, especially during the COVID-19 pandemic, as well as in response to new needs and trends in the digital age. Learning Management Systems (LMS) are one of the main instruments for formal and informal learning activities. Learners, educators, and potential new customers need LMS that are accessible to instructors and other users with disabilities, as well as produce accessible content for students. Accessibility standards, as Section 508, EN 301 549, ADA (Americans with Disabilities Act), and WCAG (Web Content Accessibility Guidelines), serve as the basis for evaluating LMS providers commitment to inclusivity. This study presents a critical assessment of the publicly available information provided by the LMS providers on their accessibility. It explores and compares the media accessibility features offered and adherence to established standards. This chapter aims to provide educators, institutions, and learners with valuable insights, enabling them to make well-informed decisions in an era where digital learning has become ubiquitous. Moreover, results of the study highlight the need for enhanced accessibility features and improved usability in creating accessible and inclusive LMS. Key themes arising from the review of LMSs regarding their accessibility features and compliance with established standards are presented.

M. Berigel (✉)
Karadeniz Technical University, Trabzon, Turkey
e-mail: muhammetberigel@gmail.com

D. S. Berigel
Trabzon University, Akçaabat, Turkey

C. Duarte
LASIGE, Faculdade de Ciências da Universidade de Lisboa, Lisbon, Portugal

C. Mettouris · E. Vanezi · G. A. Papadopoulos
Department of Computer Science, University of Cyprus, Nicosia, Cyprus

A. Yeratziotis
A.G. Connect Deaf Limited, Nicosia, Cyprus

1   Introduction and Background

In recent years, the integration of technology into education has brought about transformative changes in the way learning is delivered and accessed. Learning Management Systems (LMS) have emerged as powerful tools that facilitate the creation, management, and delivery of educational content in both traditional and online settings. While the adoption of LMS platforms has led to increased convenience and flexibility, it has also raised concerns regarding equitable access for all learners, including those with disabilities. As digital learning continues to evolve, the accessibility of LMS becomes a critical consideration in ensuring that education is truly inclusive. Moreover, characteristics and features that could transform LMS into advanced LMS from a technical perspective include learner profiling; customization/personalization/differentiated learning; ubiquitous learning; active knowledge making; multimodal meaning; recursive feedback; collaborative intelligence; and metacognition. Although implementation and adoption of the aforementioned are relatively slower in pace, learners and educators would benefit immensely, especially as these evolve over the next few years. We foresee such technologies having a significant role in enhancing equity, accessibility, inclusion, diversity and understanding and support for learners and therefore propose that they generally be considered more in the development of LMS.

1.1   Accessibility Standards and Regulations

To address the issue of digital accessibility, various international standards and regulations have been established. Notable among these are Section 508 of the Rehabilitation Act, the European Standard EN 301 549, the Americans with Disabilities Act (ADA), and the Web Content Accessibility Guidelines (WCAG) developed by the World Wide Web Consortium (W3C). These standards provide a framework for evaluating the accessibility of digital platforms, including Learning Management Systems. Institutions and organizations have increasingly recognized the importance of adhering to these standards to ensure that their educational content and platforms are accessible to individuals with disabilities.

Section 508 (U.S. General Services Administration, 2023) refers to a critical component of the Rehabilitation Act of 1973 in the United States, which mandates that federal agencies make their electronic and information technology accessible to people with disabilities. This includes Learning Management Systems (LMS) used in digital education. Compliance with Section 508 ensures that students and educators with disabilities have equal access to educational resources and opportunities. In the context of digital education, Section 508 plays a pivotal role in fostering inclusivity and eliminating barriers for individuals with diverse needs.

Across the Atlantic, the European Standard EN 301 549 (ETSI, CEN, & CENELEC, 2021) establishes accessibility requirements for ICT products and

services, including those used in education. Developed by the European Telecommunications Standards Institute (ETSI), this standard aims to create a more inclusive digital environment. EN 301 549 considers a wide range of disabilities and ensures that learning materials and platforms, including Learning Management Systems, are designed to accommodate diverse learners. In the realm of digital education, adherence to this standard enhances accessibility, creating an environment conducive to learning for all.

The Americans with Disabilities Act (ADA) (U.S. Department of Justice Civil Rights Division, 2008) is a landmark piece of legislation in the United States that prohibits discrimination against individuals with disabilities. In the context of digital education, ADA compliance is crucial for ensuring that online learning platforms, including Learning Management Systems, are accessible to all students and educators. ADA extends beyond federal agencies to cover a broader spectrum, emphasizing the importance of inclusivity in the digital education landscape.

The Web Content Accessibility Guidelines (WCAG) (W3C, 2024) provide a comprehensive set of recommendations for making web content, including educational materials on Learning Management Systems, more accessible. Developed by the Web Accessibility Initiative (WAI), these guidelines are internationally recognized and serve as a benchmark for digital inclusivity. Adhering to WCAG ensures that educational content is perceivable, operable, and understandable by a diverse audience, reinforcing the principles of universal design in the realm of digital education.

