Learning to Learn II: Evaluation of Learning Systems for Supporting Competency Based Education

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ABSTRACT

This research evaluates criteria for differentiating Learning Management Systems in their posture for supporting Competency-Based Education (CBE) within online learning environments. Building upon a foundational analysis of lessons learned and best practices identified in previous study "Learning to Learn: The Trials and Tribulations of CBE Implementation in Technical Training," by Ferrara & Jones (2023) this current study provides a thorough assessment of the alignment between existing commercial off the shelf (COTS) platforms and the pedagogical principles and operational needs of CBE. This evaluation examines key features of these systems, highlighting their capabilities to support flexible learning pathways, assessment options, and personalized learning experiences. The evaluation criteria draw upon CBE implementation insights from prior research, emphasizing learner-centered outcomes, mastery-based progression, and the integration of real-world skills. Results indicate substantial variability in how well COTS platforms accommodate CBE, identifying both viable solutions for course hosting and persistent gaps in the market. From these findings, key areas are identified that separate viability of various LMSs supporting modern learning and CBE as well as areas that continue to be shortfalls when selecting and implementing technological solutions in CBE-focused online programs. The study aims to assist educators, administrators, and policymakers in making decisions regarding use of online systems and selection criteria that enhance the efficacy of CBE initiatives, thereby improving learning outcomes and better aligning with industry competencies.

ABOUT THE AUTHORS

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Nate Ferrara is the Programs Director at the Spinnaker Institute, Inc. and an experienced training program developer and instructor of Competency-Based Education in collegiate technical programs for 10 years. His firsthand experience in the development of multiple CBE programs and in classroom execution of those programs provides a unique perspective that is leveraged in consulting for building more effective solutions. Prior to becoming a CBE program developer and instructor, Mr. Ferrara spent over 15 years working in technical trades which provides a solid foundation as a learner, developer, instructor, and consultant.

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INTRODUCTION

Competency-Based Education (CBE)

Competency-Based Education (CBE) represents a significant shift from traditional education models by focusing on the mastery of specific competencies rather than time-based progression through a curriculum. This pedagogical approach prioritizes the achievement of defined learning outcomes, wherein students progress at their own pace, demonstrating proficiency through practical application and assessment. Central to CBE is the principle that education should be as personalized as possible, allowing each learner to understand material fully and move forward based on their competency, rather than moving together with a cohort on a fixed schedule (Khiat 2017). This approach not only caters to individual learning styles but also aligns educational experiences more closely with real-world skills and job requirements, which are critical in many professional fields today.

From an operational standpoint, implementing CBE requires educational institutions to adopt a flexible framework that can accommodate the varied paces at which students learn. This includes rethinking how courses are structured, scheduled, and assessed. Traditional semester-based timelines are often replaced with more fluid and open-ended schedules that allow students to start and complete modules as they achieve the required competencies. Such a system necessitates robust Learning Management Systems (LMS) that can support these dynamic pathways by tracking individual progress, facilitating seamless content access, and integrating sophisticated assessment tools that evaluate student performance against specific competencies (Ferrara & Jones 2023; Khiat 2015).

Furthermore, the operational requirements for CBE extend into the realm of curriculum development and instructional design. Educators must develop clear, measurable learning objectives that define what competencies students need to acquire (CEPH 2011). These objectives must be backed by appropriate instructional materials and activities that support competency development. This approach requires a significant amount of upfront planning and ongoing adjustments to ensure that the educational content remains relevant and effectively meets learners' needs. Additionally, faculty must be trained not only in the subject matter but also in the principles of CBE, to shift from traditional lecture methods to more facilitative, coaching-based instructional techniques (Ferrara & Jones 2023).

The integration of technology in CBE also plays a pivotal role. Advanced technologies, including artificial intelligence, analytics, and immersive learning tools such as virtual reality/augmented reality (VR/AR), can enhance the CBE experience by providing personalized learning paths and real-time feedback (Wilson, 2023). These technologies help create an engaging learning environment that mirrors complex real-life scenarios, making learning more relevant and impactful. For institutions, investing in such technologies means considering not just the immediate educational benefits but also the long-term gains in learner engagement and success rates, positioning them at the forefront of educational innovation and effectiveness.

Urgent Need

According to the World Economic Forum, by 2025, 44% of the skills required for employees to perform their roles effectively will undergo significant transformation (Zahidi, et al 2020). This highlights the persistent and escalating challenge of skill gaps, as the competencies in demand across various professions continue to evolve. The necessity for

robust interventions in reskilling and upskilling initiatives is particularly pressing for the public sector, which must enhance its support mechanisms to address these dynamic skill requirements. Complementing this perspective, Gartner's 2021 analysis underscores the urgency of this issue, revealing that 58% of the current workforce already requires new skills to maintain their professional efficacy (Baker & Zuech). These findings collectively underscore the critical need for comprehensive and proactive strategies to bridge the skill gaps and ensure workforce readiness in the face of rapidly changing job requirements.

