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An Evaluation Rubric for Learning Management Systems: Enhancing Accessibility and Artificial Intelligence in Educational Settings and Industry Applications.

By

Laura Leonard

Dissertation by practice submitted in partial fulfilment of the requirements for MA in Education, Learning and Development (QQI)

Faculty of Teaching and Learning

Griffith College Dublin

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Declaration

I hereby certify that this material, which I now submit for assessment on the programme of study leading to the award of the MA in Education, Learning and Development, is my own; based on my personal study and/or research, and that I have acknowledged all material and sources used in its preparation. I also certify that I have not copied in part or whole or otherwise plagiarised the work of anyone else, including other learners.

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Abstract

This dissertation by practice develops an innovative rubric (initially adapted from the Anstey and Watson model) for evaluating Learning Management Systems (LMSs) with a dual focus on Accessibility and Artificial Intelligence (AI), addressing current gaps in evaluation practices within educational and industry settings. The study utilises a mixed-methods approach, reviews existing literature, and integrates criteria underpinned by learning theory, culminating in the development of an enhanced LMS evaluation rubric. Based on feedback from empirical testing, including surveys, observation studies, thematic analysis and decision analysis, the rubric was further refined, ensuring its relevance and effectiveness in addressing the specific needs of accessibility and AI integration in learning environments. This research provides a robust tool for educators and industry professionals, proposing a standard for future evaluations that prioritise inclusive and technologically advanced learning environments. The implications extend to better-informed decisions in selecting and implementing LMSs, significantly influencing educational strategies and corporate training programs.

Keywords

Accessibility, Accessible Learning, AI Act, Artificial Intelligence (AI), Artefact, Courses, E-Learning, Evaluation Criteria, Evaluation Research, LMS Evaluation Rubric, European Accessibility Act (EAA), Framework, Learning Analytics, Learning Management Systems, LMS, Learning Styles, Model, Rubric, Training, Universal Design for Learning (UDL), WCAG

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For Liz, Rest in Peace

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1 Chapter 1 Introduction

1.1 Overview

This dissertation by practice seeks to address a significant gap in the evaluation of Learning Management Systems (LMS). Henceforth, Learning Management System will be referred to as LMS or LMSs. Despite widespread LMS adoption, current evaluation frameworks lack criteria for Accessibility and Artificial Intelligence (AI), resulting in LMS solutions that may not meet the diverse needs of learners or leverage AI to enhance learning.

This research aims to support two audiences: Learning and Development professionals in industry and academia, and MSc Interactive Digital Media (MSCIDM) students at Griffith College, Dublin. MSCIDM students conducting dissertations by practice collaborate on a group project to develop an application. Those focusing on e-learning projects create content and select an LMS, often integrating with a website. Since supervisors assist mentees in the selection of an LMS, providing an additional tool to support this selection process allows them to critically analyse the tools available. Similarly, for industry experts, this tool will assist in performing decision analysis, ensuring that the chosen LMS provides the best results and utilises resources efficiently and strategically.

This study will:

1. Identify criteria underpinned by learning theory for LMS evaluation.
2. Propose solutions integrating AI and Accessibility criteria for diverse learner needs.
3. Develop and enhance an artefact based on the literature review and participant feedback.

1.2 Research Question

The objective is to create a practical tool for assessing and selecting a suitable LMS, addressing gaps in evaluation by integrating AI and Accessibility features. The guiding research question is:

Which Accessibility and AI criteria should be included in the evaluation of an LMS appropriate for e-learning development and integration?

Exploring this question, the study introduces an innovative evaluation rubric aimed at enhancing accessibility and AI criteria. The **Revised LMS Evaluation Rubric**, used in the

pilot, includes various categories, each with a set of criteria based on a detailed literature review. The final artefact will contain revised criteria based on participants feedback from piloting the evaluation rubric.

To provide clarity, the development of the artefact progressed through three stages:

1. **Original Rubric for Evaluating E-Learning Tools** –This initial model by (Anstey and Watson, 2018b), forms the basis of the evaluation rubric. Although other models were considered, this framework was determined to be the most suitable due to its flexibility, and after taking into account pedagogical, and technical considerations.
2. **Revised LMS Evaluation Rubric** – A revised model contained in **Appendix B** represents the intermediate stage in which the criteria were refined following a literature review. This rubric focuses solely on LMSs and was used by participants in the study.
3. **Final LMS Evaluation Rubric –** This artefact includes further refinements and enhancements informed by the literature review and feedback from the evaluation pilot involving 30 participants. It also includes a numerical scoring system corresponding to a performance rating scale ("Works Well", "Minor Concerns", "Serious Concerns", "Not Applicable") to aid in decision making. The final artefact is contained in **Appendix F** and will also be available online for practitioners to utilise.

The above terms will be used consistently throughout this document to distinguish between the three variants. The next chapter examines the relevant literature underpinning the accessibility and AI criteria used in the **Revised Evaluation Rubric**, as well as the selection process of the model as a basis of this study.

1.3 Structure

This dissertation is structured as follows: **Chapter 1** introduces the problem statement and research question. **Chapter 2** reviews the literature on accessibility and AI criteria. **Chapter 3** details the methodology for developing the evaluation framework and presents the results of this study. **Chapter 4** provides a discussion on the findings and **Chapter 5** offers conclusions and recommendations for future research.

2 Chapter 2 Evidence of Research

2.1 Introduction

In addressing an 'unmet need' for a comprehensive LMS evaluation tool, this chapter establishes the foundation for the proposed artefact. The aim extends beyond compiling a list of evaluation criteria by ensuring the criteria within each category of the rubric is underpinned by learning theory and adherence to policy and accessibility standards. To ensure the proposed evaluation tool's effectiveness, relevant research in the field of Learning and Development is considered.

2.2 Terminology

Before examining the existing body of research and current literature, it is beneficial to define and contextualise key terminology. The term e-learning is frequently linked with LMSs, yet important distinctions exist between the two. E-learning plays a distinct role in corporate and educational settings by facilitating the online access and interactive engagement with educational content (Clark and Mayer, 2016, p. 10). Anderson refers to e-learning as 'Online Learning' (OLL), which uses the internet to access content, engage interactively with materials, instructors, peers, and receive ongoing support. This framework is designed to facilitate knowledge acquisition, construct personal meaning, and foster developmental growth stemming from the learning experience (Anderson, 2008, p. 17). These definitions are not dissimilar to traditional learning. (Haythornthwaite and Andrews, 2011, p. 28) impart that e-learning shares several core principles with conventional learning. Both approaches recognise that learning is a psycho-social process, accommodating different motivations among learners and acknowledging the distinction between development and learning.

An LMS enables personalised instruction, providing registration and access to course materials, automatically tracking learner progress and performance, directing learners to optimal learning events, and providing actionable feedback on learning resources (Allen, 2016, pp. 214–215). An e-learning system encompasses any software designed to facilitate the access and consumption of e-learning content. Although some LMS qualify as e-learning systems, not all LMSs include built-in tools for content authoring (TrustRadius, 2024).

Dias and others define an LMS as an information system that has clearly defined pedagogical purposes and centres on the process of communication and collaboration (Dias, Diniz and Hadjileontiadis, 2013, p. 42). LMSs are categorised into cloud-based, open-source, and on-premise. A cloud-based LMS is hosted remotely and managed by a provider.

An open-source LMS is developed collaboratively, allowing feature additions and bug-fixes. An on-premise LMS is installed on local servers and managed in-house (Boggs, 2024).

The LMS market was worth US$ 16.3 billion in 2022 and is expected to grow to US$ 48.8 billion by 2028. In North America, this figure was US$ 8.63 billion in 2023 (Fortune Business Insights, 2024; Research and Markets, 2024). Pappas (2022), states over 800 different LMS options cater to multiple learning needs, including free open-source and commercial providers.

LMS plugins designed for WordPress represent another segment of the market, appealing to solo entrepreneurs and independent educators. LMS plugins fall under the cloud-based category and prioritise flexibility, community support, and a freemium model that emphasises personalised learning and one-on-one coaching experiences (Brown, 2023).

Recognising these diverse LMS paradigms, this dissertation aims to address the challenges faced by students and industry professionals by developing a practical LMS evaluation rubric. **The goal is to assist users in selecting LMS technologies aligned with their e-learning use case**.

2.3 Learning and Technology

> "Learning is an enduring change in behaviour, or in the capacity to behave in a given fashion, which results from practice or other forms of experience."
>
> (Schunk, 2013, p. 3)

The consensus within the learning community is that technology should be designed to enhance, rather than replace, the educational process. According to (Bates and Poole, 2003, pp. 34, 73–74), learning is seen as a social process, requiring communication among the learner, teacher and others. This social process cannot be replaced by technology, although technology may facilitate it. Reflecting on this, it becomes clear that the methods through which people learn remain as relevant today as they were when learning psychologists such as Pavlov, Watson, and Skinner developed behaviourism, Piaget advanced cognitivism, and Vygotsky explored constructivism. The disciplines of behaviourism, cognitivism and constructivism outline the diverse influences on human learning and underscore the potential of technology to facilitate a multi-faceted, experiential educational environment. (Clark and Mayer, 2016, pp. 33–35) summarises the methods through which people learn into three

metaphors of learning aligning with the psychologists' viewpoints. The following sections briefly examine the metaphors and their relationship with the learning theory.

2.3.1 Behaviourism

As (Schunk, 2013, p. 24) details, behaviourism, notably advanced by Pavlov, Watson, and Skinner, views learning primarily as a change in observable behaviour through external conditioning. This is effectively encapsulated by the metaphor of 'Response Strengthening', which (Clark and Mayer, 2016, pp. 33–35) summarise as the strengthening or weakening of associations between stimuli and responses. In this model, learners are seen as passive recipients of rewards and punishments, with instructors acting as the dispensers of these consequences. The emphasis is on observable outcomes and the shaping of behaviour through reinforcement, without delving into mental states.

2.3.2 Cognitivism

Cognitivism, emerging as a critique of behaviourism's limitations, focuses on the mind's internal processes of thinking, memory, and problem-solving. (Clark and Mayer, 2016, pp. 33–35) connect this with the metaphor of 'Knowledge Construction', where learning involves building mental representations of the world. Drawing on the insights of Piaget, Bruner, and Gestalt psychologists (Bauer, 2024), (Schunk, 2013, p. 24) emphasises how information is processed, organised, stored, and retrieved by the mind. Here, learners are active processors of information, with instructors providing cognitive guidance to facilitate this organisation.

2.3.3 Constructivism

In contrast, constructivism, influenced by thinkers like Piaget and Vygotsky, posits that learners actively construct their own knowledge through experiences and interactions (Vygotsky *et al.*,1978, pp. 86–87) .This perspective aligns with the metaphor of 'Information Acquisition' as described by (Clark and Mayer, 2016, pp. 33–35) focusing on the learner's active role in absorbing and making sense of new information. According to (Schunk, 2013, p. 313), the instructor here serves as a facilitator, aiding the learner's personal and social construction of knowledge, thereby recognising the learner's engagement with and interpretation of information.

The learning paradigms presented above illustrate a range of theoretical perspectives that continue to influence contemporary education. The subsequent section examines existing

evaluation models and explains the rationale for building upon the Anstey and Watson model.

2.4 Evaluation Models

This section explores three models for the purposes of evaluating educational technology:

1. LMS Evaluation Model (Kim and Lee, 2008).
2. The SECTIONS (Bates and Poole, 2003).
3. Rubric for Evaluating E-Learning Tools (Anstey and Watson, 2018a).

2.4.1 LMS Evaluation Model

Kim and Lee (2008), developed an LMS Evaluation Model based on the seven aspects of criteria outlined in **Table 1**. In response to Maslowski et al. (2000, p.5) who criticised previous methods for comparing platforms with different features, Kim and Lee developed an LMS Evaluation Model that considered the end function of an LMS: teaching and learning (Conklin, 2020, p. 74).

Table 1 LMS Evaluation Criteria Model (Kim and Lee, 2008).

Instructional Management: Includes user accessibility, the ease of course management, and safety management.
Interaction: Highlights the communication variety, tool availability, and navigation ease.
Evaluation: Assesses the ease of test management and the variety and reliability of test items.
Information Guidance: Focuses on the system's ease of use, searchability, and accessibility.
Screen Design: Focuses on the clarity of directions, appropriateness of learning demand, and overall consistency and unity in design.
Organisational Demand: Examines the economic validity and system interoperability.
Technology: Includes system stability and the appropriateness of learning demand.

Recognising the need for a more streamlined and functional approach, (Kim and Lee, 2008, p. 286) refined their criteria using factor analysis. This refinement led to the division of the model into two principal factors.

Table 2 LMS Evaluation Criteria following Factor Analysis (Kim and Lee, 2008, p. 290)

Factor 1	Sub Factor	Factor 2	Sub Factor
Instruction Management, Screen Design, and Technology Suitability of design in screen and system.	1. *Ease of course procedure* 2. *Interoperability of system and suitability of academy administration* 3. *Ease of instruction*	Interaction and Evaluation.	1. *Flexibility of interaction and test and learner control* 2. *Variety of communication and test types* 3. *User accessibility*

(Kim and Lee, 2008, p. 291) also communicated the need for future research to create more detailed models tailored to different organisations, reflecting the specific educational and training practices of academic institutes and organisations.

2.4.2 The 'SECTIONS' Model

The second model examined was the 'SECTIONS' model by (Bates and Poole, 2003, pp. 75–105), a framework for selecting and using media and technology in higher education. It provides guidance to instructors considering technology integration as summarised in **Table 3**.

Table 3 The SECTIONS Model (Bates and Poole, 2003, pp. 75–105).

Students: When selecting media and technology consider student demographics, access to technology, and multiple learning styles.
Ease of use and reliability: Considerations include the intuitiveness of the technology for both teachers and students, its reliability, and the simplicity of its maintenance and upgrades.
Costs: Considerations include detailing specific expenses and what influences these costs.
Teaching and Learning: Identify the required types of learning and the instructional methods that will fulfil these needs, along with the most effective technologies to support these educational activities.
Interactivity: Effective learning requires active engagement. Consider what types of interactions the technology facilitates.
Organisational Issues: Address the organisational needs, identify and overcome obstacles for successful technology implementation, and specify the necessary organisational changes.
Novelty: Assess the innovativeness of the technology along with its benefits and drawbacks.
Speed: Consider how quickly courses can be implemented with the chosen technology and the ease of modifying course materials.

Bates and Poole state: “This process can be used in the initial selection of technologies for a course, program or institution and in making decisions during the actual course design process, with respect to appropriate media” (Bates and Poole, 2003, p.105).

2.4.3 Rubric for Evaluating E-Learning Tools in Higher Education

The third model is the **Rubric for Evaluating E-Learning Tools** created by Anstey and Watson which provides educators with a structured framework to evaluate e-learning tools based on criteria measured against a three-point scale. This helps determine the tools' suitability for learners, learning outcomes, and teaching (Anstey and Watson, 2018a). The Rubric for E-learning Tool Evaluation contains eight sets of criteria as detailed in **Table 4**.

Table 4 Evaluating E-Learning Tools Rubric (Anstey and Watson, 2018a).

Category	Criteria
Functionality	Operations, tech-support, usability, Hyper-mediality.
Accessibility	User-focused participation, adherence to WCAG standards, costs, required equipment.
Technical	Compatibility with browsers and operating systems, downloads, LMS integration.
Mobile Design	Online/Offline access, functionality, portability.
Privacy	Data privacy and ownership, registration, archiving.
Social Presence	Diffusion, user accountability, collaboration.
Teaching Presence	Learning analytics, facilitation, customisation.
Cognitive Presence	Higher-order thinking, Enhancement of cognitive tasks, metacognitive engagement.

Among the three models researched, Kim and Lee's model emphasised broad efficiency and effectiveness across various settings, streamlining the tool in support of instructional activities, rather than focusing on the functions and features of LMSs (Kim and Lee, 2008, p. 285) The SECTIONS model by Bates and Poole focuses on media and technology selection, which was less aligned with the specific objective of evaluating LMS tools for their detailed functionality and pedagogical impact. The Anstey and Watson (2018b) rubric, was originally created for practical application in post-secondary education, however, they have encouraged other researchers to adapt the rubric for their local context. Available under a Creative Commons license (Creative Commons, 2024), this flexibility facilitates its use, allowing researchers to update and refine the framework to maintain its relevance with technological advancements. Therefore, due to its flexibility and direct emphasis on the practical and pedagogical elements of educational technology, the Anstey and Watson rubric proved most relevant to this study.

2.5 Proposal – Revised LMS Evaluation Rubric

In establishing that LMSs are pivotal in the modern educational landscape, particularly for e-learning, as they evolve, it is necessary to consider advanced features such as accessibility and artificial intelligence that are not sufficiently covered by existing evaluation frameworks (Kamalov, Santandreu Calonge and Gurrib, 2023, p. 9).

The Anstey and Watson model has limitations in this space, therefore, this study has adapted and refined the model to include AI criteria and expand the existing Accessibility criteria. The adaptation of this model; the artefact in **Appendix B** , has relevance beyond academic circles. It has been extensively reviewed and its utility is applicable to the broader industry. Each section of the rubric is supported by relevant scholarly works, ensuring that the criteria for evaluation are not subjective, instead grounded in educational principles and research findings. The **Revised Rubric for LMS Evaluation** has been expanded from eight to ten categories as detailed in **Table 5**.

Table 5 Revised Rubric for LMS Evaluation

Category	Description
Accessibility	Assesses LMS compliance with WCAG guidelines, ensuring it is perceivable, operable, understandable, and robust. Incorporates UDL principles; Engagement, Expression and Representation. This category also considers cost of use.
Artificial Intelligence	Analyses LMS AI capabilities in generating personalised learning experiences, providing intelligent support, and enhancing educational outcomes.
Functionality	Evaluates the operations and suitability of LMS functions for online teaching and learning.
Mobile	Evaluates LMS Online/Offline access, functionality and portability.
Technical	Examines the LMS's integration with educational systems, compatibility with operating systems, and additional software requirements.
Privacy, Data Protection, and Rights	Evaluates LMS adherence to data protection standards, secure sign-in processes, data ownership, and archiving capabilities.
Social Presence	Measures LMS capacity to support community building among learners through collaboration, accountability, and user familiarity.
Teaching Presence	Assesses LMS features that support instructors in facilitating, customising, and monitoring the educational process.
Cognitive Presence	Evaluates LMS support for cognitive engagement, higher-order thinking, and metacognitive feedback.
Other	Allows for comments/suggestions to improve or enhance the Rubric.

The ensuing section will examine the primary areas of focus: Accessibility and AI categories. This does not exclude other categories, as they are as equally important. A literature review of the remaining sections of the rubric is contained in **Appendix A**.

2.6 Accessibility

"Hearing the lived experience of disabled students is central to ensuring that their needs are met and moving the inclusive agenda forward"
– (*Dr Vivian Rath, Adjunct Teaching Fellow, Trinity College Dublin*, 2022).

Accessibility is the extent that persons with disabilities can access devices and services without barriers. This involves accommodating the requirements of individuals with various disabilities, including physical, cognitive, sensory, and mental health, by designing or adapting products, services, and environments to be usable by everyone (Haught, 2023).

It is estimated, 16% (1.3 billion people) of the world's population experience disability at some point in their lives (World Health Organisation, 2023). Approximately 1.1M people in Ireland reported having a disability, which represents 22% of the population (Disability Federation of Ireland, 2021).

Standards such as WCAG (Web Content Accessibility Guidelines) serve as the benchmark for creating technology solutions that are accessible to all users, regardless of disability (W3C Consortium, 2023a). The WCAG is based on four main guiding principles of accessibility, known by the acronym POUR: Perceivable, Operable, Understandable, and Robust. These principles ensure that everyone can access and use web content. By aligning the criteria with these principles, the evaluation rubric aims to effectively assess the accessibility of LMSs. The POUR Criteria Implemented by WCAG (W3C Consortium, 2023a) is defined in **Table 6**.

Table 6 The POUR Criteria Implemented by WCAG

Perceivable : Content must be presented in ways that all users can perceive regardless of their sensory capabilities. This includes providing alternative formats such as text descriptions for images captions for videos and ensuring that all content can be accessed through assistive technologies.
Operable : User interface components and navigation must be operable by all users. This means supporting navigation by keyboard voice and other assistive technologies ensuring that interactive elements are easily operable for users with various disabilities.
Understandable : Information and the operation of the user interface must be understandable ensuring clear communication by using simple language providing consistent navigation mechanisms and explaining complex concepts to facilitate ease of use for all learners.
Robust : Content must be robust enough to be reliably interpreted by a wide variety of user agents including assistive technologies. This involves ensuring compatibility with current and future tools allowing all users to access and benefit from the LMS without technological barriers (IA Labs, 2022; W3C Consortium, 2023a).

Another useful tool is the Voluntary Product Accessibility Template (VPAT) which is used to document a product's conformance with accessibility standards and guidelines, such as the Web Content Accessibility Guidelines (WCAG). Implementing a VPAT that translates accessibility requirements and standards into actionable testing criteria would allow users to test their products and services against each section of the VPAT and use the template to document results. This document outlines the essential requirements and best practices for authors to produce accurate and consistent Accessibility Conformance Reports. Once completed, the VPAT with documented testing results is referred to as an Accessibility Conformance Report (ACR) that details the accessible features of the tested product or service (ITIC, 2024). Using a VPAT in conjunction with the rubric will strengthen the accessibility analysis of an LMS.

Some LMSs also incorporate “authoring tool” capability allowing instructional designers to create learning content within the LMS itself. Established in 2024 by the Web Accessibility Initiative (WAI), the Authoring Tool Accessibility Guidelines (ATAG) have defined the global

standards for accessibility within LMSs. ATAG consists of two parts: Part A focuses on enhancing the accessibility of the authoring tools themselves, while Part B aims to assist authors in creating accessible content (WAI Initiative and W3C Web Accessibility, 2024).