1.2 Digital Inclusion in Education

The concept of digital inclusion in education goes beyond compliance with accessibility standards; it embodies the principle that all learners, regardless of their abilities, should have equal access to educational opportunities. Accessible LMS platforms play a pivotal role in removing barriers to learning for individuals with disabilities. A study by Burgstahler and Cory (2008) highlights that accessible online learning environments not only benefit students with disabilities but also enhance the overall learning experience for all students by providing diverse means of engagement and interaction.

Accessible LMS platforms encompass a range of features and technologies designed to accommodate different types of disabilities. These include video subtitles to aid individuals with hearing impairments, easy navigation and interactivity options for intuitive use, screen reader support for visually impaired users, accessible text editors for content creation, support for accessible course content, high-contrast themes for improved visibility, and keyboard accessibility for those who rely on keyboard navigation.

While substantial progress has been made in improving the accessibility of LMS platforms, challenges persist. These challenges range from ensuring that accessibility features are effectively implemented to keeping pace with evolving technologies.

Future research in this domain should address the practical implementation of accessibility standards and explore innovative solutions to enhance the overall usability of LMS platforms for individuals with disabilities.

In conclusion, the accessibility of Learning Management Systems is a pivotal aspect of modern education, reflecting the commitment to inclusivity and equitable access to knowledge. This literature review sets the stage for a comprehensive examination of LMS platforms, evaluating their adherence to accessibility standards and the presence of key accessibility features. The study aims to contribute to the ongoing dialogue on accessible digital education, providing valuable insights for educators, institutions, and learners alike.

1.3   Literature Review on Accessibility in LMS

In the literature, many papers explore whether LMS conform to accessibility standards and the level to which they do. Most LMS include accessibility barriers that make the creation of accessible e-learning environments difficult for teachers and administrators (Calvo et al., 2014). Calvo et al. (2014) evaluated the accessibility of the Moodle authoring tool with a study focused on visual impairment. According to the World Health Organization (WHO), an estimated 2.2 billion people have a near or distance vision impairment (WHO, 2023). Visually impaired users confront numerous difficulties daily when accessing web pages and online content. The authors mention two studies (Creven, 2003; Disability Rights Commission, 2004) that concluded that visually impaired users using screen readers were found to take three times as long as non-disabled users to complete a given task. Common problems faced by screen reader users include the lack of labels associated with controls like inputText, complex Web page structures and layouts, the lack of alternative texts for images, the impracticality of certain navigation techniques, inadequate color contrasts used, and incorrect size of elements (Disability Rights Commission, 2004).

Especially in LMS, visually impaired users often face difficulties in accessing online courses or learning content, while visually impaired teachers and administrators face difficulties in uploading their learning materials and managing their courses (Calvo et al., 2014). It is important to note here that, regarding LMS, besides the system itself, all documents and resources created by the teachers and presented via the LMS should also be accessible. For example, screen reader users require alternative text in all images, while hearing-impaired users require appropriate subtitles for videos (Calvo et al., 2014).

Regarding studies that evaluate LMS according to accessibility guidelines, it is mentioned that in most studies, LMS like Moodle, dotLRN, Blackboard ATutor, and Sakai have been found to contain serious barriers to accessibility with respect to WCAG 1.0 and ATAG 2.0 (Calvo et al., 2014; Iglesias et al., 2014; Power et al., 2010). Accessibility problems for visually impaired users in Moodle were also found in the diverse images used to convey information and the lack of headings in the application (Moreno et al., 2012). Hence, Moodle did not conform to ATAG 2.0 or WCAG 2.0.

Calvo et al. (2014) conclude with recommendations for improving the accessibility of Moodle interface and the content created therein, the most important of which are: checking the accessibility of any external elements before using them in Moodle, avoiding common accessibility errors, and providing mechanisms to enable authors to avoid mistakes such as buttons for the cancellation of each task, mechanisms to undo actions executed, functionalities to periodically save the actions executed to prevent information loss, ways to save user preferences regarding auto-saving, colors, font size, etc.

In Iglesias et al. (2014), a comparative study of the accessibility of three LMS, Moodle, ATutor, and Sakai, was conducted as regards the compliance of each system with ATAG 2.0 and each system's user interface with WCAG 1.0. The results of the study indicate that indeed barriers to accessibility exist in each of the three systems evaluated. More to the point, the authors conclude that ATutor facilitates the creation of accessible learning content better than the other two LMS. However, problems were observed in all three LMS that would likely limit their accessibility for certain groups of users like elderly people and people with disabilities. Such accessibility barriers could partially or completely exclude these users from interacting with the LMS (Iglesias et al., 2014).

