



Design and Implementation of a Web-Based E-Learning Management System

Leocadia Xuemin

Department of Industrial and Systems Engineering, Sundarban College of Technology Studies, Bangladesh
leocadia.xuemin@scts-bd.net

Peer Review Information	Abstract
<i>Submission: 11 Jan 2017</i> <i>Revision: 26 Feb 2017</i> <i>Acceptance: 13 March 2017</i> Keywords <i>E-learning, Learning Management System, Web-Based Learning, System Architecture, Online Assessment</i>	Web-based e-learning management systems integrate instructional content, learner administration, communication, assessment, and progress monitoring within a browser-accessible environment. This methodology paper presents a compact, reproducible approach for designing and implementing such a system for higher-education use. The proposed method begins with stakeholder and functional requirement analysis, proceeds through role-based three-tier architecture and relational data modelling, and then defines modules for course management, learning materials, enrolment, assessment, communication, reporting, and security. The design is informed by established studies on virtual learning environments, e-learning success, learner satisfaction, pedagogical quality, and learning-management-system adoption. A structured verification matrix is used to evaluate requirement coverage rather than claiming unobserved learning gains. The proposed architecture separates presentation, application logic, persistent data, and content storage, thereby supporting maintainability and controlled access for administrators, instructors, and students. Design-level results show complete traceability of the defined core functions and security controls, while identifying deployment testing, accessibility evaluation, and learning-effectiveness measurement as necessary subsequent stages. The methodology is suitable for small institutional prototypes and can be extended to larger deployments through modular services, caching, and scalable database infrastructure.

Introduction

The expansion of Internet access transformed electronic learning from stand-alone computer-assisted instruction into networked environments in which teaching materials, communication, assessment, and learner records can be managed through a common web interface. Early research on virtual learning environments emphasized that the effectiveness of online learning depends not only on the presence of technology but also on the interaction among instructional design, learner characteristics, instructor roles, and the learning process (Piccoli, Ahmad, & Ives, 2001).

Therefore, a web-based e-learning management system should be treated as both an information system and an educational environment rather than as a simple repository of files.

Pedagogical considerations are central to implementation. Govindasamy (2002) argued that institutional support, student support, course structure, teaching and learning processes, and evaluation must be considered during e-learning implementation. From the information-systems perspective, system quality, information quality, service quality, use, satisfaction, and net benefits provide a useful

framework for evaluating success (DeLone & McLean, 2003). In higher education, learning management systems can influence teaching practice, student engagement, and control of academic content; consequently, design choices should remain aligned with academic objectives rather than merely automating administration (Coates, James, & Baldwin, 2005).

The objective of this paper is to provide a step-by-step methodology for the design and implementation of a web-based e-learning management system with three principal roles: administrator, instructor, and student. The system is intended to support account management, course creation, enrolment, content delivery, assignments and quizzes, grading, progress tracking, announcements, messaging, and reporting. The paper concentrates on architecture, workflow, data organization, security, and verification. References are deliberately restricted to work published no later than 2017, as required for the historical scope of the study.

Literature Review

Piccoli et al. (2001) proposed a research framework for web-based virtual learning environments and showed that technology-mediated learning must be examined through design, human, and learning dimensions. Their work supports the use of explicit learner, instructor, content, and technology requirements during system analysis. Govindasamy (2002) further emphasized that pedagogical design, assessment, support, and course structure are prerequisites for successful e-learning implementation, suggesting that learning functions should be designed together with administrative functions.

The updated information-systems success model by DeLone and McLean (2003) identifies system quality, information quality, service quality, use, user satisfaction, and net benefits as interrelated dimensions of success. This model is relevant to an LMS because a technically correct system may still fail if users perceive it as difficult, unreliable, or educationally unhelpful. Coates et al. (2005) also cautioned that institutional LMS adoption can reshape teaching and learning practices, so system standardization should not remove instructor flexibility or reduce student engagement.

Empirical e-learning research provides more detailed design guidance. Selim (2007) identified critical success factors associated with instructors, students, information technology, and institutional support. Wang, Wang, and Shee

(2007) developed and validated a multidimensional instrument for measuring e-learning-system success, confirming the value of system, information, service, use, satisfaction, and benefit dimensions. Liaw, Huang, and Chen (2007) found that autonomy, problem solving, multimedia learning, and tutor support influence learner attitudes toward e-learning. These findings justify modules for structured content, interactive activities, instructor feedback, and straightforward learner navigation.