This research has also identified the work of 1EdTech, an organisation involved in integrating accessibility standards into technology evaluation. Their TrustEd Apps Accessibility Rubric Specification v1.0 offers a structured self-assessment tool that facilitates Accessibility evaluations for tool providers (Haught, 2023). By exploring insights from the 1EdTech rubric, the artefact's accessibility section is strengthened with a recognised standard of excellence. It allows evaluators to check if LMSs are 1EdTech certified. The 1EdTech rubric also encourages a reflective approach to tool evaluation, considering varied and flexible options for presentation, expression, and engagement that cater to diverse learning styles, echoing the principles of the Universal Design for Learning (UDL) framework, which are key to understanding and implementing inclusive education.

Universal Design for Learning (UDL) is a set of principles for curriculum development that give all individuals equal opportunities to learn, including students with disabilities (AHEAD, 2024b, SOLAS, 2024). The three main principles are outlined in **Table 7**.

Table 7 The UDL guidelines are structured around three main principles:

i.	**Engagement (The Why of Learning):** UDL guidelines recommend stimulating learners' interest and motivation to learn. This can involve creating a learning environment that offers choices and challenges to keep students engaged.
ii.	**Multiple Means of Representation (The What of Learning):** UDL guidelines emphasise presenting information in various ways to cater to diverse learners. This includes providing content that's accessible to all and can be perceived in multiple ways, such as through auditory and visual means.
iii.	**Multiple Means of Action and Expression (The How of Learning):** UDL suggests differentiating the ways students can express what they know. This means allowing for varied methods of response and navigation, offering options for learners to demonstrate their understanding in ways that work best for them.

These guidelines are based on neuroscientific research and suggest flexible learning environments that accommodate individual learning differences (Heelan, Tobin and Ryder, 2021, pp. 6, 12; CAST, 2023). They form a natural part of the Accessibility criteria by ensuring diverse learning needs are met. Additionally, the ARK programme developed by (AHEAD, 2024a) provides several resources to support educators creating accessible virtual learning platforms. Resources include a range of accessibility courses, an introduction to key legislation and links to several sources of relevance.

The **Cost of Use** criterion is a socioeconomic factor and falls under the Accessibility assessment. In the case of commercial usage, the company typically absorbs the LMS cost as an overhead. However, in academia, beyond tuition, learners often face substantial costs related to course materials. Several authors state the financial burden intensifies when learners need to purchase e-learning tools. Instructors need to find a balance between the use of these tools and the expenses imposed on learners. Ideally, tools should be freely accessible, included in the tuition, or subsidised by the educational institution (OECD, 2012, p. 70; OUSA, 2023, p. 15).

As explored in the literature, the importance of Accessibility and Universal Design for Learning in LMS platforms is established by a number of agencies that directly inform the criteria detailed in the Accessibility section. This alignment ensures that each criterion based on POUR, UDL and Cost adheres to best practices and aligns with global standards. The overarching goal is to offer a robust set of LMS Accessibility evaluation criteria that empowers users to select solutions fostering an inclusive educational environment, where the diverse needs and potential of all learners are considered. In addition, technology providers have a legal obligation to ensure equality. The European Accessibility Act (EAA) is a new directive defining a single set of Accessibility standards. Learning content falls under digital content and the EAA seeks to ensure equal access to digital products and services throughout Europe. The EAA will be enforced on June 28, 2025 for all member states (Evers, 2024). Furthermore, AI-powered LMSs enhance content accessibility, offering various learning opportunities to visually impaired individuals to improve their learning experience (Fortune Business Insights, 2024). The following section will explore the intricacies of AI and its role in LMSs.

2.7 Artificial Intelligence (AI)

"Any aspect of Learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it" – John McCarthy

Artificial Intelligence (AI), a term coined by John McCarthy, refers to the simulation of human intelligence by computers, described so precisely that machines can execute tasks traditionally requiring human cognition. McCarthy developed the LISP programming language, pivotal in AI research for processing symbolic information (Nilsson, 2012).

While the underlying science and technology behind AI is beyond the scope of this research, it is helpful to be aware of its components. AI's breadth, as illustrated in Figure 2, spans several layers from machine learning to deep learning and generative AI. Machine learning enables machines to emulate intelligent behaviour. Deep learning utilises complex neural networks to process vast data, determining the significance of each connection within the network (Brown, 2021). Generative AI (GenAI), distinct in its ability to create new data, has evolved significantly in complexity and scale (Zewe, 2023). The development towards GenAI have been marked by significant advancements in machine learning and neural networks. ChatGPT quickly became the fastest-growing product in conversational systems, reaching 100 million users in its first 3 months. (WIPO, 2024).

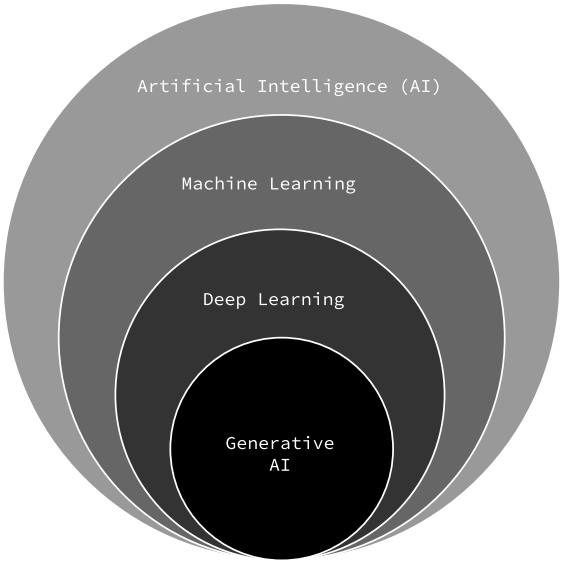

Figure 1 Layers of Artificial Intelligence (Wade et al., 2024)

Most research on AI in education has been centred around its four key functions within e-learning: adaptive systems, personalisation, evaluation and assessment, profiling and

prediction and intelligent tutoring systems. (Zawacki-Richter *et al.*, 2019, p. 11). AI's applications in LMSs are growing, particularly through Learning Analytics (LA) and Educational Data Mining (EDM). These tools use AI to predict learner outcomes, enhance self-directed learning, and identify at-risk learners (DDI Development, 2023). According to Almohammadi *et al.* (2017, p. 52), educational data mining methods are divided into are 'Predictive', which involves sequential prediction and interpolation, and 'Descriptive', focused on clustering and exploratory analysis. This supports the **AI-Enhanced Predictive Analytics** criteria in the artefact, highlighting AI's capability to utilise machine learning and statistical tools to forecast learning outcomes and identify learners who may require additional support.

AI powers machines to perform tasks typically requiring human cognitive abilities, such as decision-making, problem-solving, natural language comprehension, and learning from unstructured data (Hamilton and Swanston, 2023). This capability extends to AI's role in learning and development where it processes educational content to generate assessment tools that are both dynamic and instructive. This supports the **Knowledge Check/Quiz Generation** criterion in the evaluation artefact. The ability of AI to autonomously generate relevant and challenging quizzes exemplifies its role in enhancing educational assessments. By ensuring that quizzes are closely tied to learning content and learning outcomes, AI-driven quiz generation systems contribute significantly to the educational efficacy of LMS.

To remain competitive, many LMS providers are now incorporating AI functionalities, a trend that is expected to progress. It is anticipated that LMS platforms entirely supported by AI will soon become the norm (Pelletier *et al.*, 2024, p. 19). However, LMSs were developed before the age of personalised delivery, smart software, and AI. According to Clark, these systems often use outdated technology that does not meet today's rapidly evolving agile learning and business needs. Clark suggests that the future lies with Learning Experience Platforms (LXP), which are designed to be more adaptive and focused on individual learning needs rather than organisational requirements (Clark, 2020, p. 159). LXPs leverage cognitive psychology and behavioural psychology to provide a personalised learning experience. This is where AI can significantly contribute by tailoring learning experiences to individual preferences and needs, potentially improving engagement and learning outcomes. This aligns with the **Personalised Learning** criteria, where AI's ability to offer personalised recommendations and adaptive learning paths enhances the learner's experience and effectiveness of the educational platform.

Clark argues

“We must focus on ‘learning experiences’ not as ‘experiences’ in themselves but as experiences delivered, behind the scenes, by smart AI. An LXP must also learn from its own experiences through machine learning. Without these experiences being AI-driven experiences, all that is being delivered is the same old ‘edutainment’ that has been around for decades.”

(Clark, 2020, p. 161).

Despite Clark's emphasis on AI's transformative potential, the evolution within the industry shows a more incremental change. LMS providers are starting to blur the lines between LMS and LXP by including LXP features to increase their emphasis on learners. AI has been employed by some LMS service providers to give an enhanced learning experience for the learner with personalised features and better outcomes (Kavitha and Lohani, 2019, pp. S6987, S6988). This could include personalised learning recommendations and greater content discoverability powered by AI and machine learning algorithms. These features enable users to discover a variety of content formats and sources, enhancing the overall learning experience (Kundariya, 2022).

For example, a learner using an LXP might start with an interest in project management. The LXP uses AI to recommend a personalised learning path that includes podcasts on project management trends, video tutorials, blog posts, and community discussions. This contrasts with a traditional LMS, where the learner might only have access to a set sequence of slide-based courses (Goff, 2023).

While both LMSs and Learning Experience Platforms (LXP) have unique roles aimed at fostering more learning opportunities, they operate differently. An LMS is responsible for administering, delivering, and tracking formal online courses, enhancing learning and skill development. Conversely, an LXP supports a self-directed and personalised learning model, often described as the Netflix of Learning. It aggregates various types of content like podcasts, videos, blogs, and webinars from the internet, allowing learners to select the content they wish to learn in an informal setting (O’Neill, 2020).

Integrating an LMS with LXP functionalities allows for a seamless transition between formal courses managed within an LMS and a broader learning experience offered by an LXP, with all learning opportunities presented in one solution (Association for Talent Development, 2024).

A chatbot, powered by AI, can function as an intelligent academic support system. Notably, AI enhances chatbots such as Siri, Alexa, and Google Assistant, enabling them to interpret user inquiries and perform tasks effectively. In the context of LMS, these AI-supported chatbots are capable of delivering 24/7 interactive learning support across various subjects (Murad *et al.*, 2019, p. 2). In a study by Lo, (2023, p. 5), ChatGPT demonstrated varied performance across different subject domains and its potential benefits when serving as an assistant for instructors and as a virtual tutor for students. However, its use raises various concerns, such as the Limitations in the LLM's understanding of the subject domain and the generation of incorrect or fabricated information known as 'Hallucinations' – and the threat it poses to academic integrity (O'Keefe, 2024). Rogers (2023) suggests using chatbots alongside focus groups in educational settings can prompt discussions and critical thinking with open-ended questions. The objective is to enhance student engagement and collaboration, encouraging deeper understanding and analysis through guided prompts. These chatbots could effectively be integrated into LMSs to facilitate interactive learning and improve analytical skills.

While the concept and initial applications of AI-powered chatbots exist, their integration into mainstream, open-source LMS platforms is still in its early stages (Raghavendrachar *et al.*, 2023, p. 1234). The functionality of these AI-driven chatbots directly corresponds to the **Chatbot/Help Assistance** criteria in the evaluation artefact.

AI-driven systems present numerous challenges that necessitate urgent attention. Recognising the nature of these issues, the European Union enacted Artificial Intelligence (AI) legislation in April 2024. The act stipulates the ethical use of data, algorithm transparency and the ability of the system to safeguard data privacy and protection, and to guarantee that AI-generated results are fair and non-discriminatory (Brakel and Uuk, 2024).

Developed by the University of Oxford, the capAI tool offers practical guidance for organisations to translate high-level ethical principles into actionable, verifiable criteria that inform the design, development, deployment, and usage of ethical AI systems. This tool aids in demonstrating the trustworthiness of AI systems' development and operation, and is currently being validated through conformity assessments by partnering organisations, aligning with the EU Artificial Intelligence Act (Floridi *et al.*, 2022, pp. 1–2).

Concerns surrounding AI do not stem from doubts about its potential, but rather, the predefined programming could dictate the implementation of education. If students do not align with this predefined framework, they may be excluded from situations where human

compassion could make a difference. Ultimately, AI's most significant impact could be in highlighting the irreplaceable role of humans within the educational framework (Weller, 2020).

Facer also observes that:

“The devolution of responsibility to machines, however, doesn’t only raise questions about whether we know how to manage and control the resulting systems. Instead, moral and ethical questions are also raised about what we should and should not offload to non-human actors”

(Facer, 2011, p. 68).

Expanding on ethical considerations in AI, it is worth delving deeper into the domain of data privacy. The rubric contains a section on Privacy, Data Protection, and Rights which is explored in detail in **Appendix A** along with the remaining categories.

2.8 Summary

Chapter 2 established the foundation for developing accessibility and AI criteria to form part of the LMS evaluation rubric through a detailed literature review. The Anstey and Watson model was selected as the basis of the artefact. Gaps in this model were identified, and criteria were enhanced, added or adjusted to focus on LMS evaluation. Although this study focuses on accessibility and AI criteria, it is equally important to consider all criteria to ensure its relevance to LMS evaluation. Therefore **Appendix A** is dedicated to the remaining criteria across the categories: Functionality, Mobile, Technical, Privacy and Data Protection, Social Presence, Teaching Presence and Cognitive Presence. The ‘Other’ category provides the opportunity to document additional information related to the LMS being evaluated, not covered in the main categories.

Chapter 3 will detail the development of this artefact, a refined LMS evaluation rubric, guided by these insights, aiming to provide a practical and inclusive resource for evaluating LMSs.

3 Chapter 3 Development

3.1 Introduction

The format of a Dissertation by Practice was purposely chosen to integrate theoretical insights with practical application. This approach allowed the dissertation to propose theoretical underpinnings and to test these in real-world settings, leading to the development of a practical, user-friendly **Revised LMS Evaluation Rubric**. The objective was not solely to refine the evaluation criteria but also to expand the area of Accessibility and introduce a new evaluation section on Artificial Intelligence. The artefact is worthy of development because it serves as a practical resource for e-learning students, educators and learning and development professionals. This study adopted an inclusive approach by not favouring one category of LMS over another. Participants were encouraged to apply the evaluation rubric to any LMS of their choosing. The aim was not to call out specific LMS features, rather test the effectiveness of the rubric's criteria. This non-discriminatory stance ensured that the resulting rubric encompasses a wide range of evaluation criteria, suitable for diverse LMS applications.

3.2 Revised LMS Evaluation Rubric Criteria

To develop and validate an evaluation model, a criteria framework was constructed based on insights gathered from an extensive literature review. This **Revised LMS Evaluation Rubric**, was specifically tailored to assess LMSs with a focus on new criteria such as Accessibility and Artificial Intelligence. Aside from these developments, the modifications to all sections aimed to narrow the focus specifically towards LMSs.

The **Revised LMS Evaluation Rubric** contained in **Appendix B** was translated into a survey as this was the easiest way to capture the respondents' answers. This was administered via Survey Monkey and took participants between 30 minutes and 2 hours to complete. The survey consisted of 41 questions, across 10 categories. The LMS table in **Appendix C** provides concise descriptions of each platform and their market segments. Each category contains a set of criteria that can be awarded a measurement of satisfaction across a performance rating scale: Works Well, Minor Concerns, Serious Concerns or Not-applicable. Additionally, this study employed a mixed-methods approach incorporating a focus group, observation study and quantitative analysis as outlined in the Methodology section that follows.

3.3 Methodology

In aligning with (Saunders, Lewis and Thornhill, 2019, p. 130) research onion, this study utilised the methodological layers outlined in **Table 8** and **Table 9**.

Figure 2 Research Onion (Saunders, Lewis and Thornhill, 2019).

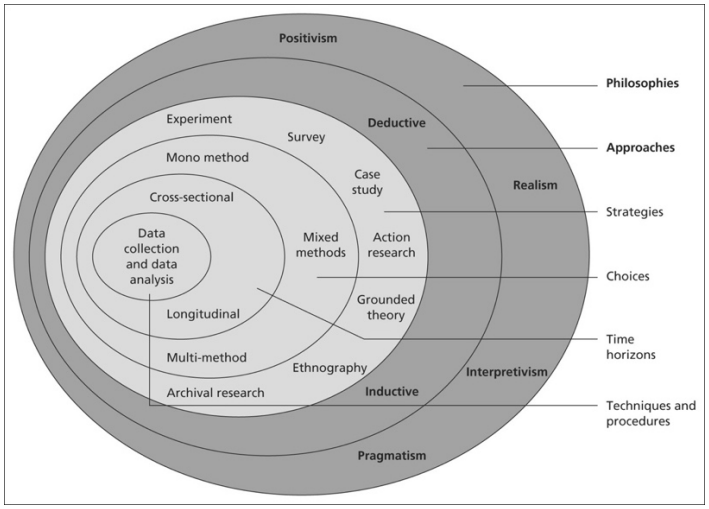

Table 8 Methodological Layers – The Research (Saunders, Lewis and Thornhill, 2019, p. 130).

Research Philosophy: Pragmatism	This research adopts a pragmatic approach, focusing on practical solutions to real-world problems in evaluating LMS.
Research Approach: Deduction	A deductive approach was employed, developing hypotheses and frameworks based on existing literature and then testing these through empirical research.
Research Strategy: Mixed Methods	The mixed methods strategy was chosen to combine qualitative and quantitative data collection, ensuring a comprehensive evaluation of LMSs.
Research Choices: Multi-Method Quantitative and Qualitative Studies. This research involved various methods, including surveys, focus group, observation studies and the application of a decision support tool, to gather both quantitative and qualitative data.	
Time Horizon: Cross-Sectional	The study was conducted by 30 participants within a specific timeframe, therefore a cross-sectional approach was adopted for collecting data at a single point in time.

Table 9 Methodological Layers – Techniques and Procedures
(Saunders, Lewis and Thornhill, 2019, p. 130).

Techniques and Procedures:	
Literature Review:	To identify and establish the criteria for LMS evaluation.
Survey:	To gather qualitative data on the applicability and effectiveness of the proposed LMS evaluation criteria using a performance rating scale (Works Well, Minor Concerns, Serious Concerns, N/A).
Focus Group:	A drop in session was arranged to share ideas and collect qualitative feedback from industry professionals, recent graduates and students.
Observation Studies:	Two observational studies were conducted where participants installed and evaluated different LMS platforms.
Pilot Testing:	To test the initial evaluation tool and gather feedback for its enhancement.
Thematic Analysis:	To analyse qualitative data gathered from the pilot and open-ended survey responses.
Decision Support Tool	To analyse the scores given to each set of criteria in the rubric based on aggregated ratings from the pilot study. For the final rubric, weightings were omitted to ensure equal importance for each criterion. Scores are averaged by the number of applicable criteria, excluding "Non Applicable" responses to maintain a fair and unbiased assessment. This refined method enhances the simplicity and transparency of the scoring process.

The development and refinement of this framework have been informed by engaging 30 stakeholders, encompassing Learning and Development industry professionals from both corporate and academic settings, as well as recent MSc Interactive Digital Media (MSCIDM)

graduates from Griffith College Dublin and students from various universities across Ireland and UK.

3.3.1 Ethics

Ethical approval was obtained prior to the initiation of participant engagement. Potential participants were contacted via email, which included an information sheet detailing the study's objectives, their expected role and involvement, and details of the measures used to ensure confidentiality and data protection. Consent was obtained from all those respondents who decided to participate.

3.3.2 Focus Group

To facilitate engagement and provide clarity, a focus group via Zoom was arranged, allowing participants to ask questions and seek clarification about the evaluation tool. Additionally, a video presentation and tutorial was created to guide participants on how to approach the survey, informing them of the time commitment involved, which ranged between 30 minutes to 2 hours. This time variation was dependent on whether participants needed to install an LMS from scratch. Participants were advised to draft their responses in a document template before transferring their scores to the survey platform.

3.3.3 Observational Study

An observational study involved two individuals installing different LMSs from scratch: Moodle and Cluevo. The Moodle user faced installation issues due to application conflicts, eventually abandoning it for another tool. The Cluevo user found it difficult to use but completed the rubric evaluation tool to document their findings. These experiences highlight typical challenges e-learning students face in group projects, particularly MSCIDM students who often build a website integrated with an LMS for their dissertations by practice.

The active involvement of these stakeholders in the evaluation process has enriched the rubric with practical insights from both industry and academic perspectives. This blend of expertise ensures that the rubric's criteria are not only grounded in educational theory and pedagogical principles but also reflect the operational realities of both academia and various sizes of businesses.

3.3.4 Data Collection and Analysis

The analysis of the data collected predominantly focused on the Accessibility and Artificial Intelligence categories. This focus does not diminish the importance of the other categories which are reviewed in **Appendix A**, resulting in the final artefact (**Appendix F**) removing

redundancy and streamlining the criteria across all 10 categories.

Appendix D includes the Accessibility and AI quantitative and qualitative data from the survey, followed by a thematic analysis in **Appendix E** of the Accessibility and AI sections, identifying common themes in the qualitative feedback. Importantly, **Appendix F** contains the revised rubric based on the literature review, survey (pilot of the rubric), quantitative analysis using a decision support tool and participant feedback. The remainder of this chapter presents the participant demographic, thematic analysis and quantitative analysis to support the triangulation of the data. Finally, details of the revised rubric have been documented.

3.3.5 Experience and Participant Category

The participant demographic comprised professionals and students with varying levels of experience, from beginners to advanced. Participants represented several organisations ensuring a comprehensive evaluation of the rubric from different user perspectives.

Table 10 Participant by Organisation

Industry (50%)	**Academia (50%)**
Dell	Griffith College Dublin
HubSpot	Maynooth University
ICON plc	Ravensbourne College UK
Skillsnet	Technological University Dublin
Theseus UK	University College Cork
Workday	University College Dublin

Respondents were predominantly industry professionals (77%), followed by students (17%) and Graduates (7%) with varying levels of experience with the tool. Intermediate users (47%) made up the majority of respondents, followed by beginners (37%) then advanced users (17%).

