

Modeling of web-based collaborative learning management system

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ABSTRACT

The challenges faced by most learning management systems (LMS) can be classified into two main areas: pedagogical and technical issues. A comprehensive exploration of these interrelated challenges provides valuable insights for developing a new and more effective model for LMS. In this paper, a novel conceptual model for a web-based collaborative LMS is introduced, merging two distinct learning theories: behaviorism and social constructivism. Through an analysis of the strengths and limitations of each theory, the study moves on to outline the fundamental principles and technical features of the proposed LMS model, which stems from this integration. In conclusion, the paper explores the implications of creating user-centered LMS solutions, with a specific focus on addressing the varied requirements of learners.

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1. INTRODUCTION

In the last decade, significant advancements have shaped the landscape of e-learning platforms. However, despite these advancements, various comparative studies reveal that the life cycle of these platforms is undergoing continuous and rapid evolution [1], [2]. Traditionally, e-learning platforms, including learning management systems (LMS), have been characterized by a pedagogical model where the teacher is perceived as being the sole knowledge holder, tasked with imparting it to learners through diverse methods. Many existing e-learning platforms are primarily structured as teaching management systems (TMS), with a primary focus on supporting teachers in course creation and management, often overlooking the needs and experiences of the learners [3]. These platforms have consistently followed a standardized, technology-centric logic and architecture, limiting the diversity of applied pedagogical theories and frequently disregarding alternative approaches.

Considering these limitations, our research aims to introduce an innovative conceptual model that integrates various learning theories to enhance both teaching and learning processes. The envisioned LMS, built upon this conceptual model, is conceived as a free and open-source software platform with a strong emphasis on collaborative learning. It empowers both teachers and learners to generate, organize, and participate in a variety of interactive activities, including forums, wikis, and blogs. Users have the flexibility to access and manage these activities based on their unique learning needs and goals, fostering a dynamic and adaptable learning environment. At the core of our approach lies the principle of ensuring equal opportunity

for all users, offering personalized workspaces and access to diverse activity spaces within the LMS for both teachers and learners. This inclusive design fosters heightened interactivity, knowledge sharing, and collaboration among users. Moreover, tracking services are seamlessly integrated to monitor and document users' activities and interactions with various tools, providing data-driven insights into the learning process.

In the field of education, assessing the effectiveness of a tool is contingent on its ability to support pedagogy and cater to the diverse needs of learners. While e-learning platforms have the potential to overcome physical and temporal constraints, it is essential to ensure that their design aligns with crucial pedagogical principles. Therefore, in designing our LMS, we prioritized addressing the following questions:

- How can the design of our LMS align with the standards and norms of e-learning programs?
- What innovative technical features can our LMS offer, and what engineering methods should we employ to ensure its success?
- How can we seamlessly integrate learning theories to foster effective online learning within our LMS?

Our conceptual model of the platform was developed to address inquiries and assess its value and effectiveness in guiding the design, evolution, and implementation of e-learning systems, with a specific focus on the LMS. The overarching goal is to evaluate the feasibility and practicality of our proposed model. To accomplish this, the study begins by highlighting two pivotal learning theories that shape our platform: behaviorism and social constructivism. These enduring theories, with significant influence on the evolution of computer applications, serve as foundational cornerstones. Subsequently, we integrate these well-established theories with emerging pedagogical potentials to formulate innovative frameworks for our new web-based collaborative LMS. The envisioned platform aims to strategically leverage technology for learning, recognizing users as active participants and transcending the boundaries of passive consumption [4].

In the subsequent sections, we undertake an in-depth examination, assessing usability and evaluating technology acceptance for our contributions. We explore the integration of multiple learning theories in our unique approach, its promotion of collaboration, and its contributions to advancing e-learning platforms. Additionally, we delve into the implications of our findings and discuss how they may influence the future of e-learning, fostering more effective and inclusive educational experiences.

2. METHOD

LMS encounter challenges encompassing both pedagogical and technical dimensions, underscoring the necessity to analyze these interconnected issues for the development of a more suitable solution, especially tailored for learners. While the potential of the LMS is considerable in fostering knowledge construction and competency growth, its effectiveness in achieving authentic pedagogical success relies on its alignment with firmly established and validated learning theories [5]. The innovative model presented here is designed to address these challenges based on three foundational principles.

The first principle involves categorizing the types of learning activities proposed and their structures, including unrestricted, sequential, conditional, and others. This classification serves to establish a clear and organized platform for learning activities, facilitating easier navigation and comprehension of course content for learners. The second principle recognizes the diverse actors and/or groups in terms of their roles and responsibilities. This guarantees that everyone engaged in the learning process, including instructors, learners, and administrators, comprehends their specific roles and responsibilities. This clarity promotes effective communication and collaboration among the participants.