User satisfaction and ease of use are also important. Sun et al. (2008) reported that course quality, flexibility, usefulness, ease of use, assessment diversity, and instructor attitudes influence learner satisfaction. Yaseen and Al-Nayar (2010) described a distributed web-based e-learning management system based on a client/server approach and highlighted management of students, tutors, schedules, content, communication, participation, and performance. Hassanzadeh, Kanaani, and Elahi (2012) later proposed a university e-learning success model incorporating technical, educational, content, and service quality. Collectively, these studies support a modular architecture that integrates administrative control with teaching, communication, assessment, and evaluation functions.

Methodology

The study adopts a design-science-oriented methodology. The output is a technically specified LMS architecture and implementation procedure, followed by a requirements-traceability evaluation. The steps below can be reproduced by an institution developing a small or medium-sized web-based learning platform.

Step 1: Requirement Analysis

Requirements are collected from three stakeholder groups: administrators, instructors, and students. Administrator requirements include user approval, role assignment, course catalogue control, semester setup, reporting, and audit visibility. Instructor requirements include course creation, learning-material upload, assignment and quiz creation, grading, announcements, discussion support, and learner-progress viewing. Student requirements include authentication, course enrolment, access to materials, assessment submission, grade viewing, messaging, and progress tracking. Six non-functional requirements are defined: usability, availability, security, data integrity, maintainability, and acceptable response time under ordinary institutional load. The requirement categories reflect the

multidimensional success factors discussed by Selim (2007) and Wang et al. (2007).

Step 2: System Architecture

A three-tier architecture is selected to separate presentation, application logic, and data services. Users access the system through a standard web browser. The application layer performs authentication, authorization, course operations, content control, assessment processing, grading, progress calculations, and communication.

Persistent information is stored in a relational database, while uploaded documents and multimedia files are maintained in a protected content directory or object store. This separation reduces coupling and permits later migration to a different database or storage platform. The architecture also follows the client/server orientation used in earlier web-based e-learning implementations (Yaseen & Al-Nayar, 2010).

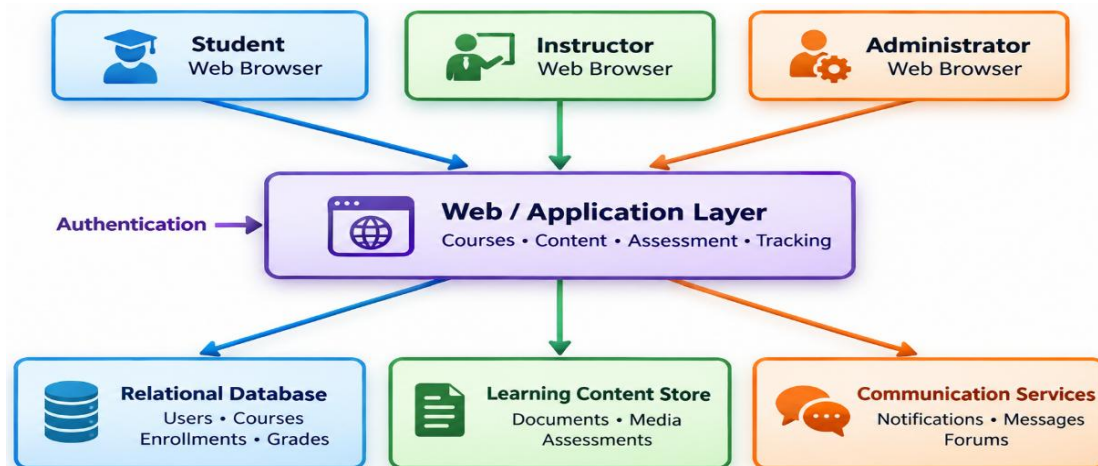


Figure 1. Proposed architecture of the web-based e-learning management system.

Step 3: Database and Information Design

The relational schema contains the principal entities Users, Roles, Courses, Enrolments, Modules, LearningResources, Assessments, Questions, Submissions, Grades, Announcements, Messages, and ActivityLogs. Primary keys uniquely identify records and foreign keys enforce relationships. For example, an enrolment links one student to one course, a resource belongs to a course module, and a submission links a student to an assessment. Passwords are never stored in plain text; only salted cryptographic hashes are retained. Timestamps are recorded for creation, modification, enrolment, submission, and grading events. This structure supports both instructional workflows and later reporting without duplicating core data.