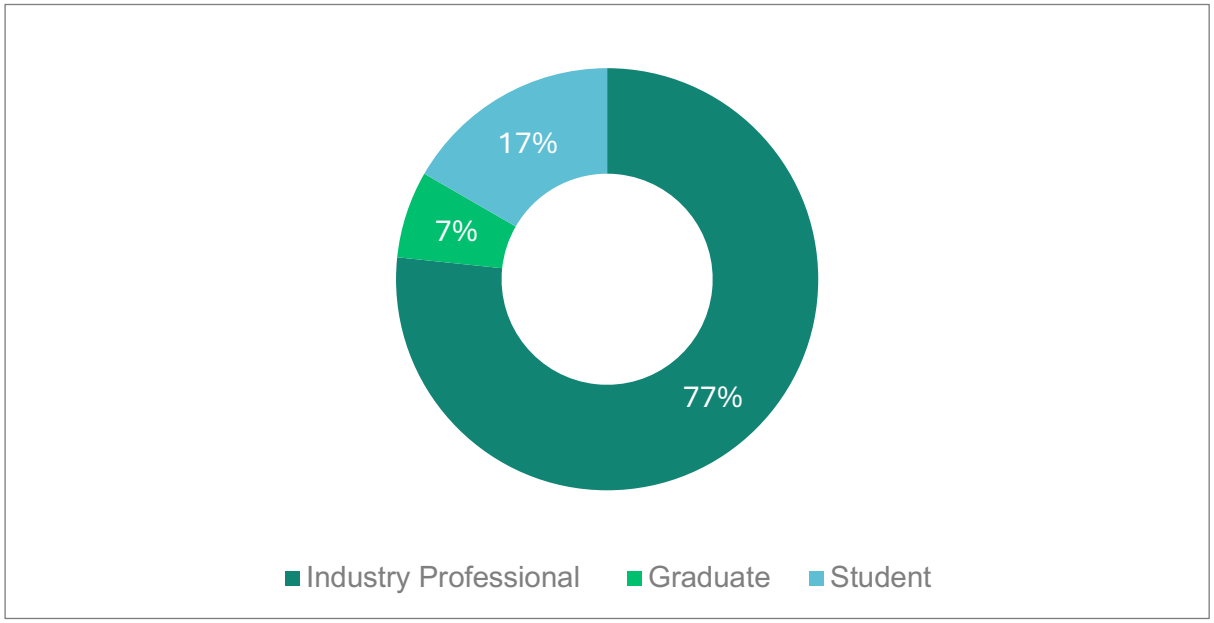

Figure 3 Respondent Category by Profession

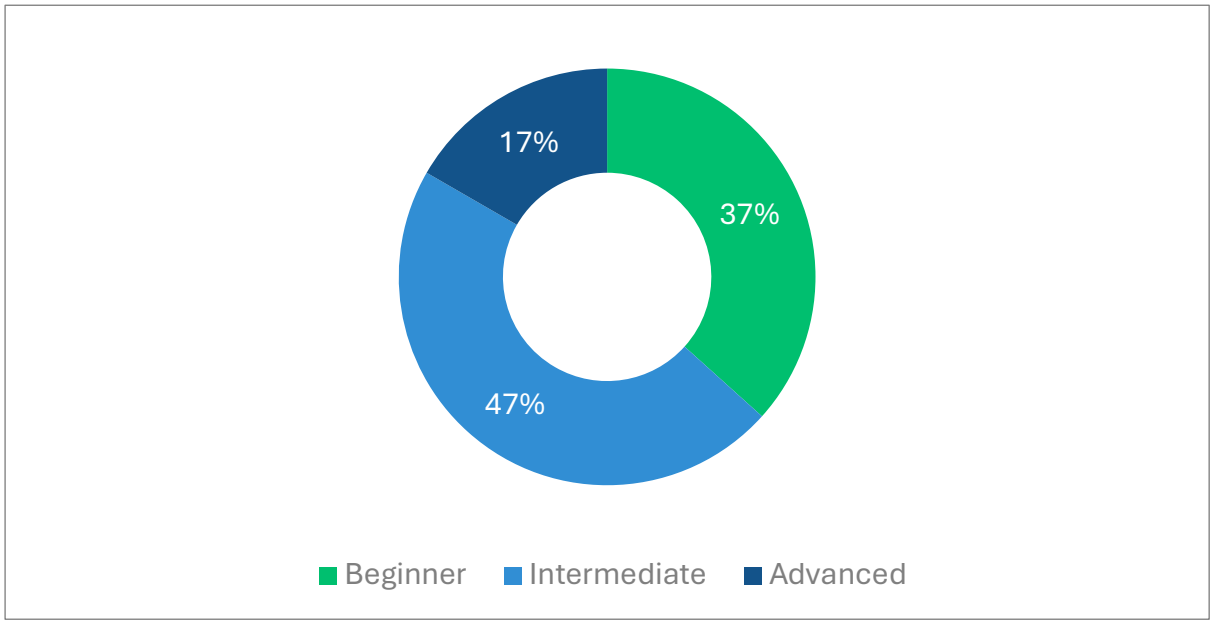

Figure 4 Respondent Category by Experience

3.3.6 Thematic Analysis

The purpose of a thematic analysis is to identify patterns or themes when trying to find out something about participants views, opinions, knowledge, experiences or values from within a set of qualitative data (Delahunt and Maguire, 2017). This study collated all of the comments from the Accessibility and AI sections of the rubric and followed a 6-step process as outlined by Braun and Clarke (2006, p. 87) to complete a thematic analysis.

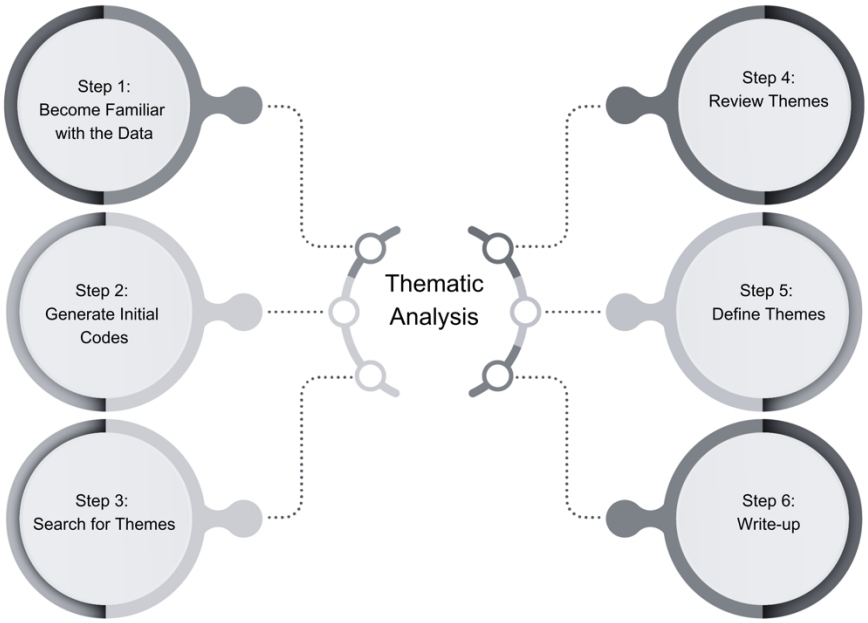

Figure 5 Thematic Analysis 6 Step Process (Braun and Clarke, 2006).

After completing Step 1: becoming familiar with the data and noting recurring issues and standout phrases that highlighted Accessibility and AI features – the codes and themes were generated for both of these categories as summarised in **Appendix E** which, provides a condensed overview of the main points and common meanings that recurred throughout the data.

Performing a thematic analysis of Accessibility and AI features evaluated the rubric's effectiveness for evaluating LMSs. This method identified themes from qualitative data, providing insights into user perceptions and interactions. The insights gained have led to adjustments in the criteria to enhance the rubric's validity. Notably, descriptions have been improved to better assist and inform evaluators. By aligning the rubric more closely with

identified themes and user feedback, it becomes a more reliable tool for stakeholders to evaluate. When evaluators use the rubric in the future, especially on an individual basis or for small group comparisons, it is important to capture user feedback that is not easily measured on a performance rating scale. Given that the thematic analysis was performed with 30 participants piloting the rubric, this feedback has helped to refine its application in real-world settings.

3.3.7 Quantitative Analysis.

The Accessibility and Artificial Intelligence data collected from the survey was processed using a quantitative decision analysis tool to score the various criterion, drawing on the work of Litke and Pelletier (2002) and Bandor (2006). By applying this structured approach, the study ensures a rigorous and objective assessment of the LMS.

Bandor emphasises:
“A successful evaluation is not simply picking a product based on intuition. It involves a formal process, the right mixture of evaluators, and a specific quantifiable set of evaluation criteria”

(Bandor, 2006, p. 10).

3.3.8 Scoring Methodology

The performance rating scale used in the evaluation rubric and survey has provided clear, actionable insights into the strengths and weaknesses of various LMS platforms. A scoring legend was applied to this scale as shown in **Table 11**.

Table 11 Scoring Legend

Scale	**Score**
Works Well	1.0
Minor Concerns	0.5
Serious Concerns	-0.5
Not Applicable	0

3.3.8.1 Weighted Criteria Analysis

Each criterion is assigned a percentage weight, with the total summing to 100%. There is an opportunity to assign weights to each criterion based on its importance, allowing more critical aspects to have a larger impact on the overall evaluation. However, in the Accessibility category, the weights were distributed evenly among 8 criteria, each weighted at 12.5%. Similarly, in the Artificial Intelligence category, 4 criteria were each weighted at 25%. This approach ensures fairness and impartiality, as the formula could easily be manipulated by altering the weights to favour certain LMS that meet specific criteria. By carefully maintaining an unbiased weighting process, the goal is to objectively identify the best LMS for the specific e-learning use case (Litke and Pelletier, 2002).

3.3.8.2 Calculation of Scores

The average and weighted scores were calculated as follows:

Average Score=(%Works Well×1.0)+(%Minor Concerns×0.5)+(%Serious Concerns×−0.5)+(%Not Applicable×0)

Weighted Score=(100/%Weight) x Average Score

Consider the "Perceivable" criterion as shown in **Table 12**.

Table 12 Calculation of Scores for Perceivable Criteria

Calculation Type	**Formula**	**Result**
Average Score Calculation:	(37%×1.0)+(40%×0.5)+(20%×−0.5)+(3%×0)	0.47
Weighted Score Calculation:	(100/12.5%) × 0.47	0.059

Scores for each criterion are then accumulated to derive the overall weighted score for each category as shown in **Table 13** and **Table 14.**

The overall weighted score of 0.4 for Accessibility suggests that LMS platforms generally meet the accessibility criteria well, with most aspects either working well or presenting only

minor concerns. However, there is still considerable room for improvement across various accessibility criteria as follows:

- **Perceivable**: Weighted score of 0.06, indicating moderate content availability in alternative formats and screen reader support. 37% of respondents indicated content is available in alternative formats and supports screen readers, while 40% had minor concerns, 20% had serious concerns, and 3% marked this criterion as not applicable, indicating some content is still inaccessible.
- **Operable**: Weighted score of 0.05, indicating that LMSs are generally navigable but with significant minor and serious concerns. 17% reported the LMS is fully navigable via keyboard and supports voice commands. However, 57% had minor concerns, 10% had serious concerns, and 17% marked it as not applicable, highlighting the need for better operability.
- **Understandable**: Weighted score of 0.07, showing that while most users find the LMS clear, a significant number still find parts complex. 37% stated the LMS interface and content are clear and intuitive. However, 47% had minor concerns, 13% had serious concerns, and 3% marked it as not applicable, suggesting that some users find the interface complex or confusing.
- **Robust**: Weighted score of 0.04, indicating compatibility with current user tools but with serious concerns for some users. 33% stated the LMS content is compatible with current user tools, including assistive technologies. However, 23% had minor concerns, 23% had serious concerns, and 20% marked it as not applicable, indicating compatibility issues with some user tools.
- **Engagement**: Weighted score of 0.05, showing moderate support for user-focused participation but needing more diverse engagement options. 27% indicated the LMS excels in user-focused participation. However, 47% had minor concerns, 23% had serious concerns, and 3% marked it as not applicable, highlighting the need for more diverse engagement options.
- **Multiple Means of Representation**: Weighted score of 0.03, indicating limited content format diversity and adaptability. 27% stated the LMS provides content in diverse formats and supports adaptability. However, 33% had minor concerns, 33% had serious concerns, and 7% marked it as not applicable, indicating the need for better adaptability features.
- **Multiple Means of Action and Expression**: Weighted score of 0.06, showing a variety of assessment methods but with room for improvement. 40% indicated the

LMS allows for a variety of assessment methods and student responses. However, 37% had minor concerns, 20% had serious concerns, and 3% marked it as not applicable, suggesting a need for more varied expression methods.

- **Cost of Use**: Weighted score of 0.04, indicating some aspects are free but with concerns about potential financial burdens. 33% stated all aspects of the LMS can be used free of charge. However, 20% had minor concerns, 17% had serious concerns, and 30% marked it as not applicable, indicating that some aspects of the LMS may pose a financial burden on students, while others stated N/A as the costs are absorbed by the organisation.

The overall weighted score for the AI category is 0.08, suggesting that AI features in LMS platforms are not yet widespread or fully developed. The data highlighted several key areas needing improvement:

- **Knowledge Check/Quiz Generation:** Weighted score of 0.03, indicating issues across all response categories. Only 13% felt this feature worked well, while another 13% had minor concerns,17% had serious concerns. Significantly, 57% indicated "Not Applicable," suggesting it is either not present or not accessible in their LMS.
- **Chatbot/Help Assistance:** Weighted score of 0.01, reflecting significant deficiencies in functionality. Only 7% reported it works well, while 13% had minor concerns, and 17% had serious concerns. A substantial 63% marked this criterion as "Not Applicable," indicating chatbots may not be integrated into many LMS platforms.
- **Personalised Learning** Weighted score of 0.03, with 13% stating it works well, 20% had minor concerns, and 20% had serious concerns. Nearly half (47%) indicated this feature was "Not Applicable," suggesting limited implementation of personalised learning in current LMS platforms.
- **Enhanced Predictive Analytics:** Weighted score of 0.01, with 10% stating it works well, 10% had minor concerns, and 27% had serious concerns. Over half (53%) selected "Not Applicable," indicating this advanced AI capability is not yet common in LMS platforms.

From these findings, it is evident that LMS Accessibility features need significant enhancement, and AI functionalities in current LMS platforms are still in their early stages, requiring substantial development. These figures also support the qualitative data, where respondents, especially in higher education, approach AI in educational tools with considerable caution.

Table 13 Accessibility Calculation Performance Rating Scale

Accessibility Criterion	Weight (%)	Works Well (%)	Minor Concerns (%)	Serious Concerns (%)	N/A (%)	Score for Works Well	Score for Minor Concerns	Score for Serious Concerns	Score for N/A	Average Score	Weighted Score
Perceivable	12.5	0.37	0.40	0.20	0.03	1	0.5	-0.5	0.00	0.47	0.06
Operable	12.5	0.17	0.57	0.10	0.17	1	0.5	-0.5	0.00	0.4	0.05
Understandable	12.5	0.37	0.47	0.13	0.03	1	0.5	-0.5	0.00	0.54	0.07
Robust	12.5	0.33	0.23	0.23	0.20	1	0.5	-0.5	0.00	0.34	0.04
Engagement	12.5	0.27	0.47	0.23	0.03	1	0.5	-0.5	0.00	0.39	0.05
Multiple Means of Representation	12.5	0.27	0.33	0.33	0.07	1	0.5	-0.5	0.00	0.27	0.03
Multiple Means of Action and Expression	12.5	0.40	0.37	0.20	0.03	1	0.5	-0.5	0.00	0.49	0.06
Cost of Use	12.5	0.33	0.20	0.17	0.30	1	0.5	-0.5	0.00	0.35	0.04
Total	**100**										**0.4**

Note: Numbers have been rounded up.

Table 14 Artificial Intelligence (AI) Category Calculation Performance Rating Scale

Artificial Intelligence Criterion	Weight (%)	Works Well (%)	Minor Concerns (%)	Serious Concerns (%)	N/A (%)	Score for Works Well	Score for Minor Concerns	Score for Serious Concerns	Score for N/A	Average Score	Weighted Score
Knowledge Check	25	0.13	0.13	0.17	0.57	1	0.5	-0.5	0.00	0.13	0.03
Chatbot/Help Assistance	25	0.07	0.13	0.17	0.63	1	0.5	-0.5	0.00	0.05	0.01
Personalised Learning	25	0.13	0.20	0.20	0.47	1	0.5	-0.5	0.00	0.13	0.03
AI-Enhanced Predictive Analytics	25	0.10	0.10	0.27	0.53	1	0.5	-0.5	0.00	0.05	0.01
Total	**100**										**0.08**

Note: Numbers have been rounded up.

3.4 Final LMS Evaluation Rubric

The **Final LMS Evaluation Rubric** template (contained in **Appendix F)** has been refined based on empirical findings from the survey and quantitative insights from the decision support tool. Additionally, an online artefact has been created which allows evaluators to calculate a value for each category. The method provides the advantage of enabling evaluators to revisit categories to adjust their scores if necessary. This flexibility is particularly useful for those evaluators who are somewhere between deciding if a criterion 'works well' or there are 'minor concerns.' The minor concerns may not be sufficient to discount the LMS, especially if features are still in development.

3.4.1 Changes to the Calculations

For the final revised rubric, the decision was made to omit the weightings assigned to each criterion. This change ensures that each criterion holds equal importance in the final evaluation. The calculation now divides by the number of applicable criteria to derive the average score, ensuring that no single criterion disproportionately influences the overall score. This approach maintains simplicity and transparency in the scoring process, ensuring that all criteria are considered equally significant in evaluating the LMS platforms.

3.4.2 Key Features

Some criteria in other categories overlap or align with those in the Accessibility and AI categories. For example, Learning Analytics in the Teaching Presence category overlaps with Predictive Analytics in the AI category. Both criteria aim to provide insights into student performance to improve teaching strategies and support student success. The key difference lies in the use of AI in the predictive analytics criteria to enhance these insights further. Another example is Multi-Modality in the Functional category, this aligns with the Multiple Means of Expression criterion in the Accessibility category. Both criteria emphasise the importance of providing various methods for users to interact with content and express themselves. The Functionality section encompasses 'Ease of Use', while the Accessibility section incorporates the 'Understandable' criterion, which is closely aligned with usability. Both concepts are designed to ensure that users can engage with content or systems efficiently and effectively, without difficulty.

1. Streamlined criteria to reduce overlap:
    a. Moved Learning Analytics in the Teaching Presence category to the AI category as this overlaps with Predictive Analytics.
    b. Removed Multi-Modality in the Functional category, this aligns with the Multiple Means of Expression criterion in the Accessibility category.

c. Removed ‘Ease of use” from functionality as this is covered in Accessibility under the ‘Understandable’ criteria - closely aligned with usability.

2. Accessibility: Expanded criteria with detailed WCAG and UDL compliance. Added links to resources and tools required to conduct a thorough evaluation.
3. AI Capabilities: New section evaluating AI functionalities: Knowledge/Quiz Generation, Predictive Analytics, Personalised Learning, and AI Generated Chatbots. Ensured descriptions are clearer and referenced AI implementation guidelines and other resources.

3.4.3 Development and Testing

1. Empirical Testing: Involved 30 participants from industry and academia, who evaluated 17 different LMS platforms. This initial testing identified practical issues and areas for enhancement.
2. Feedback Integration: Qualitative feedback was thematically analysed to inform final modifications.
3. Decision Analysis Tool: This system applies scores to the performance rating scale: Works Well, Minor Concerns, Serious Concerns as well as the Not-applicable option.

3.5 Final LMS Evaluation Rubric (Online)

In the final LMS evaluation rubric, each criterion is scored using a scale, similar to the decision support tool used to triangulate the data from the pilot described earlier. In the evaluation of LMSs, it is essential to ensure that the assessment is fair and unbiased, particularly when certain criteria may not be applicable. A method to calculate the average scores of various categories is employed, adjusting for criteria marked as "Not Applicable".

3.5.1 Handling Entire Categories Marked as "Not Applicable"

If all criteria within a category are marked as "Not Applicable," the category's score is excluded from the overall average calculation. This is achieved by evaluating whether the denominator is zero. If it is, the category is not considered in the final average.

Table 15 Average Score Calculation

Step-by-Step Explanation: For each category, the average score is calculated by summing the scores of all applicable criteria (excluding "Not Applicable") and then dividing by the number of applicable criteria. The formula counts all values different to “Not Applicable”, considering them relevant criteria. A common error is giving "Not Applicable" criteria a value of 0, which negatively impacts the average score. Instead, "Not Applicable" responses should be excluded to ensure the average score accurately reflects only the relevant responses. For example: if a value is applied to Not Applicable the Total Average, the Score is 40%. If Not Applicable is excluded the Total Average, the Score is 50%:

Criteria	**Performance Rating Scale**	**Score**	**Criteria**	**Performance Rating Scale**	**Score**
A	Works Well (WW)	1	A	Works Well (WW)	1
B	Works Well (WW)	1	B	Works Well (WW)	1
C	Minor Concerns (MC)	0.5	C	Minor Concerns (MC)	0.5
D	Serious Concerns (SC)	-0.5	D	Serious Concerns (SC)	-0.5
E	Not Applicable (NA)	0	E	Not Applicable (NA)	N/A
Sum the scores above, divide by 5, and multiply by 100: (SUM(ABOVE) / 5) * 100		**40%**	Sum the scores above (exclude N/A), divide by 4, and multiply by 100: (SUM(ABOVE) / 4) * 100		**50%**

3.5.2 Calculating the Final Overall Score

To obtain the final overall score, the scores of all categories are averaged, excluding those entirely marked as "Not Applicable". This formula ensures that each category contributes equally to the final score, regardless of the number of criteria within each category, and excludes categories that have no applicable criteria. Using this method, ensures a balanced and fair evaluation of an LMS. The approach adjusts for "Not Applicable" criteria, preventing them from negatively impacting the overall score, and ensures that categories with varying numbers of

criteria are weighted equally in the final assessment.