Previous Research

Ferrara, Jones (2023) presented an evaluation of CBE implementations within technical training programs that revealed a nuanced interplay between curriculum design, technological integration, and pedagogical strategies. This analysis discussed three case studies: Marine Engineering Management and Seamanship (MEMS), Diesel Service Technician (KDIS), and Professional Truck Driving (KPDR), all transitioning to CBE frameworks. Each program's success was distinctly influenced by its LMS capabilities and enrollment strategies, demonstrating the critical role of educational technology in CBE settings.

The MEMS program encountered significant challenges, with only 20% of the initial enrollees completing the program. These challenges were exacerbated by the program's limited LMS functionality, which failed to support open enrollment and flexible scheduling. This lack of technological adaptability contributed to low student engagement and high dropout rates over the 10-month duration. Conversely, the Diesel Service Technician program exhibited moderate success with a 41% completion rate, benefiting from a well-designed LMS and an open enrollment system that accommodated students' varying schedules, thereby enhancing participation and progression.

The most successful implementation was seen in the Professional Truck Driving program, which achieved an 85% completion rate. This program effectively utilized a LMS implementation that supported short course durations and clear competency goals, significantly facilitating skill mastery. The high completion rate in this program illustrates the importance of aligning technological tools with educational objectives, particularly in terms of providing real-time, adaptable learning environments that respond to student needs. These cases collectively underscore the necessity for CBE programs to incorporate advanced LMS features that promote flexibility, accessibility, and student-centered learning to overcome the limitations identified and achieve successful outcomes.

Purpose

Learning to Learn II is a continuation of previous research that was presented by Ferrara and Jones (2023). The previous research examined the implementation of three CBE programs for technical trades and the challenges encountered during the conversion and implementation processes. While the programs demonstrated significant benefits for technical training the implementation process presents numerous challenges that were presented. One of the key attributes identified was limitations imposed by the selection of the Learning Management Systems (LMS). The research showed the negative impact the LMS selection and implementation can have on educational outcomes and learner experience.

Selecting appropriate LMS and cloud-based educational technologies is crucial for the successful implementation of CBE. These technologies form the backbone of online learning environments, providing the infrastructure necessary for delivering personalized education and managing the mastery-based progression that is central to CBE. A well-chosen LMS can facilitate flexible learning pathways and robust assessment capabilities, enabling educators to tailor educational experiences to individual learner needs and competencies. Moreover, these systems play a pivotal role in integrating real-world skills into the curriculum by supporting diverse multimedia content and interactive learning experiences. Therefore, the careful evaluation and selection of these technologies are imperative to ensure they meet the specific pedagogical and operational requirements of CBE, ultimately impacting the effectiveness of educational programs and their alignment with industry standards and learner outcomes.

The purpose of this next phase in research is to systematically evaluate the readiness of Commercial Off-The-Shelf (COTS) LMS platforms in facilitating a modern CBE implementation within online learning environments. It aims to assess how well these platforms align with the pedagogical demands and operational needs of CBE, drawing on a range of established best practices and lessons learned from previous research. Ultimately, this analysis seeks to provide

actionable insights and tools for educators and administrators to optimize the selection and implementation of educational technologies in support of CBE initiatives as well as identify areas for further research and development.

METHODOLOGY

Criteria Identification & Evaluation Process

The methodology employed for evaluating LMSs within the context of a modern CBE program involved the creation of a comprehensive 35-criteria evaluation matrix. The selection of these criteria and the development of the corresponding evaluation scales were core in providing a robust framework for analyzing the alignment of LMS capabilities. The matrix was developed, drawing from insights outlined by Ferrara and Jones (2023), best practices and quality framework published by Competency Based Education Network (CBEN) (2024). Each criterion was explicitly defined to ensure clarity and consistency in assessment. To facilitate a structured and quantifiable evaluation, a five-point scale was defined for each individual criterion. This scale ranged from "not available" represented as a "0" score to "exceeds needs," represented as a "4" score; allowing the evaluators to systematically assess and rate the performance of various LMS features against the identified criteria. For each measurement on the 0-4 scale, the team collaboratively defined what meets the criteria as well as what was considered to exceed the criteria. For each score, the reason for the selected score was recorded into the scoring matrix along with the score assigned.

Table 1 provides an example criteria definition and measurement definition. This was completed for every criterion. The final matrix included 35 evaluation criteria, 20 LMSs, 175 score definitions, and 700 scores. Presented in Table 1 are the criteria that were selected and defined. The full criterion and scoring definitions are not presented in this paper due to space constraints.