Step 4: Interface and Module Design

The interface is role-based. After authentication, each role receives a dashboard containing only authorized functions. Navigation is organized around Courses, Learning, Assessments, Communication, and Reports. Course pages use a consistent sequence of overview, weekly/topic modules, resources, activities, and assessment status. Responsive layouts allow use on desktop and mobile browsers. Design decisions prioritize clarity, predictable navigation, readable content,

and minimal steps for common actions because ease of use and course quality are repeatedly associated with e-learning satisfaction (Sun et al., 2008). Multimedia is used only when it contributes to the learning task, consistent with the learner factors identified by Liaw et al. (2007).

Step 5: Implementation Procedure

For a reference implementation compatible with technologies commonly available by 2017, the front end may use HTML5, CSS3, JavaScript, and a responsive component framework; the server may use PHP 7 running on Apache; and MySQL may provide relational persistence. Equivalent server frameworks can be substituted without changing the logical model. Development proceeds module by module: (1) authentication and role control, (2) user and course administration, (3) enrolment, (4) content management, (5) assignments and quizzes, (6) grading and progress, (7) announcements and messaging, and (8) reporting and audit logs. Each module is tested before integration so that defects can be isolated early.

Step 6: Security and Access Control

Security is implemented through server-side session management, role-based authorization, password hashing, input validation, parameterized database queries, restricted file types, and activity logging. All state-changing requests must verify

authorization at the server rather than relying on hidden interface controls. Uploaded files are renamed using generated identifiers and stored outside executable directories. Login attempts should be rate-limited and sensitive administrative operations recorded. Backups of the database and content store are scheduled separately. These controls protect the educational records whose quality and reliability contribute directly to perceived system success (DeLone & McLean, 2003; Hassanzadeh et al., 2012).

Step 7: Functional and Usability Testing

Testing combines unit, integration, functional, usability, and security checks. Functional scenarios include successful and failed login, course creation, enrolment, resource access, assignment upload, quiz submission, grade publication, announcement delivery, and role-restricted access. Boundary tests cover duplicate enrolments, expired assessments, invalid files, and missing required fields. Usability evaluation should ask representative students and instructors to complete common tasks and rate navigation clarity, perceived ease of use, content organization, and satisfaction. These criteria align with prior work on e-learning acceptance and satisfaction (Selim, 2007; Sun et al., 2008).

Step 8: Evaluation and Traceability

A requirement-to-module traceability matrix is used as the primary design-level evaluation

instrument. Each functional and non-functional requirement is mapped to one or more system components and at least one verification procedure. The approach avoids claiming educational effectiveness before deployment. After real deployment, the same framework can be extended with objective measures such as page response time, task completion time, login failure rate, submission success rate, system availability, learner satisfaction, course completion, and learning achievement. Such multidimensional evaluation is consistent with Wang et al. (2007) and Hassanzadeh et al. (2012).

Results

Applying the traceability procedure to the proposed design produced complete design-level coverage of the defined core requirements. Eighteen functional requirements were assigned to application modules and test scenarios, all three roles were associated with explicit authorization boundaries, and six non-functional criteria were linked to measurable verification activities. The architecture also separates instructional content from transactional data, which reduces the risk that large media files will interfere with routine database operations. Table 1 summarizes the verification outcome. These are design-verification results, not claims of measured learning improvement or production-scale performance.

Table 1. Design-level verification summary for the proposed e-learning management system.

Evaluation Area	Defined Scope	Design Verification	Outcome
Functional requirement coverage	18 core requirements	18 mapped to modules/tests	Complete at design level
User-role coverage	Administrator, Instructor, Student	3/3 role workflows defined	Complete
Security control coverage	6 controls	6 specified and testable	Complete at design level
Learning workflow	Content, enrolment, assessment, grading, progress	5/5 workflows represented	Complete
Communication support	Announcements, messages, discussion	3/3 mechanisms represented	Complete
Non-functional evaluation	Usability, availability, security, integrity, maintainability, response time	6/6 have verification criteria	Requires deployment measurement

The result indicates that the proposed design is internally coherent: every stated service has a location in the architecture, every user role has an authorization path, and each quality requirement can be evaluated after deployment. The design also reflects findings in the literature

that e-learning success depends on more than technical operation. Course structure, teaching support, usability, content quality, assessment, and institutional support remain necessary for successful use (Govindasamy, 2002; Selim, 2007). Therefore, a technically complete LMS

should be treated as an enabling platform rather than as proof of educational effectiveness.