3.5.3 Application

This rubric serves as a versatile checklist guiding users in selecting an LMS that aligns with their e-learning needs, making informed decisions about LMS adoption.

3.5.4 Summary

This detailed analysis provides a view of where LMS platforms stand in terms of Accessibility and AI capabilities and where LMS providers and LMS administrators need to focus their efforts. The effectiveness of the rubric has been demonstrated through both quantitative scores and qualitative feedback. The thematic analysis of the qualitative data has further validated that the criteria used in the rubric are appropriate with minor amendments applied in the final artefact.

4 Chapter 4 Discussion

This research tested the effectiveness of a rubric for evaluating LMSs, rather than comparing specific LMS functionalities. A thematic analysis of feedback from 30 participants, combined with quantitative data measured against a performance rating scale (“Works Well”, “Minor Concerns”, “Serious Concerns”, “Not Applicable”), was used successfully to validate the rubric's effectiveness’. The LMS is an essential system, integral to the core educational operations of the institution or organisation. Since the rubric assists evaluators in testing certain criteria, Barreto, Rottmann, Rabidoux, et al. (2020) recommend that, in addition, LMS evaluation should be conducted by several stakeholders to ensure diverse perspectives from both educational and corporate sectors are considered. The evaluation of AI functionalities revealed concerns among participants who attempted to assess unfamiliar features. These concerns were often indicated by high numbers of "Not Applicable" responses. In addition, among those who assessed AI features, significant concerns were noted about quiz generation, chatbot assistance, and personalised learning. This suggests that the current AI capabilities in the LMS may not be fully effective or well-integrated. With open source LMSs such as Moodle, some institutions may disable AI features until they are confident in the security and reliability. Similarly in the corporate world, while machine learning has been used for learning pathways and personalised learning, generative AI in LMS platforms is extremely new. The issues surrounding accuracy, bias and hallucinations described in Chapter 2 contribute to this overall assessment. Another issue that emerged was the varying levels of participant knowledge and experience. Though a diverse range of participants was necessary, some respondents did not know the answer to some of the questions or did not know how to fully test the criteria due to lack of knowledge in a particular area. Those with admin access to the LMS or the more experienced users were better placed to answer some of the more technical questions. However, the descriptions at the top of each section and in the individual cells supported participants with one person stating: “I especially appreciated the descriptions of what you were looking for in the various cells. I tried to add meaningful comments to help justify my ratings and for my personal reference.” Nonetheless, a review of the descriptions for each category was conducted, and descriptions were updated accordingly. The overlapping criteria identified in Chapter 3 were leveraged to streamline the rubric, removing redundancy and reducing evaluation time.

4.1 Implications and Recommendations

GenAI can play a pivotal role in analysing data across the LMS, facilitating the creation, validation, and refinement of learning analytics. By generating human-like content to enrich the modality of analytics, it aids educators in understanding the overall learning experience and guides them into making informed decisions (Yan, Martinez-Maldonado and Gašević, 2023, pp. 1, 6). The survey results highlight the need for LMSs to enhance their personalisation, user interfaces, and accessibility features. However, better integration and user education could address gaps in AI feature implementation. The survey results for learning analytics among advanced users emphasise the evolving role of AI in education. These users recognise that while the data is available, some institutions may disable certain features due to regulatory concerns. Another critical aspect highlighted by Ford (2016, pp.133–136), is the fear concerning AI's role in automating educational tasks, such as the marking of assignments. These concerns are warranted as we integrate AI into learning platforms, ensuring that the technology enhances rather than undermines educational integrity.

Evaluation of responses to the survey has identified key areas for improvement. The rubric is broad, encompassing 10 sections where some sections could become evaluation frameworks in their own right. This breadth is advantageous because it allows different criteria to be tested in isolation depending on specific needs. Accessibility teams, in particular, could use the rubric in tandem with checklists covering the WCAG standards. Additionally, evaluators could request an LMS provider to use a structured accessibility self-assessment tool such as TrustEd.
During this study, Aurion Learning delivered an Accessibility workshop as part of their ‘Future of Learning’ event. They recommended using a variety of screen readers; including JAWS, NVDA and VoiceOver (Mac) to cover all operating systems. Additionally, they suggested using Google Lighthouse and WAVE for auditing accessibility (Aurion Learning [@aurionlearning], 2024).One participant in this study cleverly used the accessibility checker tool to test some of the criteria. Therefore, the revised rubric will contain links to this, and similar, resources in the description area, providing additional support to those evaluators who are new to UDL, WCAG and Accessibility testing. Many LMSs were designed before the integration of AI and treat accessibility as an afterthought. However, these attitudes are changing due to policy reforms, notably with the introduction of the European Accessibility Act (EAA) on June 28, 2025. Similarly, the AI Act was introduced during this study. Given the newness of these legal domains, the rubric could evolve to include new criteria centred around compliance.

According to Taylor and Vinauskaite (2023), many companies adopting AI are concerned about sharing proprietary or sensitive data with AI tools, and whether these tools comply with

regulations. In Higher Education, a study by Educause revealed that data privacy and security are central concerns for institutions working on an AI-related strategy (Educause, 2024). The introduction of the AI Act not only puts in place safeguards but also protects against the misuse of AI, particularly when evaluators must determine if the AI system or model is deployed in a high-risk sector. Annex III of the AI Act defines eight major areas of activities identified as 'high risk' with education and vocational training being one of these high risk categories (Tordeux-Bitker *et al.*, 2024). This goes some way in explaining the evaluation of AI functionalities, which revealed that many participants were unfamiliar with these features, as indicated by high "Not Applicable" responses, suggesting the criteria were not present in the LMS being evaluated.

Organisations, especially in the Learning industry, may be exercising caution and balancing whether to use AI or not because of the high-risk classification. This also aligns with O'Brien (2024) who states that AI in education is complex and requires considerable thought and collaboration. In response to this rapidly evolving field, the National Academic Integrity Network (NAIN) has published GenAI Guidelines for Educators. These guidelines aim to provide support and advice for educators to reflect, share, and discuss with their students the implications of what is and is not permissible (NAIN, 2023). Additionally, the Global AI Safety Summit has emphasised the importance of addressing AI safety and ethical considerations on a global scale, calling for international cooperation to manage the associated risks and opportunities (GOV.UK, 2023). At a local level, the Government of Ireland has established a strategy that sets out how Ireland can be an international leader in using AI to benefit our economy and society, through a people-centred, ethical approach to its development, adoption and use (GOV.IE, 2024). The International Standards Organisation (ISO) has published several AI standards to enhance transparency, data quality, and system reliability, thereby, helping to bridge the gaps in regulation (ISO, 2024). Tech companies such as Google (2024a) and Microsoft (2024) have extensively documented their responsible AI practices. The NCCE recently published a framework intended to provide education leaders with a strategic approach to integrating AI capabilities into educational settings (NCEE, 2024). Moreover, capAI, discussed in the literature review is an evolving procedure designed to help organisations ensure their AI systems comply with the ethical and regulatory standards outlined in the EU AI Act (Floridi *et al.*, 2022).

In response to participant feedback, the **Final LMS Evaluation Rubric** will contain links to the aforementioned resources and related literature in the AI description area, offering support to individuals new to AI. There is an abundance of information and resources available, and these are just a few pointers that will assist evaluators in navigating this rapidly advancing technological landscape.

5 Chapter 5 Conclusion

A key characteristic of evaluation research is its intended utility. Although evaluation theorists have various definitions, the majority of literature emphasises evaluation as a means to assist decision-makers (Clarke and Dawson, 1999, p. 173). This study aims to fulfil this purpose by providing the **Final LMS Evaluation Rubric** that professionals and e-learning students can use to evaluate LMSs. The study has been structured to provide clear insights into the methodology, the application of the **Revised LMS Evaluation Rubric**, and the results of its practical implementation. It proposes new standards in the selection and utilisation of LMSs, significantly contributing to the field of e-learning. As long as providers continue to offer updated software with improved features, the **Final LMS Evaluation Rubric** proves highly effective for stakeholders in identifying the most suitable LMS for their specific needs.

To ensure evaluations are effective, evaluators require technical skills and a deep understanding of different research methods. They also need to communicate findings in ways stakeholders find accessible (Clarke and Dawson, 1999, p. 185). The advantage and added value of the **Final LMS Evaluation Rubric** over the **Original Rubric for Evaluating E-Learning Tools** is that it allows evaluators to assess multiple categories simultaneously or individual categories in isolation, generating comparisons weighted by the performance rating scale (“Works Well”, “Minor Concerns”, “Serious Concerns”, “Not-Applicable”). Furthermore, because it is now available online as a spreadsheet, users can compute values against the scale, providing an overall percentage of how each category performs. A key characteristic of this tool is it can effectively support evaluators in presenting their findings to leadership and relevant stakeholders with ease.

In conclusion, the study’s methodology involved a comprehensive literature review and iterative refinement of the rubric based on participant feedback. Piloted with 30 participants the **Revised LMS Evaluation Rubric** focused specifically on LMSs, incorporating updated Accessibility criteria and new AI criteria. Recognising the foundation of the **Original Rubric for Evaluating E-Learning Tools,** the **Revised LMS Evaluation Rubric** became a more targeted tool**.** The validation process identified areas for improvement, resulting in the **Final LMS Evaluation Rubric,** which removed redundancy, added detailed descriptions, and advises the use of additional resources to support the evaluation. The **Final LMS Evaluation Rubric**, available online, is the culmination of this iterative process, resulting in a practical tool for LMS evaluations.

5.1 Future Research

As technology advances, there is an opportunity to expand the rubric to align with future developments associated with learning platforms. Modern LMSs are morphing into Learning Experience Platforms (LXPs) with an emphasis on AI in the learning design process. **The Final LMS Evaluation Rubric** already includes criteria for AI-generated chatbots and personalised analytics, which are well-placed to evaluate these emerging AI enhancements.

The current criteria for AI in the **Final LMS Evaluation rubric** can be further enhanced as organisations innovate with this technology. The standards laid out in the European Accessibility Act will provide guidance and inspiration, ensuring that digital platforms, including LMSs, are inclusive for all users. The current criteria for Accessibility in the **Final LMS Evaluation Rubric** can also be enhanced as more and more LMSs become compliant. For instance, AI-driven content personalisation can adapt interfaces for individual needs, improving accessibility for users with cognitive disabilities.

The fusion of AI and Accessibility technologies offers transformative potential by dynamically adjusting learning environments to meet diverse learner needs, such as real-time language translation and context-aware assistance (Negi, 2024). Voice recognition technology, screen readers, and magnification tools are also integral to meeting accessibility standards, making digital content more accessible for users with visual or motor impairments. Implementing these technologies ensures compliance and enhances the overall user experience, fostering a more inclusive digital environment (W3C Consortium, 2023b).

As we look to the future, provided we exercise caution and adhere to regulatory guidelines and ethical considerations, the continued evolution and integration of AI and Accessibility features within LMS platforms promise more personalised, secure, and inclusive learning environments, ultimately driving better educational outcomes and fostering an inclusive digital learning experience for us all.

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Appendix A - Literature Review on Remaining Categories of the Rubric

I. Privacy, Data Protection, and Rights

Privacy concerns have long been linked to the ethical use of student data in learning analytics. The following section offers perspective that aligns with recent regulatory changes and the heightened risks associated with online learning environments.

The swift transition in recent years to online learning has exacerbated these issues, often leading institutions to favour cost-effective and easy-to-use technologies over those with stringent privacy protections. This shift can result in the increased risk of misuse of student data

The "Irish National Digital Experience (INDEx)" survey published in 2020, revealed 52% of students concurred that their institution protected their data privacy, fewer than a third (30%) agreed that they were informed about how their personal data was stored and used. 52% of staff stated that they were informed about their responsibilities with regard to managing learner data securely. In response to this report, institutions acted by communicating resources for students and staff addressing data privacy, digital safety and digital wellbeing, including resources on GDPR and data literacy (National Forum for The Enhancement of Teaching and Learning In Higher Education, 2020).

The AI Act mentioned earlier, categorises certain uses of AI in education and vocational training as high risk due to their significant impact on individual rights and opportunities including Access and Admission, Evaluation and Learning Outcomes, Level Assessment and Behaviour Monitoring. Educational institutions planning to implement AI systems for assessment and monitoring must undertake a Fundamental Rights Impact Assessment. This assessment is essential to ensure that the systems do not infringe on students' rights and comply with ethical standards (Wade, Kelleher and McNiff, 2024).

The General Data Protection Regulations (GDPR) govern the processing of personal data with strict principles such as data minimisation, consent, right to access, and data portability. Organisations must comply or face significant penalties. The Data Protection Commission details personal data definitions, lawful processing, rights for individuals, and responsibilities for data controllers and processors (Data Protection Commission, 2018). The data privacy laws corresponds to the criterion of Data Privacy and Ownership and Archiving, Saving, and Exporting

Data in the rubric. The LMS's sign-in process is evaluated based on its adherence to GDPR mandates, which emphasise secure data handling and user consent. The platform should offer a secure sign-in process, ideally incorporating two-factor authentication and encrypted data storage to comply with GDPR's rigorous standards for data protection and privacy. This setup demonstrates an LMS's commitment to safeguarding user data, a central aspect under the GDPR's principles of data minimisation and secure processing. This directly ties GDPR's emphasis on security and user consent to the LMS's Sign Up and Sign In Process criteria showing how they meet the Data Protection Commission's guidelines (Data Protection Commission, 2024).

II. Functionality

This section evaluates the operations or affordances of the LMS and the quality or suitability of these functions to the intended purpose. Essentially, does the LMS effectively support and enhance the process of teaching and learning online? The LMS is designed not just to facilitate courses, but to act as a platform for course delivery, management, and interaction (Anstey and Watson, 2018a). Functionality therefore measures criteria to include scale, ease of use, tech support and multi-modality.

Scale refers to how well the LMS platform is able to support an increasing number of learners and courses and its ability to function optimally when the size, volume, or the demands placed on the system change (Gutierrez, 2022). The Scale criterion assesses the LMS's ability to handle varying sizes of user bases effectively. For small institutions or businesses, a simple LMS plugin may be adequate. In contrast, a rapidly expanding large institution or corporate organisation will require robust scalability features that can accommodate significant increases in user load and data volume without compromising performance. Scalability is an important consideration in ensuring the LMS can adapt to growth and changing needs over time.

The APA defines Psychology as the study of the mind and behaviour (APA, 2024). Similarly, Norman (2013) emphasises the importance of understanding human cognition and behaviour in design and posits that we need to know about the human mind because things are designed to be used by people, and without a deep understanding of people, designs are likely to be ineffective. In the context of educational tools we need to ensure they are easy to use and understand. The **Ease of Use** criterion in the Functionality section is linked to the Operable criterion in the Accessibility section. These criteria are focused on making sure that the interface is user-friendly and can be managed without unnecessary complexity, which is essential for the

usability of any technology tool, particularly in educational environments where users range widely in their technical proficiency (W3C Digital Accessibility Foundations, 2023).

As depicted in figure 4 and figure 5, the theory underpinning the multi-modality criteria in the rubric falls under two principles by Mayer (2020, pp. 117, 281):

i. **Multimedia Principle:** Learning is more effective from a combination of text and images rather than text alone
ii. **Modality Principle:** Learners comprehend better with a mix of spoken words and visuals compared to just text and images.

Clark and Mayer, (2016) explain the modality principle as a way to decrease cognitive strain on the learner's visual system by transferring some of the cognitive load to the auditory system. The muti-modality principle correlates to the Multi-Modality criteria in the functionality section of the rubric.

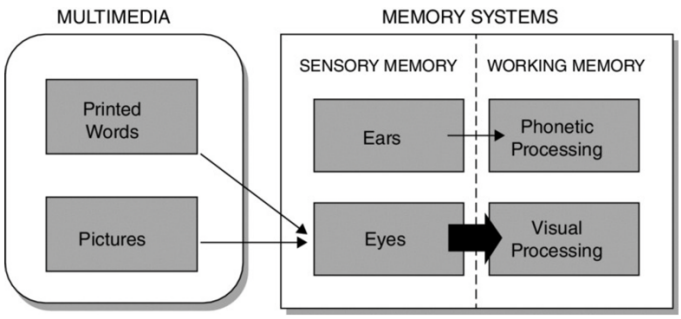


Figure 6 Overloading of Visual Channel with Presentation of Written Text and Graphics – Adapted from Mayer, 2009 (Clark and Mayer, 2016)

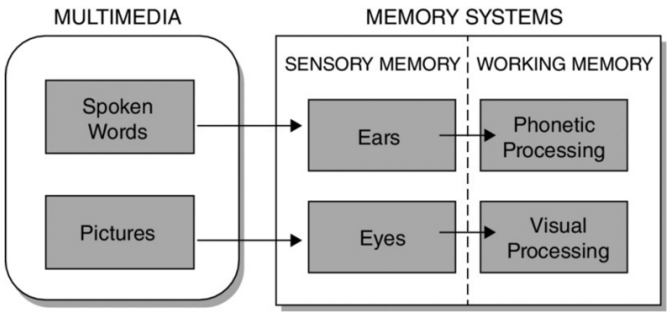


Figure 7 Balancing Content Across Visual and Auditory Channels with Presentation of Narration and Graphics – Adapted from Mayer, 2009 (Clark and Mayer, 2016)

The role of the instructional professional extends beyond just delivering information; it involves presenting this information in a manner aligned with cognitive learning theories. According to Mayer, (2020), effective learning hinges not just on the presented material, but also on the learner's cognitive processes during the learning experience. By supporting multimodality, the LMS facilitates diverse communication methods (audio, visual, textual) and promotes a non-linear, adaptable learning approach.

III. Mobile

The ubiquity of mobile devices and the diverse range of operating systems necessitate that e-learning tools be compatible across all platforms. Research by Anstey and Watson, (2018a) supports the need for LMSs to be accessible regardless of the device or operating system, emphasising that inclusivity in mobile access is imperative for modern educational tools. This reflects the Access criteria in the rubric, which assesses the universal compatibility and responsiveness of LMS across different mobile platforms.

Consistency in user experience across various devices is essential to ensure effective learning. Anstey and Watson, (2018a) also highlight that the mobile functionality should ideally mirror the desktop environment to avoid learning disruption and maintain engagement. This aligns with the Functionality criterion in the rubric, which evaluates whether mobile versions of LMS maintain parity with their desktop counterparts in terms of features and user experience.

The ability to access educational tools offline is particularly important in regions with unstable internet connectivity. According to Anstey and Watson, (2018a), providing offline access to learning resources ensures that learning activities are not hindered by connectivity issues, thereby enhancing the flexibility and accessibility of the educational tool. This supports the Offline Access criterion in the rubric, ensuring that LMS can serve a broad user base, including those in low-bandwidth areas.

IV. Technical

This section of the rubric deals with issues such as the technical constraints of the delivery platform and evaluates the LMS educational technology ecosystem; all the components of an integrated system necessary for appropriately using tools and equipment for educational purposes (Bates and Poole, 2003). It considers the basic technologies needed to make the LMS work. The technical criteria in this section measures Integration/ Embedding within a Web Site or

installed on a network, Desktop / Laptop Operating Systems, Browser Compatibility, Additional Downloads and support for SCORM.

Bates and Poole, (2003) have long emphasised that the integration of educational technologies should support a broader ecosystem of learning tools. This perspective is echoed in recent studies which highlight the importance of LMS platforms supporting LTI (Learning Tools Interoperability) standards to facilitate embedding and integration of diverse educational tools and resources directly into LMS platforms (Haggerty, Harrington and Scott, 2022, p. 117). The criterion Integration/ Embedding within a Web Site or installed on a network relates to this broader ecosystem of learning tools. Compatibility with various operating systems ensures that LMS platforms are accessible to a broader audience. LMS platforms must support a range of up-to-date operating systems to avoid limiting user access and to accommodate diverse technological environments. An effective LMS should be operable on both Windows and macOS platforms, ensuring universal accessibility for desktop and laptop users. This supports the **Desktop / Laptop Operating Systems** criterion.

Browser Compatibility is another criterion affecting the usability of LMS platforms. Research indicates that LMS platforms optimised for use with multiple standard, up-to-date web browsers prevent accessibility issues and ensure a consistent user experience. Ensuring broad browser consistency can significantly impact user satisfaction and engagement, as differences in browser performance can affect how educational content is delivered and accessed (Arora, Bhardwaj, and Sonia, 2022, p. 521).

SCORM is the final criterion in technical section which stands for Shareable Content Object Reference Model and is the de facto industry standard for e-learning interoperability. Specifically, SCORM governs how online learning content and LMSs communicate with each other. SCORM is primarily a technical standard, its capabilities for tracking learner progress and assessment data can indirectly support instructional design and pedagogical decisions. It ensures that e-learning content is interoperable and can be used across different LMS platforms by specifying how content should be packaged and how data should be exchanged. LMSs can use SCORM to track learner performance, specifically:

I. Time – How long did the course take?
II. Completion – Did the Learner complete the course?
III. Pass/fail – Was the answer correct?
IV. Score – How many questions were correct? (Rustici Software, 2024a).

Also known as Tin Can API, The Experience API (xAPI) is a newer standard that builds upon SCORM's capabilities, offering more detailed tracking and better support for learning analytics which allows one to track, in much more detail (from many different sources, learning experiences and content, even those outside of the LMS) than its predecessor SCORM. The LMS and SCORM is about packaging, delivery and management of content. The new specification, xAPI, is about learners and their behaviour (Clark, 2020, p. 163; Rustici Software, 2024b).

V. Social, Cognitive and Teaching Presence

Learning does not happen in a vacuum, the growth of technology has facilitated the delivery of online, global education programmes, with social interaction now taking place in a global context (Alexander, Schallert and Reynolds, 2009, p. 183; Whitaker, 2017, p. 90). LMSs are often referred to as the "middle ware" that links repositories and the educational process. This infrastructure supports the creation of knowledge as well as managing its preservation and dissemination. Equally important is the recognition and integration of communities of practice where teachers and students can manage and share information and knowledge with regard to curriculum, course management and pedagogical processes (Garrison, 2017, pp. 24–27).