Criteria	**4 – Exceeds**	**3 – Meets**	**2- Has but should be improved**	**1 – Has some element but not entirely**	**0 – Does not provide**
Does the platform accommodate self-paced learning?	Advanced adaptive technologies that tailor content and pace to individual needs seamlessly.	Effective self-paced learning with some adaptive features.	Self-pacing options are limited in scope or support.	Minimal self-pacing features, not effectively supporting individual needs.	No self-paced learning options available.

Table 1 Criteria & Measurement Definition Example

Self-Paced Learning	Adaptive Learning	Interactive Content
PC Mobile 3D Access	VR/AR Accessibility	360 Immersive Accessibility
Real Time 3D Accessibility	Flexible Learning Paths	Varied Assessment Strategies
Defined Learning Objectives	Measure Learning Objectives	Define Competencies
Measure Competency	Robust Assessment Tools	Competency Mapping
Student Communication	Independent Learning Paths	Discussion Forums
Chat Tools	Collaboration Spaces	Personalized Feedback
Personalized Instruction	Tailored Learning Experience	Personalized Learning Paths
Accessibility Features	Progress Driven Registration	Advanced Progress Tracking
Support Mini Milestones	Open Enrollment	Instructor Content Tools
Individual Contact Methods	Contact Tracking	Student Engagement Tools
	Supports Blended Learning	

Table 2 Evaluation Criteria

LMS selection

To select the LMSs for evaluation, the team leveraged education and training review websites to identify and compile lists of leading LMS platforms as a representative set of the market aiming to encompass a broad spectrum of opinions and insights. The selection process focused on identifying LMSs that were consistently recognized across different sources, thereby reducing the influence of marketing biases inherent in single-source lists. Special attention was given to platforms that not only held a significant market share but also explicitly claimed to support CBE. This dual focus ensured a balanced representation of widely used systems and those specifically tailored to meet the unique requirements of CBE, facilitating a comprehensive and fair evaluation of their capabilities and effectiveness in supporting competency-based learning modalities.

Anthology (Blackboard)	Moodle	Canvas LMS	Docebo
Absorb LMS	Learn Upon	Cornerstone LMS	Talent LMS
Google Classroom	360Learning	Adobe Learning Manager	Schoology
iSpring	Edsby	Acorn	D2L Brightspace
Workramp	Creatrix Campus	OpenLMS	RealizeIt Learning

Table 3 LMSs Selected for Evaluation

Limitations

This effort did not include user experience studies. Qualitative research, including user surveys and focus groups, could complement quantitative findings, offering deeper insights into why certain features are more effective or preferred by users. This could help refine feature design and functionality or influence selection criteria for an LMS.

The analysis did not fully capture the customization capabilities of each platform, which can significantly enhance their utility and user satisfaction. For example, platforms like Moodle are known for their high customizability, which could lead to higher ratings if these aspects were thoroughly evaluated with available third-party tools. The flexibility of these platforms allows users to tailor the systems more closely to specific educational needs and contexts, potentially improving their effectiveness beyond what was measured in this study.

The ratings were based on documentation and standard features as outlined by the providers, without considering day-to-day performance variations. In practice, the effectiveness and utility of features can vary widely depending on actual use cases. Daily user interactions and long-term engagement with these platforms might reveal strengths or weaknesses that are not apparent from documentation alone. This variability means that some features might be used in ways not originally intended by the developers, possibly affecting the overall user experience and satisfaction in unforeseen ways.

The results are not intended to endorse any LMS over another. Changing elements of selection criteria for an individual organization's needs will likely change results. The intent is to look at trends. The criteria utilized by this team is not intended to be a defined set for choosing an LMS. Depending on the specific needs of individual organizations, the criteria should be tailored to their needs. The established criteria were selected without any specific organization's needs and therefore criteria were not weighted. Utilizing the criteria for selecting an LMS to implement should include adding weighting to the criteria based on the specific organization's education and training needs and administrative requirements. The research team also recognizes that the LMS platforms are continuously improving, and rating for each criteria would be expected to change over time.

RESULTS

Given that our research is focused on identifying trends in the criteria that are not well supported by the representative LMS systems, descriptive statistics were selected for further exploration. The results for each LMS and criteria are presented. For each criterion across all LMSs, we computed summary statistics including:

- Mean: The average score for each criterion.

- Standard Deviation (std): Measures the amount of variation or dispersion of the scores.
- Minimum (min) and Maximum (max): The lowest and highest scores respectively.
- Quartiles (25%, 50%, 75%): Represent the 25th, 50th (median), and 75th percentile of the scores.

These statistics provide an initial understanding of the distribution and central tendency of the scores assigned to various features of the LMS platforms. Overall, criteria with 2.0 or higher mean score indicates marketplace has some capabilities. Conversely, criteria below a 1.0 mean score indicate the marketplace broadly does not have the capabilities.