The third principal entails defining distinct spaces for activities within the learning system, incorporating a diverse range of resources like multimedia documents, discussion forums, wikis, video conferencing, mind maps, and exercises. This assortment equips learners with a variety of tools and resources, encouraging different approaches to engage with content and fostering active learning. Integrating these principles into our web-based collaborative LMS enables the development of a more effective and learner-centered platform, addressing both pedagogical and technical challenges encountered by traditional LMS. This approach offers a personalized and engaging learning experience for learners while fostering effective communication and collaboration among all participants in the learning process.

Following the prototyping phase of our web-based collaborative learning platform, the system underwent testing and evaluation by teachers (N=20) concerning usability issues and their acceptance of the system. Utilizing standard questionnaires from the computer system usability questionnaire (CSUQ) version 3 as a theoretical framework, we assessed the system's usability through a survey comprising 16 items, with responses recorded on a 7-point scale. The CSUQ is commonly used for evaluating perceived usability and is categorized into three subscales: system quality, information quality, and interface quality [6]. Furthermore, to explore teachers' acceptance of the proposed LMS, the technology acceptance model (TAM) was employed, gathering responses on a 5-point scale. The framework is composed of three fundamental constructs: perceived usefulness (PU), perceived ease of use (PEU), and behavioral intention to use (BIU) the proposed

system [7]. In the context of this study, we introduced external variables into the TAM, such as attitude toward the system (ATT), perceived interaction (PI), self-efficacy (SE), user interface design (UID), and online course design (OCD). This inclusion was made to gain a more nuanced understanding of teachers' acceptance of our proposed LMS [8], [9].

3. RESULTS AND DISCUSSION

3.1. Modeling of a LMS

The presented LMS model emerges as a promising instrument for online learning. The combination of pedagogical and technical features is noted as having the potential to significantly enhance the effectiveness of online training. In facilitating the learning process, the LMS assists learners in accessing and interacting with course materials, monitoring their progress, and receiving feedback from instructors. Technical functionalities may encompass features like gamification, interactive assessments, and multimedia resources, contributing to a more engaging and effective learning experience.

Furthermore, by facilitating the design and development of online training systems, the LMS supports instructors in the creation and delivery of high-quality online courses. This involves incorporating features such as course templates, content authoring tools, and collaboration tools to enhance the development and delivery of engaging and effective online learning experiences. Founded on a distinctive pedagogical framework, our LMS combines two separate learning theories with their corresponding functionalities. This integration aims to enhance the teaching and learning experiences for all users. Each of these two learning theories brings distinct advantages that collectively enhance our LMS, reinforcing both its pedagogical and technical capabilities.

The LMS we propose is based on two separate learning theories, each contributing unique functionalities to enhance both teaching and learning experiences. Drawing from behaviorism, our LMS is organized into learning units that provide structured knowledge, gradual application exercises, and essential support. The incorporation of internal and external applications, promoting communication and collaboration among educational participants, is rooted in social constructivism. This approach prioritizes collective knowledge-building over individualized learning paths.

Users can customize the LMS according to their preferences, facilitated by integrated web services accessible through modular interfaces. This capitalizes on the flexibility offered by our LMS. As Hoogstoel [10] suggests, this flexibility "enhances individual motivation and encourages engagement."

The modeling approach introduced combines two learning theories to create an optimal blend of pedagogical and technical richness for both learners and teachers. This is achieved while maintaining adherence to principles of reusability and interoperability. The approach emphasizes focused resources, rooted in the concept of "bricks" and "aggregates," contributing significantly to this harmonized framework [11], enhancing the utilization and reusability of learning objects across various contexts, regardless of the employed pedagogical approaches and scenarios. Additionally, our approach is inspired by Koper's [11] concept of learning units and pedagogical activities. This empowers users of our LMS to personalize their preferred activities, aligning them with the roles envisioned in the proposed learning ecosystem. Within this ecosystem, a wide range of services, resources, and tools are available, all geared toward achieving learning objectives. Essentially, the proposed modeling approach ensures effective management of online interaction, enhances learners' independence and sustains their motivation.