Regarding accessibility of mobile applications for LMS, a recent study showed that many educational mobile apps remain inaccessible to users with disabilities who require accessibility features such as talkback or screen reader features (Aljedaani et al., 2023; Brito & Dias, 2020). The authors in Aljedaani et al. (2023), Brito and Dias (2020) explore the accessibility status of the Blackboard mobile app, a well-known and widely used LMS. They have conducted a survey on students' perceived usability of the Blackboard mobile app, where 1308 hearing students and 65 deaf and hard-of-hearing students participated. In addition, the authors collected and analyzed 15,478 user reviews from the Google Play Store to identify any accessibility issues. The outcome of this study was that most deaf and hard-of-hearing students found difficulty in using the Blackboard mobile app compared to hearing students. For example, the lack of captions in some videos caused problems for deaf students, as they could not hear what the teacher was saying and solely relied on captions. This problem was reported for both live-streaming content and pre-recorded videos. The app store analysis showed that only 31% of the reviews reported violations of accessibility principles that apps like Blackboard must comply with. The study highlights these violations and their corresponding implications to support LMS frameworks in becoming more inclusive for all users.

We aim to provide a complementary study by examining compliance with accessibility standards and key accessibility features regarding the 10 most widely used Learning Management Systems, a combination that no other work studied so far.

2 Methodology

The methodology for this study involved a critical assessment of the publicly available information provided by the LMS providers. This included reviewing provider Web sites, product documentation, and marketing materials to identify the accessibility features and limitations of their LMSs. The information was then analyzed using a content analysis approach (Krippendorff, 2019) to identify patterns, themes, and trends in the data. An overview of the methodology is presented in Fig. 1.

2.1 Research Objective

This study aims to assess the reported accessibility standards compliance and the availability of key accessibility technology features within the 10 most widely used Learning Management Systems (LMS). The primary focus is to provide an overview of the current accessibility status of these LMS platforms as reported by their providers.

2.2 Selection of Learning Management Systems

A purposive sampling method is employed to select the 10 LMS platforms for examination. These platforms are chosen based on their popularity and extensive usage in
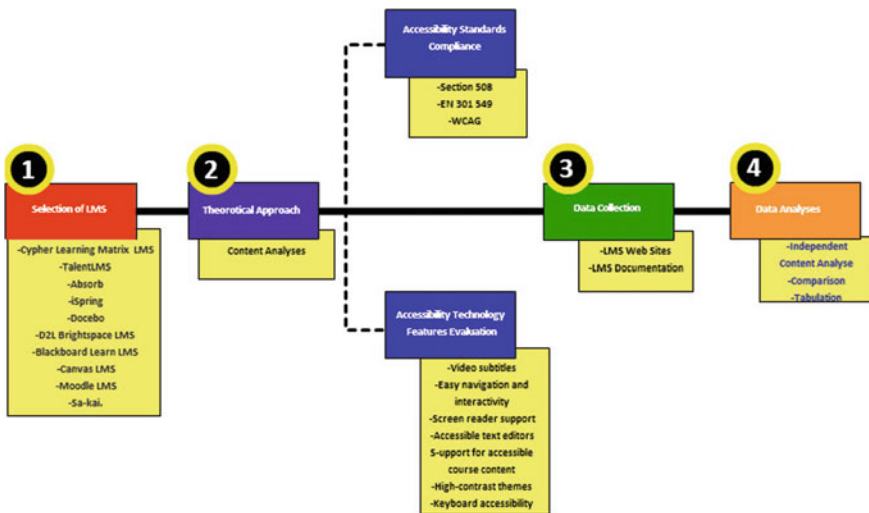
Fig. 1 Study methodology

educational settings, ensuring the representation of a broad spectrum of users. The selected LMS platforms, presented in Table 1 include Cypher Learning's MATRIX LMS, TalentLMS, Absorb, iSpring, Docebo, D2L Brightspace LMS, Blackboard Learn LMS, Canvas LMS, Moodle LMS, and Sakai.

2.3   Accessibility Standards Compliance

In our study, we undertook a compliance check of accessibility standards for LMS. The selection of the accessibility standards was based on their global acceptance, comprehensive coverage, and relevance to digital learning environments. We chose Section 508, the EN 301 549, and WCAG 2.0 and 2.1. Section 508 was selected due to its broad application within the U.S. federal agencies and its emphasis on electronic and information technology. The EN 301 549 was chosen for its extensive applicability in the European market and its focus on ICT products and services. WCAG 2.0 and 2.1 were selected for their worldwide acceptance and their specific guidelines for web content accessibility. Moreover, these standards collectively provide a comprehensive framework for digital accessibility, thus ensuring that our compliance check was thorough. We then proceeded to scrutinize the LMS information provided by vendors to determine their compliance with these selected standards. This involved a detailed analysis of vendor documentation and product specifications, enabling us to assess the degree to which each LMS adhered to the chosen accessibility standards.