Criteria	Mean	Std	Min	25%	50%	75%	Max
self_paced_learning	2.90	0.447214	2	3.00	3.00	3.00	4
adaptive_learning	2.20	0.767772	1	2.00	2.00	2.00	4
interactive_content	0.90	0.788069	0	0.00	1.00	1.25	2
pc_mobile_3d_access	0.75	0.716350	0	0.00	1.00	1.00	2
vr_ar_accessibility	0.40	0.502625	0	0.00	0.00	1.00	1
360_immersive_envs	0.40	0.680557	0	0.00	0.00	1.00	2
game_like_learning_envs	2.10	0.718185	1	2.00	2.00	3.00	3
flexible_learning_paths	2.85	0.587143	2	2.75	3.00	3.00	4
varied_assessment_strategies	2.85	0.745160	2	2.00	3.00	3.00	4
define_learning_objs	2.90	0.552506	2	3.00	3.00	3.00	4
measure_learning_objs	2.55	0.604805	2	2.00	2.50	3.00	4
define_competencies	2.35	0.988087	0	2.00	2.00	3.00	4
measure_competency	2.30	0.978721	0	2.00	2.50	3.00	4
robust_assessment_tools	2.45	0.604805	1	2.00	2.50	3.00	3
competency_mapping	1.95	0.759155	1	1.00	2.00	2.25	3
student_communication	2.90	0.552506	2	3.00	3.00	3.00	4
independent_learning_paths	2.70	1.031095	1	2.00	3.00	3.25	4
discussion_forums	2.45	1.050063	0	2.00	3.00	3.00	4
chat_tools	1.95	0.887041	0	1.75	2.00	2.00	4
collaboration_spaces	2.10	0.852242	1	1.75	2.00	3.00	4
personalized_feedback	2.55	0.759155	1	2.00	2.50	3.00	4
personalized_instruction	2.30	0.732695	1	2.00	2.00	3.00	4
tailored_learning_experience	2.15	0.812728	1	2.00	2.00	3.00	4
personalized_learning_paths	2.45	0.825578	1	2.00	2.00	3.00	4
accessibility_features	3.00	0.648886	2	3.00	3.00	3.00	4
progress_driven_registration	2.50	1.317893	0	1.75	3.00	3.25	4
advanced_progress_tracking	2.80	0.767772	1	2.00	3.00	3.00	4
instructor_progress_tracking	2.70	0.732695	1	2.00	3.00	3.00	4
support_mini_milestones	2.30	0.923381	0	2.00	2.00	3.00	4
open_enrollment	2.85	1.089423	0	2.00	3.00	4.00	4
instructor_content_tools	3.30	0.571241	2	3.00	3.00	4.00	4
individual_contact_methods	2.55	0.825578	1	2.00	3.00	3.00	4
contact_tracking	1.50	0.827170	0	1.00	2.00	2.00	3
student_engagement_tools	2.45	0.825578	1	2.00	3.00	3.00	4
supports_blended_learning	2.90	0.552506	2	3.00	3.00	3.00	4