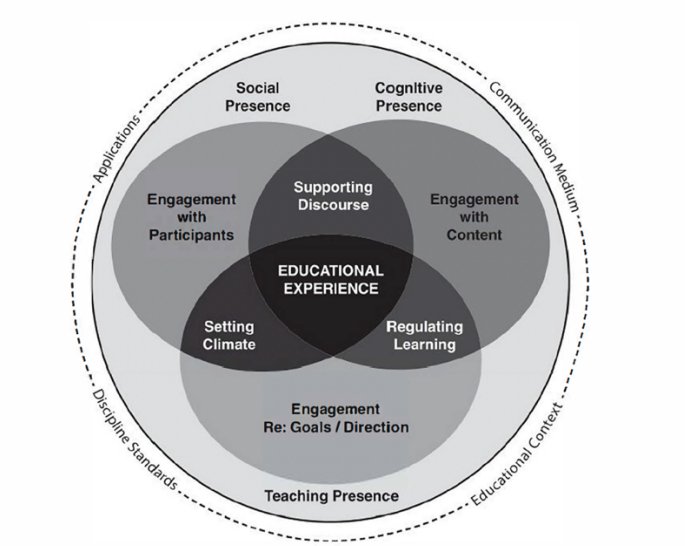


Figure 8 Community of Inquiry Model (Garrison, 2017).

Individuals learning in a social context and in groups are part of a general discourse on learning that can be traced back to early psychologists such as Vygotsky. However, the formal concept of a social learning system emerged a lot more recently (Blackmore, 2010, p. 1). In the 1960s Bandura stated by interacting with and observing others in a social context, one forms an idea of how new behaviours are performed (Gould, 2012, p. 110). (Haythornthwaite and Andrews, 2011,

p. 109) suggest learning communities have changed the role of the learner from passive recipient to creator of information and learning contexts.

The Cognitive, Teaching, and Social Presence categories of the rubric derive from the Community of Inquiry (CoI) model, as illustrated in Figure 6. This model explores how the design of online learning environments generates and sustains a sense of community among learners. (Garrison, 2017, p. 25) outlines three presences: Cognitive, Teaching, and Social. Evaluations of LMSs are informed by the CoI model to promote a rich and engaging educational experience.

Cognitive Presence refers to the extent to which learners can construct and confirm meaning through sustained reflection and discourse (Garrison, 2017, p. 26). This aligns with Vygotsky's social constructivism, which posits that cognitive development is deeply intertwined with social interaction, suggesting that collaborative activities within an LMS can significantly enhance individual learning outcomes (Gould, 2012, p. 116). Vygotsky refers to the "zone of proximal development" (ZPD), which outlines the gap between what a learner can achieve on their own, what they can accomplish with assistance, and what is beyond their reach. This concept underscores the importance of social interaction and dialogue in learning (Vygotsky *et al.*, 1978, p. 86; Weller, 2020, p. 28). The Cognitive Presence criteria of the rubric include Enhancement of Cognitive Task(s) Higher Order Thinking Metacognitive Engagement

Teaching Presence involves the design, facilitation, and direction of cognitive and social processes to achieve meaningful learning outcomes. It highlights the instructor's role in shaping the educational environment and guiding learner engagement (Garrison, 2017, pp. 26–27). The rubric measures LMS elements that enable instructors to establish and maintain their teaching presence through **Facilitation** , **Customisation** , and feedback through the use of **Learning Analytics**

Social Presence refers to the ability of participants to identify with the community, communicate purposefully, and develop interpersonal relationships. This is essential for creating a supportive and interactive online learning environment (Garrison, 2017, p. 25). The rubric criteria include Collaboration , User Accountability and Diffusion aligning with these principles.

VI. Other

During the pilot, this section of the rubric allowed participants to include additional comments or suggestions to improve the rubric.

Appendix B – Revised LMS Evaluation Rubric.

This rubric was used in the pilot. The sections were converted to a ‘Survey Monkey’ survey to facilitate the pilot where 30 participants evaluated 17 LMS (see **Appendix C** for breakdown of LMSs). This rubric is adapted from the original "Rubric for E-Learning Tool Evaluation " by Anstey and Watson, (2018b) with specific amendments tailored to evaluating Learning Management Systems (LMS). It incorporates a new section on Artificial Intelligence (AI) functionalities and expands the Accessibility criteria to include more detailed compliance with WCAG standards. Originally, the rubric was developed as a formative tool for educators in higher education to evaluate a broad range of e-learning tools to support student learning. This revised version narrows the focus to LMS tools, which are specialised platforms for delivering, tracking, and managing courses. By tailoring the rubric's criteria to reflect the unique aspects of LMS tools, this version provides a targeted framework for evaluating these platforms' effectiveness in supporting educational outcomes.

Instructions:

- Each criterion should be evaluated on its own merits, with the option to mark criteria that are not applicable to a particular LMS as "N/A".
- The rubric does not prescribe a minimum score for LMS adoption but instead aims to highlight the system's strengths and areas for improvement.
- Users of the rubric are encouraged to prioritise criteria based on their specific use case.
- A section has been dedicated to ‘Other’ – this is to allow participants to add comments and suggestions to improve or enhance the rubric based on the evaluation of their chosen LMS.

Functionality. This section evaluates the operations or affordances of the LMS and the quality or suitability of these functions to the intended purpose. Essentially, does the LMS effectively support and enhance the process of teaching and learning online? As the cornerstone of digital education, the LMS is designed not just to facilitate courses, but to act as a platform for course delivery, management, and interaction (Anstey and Watson, 2018b).					
Criteria	**Works Well**	**Minor Concerns**	**Serious Concerns**	**Comments**	**N/A**
Scale	The LMS can be scaled to accommodate any size class with the flexibility to create smaller sub-groups or communities of practice.	The LMS can be scaled to accommodate any size class but lacks flexibility to create smaller sub-groups or communities of practice.	*The LMS is restrictive to a limited number of users and cannot be scaled.*		
Ease of Use	The LMS has a user-friendly interface, and it is easy for instructors and students to become skilful within a personalised and intuitive manner.	The LMS has an interface that may be confusing to either instructor or learner; there is limited opportunity for personalisation.	The interface is not user-friendly for either the instructor or learner; it is cumbersome, unintuitive, rigid, and inflexible.		

Tech Support / Help Availability	Technical support and /or help documentation is readily available and aids users in troubleshooting tasks or solving problems experienced.	Technical support and help documentation are available but limited, incomplete, or not user friendly.	Technological support and help documentation are not available.		
Multi-Modality	The LMS allows users to communicate through different channels (audio, visual, textual) and allows for non-sequential, flexible/adaptive engagement with material.	The LMS allows users to communicate through different channels (audio, visual, textual) but is limited in its ability to provide non-sequential, flexible/adaptive engagement with material.	The LMS is restrictive in terms of the communication channels employed (audio, visual, textual) and presents information sequentially in a rigid, inflexible format.		
Accessibility: This section evaluates the LMS for compliance with WCAG, (2023b) WCAG guidelines ensuring it is perceivable, operable, understandable, and robust for all users. It also assesses how the LMS provides varied and flexible options for presentation, expression, and engagement to support diverse learning styles as outlined in the Universal Design for learning framework (CAST, 2023).					

Criteria	Works Well	Minor Concerns	Serious Concerns	Comments	N/A
Perceivable (Content is presented in ways that can be perceived by all)	All content is available in alternative formats (e.g., text transcripts for audio). Visual content has sufficient contrast and supports screen reader technology.	Most content is perceivable, but some elements may lack alternative formats or have moderate issues with contrast or screen reader compatibility.	Key content is not available in alternative formats, with poor colour contrast and lack of screen reader support, making it inaccessible for some users.		
Operable (Interface forms, controls, and navigation are operable)	The LMS is fully navigable via keyboard and supports voice commands. All interactive elements are clearly labelled and accessible.	The LMS is mostly keyboard accessible but may have some areas that are not operable through keyboard or voice commands.	The LMS cannot be navigated using a keyboard or voice commands, and interactive elements are poorly labelled, hindering operability.		

Understandable (Information and operation of the interface must be understandable)	The LMS interface and content are clear and intuitive, with consistent navigation and predictable behaviour. Language is simple and directions are clear.	The LMS may have some parts that are inconsistent navigation or complex language that could confuse users.	The LMS has a confusing interface with inconsistent navigation and jargon-rich content that makes understanding difficult.		
Robust (Content must be robust enough to be interpreted by a wide variety of user agents)	The LMS content is compatible with current user tools, including assistive technologies (e.g. screen readers).	The LMS works with most current user tools but may not be fully compliant with the latest assistive technologies (e.g. screen readers).	The LMS has compatibility issues with many user tools and does not support assistive technologies effectively.		

Engagement (User-focused Participation)	The LMS excels in user-focused participation by offering varied learning paths, challenges, and accomplishments, catering to diverse literacies and capabilities. This inclusivity fosters active engagement and broadens participation opportunities	The LMS provides some user-focused participation options, but with limited variety, which may not fully engage all learners or accommodate the full spectrum of literacies and capabilities.	The LMS lacks user-focused participation features, offering few or no choices to accommodate diverse learners, which may restrict participation and negatively impact learner engagement and interest.		

Multiple Means of Representation	The LMS provides content in diverse formats and supports adaptability, such as adjustable text size and speech-to-text capabilities, to cater to different learning preferences and needs.	There is some diversity in content formats, but adaptability features are limited or not fully intuitive to use.	Content is largely presented in a single format without adaptability features, limiting accessibility for users with varying needs.		
Multiple Means of Action and Expression	The LMS allows for a variety of assessment methods and student responses, including written, oral, and project-based demonstrations of understanding.	The LMS offers some variety in assessment methods, but options for student expression are limited.	The LMS restricts students to a narrow range of expression methods, such as multiple-choice tests, without alternative forms of assessment.		

Cost of Use	All aspects of the LMS can be used free of charge.	Limited aspects of the LMS can be used for free with other elements requiring payment of a fee, membership, or subscription.	Use of the LMS requires a fee, membership, or subscription. Use of the LMS requires a purchase that is likely to pose a financial burden on students.		
Technical. This section evaluates the LMS educational technology ecosystem; all the components of an integrated system necessary for appropriately using tools and equipment for educational purposes (Bates and Poole, 2003) It considers the basic technologies needed to make the LMS work.					
Criteria	**Works Well**	**Minor Concerns**	**Serious Concerns**	**Comments**	**N/A**
Integration/ Embedding within a Web Site or installed on a network	The LMS can be embedded (as an object via HTML code) or fully integrated into a WordPress or Native HTML website while maintaining full functionality of the LMS.	The LMS can be embedded within a website with limited functionality but cannot be fully integrated.	The LMS can only be accessed through a hyperlink on the vendor's own platform.		

Desktop / Laptop Operating Systems	Users can effectively utilise the LMS with any standard, up-to date operating system.	Users may encounter limited or altered functionality depending on the up-to-date operating system being used	Users are limited to using the LMS with one specific, up-to-date operating system. (e.g. LMS will only operate on Windows)		
Browser Compatibility	Users can effectively utilise the LMS with any standard, up-to-date browser.	Users may encounter limited or altered functionality depending on the up-to-date browser being used.	Users are limited to using the LMS through a specific browser.		
Additional Downloads	Users do not need to download additional software or browser extensions.	The LMS uses a browser extension or software that requires a download and / or user permission to run.	The LMS requires a past or version of a browser extension or software.		
SCORM	The LMS supports SCORM natively without the need for	The LMS supports SCORM but requires an additional plugin or download, which is	The LMS does not support SCORM natively, and the process to integrate		

	additional plugins or downloads.	straightforward and user-friendly.	SCORM via additional plugins or downloads is complex and not user-friendly.		
Responsive (Mobile) Design Instructional methods and LMS that deliver content using mobile technology will continue to grow and therefore warrant their own assessment category (Anstey and Watson, 2018a).					
Criteria	**Works Well**	**Minor Concerns**	**Serious Concerns**	**Comments**	**N/A**
Access	The LMS can be accessed, either through the download of an app or via a mobile browser, regardless of the mobile operating system and device. Design of the mobile LMS fully takes into consideration the	The LMS offers an app, but only for a limited set of mobile operating systems. LMS is not accessible through a mobile browser. Design of the mobile LMS constrained by the	Access to the LMS is limited or absent on a mobile device.		

	constraints of a smaller-sized screen.	limitations of the mobile device.			
Functionality	There is little to no functional difference between the mobile and the desktop version, regardless of the device used to access it. No difference in functionality between apps designed for different mobile operating systems.	Core features of the main LMS are functional on the mobile app, but advanced features are limited. Some difference in functionality between apps designed for different mobile operating systems but has limited impact on learners' use of the LMS.	The mobile app functions poorly such that core features are not reliable or non-existent. Significant difference in functionality depending on the mobile device's operating system used to access the LMS.		
Offline Access	Offers an offline mode: Core features of the LMS can be accessed and utilised even when offline, maintaining	Offers a kind of offline mode, where the LMS can be used offline, but core functionality and content are affected.	The mobile platform cannot be used in any capacity offline.		

	functionality and content.				
Privacy, Data Protection, and Rights. This section evaluates the LMS's adherence to data protection best practices, as outlined by data controller obligations under Data Protection Commission, (2018).					
Criteria	**Works Well**	**Minor Concerns**	**Serious Concerns**	**Comments**	**N/A**
Sign Up and Sign In Process	The LMS offers a secure sign-in process with two-factor authentication and encrypted data storage. Sign-in/out is straightforward, with clear options for account recovery. The system demonstrates compliance with data privacy standards.	The LMS provides encrypted sign-in but lacks two-factor authentication. The sign-in/out process may require multiple steps or may not be intuitive for all users. Privacy standards are met but not exceeded.	The LMS sign-in process is not secure, lacks encryption for stored data, or does not offer two-factor authentication. The process is cumbersome and not user-friendly, with potential privacy risks		
Data Privacy and Ownership	Users maintain ownership and copyright of their intellectual	Users maintain ownership and copyright of their intellectual	Users forfeit ownership and copyright of data; data is shared publicly and		

	property/data; the user can keep data private and decide if/how data is to be shared.	property/data; data is shared publicly and cannot be made private	cannot be made private, or no details provided.		
Archiving, Saving, and Exporting Data	Users can archive, save, or import and export content or activity data in a variety of formats	There are limitations to archiving, saving, or importing/exporting content or activity data	Content and activity data cannot be archived, saved, or imported exported		
Social Presence. This category of the rubric stems from the Communities of Inquiry (CoI) framework which considers, in part, how the design of online learning environments might best create and sustain a sense of community among learners (Garrison, 2017).					
Criteria	**Works Well**	**Minor Concerns**	**Serious Concerns**	**Comments**	**N/A**
Collaboration	The LMS has the capacity to support a community of learning through both asynchronous and synchronous opportunities for communication, interactivity, and	The LMS has the capacity to support a community of learning through asynchronous but not synchronous opportunities for communication, interactivity, and	Communication, interactivity, and transfer of meaning between users is not supported or significantly limited		

	transfer of meaning between users.	transfer of meaning between users			
User Accountability	Instructors can control learner anonymity; the LMS provides technical solutions for holding learners accountable for their actions	Instructors cannot control learner anonymity but the LMS provides some solution for holding learners accountable for their actions	Instructors cannot control learner anonymity and there is no technical solution for holding users accountable to their actions		
Diffusion	The LMS is widely known and popular, it's likely that most learners are familiar with the LMS and have basic technical competence with it	Learners' familiarity with the LMS is likely mixed, some will lack basic technical competence with its functions	The LMS is not well known/foreign, it is likely that learners are not familiar with the LMS and lack basic technical competence with its functions		
Teaching Presence. This section of the rubric also stems from the Community of Inquiry (CoI) framework and addresses the integrating force that structures and leads the educational process in a constructive, collaborative and sustained manner (Garrison, 2017). It measures the LMS elements that enable instructors to establish and maintain their teaching presence through facilitation, customisation, and feedback.					
Criteria	**Works Well**	**Minor Concerns**	**Serious Concerns**	**Comments**	**N/A**

Facilitation	The LMS has easy-to-use features that would significantly improve an instructor's ability to be present with learners via active management, monitoring, engagement, and feedback.	The LMS has limited functionality to effectively support an instructor's ability to be present with learners via active management, monitoring, engagement, and feedback.	The LMS has not been designed to support an instructor's an instructor's ability to be present with learners via active management, monitoring, engagement, and feedback.		
Customisation	LMS is adaptable to its environment: easily customised to suit the classroom context and targeted learning outcomes	Limited aspects of the LMS can be customised to suit the classroom context and learning outcomes	The LMS cannot be customised.		
Learning Analytics	Instructor can monitor learners' performance on a variety of responsive measures. These measures can be accessed through a	Instructor can monitor learners' performance on limited measures; or data is not presented in a format	The LMS does not support the collection of learning analytics.		

	user-friendly dashboard.	that is easily interpreted.			
Cognitive Presence. This category considers a tool's ability to support students' cognitive engagement in learning tasks. In the CoI framework this is the process of inquiry that moves from problem definition to exploration of relevant content and ideas, integrating those ideas into a meaningful structure or solution (Garrison, 2017; Anstey and Watson, 2018a).					
Criteria	**Works Well**	**Minor Concerns**	**Serious Concerns**	**Comments**	**N/A**
Enhancement of Cognitive Task(s)	The LMS enhances engagement in targeted cognitive task(s) that were once overly complex or inconceivable through other means.	The LMS enables functional improvement to engagement in the targeted cognitive task(s).	The LMS acts as a direct tool substitute with no functional change to engagement in the targeted cognitive task(s).		
Higher Order Thinking	Use of the LMS easily facilitates learners to exercise higher order thinking skills (given consideration to design, facilitation, and direction from instructor).	The LMS may engage learners in higher order thinking skills (given significant consideration to design, facilitation, and direction from instructor).	The LMS likely does not engage learners in higher order thinking skills (despite significant consideration to design, facilitation,		

			and direction from instructor).		
Metacognitive Engagement	Through the LMS, learners can regularly receive formative feedback on learning (i.e. they can track their performance, monitor their improvement, test their knowledge).	Opportunities for receiving formative feedback on learning are available, but infrequent or limited (i.e. poor opportunities for tracking performance, monitoring improvement, testing knowledge on a regular basis).	There are no opportunities for formative feedback on learning (i.e. lacking opportunities for tracking performance, monitoring improvement, testing knowledge on a regular basis).		
Artificial Intelligence. AI has been employed by LMS service providers to give an enhanced learning experience for the learner with personalised features and better outcomes (Kavitha and Lohani, 2019). This section evaluates Artificial Intelligence in an LMS based on its capability to generate personalised learning experiences, provide intelligent support, and enhance educational outcomes through predictive analytics and adaptive content.					
Criteria	**Works Well**	**Minor Concerns**	**Serious Concerns**	**Comments**	**N/A**
Knowledge Check/Quiz Generation	The LMS AI analyses course content to create relevant and	The LMS AI offers quiz generation with some relevance to the course	The LMS AI fails to generate quizzes that are relevant or		

	challenging quizzes. It accurately interprets textual and multimedia content, tailors difficulty to course level, and aligns questions with learning outcomes.	material, but may produce questions that are off-topic or not optimally challenging. There may be occasional misinterpretation of course content nuances.	appropriately challenging, often misinterpreting course content or producing quizzes not aligned with learning objectives, leading to a disconnect in the educational flow.		
Chatbot/Help Assistance	The LMS AI chatbot delivers accurate, context-aware assistance, responding to a wide range of queries effectively and improving the user experience by providing real-time help.	The LMS AI chatbot is available but may provide generic responses that are not always helpful, require frequent rephrasing of questions, or be limited in the scope of assistance.	The LMS AI chatbot frequently misunderstands queries, offers incorrect or irrelevant information, and fails to enhance user support, potentially leading to user frustration.		
Personalised Learning	The LMS AI effectively analyses individual student performance and learning styles to	The LMS AI provides some level of personalisation, but it may not be fully	The LMS AI does not offer meaningful personalisation options, failing to adapt to		

	tailor the educational content, pacing, and learning pathways, thus enhancing the individual learning experience.	adaptive to each student's unique needs or may occasionally misalign with their learning style.	student performance data, leading to a one-size-fits-all approach that neglects individual learning preferences.		
AI-Enhanced Predictive Analytics	The LMS utilises AI to track current student engagement and performance but also to predict future learning outcomes. It effectively identifies students at risk and suggests interventions.	The LMS's AI capabilities for predictive analytics are present but limited. It provides some insights into potential future performance, but these may not be fully accurate or actionable.	The LMS lacks AI-driven predictive analytics, offering no foresight into student performance trends or risks, missing opportunities for early intervention or personalised learning adjustments.		
Other: Use this section to add comments/suggestions to improve or enhance the Rubric for LMS Evaluation.					