2.4   Accessibility Technology Features Evaluation

A comprehensive examination of accessibility technology features and functionalities available within each LMS platform is conducted based on the information each LMS provider provides for their platforms. The key features assessed include:

1. Video Subtitle: The presence of options for adding subtitles or captions to video content.
2. Easy Navigation and Interactivity: The extent to which the LMS interface facilitates easy navigation and interaction for users with disabilities.
3. Screen Reader Support: The compatibility of the LMS with popular screen reader software.
4. Accessible Text Editors: The availability of text editors that offer accessibility features for content creation.
5. Support for Accessible Course Content: The LMS's capacity to host and deliver course materials in accessible formats.
6. High-Contrast Themes: The provision of high-contrast themes to accommodate users with visual impairments.

Table 1 Assessment of the various LMS according to their support of accessibility standards and features

LMS	Standards			Technologies/features						
	Section 508	EN 301 549	WCAG	Video subtitles	Easy navigation and interactivity	Screen reader support	Accessible text editors	Support for accessible course content	High-contrast themes	Keyboard accessibility
Cypher learning MATRIX LMS	+	–	+	–	+	+	+	+	+	+
TalentLMS	Partial	–	+	–	+	+	+	+–	+	+
Absorb	–	–	+	+	+	Partial	+	Partial	Partial	+
iSpring	+	–	+	+	+	+	+	+	+	+
Docebo	+	+	+	+	+	+	+	+	+	+
D2L Brightspace LMS	+	+	+	+	+	+	+	+	+	+
Blackboard learn LMS	+	–	+	+	+	+	+	+	+	+
Canvas LMS	+	–	–	+	+	–	Partial	+	+	+
Moodle LMS	+	–	+	+	+	+	+	+	+	+
Sakai	+	–	+	+	Partial	+	+	+	+	+

7. Keyboard Accessibility: The ease with which users can navigate and interact with the LMS using only keyboard input.
8. Standards Compliance: The accessibility standards the LMS is reported to comply with.

2.5 Data Collection

Data collection is performed on each platform's Web site and documentation, looking specifically for information related to each of the accessibility technology features identified before.

2.6 Data Analysis

The findings from the assessment of each LMS are analyzed independently. Compliance with accessibility standards and the availability of technology features are reported in Table 1.

A comparative analysis is carried out to juxtapose the accessibility performances of the 10 LMS platforms. This analysis highlights variations in standards compliance and the presence of technology features across the platforms.

3 Findings

In the study, detailed analysis and reviews were carried out for ten LMS, and accessibility reviews were carried out for each LMS.

3.1 Cypher Learning's MATRIX LMS

Cypher Learning's MATRIX LMS incorporates several features that contribute to a more inclusive learning environment. The platform offers keyboard navigation, screen reader support, accessible text editors, and high-contrast themes, ensuring that users with diverse needs can navigate and engage effectively. The provision of closed captions, transcripts, and subtitles for multimedia content reflects an understanding of the importance of multiple modalities for learning. Additionally, the platform's adherence to accessibility standards, including Section 508 and WCAG, reinforces its dedication to creating an inclusive digital education space. However, the absence of video subtitles as an accessibility feature may pose challenges for users who rely on them. Furthermore, the lack of reported compliance with EN 301 549 raises questions about the platform's accessibility in the European context.

3.2 TalentLMS

TalentLMS integrates multiple features fostering an inclusive experience in online learning. The platform offers strong support for easy navigation, screen reader compatibility, accessible text editors, high-contrast themes, and keyboard accessibility, addressing the needs of users with diverse abilities. Full compliance with WCAG is evident, emphasizing a dedication to recognized international accessibility standards. However, notable gaps exist in the absence of video subtitles and partial support for accessible course content. The lack of video subtitles may pose challenges for users who rely on them for comprehension, limiting the platform's inclusivity in multimedia learning scenarios. While TalentLMS acknowledges alignment with Section 508 and ADA requirements, the partial compliance suggests potential challenges in meeting all aspects of these regulations. Additionally, the non-reporting of EN 301 549 compliance raises questions about the platform's accessibility in the European context.

3.3 Absorb LMS

Absorb LMS incorporates various features to foster inclusivity in online learning. The inclusion of video subtitles, easy navigation, and interactive elements, along with accessible text editors and keyboard compatibility, reflects a comprehensive approach to addressing diverse user needs. The platform's alignment with WCAG standards is evident in the introduction of screen reader compatibility, enabling text-to-speech engines, and the option to customize reading orders for improved readability. While Absorb LMS has made commendable strides in accessibility, there are notable gaps. Partial screen reader support and partial availability of high-contrast themes suggest areas where further improvements can enhance the experience for users with disabilities. Additionally, the absence of reported Section 508 and EN 301 549 compliance raises questions about the platform's adherence to specific accessibility standards, particularly in the U.S. and European contexts. The platform's initiatives to make multiple-choice and true or false questions accessible for screen readers and keyboard users, along with support for timed and video pages, align with WCAG requirements. However, the inaccessibility of elements like tooltips and audio, as well as the limited compatibility of themed templates with accessibility standards, indicates areas for enhancement.