Table 4 Summary Statistics for Criteria

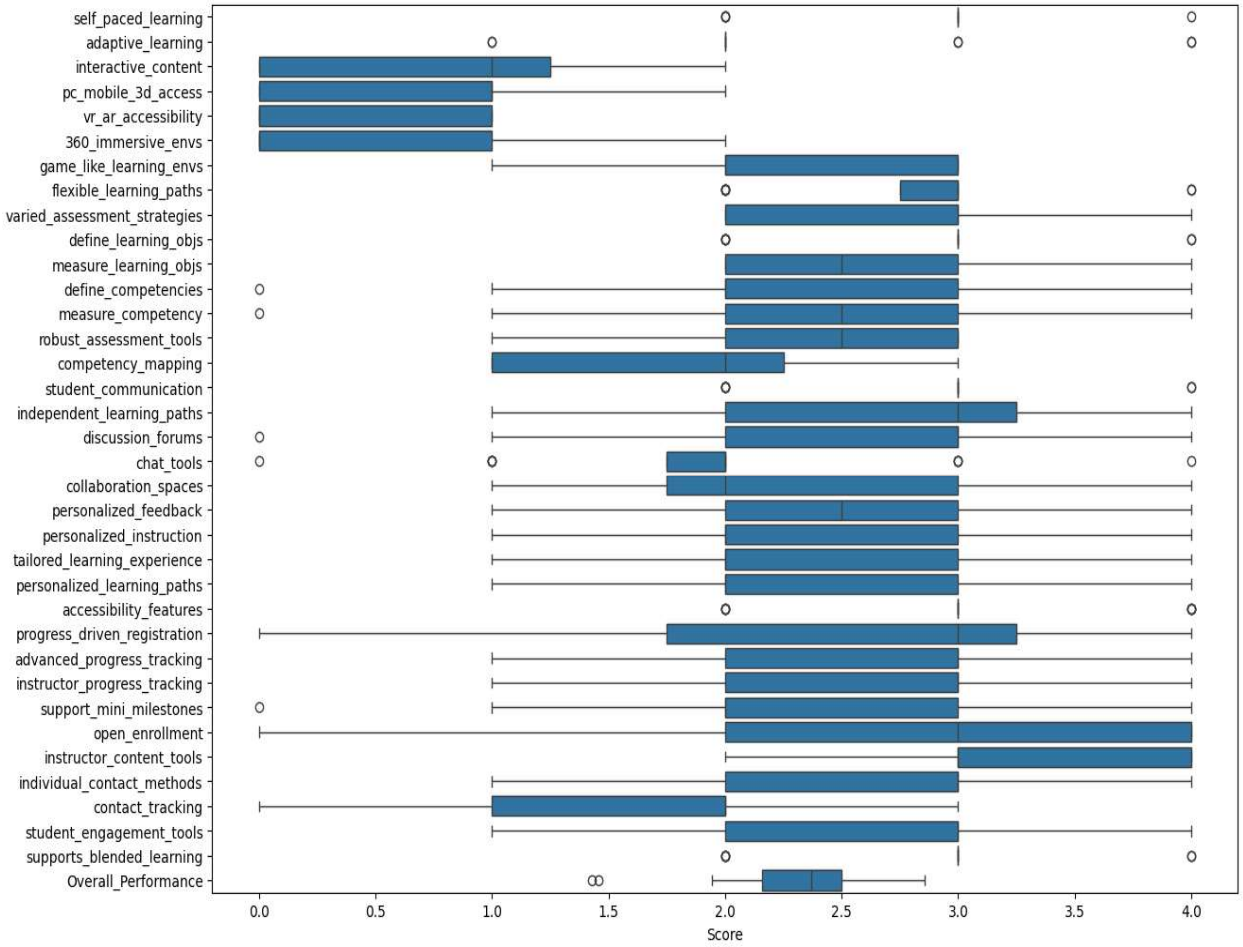
The summary statistics reveal significant insights into the performance of different LMS providers across various criteria. Below are key observations from the analysis:

- **Consistency and Variability:** Criteria such as 'Platform provides accessibility to all students' show high consistency (low std deviation and narrow range between min and max). In contrast, criteria like 'learner-driven_registration' show high variability, indicating differing levels of implementation across platforms.
- **Performance Extremes:** Certain features like '3D_accesibility' and 'vr_ar_accessibility' have low mean scores, suggesting that these are less commonly well-supported or developed across the evaluated LMS.

- **High and Low Performers:** The highest average scores were observed in 'instructor_content_tools', indicating robust support for content management across most platforms. Conversely, 'vr_ar_accessibility' and '360_immersive_envs' had the lowest mean scores, highlighting a potential area for improvement.

Distribution of the scores is presented in Figure 1. This provides a visual for easy identification of criterion where strengths and gaps exist in marketplace. Blue solid boxes on the left indicate broad market absence, where blue solid boxes to the right indicate strong market consistency in meeting and exceeding needs. Criterion without blue boxes indicate nearly all results scored same indicating high standardization in capabilities offered in marketplace.

Figure 1 Distribution of Scores Across Different Criteria



Strengths & Discriminators

The evaluation revealed several common strengths across the assessed criteria, particularly in areas where high average scores and low standard deviations were noted. For instance, the criterion 'define learning objectives' scored an average of 2.9 with a standard deviation of 0.55, and 'instructor content tools' averaged 3.3 with a standard deviation of 0.57. These scores indicate a general market strength in these areas, suggesting that most LMS platforms effectively allow instructors to set clear learning objectives and provide robust tools for content creation and management. The low variability in these scores across different systems highlights a lack of differentiation in these features, implying that they are standard across most platforms and not likely to be deciding factors when selecting between different LMS options or areas that need development focus.

Conversely, criteria such as 'progress-driven enrollment' and 'open enrollment' demonstrated high standard deviations of 1.31 and 1.089, respectively, with scores ranging widely from 0 to 4. This significant variability suggests that these

features are strong discriminators in the market; they serve as critical factors for distinguishing between LMS platforms. Systems that score highly on these criteria offer more flexibility and adaptability in enrollment management, catering effectively to varying educational needs and pacing, which is essential for CBE environments. The wide range of scores also indicates areas where lower-scoring LMS platforms could focus improvements. Enhancing capabilities in 'progress-driven enrollment' and 'open enrollment' could significantly elevate an LMS's appeal and functionality, making it more competitive and better suited to the demands of modern educational paradigms.

Correlation & Regression Analysis

Here, we discuss each feature's impact, as inferred from their regression coefficients and correlation with the overall performance metric, helping to prioritize areas for system development and strategic focus. The analysis indicates that personalization, flexibility, and interactive features significantly enhance LMS scores based on this set of criteria.