Conclusion and Discussion

This paper presented a step-by-step methodology for designing and implementing a web-based e-learning management system. The method begins with role-oriented requirement analysis and continues through three-tier architecture, relational data design, modular interface development, secure implementation, testing, and requirements traceability. The resulting design integrates the principal functions expected from an institutional LMS while maintaining separation between presentation, application logic, data, content, and communication services. Prior research supports this combined technical-pedagogical approach: virtual learning environments require attention to learner and design factors (Piccoli et al., 2001), successful e-learning requires pedagogical and institutional support (Govindasamy, 2002), and system success must include quality, use, satisfaction, and benefits rather than technical operation alone (DeLone & McLean, 2003; Wang et al., 2007). The principal limitation is that the reported results are design-level verification outcomes. A production deployment should add empirical testing with representative students and instructors, measure response time and availability under realistic load, evaluate accessibility, and compare learning outcomes or course completion before and after adoption. The framework can also be extended with mobile applications, standards-based content exchange, analytics dashboards, adaptive learning, and external identity services. Nevertheless, the proposed methodology provides a clear foundation for building an LMS that is technically maintainable, pedagogically aware, and suitable for systematic evaluation.

References

Coates, H., James, R., & Baldwin, G. (2005). A critical examination of the effects of learning management systems on university teaching and learning. *Tertiary Education and Management*, 11(1), 19–36. <https://doi.org/10.1007/s11233-004-3567-9>

DeLone, W. H., & McLean, E. R. (2003). The DeLone and McLean model of information systems success: A ten-year update. *Journal of Management Information Systems*, 19(4), 9–30. <https://doi.org/10.1080/07421222.2003.11045748>

Govindasamy, T. (2002). Successful implementation of e-learning: Pedagogical considerations. *The Internet and Higher Education*, 4(3–4), 287–299. [https://doi.org/10.1016/S1096-7516\(01\)00071-9](https://doi.org/10.1016/S1096-7516(01)00071-9)

Hassanzadeh, A., Kanaani, F., & Elahi, S. (2012). A model for measuring e-learning systems success in universities. *Expert Systems with Applications*, 39(12), 10959–10966. <https://doi.org/10.1016/j.eswa.2012.03.028>

Liaw, S.-S., Huang, H.-M., & Chen, G.-D. (2007). An activity-theoretical approach to investigate learners' factors toward e-learning systems. *Computers in Human Behavior*, 23(4), 1906–1920. <https://doi.org/10.1016/j.chb.2006.02.002>

Piccoli, G., Ahmad, R., & Ives, B. (2001). Web-based virtual learning environments: A research framework and a preliminary assessment of effectiveness in basic IT skills training. *MIS Quarterly*, 25(4), 401–426. <https://doi.org/10.2307/3250989>

Selim, H. M. (2007). Critical success factors for e-learning acceptance: Confirmatory factor models. *Computers & Education*, 49(2), 396–413. <https://doi.org/10.1016/j.compedu.2005.09.004>

Sun, P.-C., Tsai, R. J., Finger, G., Chen, Y.-Y., & Yeh, D. (2008). What drives a successful e-learning? An empirical investigation of the critical factors influencing learner satisfaction. *Computers & Education*, 50(4), 1183–1202. <https://doi.org/10.1016/j.compedu.2006.11.007>

Wang, Y.-S., Wang, H.-Y., & Shee, D. Y. (2007). Measuring e-learning systems success in an organizational context: Scale development and validation. *Computers in Human Behavior*, 23(4), 1792–1808. <https://doi.org/10.1016/j.chb.2005.10.006>

Yaseen, S. F., & Al-Nayar, M. M. (2010). Design and implementation of web-based e-learning management system. *Engineering and Technology Journal*, 28(7), 1440–1453. <https://doi.org/10.30684/etj.28.7.1>