Appendix C – LMSs Evaluated

Table 16 List of LMSs evaluated in the study

LMS	Description	Market Segmentation
Absorb	Absorb is a modern learning management system designed to boost engagement and learning outcomes in organisations (Absorb, 2024).	Caters to small to midsize businesses (SMBs) and large enterprises, with customers ranging from 100 to over 10,000 employees. Absorb is popular in corporate training and healthcare sectors (Absorb, 2024).
Aula	Aula is a learning experience platform that brings together engagement and communication in an online learning environment (Aula, 2024).	Focuses on higher education institutions, enhancing engagement and communication for students and educators. Aula serves collaborative learning environments in universities and colleges.
Blackboard Learn	Blackboard is a widely-used learning management system that offers a virtual learning environment and course management (Anthology, 2023).	Blackboard is used by educational institutions (K-12 and higher education) and corporate sectors for training. It supports large organisations and universities globally, known for robust features and scalability (Anthology, 2023).
Brightspace	Brightspace by D2L is a learning management system designed for K-12, higher education, and corporate training Brightspace (D2L - Brightspace, 2022).	Brightspace by D2L serves K-12, higher education, and corporate markets. It's used by institutions like universities and corporations for comprehensive learning experiences (D2L - Brightspace, 2022).
Canvas	Canvas is an LMS that simplifies teaching and learning by connecting all the digital	Widely adopted by higher education institutions and K-12 schools. It is used by universities and colleges for its user-

	tools teachers use in one easy place (Instructure | Canvas, 2024).	friendly interface and integration capabilities (Instructure | Canvas, 2024).
Cluevo LMS	Cluevo LMS is a flexible and customisable LMS for corporate training. The Cluevo LMS, E-Learning Platform is open source software (Cluevo LMS, 2024).	Cluevo is a WordPress LMS plugin used by small companies and individuals (Cluevo LMS, 2024).
Cornerstone	Cornerstone Learning is a robust learning management system that enables organisations to deliver, track, and report on various learning activities (Cornerstone, 2024).	Serves large enterprises and midsize businesses, especially in sectors like healthcare, finance, and manufacturing. It provides tools for employee development (Cornerstone, 2024).
Dell Internal LMS	Dell's internal learning management system is part of Dell Learning, providing training and certifications to accelerate technology adoption and skill development within the company (Dell Technologies, 2024).	Dell Learning is used internally by Dell for employee training and development (Dell Technologies, 2024).
Infinite Campus	Infinite Campus is an education software for managing student information and learning management (Infinite Campus, 2024).	Infinite Campus is used by K12 primary schools. Infinite Campus is 1EdTech Certified for both the LTI and One Roster standards (Infinite Campus, 2024).
Lessonly	Lessonly by Seismic is a training and enablement software for onboarding and continuous learning (Seismic, 2024).	Lessonly (now Seismic Learning) is used by Corporate organisations to drive Sales Enablement Training (Seismic, 2024).
Moodle	Moodle is an open-source learning management system designed to provide educators, administrators, and learners with a single robust, secure, and integrated	Powering hundreds of thousands of learning environments globally, Moodle is trusted by institutions and organisations large and small. Moodle's worldwide numbers across both academic and enterprise level

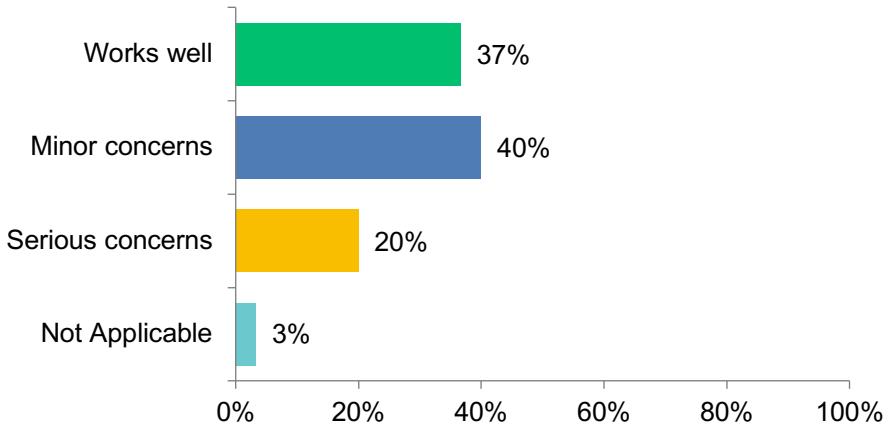
	system to create personalised learning environments (Moodle, 2024)	usage makes it the world's most widely used learning platform (Moodle, 2024).
Odoo	Odoo is an open-source suite of business applications, including a learning management system module (Odoo, 2024).	Used by businesses of all sizes for integrated enterprise resource planning and learning management (Odoo, 2024).
Reach360	Reach 360 is an LMS that enables training distribution while seamlessly integrating with courses built in Storyline, Rise or third-party providers (Articulate, 2024).	Targets corporate training and e-learning, providing tools for content creation and management. It is used by companies needing powerful authoring capabilities (Articulate, 2024).
Saba	Saba Cloud provides a talent management solution that includes learning, performance, and engagement tools (Saba | Cornerstone, 2024).	Used by large enterprises for talent management, including learning, performance, and engagement tools. It serves sectors like healthcare, finance, and technology (Saba | Cornerstone, 2024).
Sana Labs	Sana Labs is an AI-powered learning platform that personalises corporate training programs (Sana, 2024)	Sana Labs serves large enterprises and organisations looking to enhance their training with AI-driven solutions (Sana, 2024).
Tutor	Tutor LMS is a WordPress LMS plugin for creating, managing, and selling online courses (Tutor LMS, 2024).	Used by small businesses, educators, and individuals to create and manage online courses. Has over 90K active installations (Tutor LMS, 2024).
Workday Learning	Workday Learning combines professional development, peer learning, and required training into a single intuitive application (Workday, 2024).	Used by large enterprises for professional development, peer learning, and compliance training. It integrates with other Workday applications, particularly HR management (Workday, 2024).

Appendix D – Survey Results

Accessibility Criteria Results

Figure 9 Perceivable (Accessibility) Survey Results

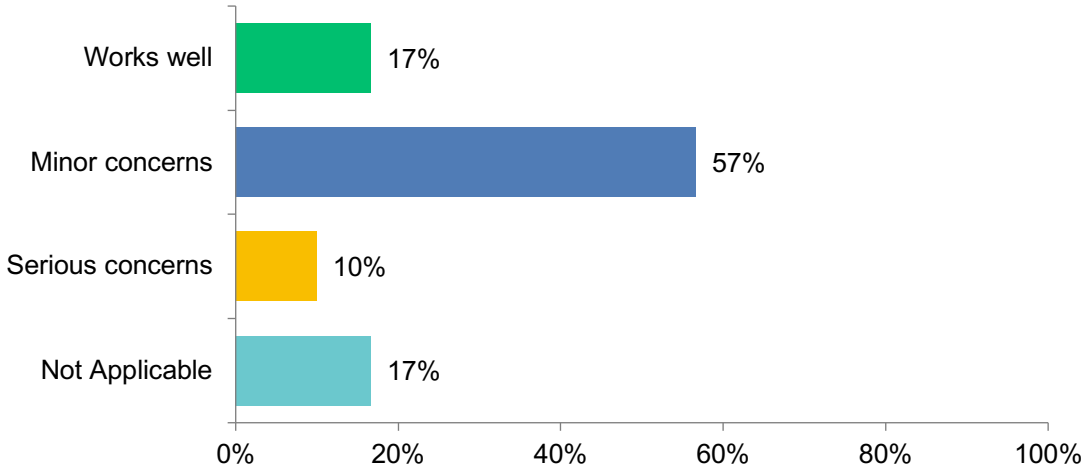
Perceivable performed moderately well with 37% of respondents indicating that content is presented in alternative formats and supports screen readers. Nevertheless, 20% had serious concerns, particularly regarding some content being inaccessible. Ensuring accessibility features are present is imperative for inclusivity.



ANSWER CHOICES	RESPONSES	
Works Well. All content is available in alternative formats (e.g., text transcripts for audio). Visual content has sufficient contrast and supports screen reader technology.	37%	11
Minor Concerns. Most content is perceivable, but some elements may lack alternative formats or have moderate issues with contrast or screen reader compatibility.	40%	12
Serious Concerns. Key content is not available in alternative formats, with poor colour contrast and a lack of screen reader support, making it inaccessible for some users.	20%	6
Not Applicable.	3%	1
TOTAL		30

Figure 10 Operable (Accessibility) Survey Results

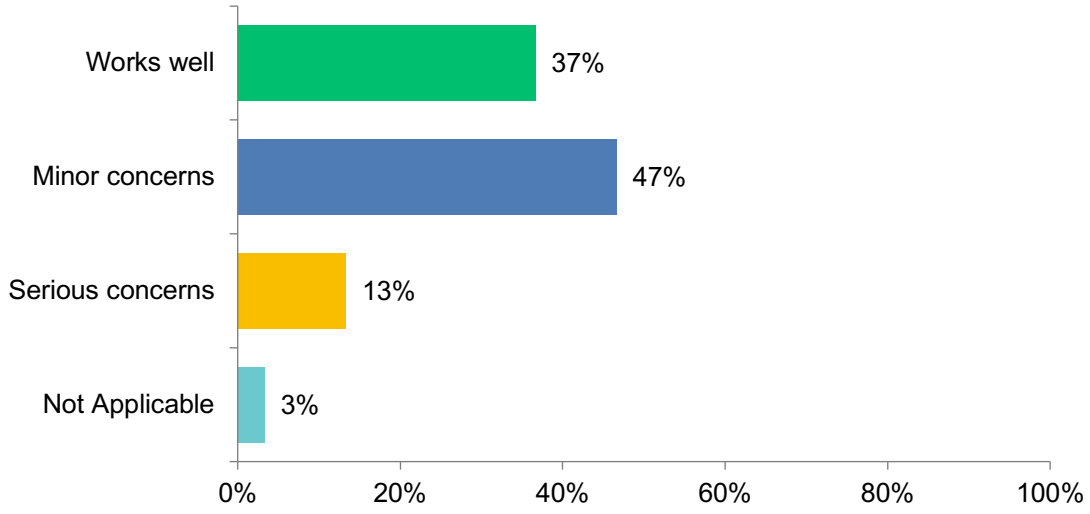
Operable: In contrast to the ease-of-use criterion in the functionality section, 57% had minor concerns about the operability of the LMS interface, while 17% said it works well. 10% still had serious concerns, and 17% stated "not applicable," implying the question may have been ambiguous or that the LMS evaluated does not align with the operability criteria presented.



ANSWER CHOICES	RESPONSES	
Works Well. The LMS is fully navigable via keyboard and supports voice commands. All interactive elements are clearly labelled and accessible.	17%	5
Minor Concerns. The LMS is mostly keyboard accessible but may have some areas that are not operable through keyboard or voice commands.	57%	17
Serious Concerns. The LMS cannot be navigated using a keyboard or voice commands, and interactive elements are poorly labelled, hindering operability.	10%	3
Not Applicable.	17%	5
TOTAL		30

Figure 11 Understandable (Accessibility) Survey Results

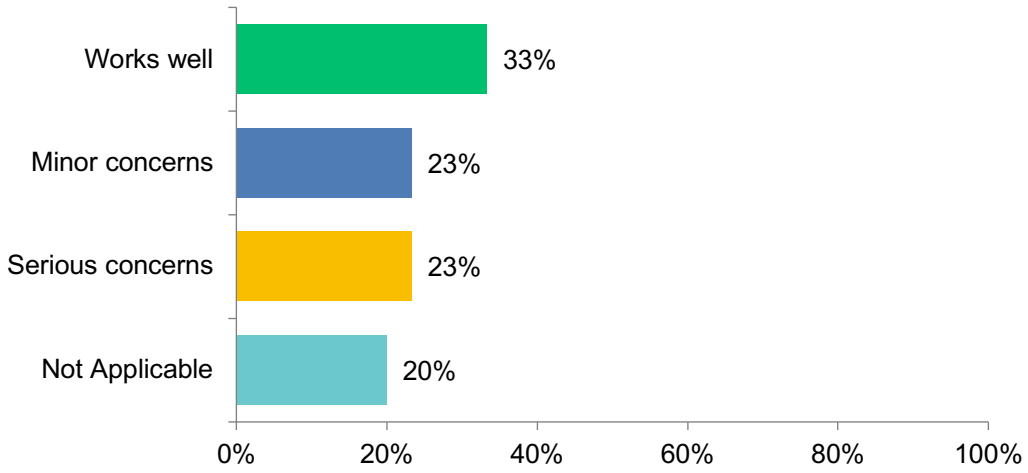
Understandable: 47% had minor concerns about the operability of the LMS interface, while 37% said it works well. 13% still had serious concerns, and 3% stated: not applicable.



ANSWER CHOICES	RESPONSES	
Works Well. The LMS interface and content are clear and intuitive, with consistent navigation and predictable behaviour. Language is simple and directions are clear.	37%	11
Minor Concerns. The LMS may have some parts that are inconsistent navigation or complex language that could confuse users.	47%	14
Serious Concerns. The LMS has a confusing interface with inconsistent navigation and jargon-rich content that makes understanding difficult.	13%	4
Not Applicable.	3%	1
TOTAL		30

Figure 12 Robust (Accessibility) Survey Results

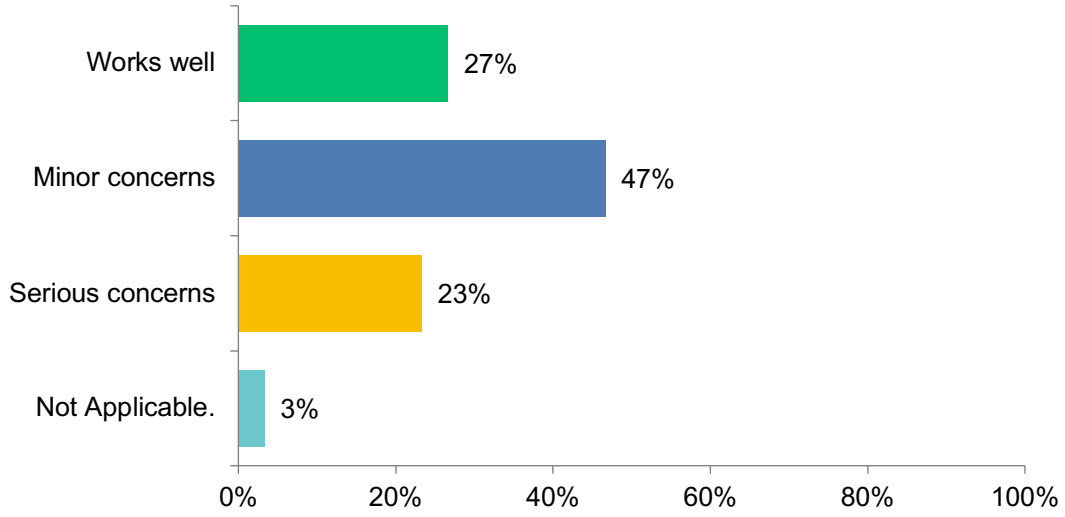
Robust: This criterion showed mixed results. 33% stated the LMS works well, 23% had minor concerns. 23% had serious concerns while 20% stated not-applicable suggesting they did not know how to test the application using assistive technology or felt this question did not apply to them.



ANSWER CHOICES	RESPONSES	
Works Well. The LMS content is compatible with current user tools, including assistive technologies (e.g. screen readers).	33%	10
Minor Concerns. The LMS works with most current user tools but may not be fully compliant with the latest assistive technologies (e.g. screen readers).	23%	7
Serious Concerns. The LMS has compatibility issues with many user tools and does not support assistive technologies effectively.	23%	7
Not Applicable.	20%	6
TOTAL		30

Figure 13 Engagement (User-focused Participation), (Accessibility) Survey Results

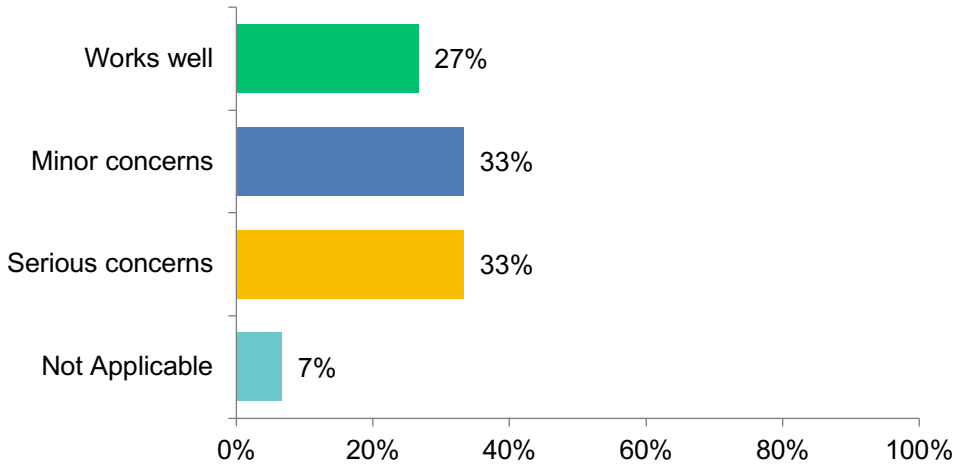
Engagement: 27% stated the LMS works well, 23% had minor concerns, 23% had serious concerns and 3% stated not-applicable.



ANSWER CHOICES	RESPONSES	
Works Well. The LMS excels in user-focused participation by offering varied learning paths, challenges, and accomplishments, catering to diverse literacies and capabilities. This inclusivity fosters active engagement and broadens participation opportunities.	27%	8
Minor Concerns. The LMS provides some user-focused participation options, but with limited variety, which may not fully engage all learners or accommodate the full spectrum of literacies and capabilities.	47%	14
Serious Concerns. The LMS lacks user-focused participation features, offering few or no choices to accommodate diverse learners, which may restrict participation and negatively impact learner engagement and interest.	23%	7
Not Applicable.	3%	1
TOTAL		30

Figure 14 Multiple means of representation (Accessibility) Survey results

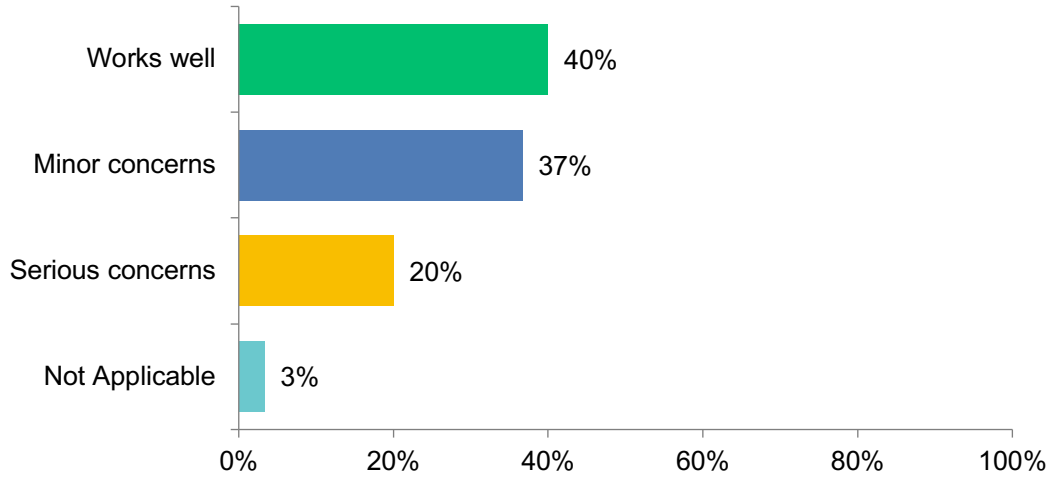
Multiple means of representation showed varying results. 27% stated the LMS works well, 33% had minor concerns. 33% had serious concerns while 7% stated not-applicable.



ANSWER CHOICES	RESPONSES	
Works Well. The LMS provides content in diverse formats and supports adaptability, such as adjustable text size and speech-to-text capabilities, to cater to different learning preferences and needs.	27%	8
Minor Concerns. There is some diversity in content formats, but adaptability features are limited or not fully intuitive to use.	33%	10
Serious Concerns. Content is largely presented in a single format without adaptability features, limiting accessibility for users with varying needs.	33%	10
Not Applicable.	7%	2
TOTAL		30

Figure 15 Multiple means of Expression (Accessibility) Survey Results

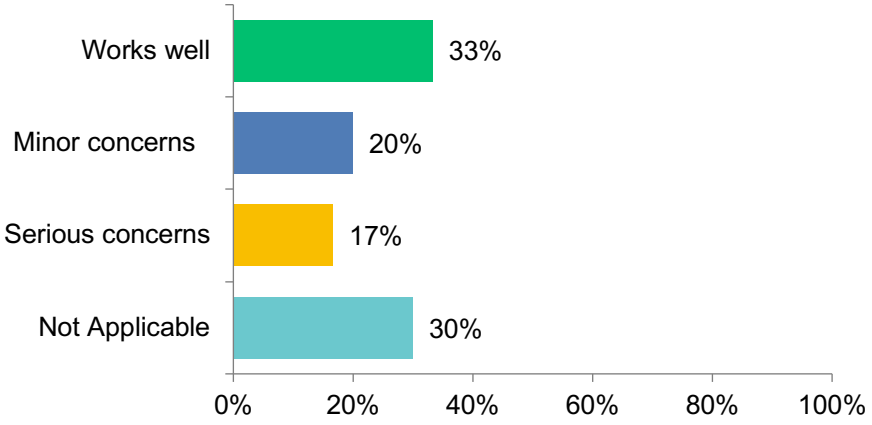
Multiple Means of Action and Expression: This criterion showed contrasting results. 40% stated the LMS works well, 37% had minor concerns 20% had serious concerns and 3% stated not-applicable.



ANSWER CHOICES	RESPONSES	
Works Well. The LMS allows for a variety of assessment methods and student responses, including written, oral, and project-based demonstrations of understanding.	40%	12
Minor Concerns. The LMS offers some variety in assessment methods, but options for student expression are limited.	37%	11
Serious Concerns. The LMS restricts students to a narrow range of expression methods, such as multiple-choice tests, without alternative forms of assessment.	20%	6
Not Applicable.	3%	1
TOTAL		30

Figure 16 Cost of Use (Accessibility) Survey Results

Cost of Use revealed mixed results. 33% stated that all aspects of the LMS can be used free of charge. 20% had minor concerns, and 17% had serious concerns. 30% rated this criterion as not-applicable, either because the LMS is a fee-paying commercial platform or because the LMS was provided by their University. In such cases, the University covers costs, making it inappropriate to categorise the LMS as either free of charge or requiring a fee.