3.4 iSpring LMS

iSpring LMS offers a comprehensive suite of accessibility features, contributing to an inclusive online learning experience. The platform provides video subtitles,

easy navigation, screen reader support, accessible text editors, and high-contrast themes, addressing the needs of users with diverse abilities. Notably, iSpring LMS achieves Section 508 compliance, reinforcing its commitment to accessibility standards in the U.S. The LMS provider underscores iSpring's commitment to inclusivity, emphasizing alignment with WCAG 2.1 standards. The unique publishing format enabling learners to switch to accessibility mode is a commendable feature, enhancing text readability, simplifying navigation, and ensuring compatibility with prominent screen readers like JAWS, VoiceOver, and NVDA. The encouragement for authors to rely on text, include meaningful data in questions, and ensure accessibility of audio and video content reflects a proactive approach to content creation. However, the absence of reported compliance with EN 301 549 raises questions about the platform's accessibility in the European context. While the provider highlights the availability of accessibility features, a more explicit acknowledgement of adherence to additional international standards would provide a more comprehensive understanding of iSpring LMS's global accessibility compliance.

3.5 Docebo LMS

Docebo LMS exhibits a comprehensive set of features that contribute to an inclusive online learning experience. The platform provides video subtitles, easy navigation, screen reader support, accessible text editors, high-contrast themes, and keyboard accessibility, addressing the diverse needs of users. Docebo's commitment to accessibility is evident through its compliance with key standards, including WCAG 2.1, U.S. Section 508, and European EN 301 549 V3.1.1, showcasing a global commitment to inclusivity. The provider emphasizes Docebo's dedication to accessibility, extending beyond legal requirements to a broader goal of inclusivity. The platform's impact on various aspects of the learning experience, from registration to layout, underscores a holistic approach to accessibility. Noteworthy features include the "skip to main content" option for users of assistive technology, enabling efficient navigation. While Docebo's commitment to accessibility is commendable, the acknowledgment that content uploaded by users must be made accessible without content checks raises considerations for ensuring comprehensive inclusivity. It would be beneficial for Docebo to implement content checks or provide clearer guidance to users on creating accessible content to enhance the overall accessibility of the platform.

3.6 D2L Brightspace LMS

D2L Brightspace Learning Management System offers an extensive array of features to create an inclusive learning environment. The platform provides video subtitles, easy navigation, screen reader support, accessible text editors, high-contrast themes,

and keyboard accessibility, aligning with stringent standards including WCAG 2.1, Section 508, and EN 301 549. Brightspace's dedication to accessibility extends beyond compliance, emphasizing a comprehensive approach to enhancing the educational experience for all users. The LMS provider underscores Brightspace's commitment to accessibility, detailing specific features that contribute to a more inclusive learning community. The integration of an HTML Editor with an Accessibility Checker is a commendable initiative, ensuring content pages are free from common accessibility issues. Encouraging proper usage of headings for visually impaired students signifies a thoughtful consideration of diverse learning needs. Brightspace's organization options, such as modules and sub-modules, contribute to smooth navigation, fostering an intuitive learning experience.

3.7 Blackboard LMS

Blackboard LMS incorporates a range of features that align with recognized standards such as WCAG 2.1 Level AA and Section 508. The platform provides video subtitles, easy navigation, screen reader support, accessible text editors, high-contrast themes, and keyboard accessibility. The structure of Blackboard Learn pages reflects a thoughtful design with a logical heading structure, consistent H1 and H2 usage, and hidden elements to improve navigation. Replacing frames with DIVs and iFrames contributes to better page accessibility, and the use of landmarks based on ARIA further enhances the platform's accessibility. The implementation of industry-standard keyboard navigation patterns demonstrates a commitment to providing an accessible interface. However, the absence of reported compliance with EN 301 549 raises questions about the platform's accessibility in the European context. While the platform's comprehensive accessibility features are commendable, ensuring transparency on European standards compliance would provide a more holistic understanding of Blackboard LMS's accessibility initiatives.

3.8 Canvas LMS

Canvas Learning Management System incorporates various features designed to create an inclusive learning environment. The platform provides video subtitles, easy navigation, support for accessible course content, high-contrast themes, keyboard accessibility, and Section 508 compliance. The use of modern HTML and CSS technologies, along with manual testing for popular screen readers and browsers, signifies a proactive approach to ensuring compatibility with assistive technologies. Region-based navigation using ARIA landmarks enhances page traversal for users relying on keyboard navigation. However, the partial availability of accessible text editors is a gap that could impact the experience for users with certain disabilities. While Canvas

encourages direct communication with third-party developers to ensure compliance, the variability in standards for integrated tools raises considerations for a consistent user experience.