3.2. Prototyping process summary report

In this subsection, we focus on introducing the general information interface of the course within the disciplinary information space, you can see in Figure 1. In the initial section of Figure 1(a), the author or teacher is endowed with several privileges essential for crafting a course that adheres to academic standards. These privileges include the ability to:

- Provide a general course title, an image, and a brief course description that are visible when the course is first accessed.
- Incorporate a concise introduction, course details, and a conclusion that becomes available when a learner seeks more detailed information about the course.
- Specify the course's start and end dates, indicating the session's duration and allowing for session closure after the designated period.
- Define the course's licensing terms to ensure compliance with copyright regulations.
- Incorporate a difficulty index into the course, facilitating the recommendation of courses suitable for each learner's proficiency level.
- Select the course's language to tailor recommendations based on each learner's language preferences.
- Choose the course area to simplify searches based on subject matter.

In the course prerequisite interface (illustrated in Figure 1(b)), the author or teacher holds several crucial privileges for establishing course objectives in alignment with academic standards. These privileges include the ability to reference prerequisites, enabling learners to commence the course session. Within the course objectives interface, as depicted in Figure 1(c), the author or teacher is endowed with the required privileges to establish course objectives by academic standards. This encompasses the ability to outline all course objectives, enabling learners to evaluate if the course aligns with their requirements. Within the course's chapter interface, as depicted in Figure 1(d), the author or teacher holds key privileges necessary for constructing course chapters in compliance with academic standards. These privileges include the ability to insert chapter titles, introductions, and conclusions for all course chapters, aiding learners in assessing the appropriateness of the course content. Chapters can be designated as "active" if they meet quality standards or "inactive" if modifications are needed.

In the block interface of a chapter section and block, outlined in Figure 1(e), the author or teacher holds several essential privileges crucial for developing section blocks that align with academic standards. These privileges include the option to choose the chapter and section for adding blocks. For each section block, the author can precisely define the title and content. Blocks can be designated as "active" if the information is well-constructed or marked as "inactive" if modifications are deemed necessary.

In the course references interface (as depicted in Figure 1(f)), the author or teacher is endowed with a range of essential privileges crucial for crafting course references by academic standards. These privileges include:

- Selecting the reference type, such as article, chapter, book, thesis, manuscript, report, and web page.
- Inputting the title, publication date, and a summary of the reference.
- Listing authors and indicating their order, including first, second, and subsequent authors for each reference.
- Providing comprehensive details like volume, issue, DOI, publication journal, and page numbers to facilitate efficient reference searches.