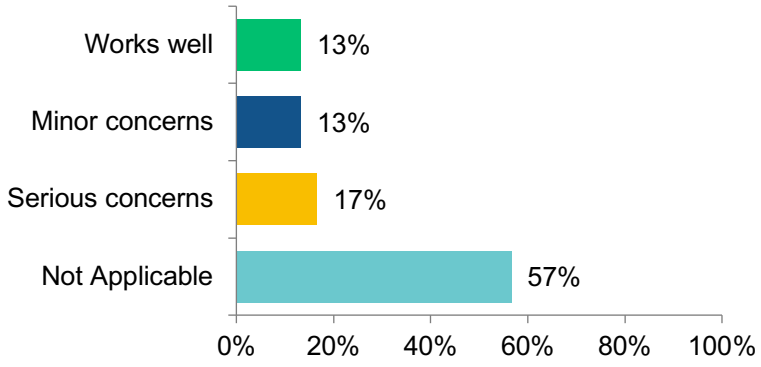


ANSWER CHOICES	RESPONSES	
Works Well. All aspects of the LMS can be used free of charge.	33%	10
Minor Concerns. Limited aspects of the LMS can be used for free with other elements requiring payment of a fee, membership, or subscription.	20%	6
Serious Concerns. Use of the LMS requires a fee, membership, or subscription. Use of the LMS requires a purchase that is likely to pose a financial burden on students.	17%	5
Not Applicable.	30%	9
TOTAL		30

Artificial Intelligence Criteria Results

Figure 17 Knowledge Check/Quiz Generation (AI) Survey Results

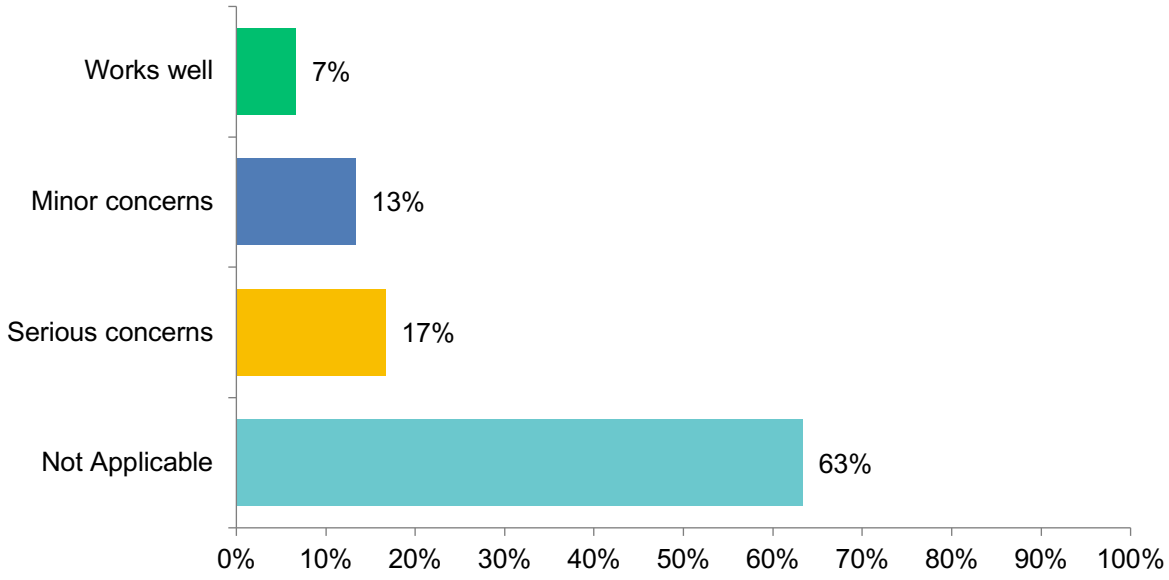
Knowledge Check/Quiz Generation: 13% said it works well, 13% had minor concerns, 17% had serious concerns while a significant amount of respondents (57%) stated not-applicable suggesting this criterion is not present in the LMS at their access level or does not exist at this time.



ANSWER CHOICES	RESPONSES	
Works Well. The LMS AI analyses course content to create relevant and challenging quizzes. It accurately interprets textual and multimedia content, tailors' difficulty to course level, and aligns questions with learning outcomes.	13%	4
Minor Concerns. The LMS AI offers quiz generation with some relevance to the course material but may produce questions that are off-topic or not optimally challenging. There may be occasional misinterpretation of course content nuances.	13%	4
Serious Concerns. The LMS AI fails to generate quizzes that are relevant or appropriately challenging, often misinterpreting course content or producing quizzes not aligned with learning objectives, leading to a disconnect in the educational flow.	17%	5
Not Applicable.	57%	17
TOTAL		30

Figure 18 Chatbot/Help Assistance (AI) Survey Results

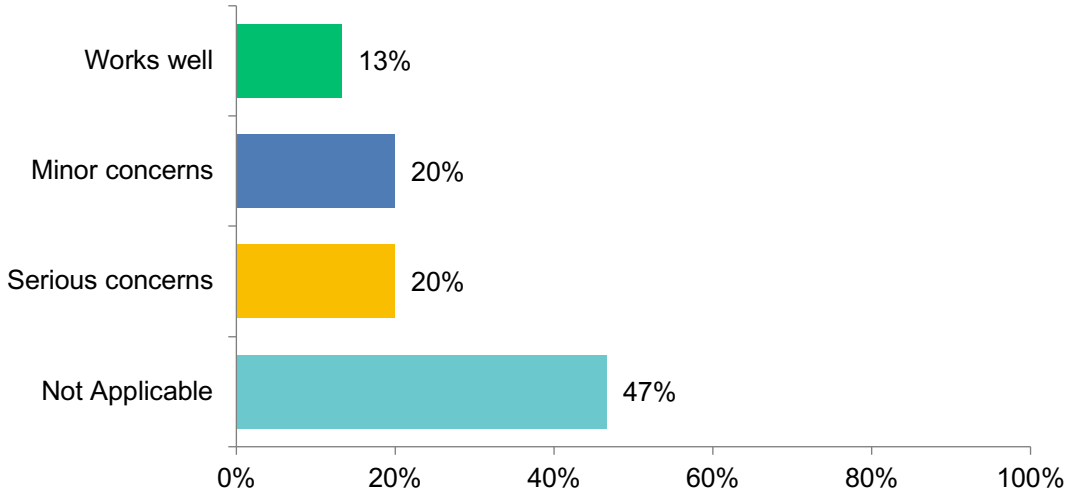
Chatbot/Help Assistance: 7% said it works well, 13% had minor concerns, 17% had serious concerns and 63% stated not applicable, suggesting this criterion is not present in the LMS being evaluated or it wasn't applicable to their role.



ANSWER CHOICES	RESPONSES	
Works Well. The LMS AI chatbot delivers accurate, context-aware assistance, responding to a wide range of queries effectively and improving the user experience by providing real-time help.	7%	2
Minor Concerns. The LMS AI chatbot is available but may provide generic responses that are not always helpful, require frequent rephrasing of questions, or be limited in the scope of assistance.	13%	4
Serious Concerns. The LMS AI chatbot frequently misunderstands queries, offers incorrect or irrelevant information, and fails to enhance user support, potentially leading to user frustration.	17%	5
Not Applicable.	63%	19
TOTAL		30

Figure 19 Personalised Learning (AI) Survey Results

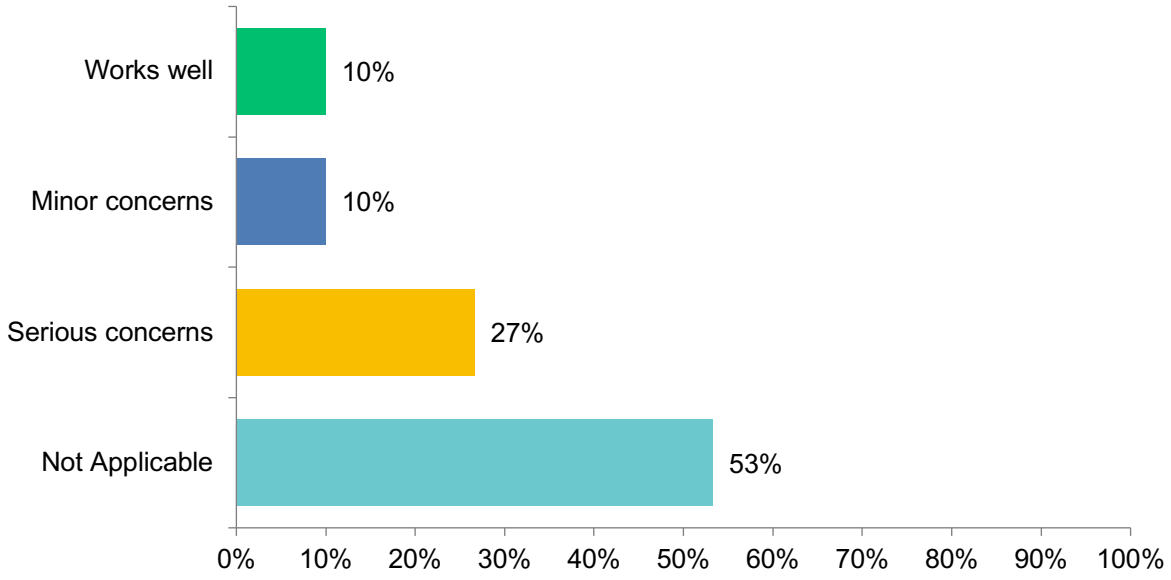
Personalised Learning: 13% said it works well, 20% had minor concerns, 20% had serious concerns and 47% stated not-applicable suggesting this criterion is not present in the LMS being evaluated or it wasn't applicable to their role.



ANSWER CHOICES	RESPONSES	
Works Well. The LMS AI effectively analyses individual student performance and learning styles to tailor the educational content, pacing, and learning pathways, thus enhancing the individual learning experience.	13%	4
Minor Concerns. The LMS AI provides some level of personalisation, but it may not be fully adaptive to each student's unique needs or may occasionally misalign with their learning style.	20%	6
Serious Concerns. The LMS AI does not offer meaningful personalisation options, failing to adapt to student performance data, leading to a one-size-fits-all approach that neglects individual learning preferences.	20%	6
Not Applicable.	47%	14
TOTAL		30

Figure 20 AI-Enhanced Predictive Analytics (AI) Survey Results

AI-Enhanced Predictive Analytics: 10% said it works well, 10% had minor concerns, 27% had serious concerns and 53% stated not-applicable suggesting this criterion is not present in the LMS being evaluated or it was not applicable to their role.



ANSWER CHOICES	RESPONSES	
Works Well. The LMS utilizes AI to track current student engagement and performance but also to predict future learning outcomes. It effectively identifies students at risk and suggests interventions.	10%	3
Minor Concerns. The LMS's AI capabilities for predictive analytics are present but limited. It provides some insights into potential future performance, but these may not be fully accurate or actionable.	10%	3
Serious Concerns. The LMS lacks AI-driven predictive analytics, offering no foresight into student performance trends or risks, missing opportunities for early intervention or personalised learning adjustments.	27%	8
Not Applicable.	53%	16
TOTAL		30

Appendix E – Thematic Analysis

Accessibility Thematic Analysis				
Common Themes	**Identified significant statements**	**Assigning Codes**	**Searching for Themes and Grouping Codes**	**Reviewing and Defining Themes**
Perceivable Criterion Support for WCAG 2.0	"Absorb LMS supports WCAG 2.0" "Brightspace is capable of all the standard accessibility functionalities that one might expect, e.g., ALT text, closed captioning..." "Most content does not follow WCAG guidelines. CCs not available on videos content. Colour contrast not considered. No alt text." "Screens are very contrast-y but cannot be adjusted." "Although the LMS supports accessibility itself but it's up to each	**Support for WCAG 2.0** **Issues with Content Accessibility** **Inconsistent Implementation**	**Support for WCAG 2.0:** Codes that indicate compliance with WCAG guidelines. **Issues with Content Accessibility:** Codes that highlight problems related to content accessibility. **Inconsistent Implementation:** Codes that show variability in the	The comments reveal a range of support for WCAG 2.0 standards, with some LMS platforms implementing comprehensive accessibility features, while others fall short, especially in content consistency and user experience.

	content owner to actually make sure their content is accessible." "Moodle alone handles voice navigation poorly, the Recite Me feature does help" "Multiple issues using https://www.accessibilitychecker.org/ Two critical issues as follows: - Visual issue: Heading elements are not in a sequentially-descending order - Visual & motor: Links do not have a discernible name."		implementation of accessibility features.	
Common Themes	**Identified significant statements**	**Assigning Codes**	**Searching for Themes and Grouping Codes**	**Reviewing and Defining Themes**
Operable Navigation Interaction	"Brightspace doesn't have a native voice command navigation." "It is possible to operate the LMS with a keyboard, but the labelling is not very clear."	**Keyboard and Voice Command Navigation** **Labelling and Interactive Elements** **Compatibility Issues**	**Keyboard and Voice Command Navigation:** Codes that indicate the ability to navigate the LMS using a keyboard or voice commands.	The comments reveal operability issues are prominent, with difficulties in keyboard and voice command navigation, poor labelling of interactive elements, and general compatibility challenges with assistive technologies.

	"Voice-over on Mac, worked for the first few minutes, but then stopped. “Not all operable items follow WCAG guidelines. The navigation options within the LMS are often confusing (i.e. retake vs review content) and the surface area of “selectable” controls (like Related Actions, table sorting, and faceted search widgets) are very small.” "The focus is on making the system 100% accessible but there are current gaps, like voice command navigation."		**Labelling and Interactive Elements:** Codes that highlight the clarity and accessibility of interactive elements. **Compatibility Issues:** Codes that show problems with compatibility of assistive technologies.	
Common Themes	**Identified significant statements**	**Assigning Codes**	**Searching for Themes and Grouping Codes**	**Reviewing and Defining Themes**
Understandable **Intuitive** **Complexity**	"The LMS interface and content are clear and intuitive." "Certain pieces of information are repeated or might not be easy to	**Clear and Intuitive Interface**	**Clear and Intuitive Interface:** Codes that indicate the interface	The clarity and intuitiveness of some LMS interfaces and content can be challenging to understand while others are clear and intuitive. These

	find." "The LMS has a confusing interface with inconsistent navigation and jargon-rich content." "The language used to label the interface is misleading and confusing." “Navigation not overly intuitive, made easier by YouTube tutorials. Selecting down arrows on far right of screen on Learning Management page only changes the arrow direction but shows nothing else. Language is simple and structured as if the spoken word, but inconsistencies in punctuation. Abbreviations used where the full word would be better (e.g., max.) for screen readers.”	**Misleading Labels and Navigation** **Complex and Jargon-Rich Content**	and content are clear and intuitive. **Misleading Labels and Navigation:** Codes that highlight misleading labels and confusing navigation. **Complex and Jargon-Rich Content:** Codes that show the presence of complex and jargon-rich content.	Understandability issues arise from misleading labels, inconsistent navigation, and jargon-rich content, affecting the overall user experience and ease of use.

Common Themes:	Identified significant statements	Assigning Codes	Searching for Themes and Grouping Codes	Reviewing and Defining Themes
Robust Testing Compatibility	"I think Moodle themselves have spent a lot of time on being compliant with user agents." "I haven't tested these myself, but I believe Brightspace to be very capable in terms of compatibility with third-party assistive technologies." "The small bit of testing I've done for this survey operability seems functional." "Couldn’t get the screen reader to work effectively." "We don't have evaluations of this ourselves, as we haven't used many agents, apart from those built into computer operating systems or some phones."	**Compatibility with Assistive Technologies** **Inconsistent Performance** **External Testing and Compliance**	**Compatibility with Assistive Technologies:** Codes that indicate compliance with and support for assistive technologies. **Inconsistent Performance:** Codes that highlight variability in performance and functionality of assistive technologies. **External Testing and Compliance:** Codes that reflect the need for or absence of external testing and evaluations	The comments on the Robust criterion reflect varied support for assistive technologies, with some LMS platforms showing good compatibility, while others struggle with consistent performance and external compliance. External testing and adherence to WCAG guidelines are essential for ensuring robust accessibility features.

	"Does not follow WCAG guidelines so I presume it does not comply with other assistive technologies."		of assistive technology compatibility.	
Common Themes:	**Identified significant statements**	**Assigning Codes**	**Searching for Themes and Grouping Codes**	**Reviewing and Defining Themes**
Engagement Learning Paths	"Brightspace offers the possibility of varied learning paths tailored to individual students or groups." "I think Moodle offers some of these opportunities, but I see some programme leadership and trainings being an obstruction." "Provides an alphabetical listing of all courses open to the learner. No additional 'learning paths', 'challenges' etc. provided." "It is difficult to search for content and the interface does not engage learners."	**Varied Learning Paths** **Lack of Engagement Features** **Basic Engagement Tools**	**Varied Learning Paths:** Codes that indicate the presence of diverse learning paths and tailored learning experiences. **Lack of Engagement Features:** Codes that highlight the absence or insufficiency of engagement features. **Basic Engagement Tools:** Codes that show the presence of fundamental engagement tools,	The comments on the Engagement criterion show a range of user-focused participation features, with some LMS platforms providing diverse and tailored learning paths, while others lack essential engagement features. Basic engagement tools are present in some platforms, though they are often minimal and insufficient for fostering active user participation.

	"For admins, this is non-existent. For learners, there are some features (like course completion) and content links that are engaging."		though they may be limited or minimal.	
Common Themes:	**Identified significant statements**	**Assigning Codes**	**Searching for Themes and Grouping Codes**	**Reviewing and Defining Themes**
Multiple Means of Representation	“The LMS is really only reliably usable in a desktop configuration. For admins, the LMS does not have a responsive design. If the browser window is too small, controls for key administration features are not discoverable.” “Yes, Brightspace allows for multiple content formats and customisation in terms of text size, html and CSS tools through Brightspace editor, etc. If utilised correctly, this can really make a big difference to the overall student experience and course look.”	**Diverse Content Formats** **Limited Adaptability Features** **Inconsistent Implementation**	**Diverse Content Formats**: Codes that indicate the presence of multiple content formats and customization options. **Limited Adaptability Features**: Codes that highlight the limitations in adaptability features like text size adjustment and speech-to-text capabilities.	The comments reveal varying support for diverse content formats and customisation options, with some LMS platforms providing these features effectively, while others have limited adaptability features and inconsistent implementation, affecting their usability across different devices and configurations.

	“The text size can only be changed through the browser, but the LMS itself does not have that capacity.” “The ability to adjust text size and speech-to-text capabilities does not exist.” “There isn’t a way to use speech to text via the system alone. It doesn’t decrease tile size if the window is smaller.” than the standard screen “Moodle does cater for multiple means of representation. Either in add on feature format, or by delving a bit deeper into the wide plugin database. Over the past few years, I have been using H5P within Moodle to create choice for MMR. Reading, video and audio pathways can be chosen to digest the same content. H5P is reasonably robust too, in		**Inconsistent Implementation:** Codes that reflect variability in the implementation of these features and their usability across different devices and configurations.	

	terms of agent navigability, and in element labelling for multiple languages." "If such features exist, I can't find them! I am told that it is possible to use external text readers, but the LMS does not include them or give clear guidance to use." "Works Well. Text to speech and text size can be used/adjusted." "For this survey I went to find how to adjust text size, and wasn't able to find anything of the sort."			
Common Themes:	**Identified significant statements**	**Assigning Codes**	**Searching for Themes and Grouping Codes**	**Reviewing and Defining Themes**
Multiple Means of Action and Expression	"SCORM content for course completions is supported. The LMS offers Training Activity Assessment configurations to allow for the upload of documents and review by	**Variety in Assessment Methods**	**Variety in Assessment Methods:** Codes that indicate the presence	The comments reveal a range of assessment methods provided by some LMS platforms, while others have limited student expression options and clunky, outdated tools.

	designated assessors." "Beyond quizzes and written tasks, Brightspace allows for multimedia presentations, video submissions, audio recordings, group projects, and discussion boards." "Students cannot upload videos etc. for assessment by instructors." "Very basic!" "Audio and visual options for students were clunky and felt outdated."	**Limited Student Expression Options** **Clunky and Outdated Tools**	of diverse assessment methods. **Limited Student Expression Options:** Codes that highlight the limitations in student expression options. **Clunky and Outdated Tools:** Codes that reflect the outdated and clunky nature of some assessment tools.	
Common Themes:	**Identified significant statements**	**Assigning Codes**	**Searching for Themes and Grouping Codes**	**Reviewing and Defining Themes**
Cost Of Use **Free of Charge** **Paid Model**	"Brightspace is free of charge once we pay college fees."	**Free Access for Employees/Students** **Subscription and Additional Costs**	**Free Access for Employees/Students:** Codes that indicate free access provided	The comments reveal a range of cost models, with some LMS platforms providing free access for employees or students, while others involve subscription models and

	"As an employee, it is free to me because it is our company's product and tool." "The free subscription limit of 300 users with a team license is great. However, for a large organization of 18,000+ it costs money." "No LMS is truly free." "LMS was provided by the university so while the LMS requires a fee/membership, the university covered the costs."	**Institutional Coverage**	by the institution or employer. **Subscription and Additional Costs:** Codes that highlight the presence of subscription models and additional costs. **Institutional Coverage:** Codes that reflect the costs covered by the institution or university.	additional costs. Institutional coverage of costs is common, making it easier for users to access the LMS without incurring direct expenses

Artificial Intelligence Thematic Analysis				
Common Themes:	**Identified significant statements**	**Assigning Codes**	**Searching for Themes and Grouping Codes**	**Reviewing and Defining Themes**

Knowledge Check/Quiz Generation	*"Recently Brightspace demoed their AI quiz integration, that pulls quizzes directly from the local course content. While impressive, I worried about the quality element of the quizzes, and oversight by lecturers on large cohorts of students. Given that the argument for errors in LLMs has still not been settled, this would have consequence for the drip feed of tiny errors, and confirmations in checks for students. If everyone was receiving a different set of quizzes that were personalised each week for every lesson, how do we* *quality assure that they were tested accurately. This would be an onerous task."*	**Quality Assurance:** LLMs errors, however minor can have consequences. **Personalisation:** Different sets of quiz each week for every lesson is randomised and difficult to monitor **Accuracy:** Pulling quizzes directly from content needs oversight of the lecturer	**Quality Assurance:** Codes that focus on the need to manage and mitigate errors within AI-generated content to ensure the reliability of the quizzes. **Personalisation:** Codes that address the challenges in personalizing quizzes at scale, ensuring each is appropriate and effectively assesses the intended learning outcomes. Accuracy: Codes that Emphasise the importance of accurate content generation and the role of lecturer	The comments highlight the integration of AI in quiz generation raises significant concerns about the quality and accuracy of the quizzes, especially when personalised for diverse educational needs. Ensuring quality assurance, maintaining accuracy, and managing personalization effectively are crucial for the successful adoption of AI in educational assessments

			oversight in verifying the validity of quizzes.	
Common Themes:	**Identified significant statements**	**Assigning Codes**	**Searching for Themes and Grouping Codes**	**Reviewing and Defining Themes**
Chatbot/Help Assistance	*"While a chatbot (in the new sense of an AI agent) would be highly useful, I feel the risk need to be evaluated"*	**Risk Evaluation:** Assessing potential risks associated with deploying AI chatbots.	**Risk Evaluation:** Codes that highlight the importance of evaluating and managing risks when implementing AI chatbots. Reviewing and Defining Themes:	The comments suggest that while AI chatbots can be highly useful, there is a need for thorough risk evaluation to ensure they are implemented safely and effectively.
Common Themes:	**Identified significant statements**	**Assigning Codes**	**Searching for Themes and Grouping Codes**	**Reviewing and Defining Themes**
Personalised Learning	*"I think this is an area for great opportunity. A whole range of learners could benefit from summaries of content, reducing down impenetrable language,*	**Diverse Learning Styles** **AI-enhanced Customization**	**Learning Styles:** Codes related to the adaptation of content to	The comments reflect the potential of AI to transform learning experiences by customising content to individual learning styles, making complex content more accessible, and

	chatting with AI about the content. Or just getting the concepts into a form that best fits their 'learning style'."	**Accessibility of Content**	suit various learning styles and preferences. **AI-enhanced Customization:** Codes that highlight the use of AI to personalize learning experiences and make content more engaging and understandable. **Accessibility of Content:** Codes that focus on how AI helps in breaking down complex information to make it accessible to all learners. Reviewing and Defining Themes:	enhancing the overall learning journey through personalised interactions.