3.9 Moodle LMS

Moodle Learning Management System offers a comprehensive set of features designed to create an inclusive learning environment. The platform provides video subtitles, easy navigation, screen reader support, accessible text editors, high-contrast themes, keyboard accessibility, and Section 508 compliance. Moodle's dedication to adhering to multiple accessibility standards, including WCAG 2.1, ATAG 2.0, and ARIA 1.1, underscores a commitment to recognized benchmarks. The acknowledgement that accessibility is an ongoing process of continuous improvement, with a focus on user feedback and expert testing, reflects a proactive approach to evolving user needs and technical environments. The platform's compliance with WCAG 2.1 AA ensures that authoring and evaluation tools align with robust accessibility criteria. Additionally, the provision of features and integrations, such as the Accessibility Starter Toolkit, further supports educators in creating accessible content. However, the absence of reported compliance with EN 301 549 raises questions about the platform's accessibility in the European context.

3.10 Sakai LMS

The Sakai Learning Management System provides various features designed to establish an inclusive learning environment. The platform provides screen reader support, accessible text editors, high-contrast themes, keyboard accessibility, and Section 508 compliance. Notably, the inclusion of Quick Access links, a Tool Menu, and a content area designed to be navigable with Access keys enhances ease of navigation and interactivity. The responsive design accommodating various screen sizes and guidance for users to modify text size and color/contrast settings contribute to a user-friendly interface. The absence of information regarding video subtitle support leaves uncertainty about the platform's multimedia accessibility. While the system likely adheres to recognized guidelines such as WCAG and Section 508, explicit mention of these standards would provide greater clarity for users seeking specific accessibility information.

4   Discussion

The section delves into a comprehensive exploration of key themes arising from the critical assessment of LMSs regarding their accessibility features and compliance with established standards. Through a systematic evaluation of prominent LMS platforms, this study has identified recurring themes, including the presence of critical accessibility features, compliance gaps, content creation and guidelines, user interaction and navigation, and global accessibility considerations. These themes encapsulate the intricacies of digital accessibility in educational technology, shedding light on both commendable practices and areas for improvement within the LMS landscape. As we navigate through each theme, we aim to unravel insights into how LMSs contribute to or hinder inclusive learning practices and digital accessibility. By initiating this discussion, we seek to foster a deeper understanding of the current state of LMS accessibility, laying the groundwork for future advancements that will facilitate a more inclusive and equitable digital education landscape.

4.1   The Presence of Critical Accessibility Features

The first theme centers on the identification and examination of critical accessibility features present in various LMSs. Notably, LMS platforms such as iSpring, Docebo, and D2L Brightspace have demonstrated a commendable commitment to inclusivity by incorporating essential features like video subtitles, screen reader support, accessible text editors, and high-contrast themes. These features cater to users with diverse needs, ensuring that individuals with visual impairments, hearing impairments, or motor disabilities can effectively engage with the learning content. For instance, iSpring's accessibility mode and Docebo's "skip to main content" option exemplify a user-centric approach to accommodate different learning styles and preferences. While Canvas and Blackboard also exhibit strong commitments to accessibility, Canvas's partial availability of accessible text editors highlights a nuanced aspect, emphasizing the need for comprehensive toolsets. The exploration of this theme underscores that the inclusion of critical accessibility features is foundational for fostering an inclusive digital learning environment. Brito and Dias (2020) found that it is important for the LMS to allow compatibility with external tools, which can in turn be adapted according to learner needs. This is a preferred approach in comparison with directly embedding facilities into the LMS. This approach would support learners with disabilities in using the adapted software and hardware needed, such as scroll wheels, touch screens, hands-free touchpads. It is thus imperative for developers to first be aware of these accessibility concerns and second develop compatible applications. This form of compatibility would further enhance the LMS under this theme. Rashikj-Canevska et al. (2021) likewise emphasize the importance of creating different types of accessibility plug-ins to ensure LMS offer greater accessibility. These extend to plug-ins with support for text-to-speech engine for blind students, a

mode for sign language support for deaf students, mode supporting dyslexic students, and speech-to-text mode for motor impaired students.

4.2 Compliance with Accessibility Standards

The second theme revolves around the examination of Learning Management Systems' adherence to established accessibility standards. Several platforms, including Docebo, iSpring, and D2L Brightspace, showcase a robust commitment to compliance with recognized standards such as WCAG, Section 508, and EN 301 549. These standards are designed to ensure that digital content is accessible to users with disabilities, emphasizing factors like perceivability, operability, and understandability. The inclusion of video subtitles, easy navigation, and screen reader support aligns with these standards, reflecting a proactive effort to meet the diverse needs of users (Batanero-Ochaíta et al., 2021). However, the absence of reported compliance with EN 301 549 in some cases raises questions about the platforms' accessibility in the European context. The discussion on this theme delves into the importance of aligning with recognized standards to guarantee a universally accessible learning environment and highlights the need for consistent reporting across different jurisdictions to ensure global inclusivity (Ingavélez-Guerra et al., 2023).