<u>High Impact</u>
These features have shown a significant correlation with individual LMS total scores overall, suggesting which criteria most influenced LMS total sum of ratings which highlights which criteria appear to correlate with other criteria: Open Enrollment (0.750), Personalized Feedback (0.734), Personalized Learning Paths (0.731).

<u>Moderate Impact</u>
These features, while still influential, have a moderate correlation with overall LMS scores: Student Engagement Tools (0.667), Mini-milestones (0.648), Self-paced Learning (0.635), Interactive Content (0.570) and Flexible Learning Pathways (0.568).

<u>Low Impact</u>
These features show positive but lower correlations, suggesting areas where enhancements could yield a substantial increase in scores: Contact Tracking (0.563), Progress Tracking (0.562), Adaptive Learning (0.535). 3D Accessibility (0.451) and VR/AR Accessibility (0.417).

Regression Analysis

The objective of this phase was to assess how different features contribute to the total sum scores; thereby removing the impact of the immersive technology accessibility low scoring criterion and common baseline capabilities for analysis. The approach entailed creating a regression model focusing on selected features deemed most critical based on their individual correlation with the overall scores. This will provide understanding of what was most impactful to the scores and could guide future development and improvement strategies. Based on preliminary correlation analysis, the top ten features most strongly correlated with overall scores were selected for further examination. These features include:

Open Enrollment	Personalized Feedback	Personalized Learning Paths
Student Engagement Tools	Mini-milestones	Self-paced Learning
Personalized Instruction	Interactive Content	Flexible Learning Pathways
Contact Tracking		

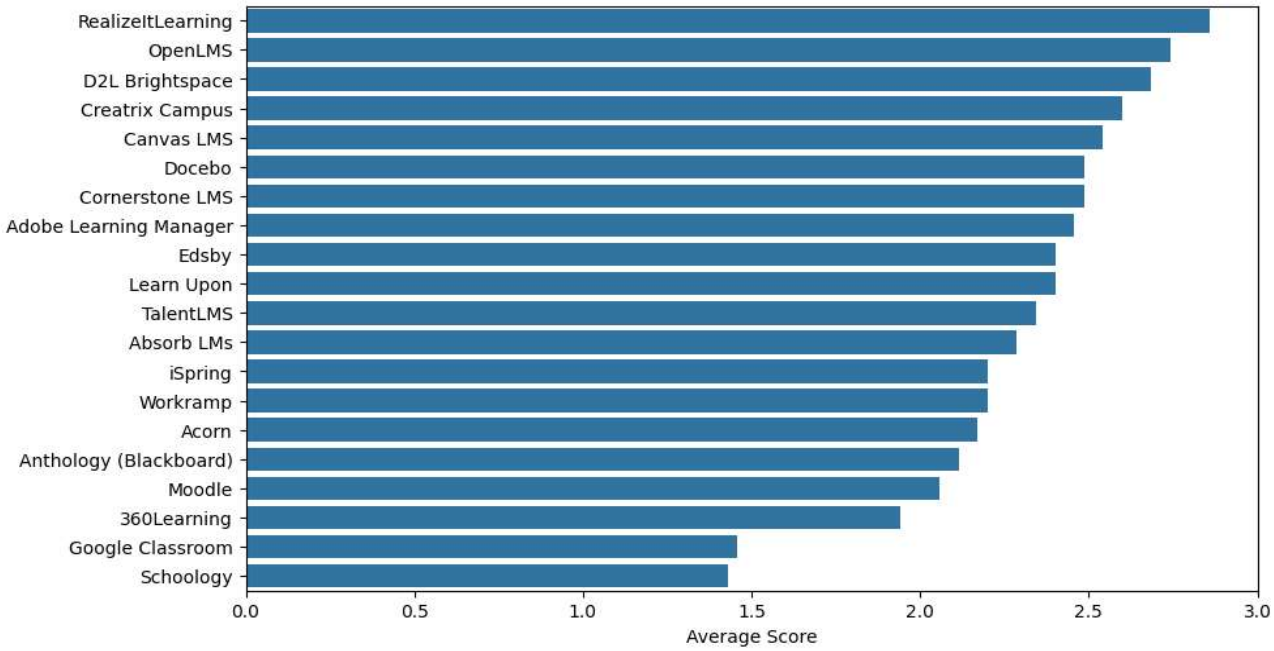
The analysis of the coefficients identified several key features that significantly influenced the overall scores, indicating their importance in the scores. Features such as 'student engagement tools' demonstrated a positive coefficient of 0.1719, which are important for enhancing student interaction and engagement within the learning environment. 'Personalized instruction' and 'self-paced learning' also showed substantial influence with coefficients of 0.099 and 0.0915, respectively. These features are crucial for tailoring the educational experience to individual learner needs and allowing students to progress at their own pace, core tenets of CBE. Additionally, 'interactive content' and 'open enrollment' had coefficients of 0.0536 and 0.0514. These results suggest that LMS platforms incorporating these features effectively scored higher in this evaluation. Which could potentially be interpreted as they are better equipped to meet diverse educational requirements and support a more engaging, flexible, and personalized learning experience. Further analysis could be gained by utilizing common factor analysis to establish which criteria are related to each other statistically, if desired for informing a financial decision.