Common Themes:	***Identified significant statements***	***Assigning Codes***	***Searching for Themes and Grouping Codes***	***Reviewing and Defining Themes***
AI-Enhanced Predictive Analytics	*"Moodle has been in development of predictive and descriptive analytics. particularly since 2018-2019 with* *Project Inspire, a low-level predictive AI engine. Some basic prediction exists in the form of some insights, At the time though, to implement this, the model would be training for many months on course data. A larger project for any institution. So, while it is possible, I don't feel that staff (human) have the sufficient understanding of the responsibility, skill and competency to responsibly use these kinds of tools without knowing their limitations, serious ethical considerations, and profound impact on the lives of our*	**Predictive Insights:** Insights gained from AI to predict student behaviour's or outcomes. **Ethical Considerations:** Concerns regarding the ethical use of AI in education. **User Understanding and Training:** The need for proper training and understanding among users to effectively utilize AI tools.	**Predictive Insights:** Codes that reflect the application of AI to foresee educational needs or risks. **Ethical Considerations:** Codes highlighting ethical issues and the need for careful consideration when implementing AI. **User Understanding and Training:** Codes emphasising the importance of equipping users with the necessary skills	The comments highlight the capabilities of AI in providing predictive analytics to enhance educational outcomes, while also pointing out the need for ethical considerations, proper training, and user understanding to ensure these tools are used responsibly and effectively.

	learners. Descriptive analytics have been the safe ground, for looking at patterns of what is happening. *"*Moodle use these analytics to inform lecturers about our engagement, like alerting them if students haven't accessed the course recently. While these insights help identify those who might need extra support, there is a risk of affirmation bias where decisions are based too heavily upon the data alone. It is important for lecturers to combine these insights with personal observation and communication to ensure fair and effective support for everyone." *"An institution would need to have a level of maturity and governance policy around predictive."*		and knowledge to use AI responsibly.	

Appendix F – Final LMS Evaluation Rubric.

This rubric has been refined based on empirical findings from the survey. As explained in the Development section of the dissertation, the template that follows is a revised version of the rubric. An online version has also been created which scores the category against the performance scale rating. The objective of the research is to create a practical tool that Learning and Development professionals and e-learning students can use to assess and select the most suitable LMS for their specific requirements. By including specific Accessibility and AI criteria in the evaluation of a LMS, this will lead to more effective and inclusive e-learning solutions that meet the needs of diverse learners.

Instructions

- Each criterion should be evaluated on its own merits, with the option to mark criteria that are not applicable to a particular LMS as "N/A".
- Although the revised rubric has a scoring system, staying true to the original ethos, the rubric does not prescribe a minimum score for LMS adoption but instead aims to highlight the system's strengths and areas for improvement. This is an important factor as technology moves quickly and LMS providers are constantly developing their platforms.
- Users of the rubric are encouraged to prioritise criteria based on their specific use case.
- A section has been dedicated to 'Other' – this is to allow evaluators to add comments or document areas of the LMS that require further research.

Categories

1. Accessibility
2. Artificial Intelligence
3. Functionality
4. Technical
5. Mobile
6. Privacy
7. Teaching Presence
8. Social Presence
9. Cognitive Presence
10. Other

By highlighting Accessibility and AI capabilities, the refined rubric offers a broad framework for evaluating LMS platforms, underscored by educational theory and practical insights.

Accessibility: This section evaluates the LMS for compliance with WCAG guidelines (W3C Consortium, 2023b) ensuring it is perceivable, operable, understandable, and robust for all users. Additionally, it assesses how the LMS provides varied and flexible options for presentation, expression, and engagement to support diverse learning styles as outlined in the Universal Design for Learning framework (UDL) (CAST, 2023). Furthermore, it considers 'cost' as a criterion, however, for commercial purposes this may be not-applicable.

Before you start - Checklist

1. Do you need a Voluntary Product Accessibility Template VPAT ? (ITIC, 2024)
2. Do you have access to a screen reader? The American Foundation for the Blind lists available screen readers including free and paid options (American Foundation for the Blind, 2024).
3. If your LMS has e-learning authoring capability, refer to ATAG (WAI Initiative and W3C Web Accessibility, 2024).
4. Is your LMS provider certified by 1EdTech (TrustEd Apps, 2024)?
5. Refer to the European Accessibility Act (European Commission, 2024).

There are a number of resources that can be leveraged as follows:

1. Web accessibility evaluation tools are resources that help determine if web content meets accessibility guidelines A list of tools curated by W3C Web Accessibility, (2024) is available: Web Accessibility Evaluation Tools List
2. Google Lighthouse is an open-source, automated tool auditing for accessibility and performance (Google, 2024b).
3. Wave is a suite of evaluation tools that helps authors make their web content more accessible to individuals with disabilities (Wave, 2024).
4. ARK is a digital accessibility hub offering practical resources to help institutional staff improve accessibility in their roles (AHEAD 2024a).

Criteria	Works Well	Minor Concerns	Serious Concerns	Comments	N/A
Perceivable (Content is presented in ways that can be perceived by all)	All content is available in alternative formats (e.g., text transcripts for audio). Visual content	Most content is perceivable, but some elements may lack alternative formats or	Key content is not available in alternative formats, with poor colour contrast and lack of		

	has sufficient contrast and supports screen reader technology.	have moderate issues with contrast or screen reader compatibility.	screen reader support, making it inaccessible for some users.		
Operable (Interface forms, controls, and navigation are operable)	The LMS is fully navigable via keyboard and supports voice commands. All interactive elements are clearly labelled and accessible.	The LMS is mostly keyboard accessible but may have some areas that are not operable through keyboard or voice commands.	The LMS cannot be navigated using a keyboard or voice commands, and interactive elements are poorly labelled, hindering operability.		
Understandable (Information and operation of the interface must be understandable)	The LMS interface and content are clear and intuitive, with consistent navigation and predictable behaviour. Language is simple and directions are clear.	The LMS may have some parts that are inconsistent navigation or complex language that could confuse users.	The LMS has a confusing interface with inconsistent navigation and jargon-rich content that makes understanding difficult.		
Robust (Content must be robust enough to be	The LMS content is compatible with current user tools, including	The LMS works with most current user tools but may not be fully compliant with the latest	The LMS has compatibility issues with many user tools and does not support		

interpreted by a wide variety of user agents)	assistive technologies (e.g. screen readers).	assistive technologies (e.g. screen readers).	assistive technologies effectively.		
Engagement (User-focused Participation)	The LMS excels in user-focused participation by offering varied learning paths, challenges, and accomplishments, catering to diverse literacies and capabilities. This inclusivity fosters active engagement and broadens participation opportunities	The LMS provides some user-focused participation options, but with limited variety, which may not fully engage all learners or accommodate the full spectrum of literacies and capabilities.	The LMS lacks user-focused participation features, offering few or no choices to accommodate diverse learners, which may restrict participation and negatively impact learner engagement and interest.		
Multiple Means of Representation	The LMS provides content in diverse formats and supports adaptability, such as adjustable text size and speech-to-text	There is some diversity in content formats, but adaptability features are limited or not fully intuitive to use.	Content is largely presented in a single format without adaptability features, limiting accessibility for		

	capabilities, to cater to different learning preferences and needs.		users with varying needs.		
Multiple Means of Action and Expression	The LMS allows for a variety of assessment methods and student responses, including written, oral, and project-based demonstrations of understanding.	The LMS offers some variety in assessment methods, but options for student expression are limited.	The LMS restricts students to a narrow range of expression methods, such as multiple-choice tests, without alternative forms of assessment.		
Cost of Use (Note for the cost of use criteria this may not be applicable if you are using a commercial platform.)	All aspects of the LMS can be used free of charge.	Limited aspects of the LMS can be used for free with other elements requiring payment of a fee, membership, or subscription.	Use of the LMS requires a fee, membership, or subscription. Use of the LMS requires a purchase that is likely to pose a financial burden on students.		

Artificial Intelligence. AI has been employed by LMS service providers to give an enhanced learning experience for the learner with personalised features and better outcomes (Kavitha and Lohani, 2019). This section evaluates Artificial Intelligence in an LMS based on its capability to generate personalised learning experiences, provide intelligent support, and enhance educational outcomes through predictive analytics and adaptive content.

Before you start – There are a number of tools and resources that can be leveraged as follows:

1. Are you familiar with the EU AI Act (European Parliament, 2023)?
2. Ensure your evaluation considers a Responsible AI strategy. Refer to Google and Microsoft publications for inspiration and guidance (Google, 2024a; Microsoft, 2024).
3. Check with the LMS provider the AI features that are available, (Note your organisation may have disabled some features due to legal or security concerns).
4. Stay informed with Local Government and Global policy (GOV.UK, 2023; GOV.IE, 2024)
5. The National Academic Integrity Network (NAIN) has published GenAI Guidelines for Educators (NAIN, 2023).
6. The capAI Procedure is under development by Oxford University for conducting conformity assessment of AI systems in line with the EU Artificial Intelligence Act (Floridi *et al.*, 2022).
7. ISO/IEC 42001 - Implementing this standard means putting in place policies and procedures for the sound governance of an organisation in relation to AI (ISO, 2024).
8. The NCCE has published a framework to provide education leaders guidance for integrating artificial intelligence capabilities into current education systems (NCEE, 2024).

Criteria	Works Well	Minor Concerns	Serious Concerns	Comments	N/A
Knowledge Check/Quiz Generation	The LMS AI analyses course content to create relevant and challenging quizzes. It accurately	The LMS AI offers quiz generation with some relevance to the course material, but may	The LMS AI fails to generate quizzes that are relevant or appropriately challenging, often		

	interprets textual and multimedia content, tailors difficulty to course level, and aligns questions with learning outcomes.	produce questions that are off-topic or not optimally challenging. There may be occasional misinterpretation of course content nuances.	misinterpreting course content or producing quizzes not aligned with learning objectives, leading to a disconnect in the educational flow.		
Chatbot/Help Assistance	The LMS AI chatbot delivers accurate, context-aware assistance, responding to a wide range of queries effectively and improving the user experience by providing real-time help.	The LMS AI chatbot is available but may provide generic responses that are not always helpful, require frequent rephrasing of questions, or be limited in the scope of assistance.	The LMS AI chatbot frequently misunderstands queries, offers incorrect or irrelevant information, and fails to enhance user support, potentially leading to user frustration.		
Personalised Learning	The LMS AI effectively analyses individual student performance and learning styles to tailor the educational content, pacing, and learning	The LMS AI provides some level of personalisation, but it may not be fully adaptive to each student's unique needs or may	The LMS AI does not offer meaningful personalisation options, failing to adapt to student performance data, leading to a one-size-fits-		

	pathways, thus enhancing the individual learning experience.	occasionally misalign with their learning style.	all approach that neglects individual learning preferences.		
Learning Analytics	Instructor can monitor learners' performance on a variety of responsive measures. These measures can be accessed through a user-friendly dashboard.	Instructor can monitor learners' performance on limited measures; or data is not presented in a format that is easily interpreted.	The LMS does not support the collection of learning analytics.		
AI-Enhanced Predictive Analytics	The LMS utilises AI to track current student engagement and performance but also to predict future learning outcomes. It effectively identifies students at risk and suggests interventions.	The LMS's AI capabilities for predictive analytics are present but limited. It provides some insights into potential future performance, but these may not be fully accurate or actionable.	The LMS lacks AI-driven predictive analytics, offering no foresight into student performance trends or risks, missing opportunities for early intervention or personalised learning adjustments.		

Functionality. This section evaluates the operations or affordances of the LMS and the quality or suitability of these functions to the intended purpose. Essentially, does the LMS effectively support and enhance the process of teaching and learning online? As the cornerstone of digital education, the LMS is designed not just to facilitate courses, but to act as a platform for course delivery, management, and interaction (Anstey and Watson, 2018b)					
Criteria	**Works Well**	**Minor Concerns**	**Serious Concerns**	**Comments**	**N/A**
Scale	The LMS can be scaled to accommodate any size class with the flexibility to create smaller sub-groups or communities of practice.	The LMS can be scaled to accommodate any size class but lacks flexibility to create smaller sub-groups or communities of practice.	The LMS is restrictive to a limited number of users and cannot be scaled.		
Tech Support / Help Availability	Technical support and /or help documentation is readily available and aids users in troubleshooting tasks or solving problems experienced.	Technical support and help documentation are available but limited, incomplete, or not user friendly.	Technological support and help documentation are not available.		
Technical. This section evaluates the LMS educational technology ecosystem; all the components of an integrated system necessary for appropriately using tools and equipment for educational purposes (Bates and Poole, 2003) It considers the basic technologies needed to make the LMS work.					

Criteria	Works Well	Minor Concerns	Serious Concerns	Comments	N/A
Integration/ Embedding within a Web Site or installed on a network	The LMS can be embedded (as an object via HTML code) or fully integrated into a WordPress or Native HTML website while maintaining full functionality of the LMS.	The LMS can be embedded within a website with limited functionality but cannot be fully integrated.	The LMS can only be accessed through a hyperlink on the vendor's own platform.		
Desktop / Laptop Operating Systems	Users can effectively utilise the LMS with any standard, up-to date operating system.	Users may encounter limited or altered functionality depending on the up-to-date operating system being used	Users are limited to using the LMS with one specific, up-to-date operating system. (e.g. LMS will only operate on Windows)		
Browser Compatibility	Users can effectively utilise the LMS with any standard, up-to-date browser.	Users may encounter limited or altered functionality depending on the up-to-date browser being used.	Users are limited to using the LMS through a specific browser.		

Additional Downloads	Users do not need to download additional software or browser extensions.	The LMS uses a browser extension or software that requires a download and / or user permission to run.	The LMS requires a past or version of a browser extension or software.		
Responsive (Mobile) Design Instructional methods and LMS that deliver content using mobile technology will continue to grow and therefore warrant their own assessment category (Anstey and Watson, 2018a).					
Criteria	**Works Well**	**Minor Concerns**	**Serious Concerns**	**Comments**	**N/A**
Access	The LMS can be accessed, either through the download of an app or via a mobile browser, regardless of the mobile operating system and device. Design of the mobile LMS fully takes into consideration the	The LMS offers an app, but only for a limited set of mobile operating systems. LMS is not accessible through a mobile browser. Design of the mobile LMS constrained by the limitations of the mobile device.	Access to the LMS is limited or absent on a mobile device.		

	constraints of a smaller-sized screen.				
Functionality	There is little to no functional difference between the mobile and the desktop version, regardless of the device used to access it. No difference in functionality between apps designed for different mobile operating systems.	Core features of the main LMS are functional on the mobile app, but advanced features are limited. Some difference in functionality between apps designed for different mobile operating systems but has limited impact on learners' use of the LMS.	The mobile app functions poorly such that core features are not reliable or non-existent. Significant difference in functionality depending on the mobile device's operating system used to access the LMS.		
Offline Access	Offers an offline mode: Core features of the LMS can be accessed and utilised even when offline, maintaining functionality and content.	Offers a kind of offline mode, where the LMS can be used offline, but core functionality and content are affected.	The mobile platform cannot be used in any capacity offline.		

Privacy, Data Protection, and Rights. This section evaluates the LMS's adherence to data protection best practices, as outlined by data controller obligations under Data Protection Commission, (2018).					
Criteria	**Works Well**	**Minor Concerns**	**Serious Concerns**	**Comments**	**N/A**
Sign Up and Sign In Process	The LMS offers a secure sign-in process with two-factor authentication and encrypted data storage. Sign-in/out is straightforward, with clear options for account recovery. The system demonstrates compliance with data privacy standards.	The LMS provides encrypted sign-in but lacks two-factor authentication. The sign-in/out process may require multiple steps or may not be intuitive for all users. Privacy standards are met but not exceeded.	The LMS sign-in process is not secure, lacks encryption for stored data, or does not offer two-factor authentication. The process is cumbersome and not user-friendly, with potential privacy risks		
Data Privacy and Ownership	Users maintain ownership and copyright of their intellectual property/data; the user can keep data private	Users maintain ownership and copyright of their intellectual property/data; data is shared publicly and cannot be made private	Users forfeit ownership and copyright of data; data is shared publicly and cannot be made private, or no details provided.		

	and decide if/how data is to be shared.				
Archiving, Saving, and Exporting Data	Users can archive, save, or import and export content or activity data in a variety of formats	There are limitations to archiving, saving, or importing/exporting content or activity data	Content and activity data cannot be archived, saved, or imported exported		
Social Presence. This category of the rubric stems from the Communities of Inquiry (CoI) framework which considers, in part, how the design of online learning environments might best create and sustain a sense of community among learners (Garrison, 2017).					
Criteria	**Works Well**	**Minor Concerns**	**Serious Concerns**	**Comments**	**N/A**
Collaboration	The LMS has the capacity to support a community of learning through both asynchronous and synchronous opportunities for communication, interactivity, and transfer	The LMS has the capacity to support a community of learning through asynchronous but not synchronous opportunities for communication, interactivity, and transfer of meaning between users	Communication, interactivity, and transfer of meaning between users is not supported or significantly limited		

	of meaning between users.				
User Accountability	Instructors can control learner anonymity; the LMS provides technical solutions for holding learners accountable for their actions.	Instructors cannot control learner anonymity but the LMS provides some solution for holding learners accountable for their actions.	Instructors cannot control learner anonymity and there is no technical solution for holding users accountable to their actions.		
Diffusion	The LMS is widely known and popular, it's likely that most learners are familiar with the LMS and have basic technical competence with it.	Learners' familiarity with the LMS is likely mixed, some will lack basic technical competence with its functions.	The LMS is not well known/foreign, it is likely that learners are not familiar with the LMS and lack basic technical competence with its functions.		

Teaching Presence. This section of the rubric also stems from the Community of Inquiry (CoI) framework and addresses the integrating force that structures and leads the educational process in a constructive, collaborative and sustained manner (Garrison, 2017). It measures the LMS elements that enable instructors to establish and maintain their teaching presence through facilitation, customisation, and feedback.					
Criteria	**Works Well**	**Minor Concerns**	**Serious Concerns**	**Comments**	**N/A**
Facilitation	The LMS has easy-to-use features that would significantly improve an instructor's ability to be present with learners via active management, monitoring, engagement, and feedback.	The LMS has limited functionality to effectively support an instructor's ability to be present with learners via active management, monitoring, engagement, and feedback.	The LMS has not been designed to support an instructor's an instructor's ability to be present with learners via active management, monitoring, engagement, and feedback.		
Customisation	LMS is adaptable to its environment: easily customised to suit the classroom context and targeted learning outcomes	Limited aspects of the LMS can be customised to suit the classroom context and learning outcomes	The LMS cannot be customised.		

Cognitive Presence. This category considers a tool's ability to support students' cognitive engagement in learning tasks. In the CoI framework this is the process of inquiry that moves from problem definition to exploration of relevant content and ideas, integrating those ideas into a meaningful structure or solution (Garrison, 2017; Anstey and Watson, 2018a).					
Criteria	**Works Well**	**Minor Concerns**	**Serious Concerns**	**Comments**	**N/A**
Enhancement of Cognitive Task(s)	The LMS enhances engagement in targeted cognitive task(s) that were once overly complex or inconceivable through other means.	The LMS enables functional improvement to engagement in the targeted cognitive task(s).	The LMS acts as a direct tool substitute with no functional change to engagement in the targeted cognitive task(s).		
Higher Order Thinking	Use of the LMS easily facilitates learners to exercise higher order thinking skills (given consideration to design, facilitation, and direction from instructor).	The LMS may engage learners in higher order thinking skills (given significant consideration to design, facilitation, and direction from instructor).	The LMS likely does not engage learners in higher order thinking skills (despite significant consideration to design, facilitation, and direction from instructor).		

Metacognitive Engagement	Through the LMS, learners can regularly receive formative feedback on learning (i.e. they can track their performance, monitor their improvement, test their knowledge).	Opportunities for receiving formative feedback on learning are available, but infrequent or limited (i.e. poor opportunities for tracking performance, monitoring improvement, testing knowledge on a regular basis).	There are no opportunities for formative feedback on learning (i.e. lacking opportunities for tracking performance, monitoring improvement, testing knowledge on a regular basis).		

Other: Use this section to add comments/suggestions to improve or enhance the Rubric for LMS Evaluation.