Examining LMS platforms through the lens of accessibility standards reveals the commitment of these platforms to providing a learning environment that caters to all. The discussion of this theme contributes to a broader understanding of how platforms can proactively engage with established benchmarks, fostering an inclusive space for learning. It also prompts considerations about the challenges associated with varying standards across different regions and the importance of a unified approach to digital accessibility in education.

4.3 Content Creation and Guidelines

Content creation plays a pivotal role in ensuring an inclusive learning experience, and the third theme underscores the strategies adopted by LMS platforms to guide authors in creating accessible content. Notably, platforms like iSpring LMS take a proactive approach by providing unique publishing formats and accessibility modes. These features empower authors to simplify navigation, enhance text readability, and ensure compatibility with prominent screen readers. The discussion on this theme delves into the multifaceted aspects of accessible content creation, including the encouragement to rely on text, inclusion of meaningful data in questions, and addressing the accessibility of audio and video content. These guidelines are crucial for fostering an environment where educational materials are perceivable and comprehensible to a diverse audience, accommodating different learning styles and preferences.

The exploration of this theme prompts considerations about the role of LMS platforms in shaping content creation practices. It raises questions about the integration of content creation guidelines directly into the authoring tools of LMSs, ensuring that accessibility considerations are seamlessly woven into the fabric of educational material development. Additionally, the theme invites discussions on the collaborative efforts between LMS providers and educational institutions in educating authors about the significance of accessible content creation. This theme highlights the transformative potential of content creation guidelines in shaping a digital educational landscape that is inherently inclusive and caters to the diverse needs of learners. The lack of work in this area is highlighted and remains a main obstacle preventing the use of LMS by learners with disabilities. According to Brito and Dias (2020), teachers also have a role to play under this theme, like in providing captions for images or tables or not uploading content in the form of a scanned PDF unless such content can be converted by OCR software.

4.4　User Interaction and Navigation

The fourth theme revolves around the critical aspects of user interaction and navigation within LMSs. Seamless navigation is imperative for an inclusive learning environment, and LMS platforms address this through various features. Region-based navigation using Accessible Rich Internet Applications (ARIA) landmarks and organizational options like modules and sub-modules contribute to a smoother learning experience. Furthermore, the use of HTML Editors with integrated Accessibility Checkers emerges as a noteworthy practice, ensuring that content pages are devoid of common accessibility issues. The discussion on this theme encompasses the importance of providing features that facilitate intuitive navigation, especially for users who rely on keyboard navigation or screen readers. Additionally, the theme encourages reflections on the ongoing advancements in user interface technologies and their implications for enhancing accessibility.

4.5　Global Accessibility Considerations

The fifth and final theme delves into the global accessibility considerations of LMSs, particularly the questions raised about their accessibility in the European context. This theme underscores the necessity for international standards compliance to ensure inclusivity on a global scale. The absence of reported compliance with EN 301 549 in some LMSs raises pertinent questions about their accessibility in the European landscape. The theme invites considerations about the complexities of adhering to diverse accessibility standards and regulations in different parts of the world. It raises questions about the strategies LMS providers employ to navigate these variations and ensure their platforms meet the expectations of users globally. This discussion also

opens avenues for exploring the evolving nature of global accessibility standards and the role of LMSs in shaping and adapting to these standards. In conclusion, the theme on global accessibility considerations prompts a deeper understanding of the challenges and opportunities associated with ensuring that digital educational platforms cater to a diverse and global user base. It emphasizes the need for collaborative efforts in standardizing accessibility practices to create a truly inclusive digital learning environment worldwide.

Inclusive learning practices can be significantly enhanced through the robust implementation of digital accessibility features in LMSs. The themes identified underscore the importance of providing a diverse range of accessibility features to cater to users with varying needs. LMSs play a pivotal role in fostering inclusivity by ensuring compliance with established standards such as WCAG, Section 508, and EN 301 549. To further support inclusive learning practices, LMS providers should prioritize closing compliance gaps, especially concerning video subtitles, to ensure equitable access to multimedia content. Moreover, a collaborative effort between LMS providers, educators, and content creators is crucial to promote adherence to content creation guidelines that prioritize accessibility. By addressing global accessibility considerations and maintaining transparency about compliance with international standards, LMSs can contribute to creating a digital learning environment that is accessible and inclusive for all learners and educators.

5   Conclusions

This study provides a comprehensive analysis of Learning Management Systems (LMSs) with a focus on their accessibility features and adherence to established standards. The literature review establishes the backdrop by emphasizing the transformative impact of technology on education and the ensuing challenges related to equitable access for diverse learners. The critical assessment of LMSs through a content analysis methodology revealed recurring themes, such as the presence of critical accessibility features, compliance gaps, content creation and guidelines, user interaction and navigation, and global accessibility considerations. These themes shed light on the complexities and opportunities within the LMS landscape concerning digital accessibility. The exploration of each theme contributes valuable insights into how LMSs either facilitate or hinder inclusive learning practices. The themes collectively underscore the importance of robust digital accessibility implementation and adherence to international standards to foster inclusivity in digital education.