Overall LMS Performance Scores

Reviewing the overall performance scores of the LMSs illustrates that no LMS achieved an overall score of '3 – meets' when averaging all 35 criteria as shown in Figure 2. This indicates significant opportunities for improvements in the market for learning systems to be enhanced to support modern CBE needs. Our model coefficient intercept score of 2.2368, or the expected value 'Overall_Performance' when all predictors are at their mean values, however, is relatively high. This suggests that a strong baseline in scores across the LMS platforms in this study.

These overall scores were most heavily influenced by shortfalls in direct access to interactive content, mobile 3D accessibility, VR/AR accessibility, and 360 immersive environments accessibility. The ability to provide immersive interactive environments for training is vital in CBE. Improvements in providing access from the LMS to such environments are potentially due to traditional use of LMSs and technological separation from immersive training environments.

Figure 2 Overall Performance Scores of LMSs



The team is not endorsing any of the LMS systems and recognizes that to inform a financial decision for selecting for use or further research and development, weighting should be applied to the criteria specific to the use case and then re-evaluate the scores of the LMSs. This chart demonstrates that variability in the market based on the equally rated criteria. Applying weighting to certain criteria may reduce the measured variability.

DISCUSSION

Immersive Content Accessibility

The data-driven analysis performed in this study offers critical insights that could substantively guide the strategic planning processes of educational institutions, particularly in the context of CBE. A significant gap identified through this research is the limited provision of immersive content across the evaluated LMS. This includes, but is not limited to, the availability of 3D content on mobile devices, VR/AR integration, and access to 360-degree environments. While certain LMS may support these features through additional plug-ins, the core offerings in the market do not directly cater to these needs. This gap is particularly impactful in CBE contexts, where the development of practical skills—especially within technical disciplines—relies heavily on spatial fidelity and enriched cognitive interactions that immersive environments uniquely provide.

The integration of such technologies into educational courses is becoming increasingly essential as modern learners anticipate seamless access to digital environments, analogous to the ease of logging into cloud-based systems or online gaming platforms. The future trajectory for LMS should ideally mirror the interactive, real-time 3D environments prevalent in contemporary gaming platforms, where logging into an educational platform to access a learning module could become as intuitive and engaging as entering a game level. As LMS platforms evolve to incorporate these advanced technological capabilities, the educational experience could potentially rival the engagement and interactivity of online gaming, thereby transforming the traditional paradigms of educational delivery and engagement.

Despite the widespread availability of gaming environments, PCs, and VR systems, their direct integration into educational platforms, particularly LMS, remains limited. As emerging technologies, these platforms are beginning to show a moderate impact on educational settings, hinting at a latent potential that could be more fully realized with broader technological adoption. The growing interest among users in these dynamic and immersive tools suggests a significant opportunity for educational technology developers. By harnessing the capabilities of these advanced systems, LMS can transform traditional learning environments into more engaging, interactive, and effective educational experiences. The eventual widespread integration of these technologies into educational frameworks could lead to a paradigm shift in how educational content is delivered and experienced, making learning more appealing and accessible through familiar and immersive digital platforms.

Variance in Capabilities

The variance observed in the scores across different criteria in the evaluation of LMS highlights the diverse priorities and developmental focuses among LMS providers. Significant disparities in scores, particularly for features like ‘open_enrollment’ and ‘progress_tracking’, underscore the uneven emphasis that various developers place on certain functionalities. These variations suggest that while some providers prioritize broad accessibility and flexible learning pathways, others may focus more on content delivery or administrative tools. The high variability in scores for features that are essential for CBE indicates that there is still much room for improvement and standardization in the market. For educational institutions, understanding these variances is crucial for selecting an LMS that aligns with their specific educational strategies and goals.

Given the critical nature of features such as ‘open_enrollment’ and ‘progress_tracking’ in supporting the dynamic needs of CBE, the significant variability in these areas could represent a strategic opportunity for LMS developers. Enhancing these features can dramatically improve user experience by providing learners with the ability to join programs as their schedules allow and to track their learning progress in real-time. This not only facilitates a more personalized and adaptable learning environment but also aligns with the modern educational demands for greater flexibility and learner autonomy. As such, LMS providers that invest in improving these critical areas may find themselves better positioned to meet the evolving needs of educational institutions and learners, potentially gaining a competitive edge in the rapidly changing educational technology landscape.