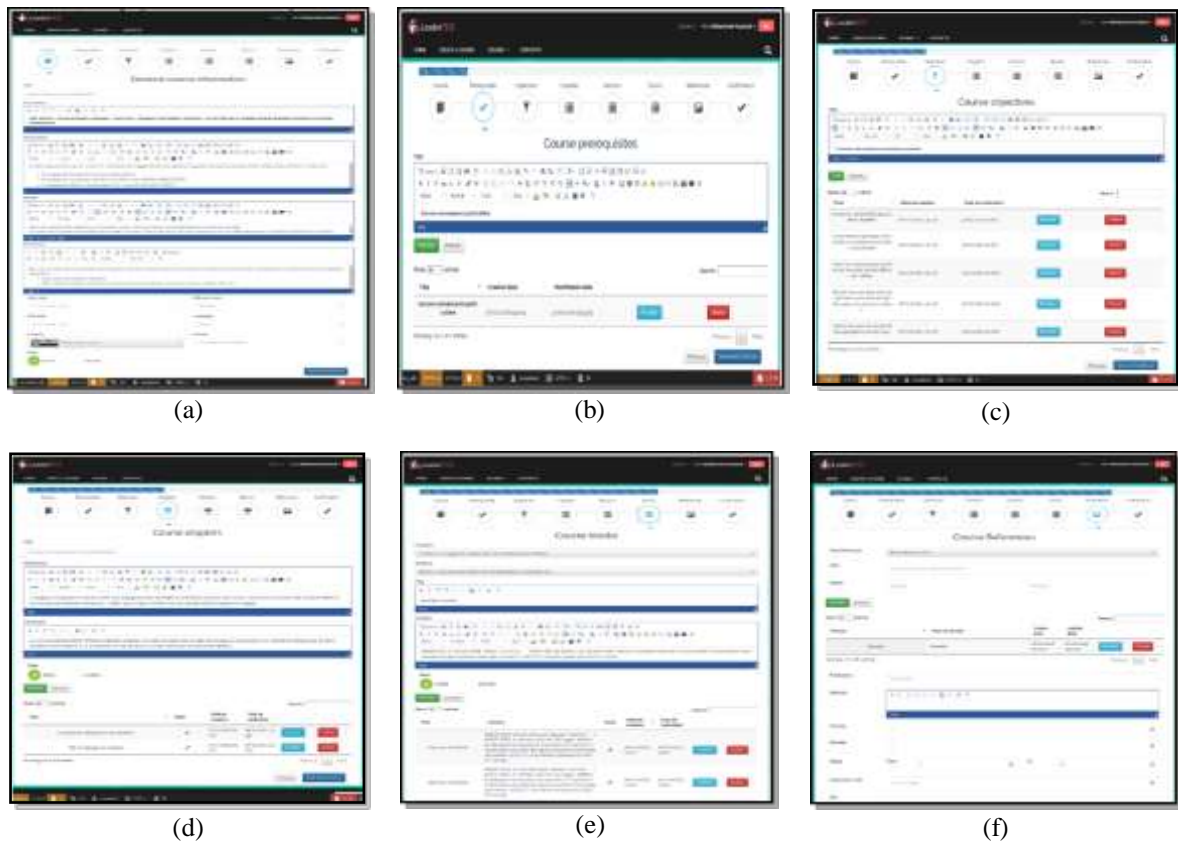


Figure 1. Prototype development result; (a) general course information, (b) course prerequisites, (c) course objectives, (d) course chapters, (e) course blocks, and (f) course references

Figure 2 provides a variety of tools tailored to accommodate diverse learning preferences. Learners can further enhance flexibility by choosing their preferred learning medium. Within the "general course outline interface" as illustrated in Figure 2(a), learners have access to view all chapters, sub-chapters, and

references within a course. Moreover, the interface provides a range of tools tailored to accommodate diverse learning styles-whether visual, auditory, or audiovisual. To enhance this flexibility, learners can choose their preferred learning medium, which may include audio, video, images, and text.

Learners also can manage the activation status of each section. They can designate a section as “active” when the information is well-presented or as “inactive” if modifications are needed to improve its quality. Within the “course details interface” depicted in Figure 2(b), learners are equipped with tools to enhance their understanding of a course by their learning styles-be it visual, auditory, or audiovisual. The system assesses the learner’s preferences in learning styles and provides recommendations for suitable learning media based on these preferences. Additionally, after each chapter, a symbol is provided to facilitate easy navigation to the next chapter for learners.



Figure 2. Content development result (a) general course outline interface and (b) course details interface

3.3. Usability validation

Preceding the evaluation phase, educators affiliated with the National School of Applied Sciences at Sidi Mohamed Ben Abdellah University in Fez, Morocco, and serving as participants, actively engaged with the system through a series of tasks. These tasks included activities like logging into the system, managing classroom affairs, assessing student tasks, and overseeing homework assignments. To ensure clarity regarding the study’s objectives and to obtain their consent for the use of shared research materials, participants were provided with a consent form, which they reviewed and signed. To assess the usability of the system, we utilized the well-established CSUQ version 3. This questionnaire consists of 16 positively formulated statements, each rated on a 7-point scale. Widely recognized as a tool for investigating software usability concerns, the CSUQ was employed in the evaluation of our web-based collaborative LMS, focusing on aspects related to system, information, and interface quality. The results, presented in Tables 1 and 2, include CSUQ rating percentages along with corresponding score descriptors. The average score for CSUQ items exceeded 5, with a score of 7 indicating strong agreement. Scores for system quality, information quality, and interface quality ranged from 5 to 7, reflecting the favorable perception of the platform across these dimensions by educators.

Table 1. Percentages of the CSUQ ratings for web-based collaborative LMS prototype (N=20)
Scale: strongly disagree to strongly agree 1-7

Score	CSUQ system quality (%)	CSUQ information quality (%)	CSUQ interface quality (%)
1-3	0%	0%	0%
4	10% (2/20)	5% (1/20)	10% (2/20)
5	40% (8/20)	35% (7/20)	25% (5/20)
6	40% (8/20)	45% (9/20)	45% (9/20)
7	10% (2/20)	15% (3/20)	20% (4/20)

Table 2. Descriptive statistics of the CSUQ scores (N=20)

Aspect items	Mean	Std. deviation
CSUQ system quality	5.55	0.88258
CSUQ information quality	5.65	0.81273
CSUQ interface quality	5.75	0.92338

3.4. Acceptance of our web-based collaborative LMS

In our research, we employed the TAM as the foundational theoretical framework to analyze the adoption and intention to use a web-based collaborative learning platform among teachers. This study integrated the three key variables of TAM: PU, PEU, and BIU, as outlined in the literature [12], [13]. The survey data, outlined in Table 3, indicates that the average scores for all TAM constructs surpassed 4.1, with the highest possible score being 5. These results imply that the platform is user-friendly and could be easily adopted by teachers, potentially enhancing their professional effectiveness in both learning and teaching contexts. Furthermore, the item related to BIU scored above 4.15, indicating a strong inclination among educators to embrace this system for remote education.