As we conclude this study, it is essential to acknowledge the avenues for future research in the realm of LMS accessibility. While this research provides a foundational understanding of current practices and challenges, there is a need for in-depth investigations into the user experience and impact of accessibility features on diverse learners. Future studies could employ user testing methodologies to evaluate the effectiveness and usability of specific accessibility features identified in this research. Additionally, longitudinal studies could track the evolution of LMS

accessibility, considering the dynamic nature of both technology and accessibility standards. Collaborative efforts between LMS providers, educators, and accessibility experts could be explored to develop best practices and guidelines that address the identified gaps and elevate the overall accessibility landscape. Moreover, extending this research to encompass a more extensive array of LMS platforms and updates would provide a more nuanced understanding of the diverse approaches to digital accessibility in education. Lastly, knowing that LMS have a crucial role in mediating knowledge processes, gamification and game elements are commonly being used nowadays to engage learners and enhance the learning experience. It is however important that learners with disabilities can also access and experience equally these gamified learning resources too and this portrays another important avenue of future research (Schimmelpfeng & Ulbricht, 2021).

References

Aljedaani, W., Alkahtani, M., Ludi, S., Mkaouer, M. W., Eler, M. M., Kessentini, M., & Ouni, A. (2023). The state of accessibility in blackboard: Survey and user reviews case study. In *Proceedings of the 20th International Web for All Conference* (pp. 84–95). Association for Computing Machinery.

Brito, E., & Dias, G. P. (2020, June). LMS accessibility for students with disabilities: The experts' opinions. In *2020 15th Iberian Conference on Information Systems and Technologies (CISTI)* (pp. 1–5). IEEE.

Batanero-Ochaíta, C., De-Marcos, L., Rivera, L. F., Holvikivi, J., Hilera, J. R., & Tortosa, S. O. (2021). Improving accessibility in online education: comparative analysis of attitudes of blind and deaf students toward an adapted learning platform. *IEEE Access, 9*.

Burgstahler, S. E., & Cory, R. C. (2008). *Universal design in higher education: From principles to practice*. Harvard Education Press.

Calvo, R., Iglesias, A., & Moreno, L. (2014). Accessibility barriers for users of screen readers in the Moodle learning content management system. *Universal Access in the Information Society*, 315–327.

Creven, J. (2003). Access to electronic resources by visually impaired people. *Information Research: An International Electronic Journal, 156*.

Disability Rights Commission. (2004). *The web: Access and inclusion for disabled people: A formal investigation*. The Stationery Office (TSO).

ETSI, CEN, CENELEC. (2021). EN 301 549 v3.2.1 Accessibility requirements for ICT products and services. Retrieved from https://www.etsi.org/deliver/etsi_en/301500_301599/301549/03.02.01_60/en_301549v030201p.pdf

Iglesias, A., Moreno, L., Martínez, P., & Calvo, R. (2014). Evaluating the accessibility of three open-source learning content management systems: A comparative study. *Computer Applications in Engineering Education*, 320–328.

Ingavélez-Guerra, P., Otón-Tortosa, S., Hilera-González, J., & Sánchez-Gordón, M. (2023). The use of accessibility metadata in e-learning environments: A systematic literature review. *Universal Access in the Information Society, 22*, 445–461.

Krippendorff, K. (2019). *Content analysis: An introduction to its methodology*. SAGE Publications.

Moreno, L., Iglesias, A., Calvo, R., Delgado, S., & Zaragoza, L. (2012). Disability standards and guidelines for learning management systems: Evaluating accessibility. In *Information resources management association, virtual learning environments: Concepts, methodologies, tools and applications* (pp. 1530–1549). IGI Global.

Power, C., Petrie, H., Sakharov, V., & Swallow, D. (2010). Virtual learning environments: Another barrier to blended and e-learning. In *Computers helping people with special needs* (pp. 519–526). Springer.

Rashikj-Canevska, O., Tasevska, A., Orechova, M., Dias, G. P., & Haubro, H. (2021). *Accessible learning management systems: Students' experiences and insights*.

Schimmelpfeng, L. E., & Ulbricht, V. R. (2021). Accessible learning management system (LMS) for disabled people: Project development based on accessibility guidelines, gamification, and design thinking strategies. In *The role of gamification in software development lifecycle*. IntechOpen.

U.S. Department of Justice Civil Rights Division. (2008). *Americans with Disabilities Act of 1990, As Amended*. Retrieved from https://www.ada.gov/law-and-regs/ada/

U.S. General Services Administration. (2023). *Section508.gov*. Retrieved from https://www.section508.gov/

WHO. (2023, August 10). *Blindness and vision impairment*. Retrieved from http://www.who.int/mediacentre/factsheets/fs282/en/

W3C. (2024). WCAG 2 Overview. Retrieved from https://www.w3.org/WAI/standards-guidelines/wcag/