Personalization

The correlation analysis suggests that LMS providers could substantially enhance their support for CBE curriculums by investing in advanced personalization and engagement features. Such enhancements are not merely functional upgrades; they are critical investments that could transform educational experiences, making them more tailored and responsive to individual learner needs. Features that allow for greater customization of learning paths and more interactive content have the potential to significantly improve learner engagement. This, in turn, can lead to higher user satisfaction and improved educational outcomes, as students are more likely to remain motivated and committed to their studies when they feel the learning environment adapts to their personal learning pace and style.

Prioritizing the development of these personalization and engagement features in selection criteria or development budgets could strategically position educational institutions and enterprises at the leading edge of educational technology. For educational leaders and technology officers, these considerations should guide the allocation of resources towards technologies that facilitate a more individualized learning experience. This strategic focus not only aligns with the pedagogical goals of CBE, which emphasize mastery and individual competency, but also meets the growing demand for education systems that resemble the user-centric models seen in other advanced digital

interactions. As such, educational entities that excel in these areas are likely to set new standards in educational delivery, influencing broader trends in the sector.

Assessment Criteria & Assessment Strategy Limitation

The scope of the current study was deliberately focused on conducting a comparative analysis of various LMS by employing a predetermined set of criteria. This methodology was designed to elucidate the disparities and parallels in the feature sets, usability, and overall industry stance towards CBE effectiveness as currently documented. Nonetheless, this study's design inherently limits its breadth by not incorporating empirical user feedback or conducting a longitudinal analysis of system performance. Such dimensions are essential for a comprehensive appraisal of the effectiveness of these systems over time and in varied educational scenarios. For instance, the emphasis placed on immersive environments, VR/AR compatibility, and 360-degree environment accessibility significantly influences the evaluation scores. Should these criteria be modified or weighted differently, the resulting scores and rankings of the LMS platforms could vary dramatically. This indicates the importance of carefully considering which features are prioritized in an LMS evaluation, as the selection of criteria can heavily impact the perceived performance and suitability of a system for specific educational needs.

Additionally, it is crucial to acknowledge that some LMS platforms may integrate third-party software to provide capabilities such as VR/AR and immersive content, which might not have been fully captured in this analysis. This reliance on external applications or plugins can obscure the native functionality of an LMS, potentially skewing the assessment of its capabilities. Institutions considering LMS options should, therefore, look beyond the base features of the platforms and consider the broader ecosystem of support and enhancements available through third-party solutions. Understanding the full scope of what each LMS can deliver, including external integrations, is essential for making informed decisions that align with the specific technological and pedagogical requirements of the institution or program.

FUTURE RESEARCH

To build on the findings of this study, future research should delve into the impacts of LMS customization on their utility across diverse educational settings. This would involve a systematic investigation into how different levels of platform adaptability affect user satisfaction, educational outcomes, and overall system effectiveness. Examining the customization capabilities of LMS could reveal critical insights into the flexibility of these systems to cater to specific pedagogical requirements and the ease with which they can be tailored to enhance educational delivery. Such research could also explore the scalability of customized solutions and their cost-effectiveness, providing valuable information for educational institutions when making decisions about LMS investments. Additionally, incorporating user feedback into this future research could offer a richer, more nuanced understanding of the practical challenges and benefits encountered by educators and students, thereby informing more targeted improvements in LMS design and implementation.

This study did not extend to the investigation of emerging technologies such as AI-driven adaptive learning systems, which represent a significant frontier in the evolution of educational technologies. Adaptive learning technologies hold the potential to profoundly enhance the personalization of education by dynamically adjusting the learning content and pathways in response to real-time user performance and engagement metrics. While these systems are not a prerequisite for implementing CBE, their capacity to tailor educational experiences to individual learner needs could revolutionize the approach to personalized learning. Future research should focus on evaluating the impact of such AI-driven systems within the LMS framework, particularly assessing how they can support or enhance the principles of CBE. This could include studies that measure the effectiveness of adaptive learning in improving learner outcomes, engagement levels, and the efficiency of competency acquisition.

Furthermore, the trend towards more personalized and immersive educational experiences highlights the necessity for LMS platforms to integrate more sophisticated technologies, such as cloud-hosted 3D environments. These technologies not only cater to the growing demand for engaging and interactive learning experiences but also align with the educational shift towards virtual and augmented realities, which offer vast new realms for educational exploration and interaction. Future research should explore the integration of these modern technological

advancements into LMS, examining their practicality, scalability, and impact on learning outcomes. This focus on integrating cutting-edge technologies will likely play a critical role in shaping the future development of LMS, making it imperative for ongoing research and development efforts to keep pace with these technological evolutions to meet the emerging needs of modern learners.

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