The survey also assessed additional TAM-related factors:

- Attitude (ATT): this measures the positive perspective of teachers towards utilizing the platform.
- Self-efficacy (SE): This evaluates teachers' confidence in their ability to obtain information and their proficiency with educational technology [14].
- Online course design: This underscores the crucial role of teachers in creating online courses.
- Interaction: This examines the dynamics of the human system and interpersonal interactions.
- User interface design: this focuses on the user-centric elements and essential aspects of software development.

All these external TAM constructs ATT, SE, OCD, PI, and UID achieved an average score above 4.1, indicating a favorable reception and endorsement of the platform by the teaching staff. In summary, teachers' evaluations are predominantly positive, leaning towards the higher end of the scale, indicating a notable level of acceptance for the system. However, the distribution of scores also reveals variability in teachers' perceptions and experiences, with some identifying more opportunities for improvement than others. This variability may stem from differences in personal preferences, specific needs of teachers, or varying levels of familiarity with technology. A more in-depth inquiry into the factors contributing to lower scores could yield valuable insights for enhancing the system.

Table 3. Survey responses for TAM original and external construct (N=20)

	Items	Mean	Std. deviation
TAM original construct	TAM perceived usefulness (1-5)	4.10000	0.71818
	TAM perceived ease of use (1-5)	4.20000	0.76777
	TAM behavioral intention (1-5)	4.15000	0.74516
TAM external construct	TAM attitude (1-5)	4.40000	0.68056
	TAM perceived interaction (1-5)	4.10000	0.71818
	TAM self-efficacy (1-5)	4.30000	0.73270
	TAM UI design (1-5)	4.30000	0.73270
	TAM online course design (1-5)	4.30000	0.73270

3.5. Discussion

Various research endeavors have delved into the exploration of a range of modeling methodologies [15]–[18], all to revolutionize unit design, architectural platforms, and adaptive, interactive e-learning tools. For instance, Sadiq and Talbi [19] introduced the concept of modeling learning units on e-learning platforms through the implementation of the IMS learning design standard, thereby promoting the development of adaptive learning units. Concurrently, Tonye [20] conceptualized a distance education model meticulously

tailored to the African context, and Chouchane [21] advocated for the adoption of an adaptive agent-based approach in mobile learning (m-learning), strategically designed to cultivate a mobile learning system that embodies efficiency and flexibility. Brunel *et al.* [22] proposed a comprehensive modeling platform based on five core functions: organization of learning, information dissemination, collaboration, guidance, and content generation. Similarly, Aammou *et al.* [23] introduced the notion of integrating conventional adaptive hypermedia features into an open environment, utilizing ontologies for describing learning elements and architectural models.

Concurrently, Dahmani [24] expounded on an ontology-driven modeling approach for interactive learning, placing a specific emphasis on employing ontological engineering to model educational domains and assess learners' comprehension. It's worth noting that Ghanim introduced an innovative ontological framework for e-learning, highlighting metacognitive awareness, adaptive tutoring, and time management skills. This framework encompasses a domain ontology, a result domain ontology, and a course ontology model [25]. Building on existing research, a novel web-based collaborative LMS was created, adopting an anthropocentric perspective and incorporating insights from various widely employed learning theories. The platform is specifically designed to address the needs of all users, with a particular emphasis on learners, aiming to optimize the experience of online learning.

4. CONCLUSION

Within this paper, we present a pioneering conceptual model for a web-based collaborative LMS, merging two distinct learning theories: behaviorism and social constructivism. Our overarching aim is to establish an LMS that is learner-centric while also accommodating dynamic contributions from educators. The proposed LMS platform incorporates adaptable web services to address users' needs, fostering flexibility in teaching and learning. This adaptability allows for the creation, adjustment, and customization of various LMS components to meet diverse needs, ultimately enhancing the educational experience. One noteworthy feature of our proposed web-based collaborative LMS is its provision of identical interactive intervention capabilities to both teachers and learners. This is facilitated through user-friendly configuration interfaces, including personalized offices and various activity spaces, to optimize the online teaching and learning experience. The practical insights gained from these tests will empower us to make informed decisions, to optimize the functionality and usability of our proposed system. These decisions will also serve as a strategic guide for promoting more effective utilization and fostering broader adoption of the LMS in the future.




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