

Development of a Standalone Adaptive Mobile Learning Management System with AI-Based Personalized Learning Recommendations

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ABSTRACT

This study focuses on the development of a Standalone Adaptive Mobile Learning Management System with AI-Based Personalized Learning Recommendations for higher education students. The proposed system aims to provide personalized learning support by using learner performance and engagement information to recommend appropriate learning materials, practice activities, and feedback. The system will integrate common Learning Management System functions, including user account management, subject and enrollment management, learning materials, assessments, assignment submission, progress tracking, notifications, offline access with synchronization, and QR-based attendance. An AI-based recommendation module will process available learner information to generate recommendations based on the learner's current progress and knowledge state. The study will use a Descriptive-Developmental Research Design and Quantitative Approach, with Agile Scrum as the system development methodology. The developed system will undergo functional testing and user evaluation focusing on usability, effectiveness, and user satisfaction. The expected output is a functional standalone mobile learning platform that integrates conventional LMS functions with adaptive recommendations and mobile-oriented learning support. The study aims to provide a more responsive and accessible learning environment while supporting the educational technology goals associated with Sustainable Development Goal 4, Quality Education.

Keywords: Adaptive Learning, Artificial Intelligence, Personalized Learning, Mobile Learning, Learning Management System.

SECTION I — INTRODUCTION (THE PROBLEM AND ITS SETTING)

1.1 Introduction

Learning Management Systems (LMS) have become an important part of modern education because they provide a centralized environment where students can access learning materials, activities, assessments, assignments, and information about their academic progress. Through an LMS, teachers can organize instructional resources and monitor learner performance, while students can access course materials and complete learning activities through digital devices. However, a common limitation of many LMS platforms is that the learning experience may still be largely the same for different students even though learners differ in their prior knowledge, pace, performance, engagement, and learning needs.

This study focuses on the development of a Standalone Adaptive Mobile Learning Management System with AI-Based Personalized Learning Recommendations. The proposed system is designed to use learner

performance and engagement information as a basis for recommending learning materials, practice activities, and feedback. Instead of relying only on a fixed sequence of lessons, the system will consider the learner's current progress and knowledge state when determining suitable learning support.

The integration of artificial intelligence (AI) and machine learning into e-learning has become an important direction in educational technology. Existing literature discusses how machine learning techniques can identify patterns in learner behavior and support adaptive instructional content. AI-based recommendation approaches can also assist learning systems in selecting learning actions according to changes in a learner's state rather than relying entirely on predetermined rules (Essa et al., 2023; Gligorea et al., 2023; Li et al., 2023).

The proposed system will combine common LMS functions with an AI-based recommendation module and learner knowledge-state information. It will include user account management, subject and enrollment management, learning content, assessments, assignment submission, progress tracking, notifications, offline access with synchronization, and QR-based attendance. The system will operate as a standalone platform, meaning that student accounts, subjects, and enrollments will be managed within the proposed system by authorized administrators or teachers instead of requiring direct integration with an external institutional information system.

The study is intended to provide higher education students with a more personalized and accessible learning environment. The system will analyze available learner information and use it to recommend appropriate content and activities. It is also designed with mobile-first access so that learning resources can be used through mobile devices. The study is mainly aligned with Sustainable Development Goal 4, Quality Education, because it explores the use of technology to support more responsive and accessible learning experiences.

1.2 Background of the Study

Traditional LMS platforms are useful for organizing online learning because they provide a structured location for course materials, activities, assessments, and student records. Nevertheless, a conventional LMS may follow a predetermined content sequence in which students are exposed to similar materials regardless of whether they have already mastered a topic or require additional practice. Differences in academic performance may therefore require additional support that is not automatically provided by a fixed learning path.

Adaptive learning addresses this concern by allowing a learning environment to respond to learner information. Adaptive systems may use assessment results, learning activities, interaction patterns, and other available information to determine what a learner may need next. Recent literature has explored adaptive learning, intelligent tutoring systems, pedagogical agents, and AI-based recommendations as approaches for supporting personalized content sequencing and feedback (Apoki et al., 2022; Demartini et al., 2024; Halkiopoulos & Gkintoni, 2024).

The proposed research places these ideas within a standalone LMS. Rather than depending on the school's existing enrollment or student information system, the proposed platform will have its own database and management functions. Authorized administrators or teachers will be able to create subjects, manage students, organize learning resources, and assign students to subjects. This approach allows the proposed system to function as an independent learning platform while still providing the essential features expected from an LMS.

Mobile accessibility is another important consideration of the proposed system. Higher education students may access learning resources through smartphones and other mobile devices, and internet availability may vary depending on location and connectivity. For this reason, the system will include mobile-first features such as push notifications and selected offline learning access with synchronization when connectivity

becomes available. QR-based attendance will also be included as a supporting classroom-management feature.

The study therefore proposes a Standalone Adaptive Mobile Learning Management System with AI-Based Personalized Learning Recommendations. The system will bring together LMS functions, learner performance information, adaptive recommendations, and mobile-oriented features in one platform. The researchers will develop and evaluate the proposed system based on usability, effectiveness, and user satisfaction.

1.3 Objectives of the Study

The general objective of this study is to design, develop, and evaluate a Standalone Adaptive Mobile Learning Management System with AI-Based Personalized Learning Recommendations that provides individualized learning support to higher education students.

Specifically, the study aims to:

1. Develop a standalone mobile Learning Management System that manages students, subjects, learning content, assessments, assignment submission, and progress tracking.
2. Design and integrate an AI-based recommendation module that analyzes learner performance and engagement and recommends appropriate learning materials, practice activities, and feedback.
3. Integrate mobile-first features such as push notifications, offline access with synchronization, and QR-based attendance.

Evaluate the developed system in terms of usability, effectiveness, and user satisfaction based on feedback from intended users.

1.4 Scope and Limitation of the Study

The study focuses on the design, development, and evaluation of a standalone Adaptive Mobile Learning Management System with AI-based personalized learning recommendations for higher education students. The system will include user accounts, subject and enrollment management, learning materials, assessments, assignment submission, progress tracking, AI-based recommendations, push notifications, offline access with synchronization, and QR-based attendance.

The system will operate independently and will not require direct integration with the school's existing Student Information System or other external institutional platforms. Student accounts, subject records, and enrollment information will be managed inside the proposed system by authorized administrators or teachers.

The adaptive recommendation feature will use learner performance and engagement information available within the system. AI-based recommendations will be generated through the system's online recommendation component. During offline use, selected learning materials and previously generated recommendations may remain accessible on the mobile device. Learner activities completed while offline will be stored locally and synchronized with the system when an internet connection becomes available, after which updated learner information may be processed for subsequent recommendations.

The recommendations will be intended as learning support and will not completely replace teachers, instructors, or human tutoring. The system will also be limited to the functions defined by the researchers and the participating institution. The final number of respondents, implementation period, and evaluation sample will depend on research approval and participant availability.

The study will focus on system development and user evaluation rather than establishing that the system produces long-term improvements in academic achievement. Evaluation will concentrate on usability,

effectiveness, and user satisfaction as identified in the research objectives.

1.5 SIGNIFICANCE OF THE STUDY

Students. The system may help students access learning materials, practice activities, assessments, and feedback that are more closely related to their current performance and progress. Mobile access and offline synchronization may also support learning when internet connectivity is not continuously available.

Teachers. The system may help teachers organize learning resources, monitor learner progress, review assessment results, and provide additional learning support through the recommendations generated by the system.

School Administration. The system may provide an independent platform for managing students, subjects, enrollments, learning content, assessments, and other academic information included within the scope of the project.

Future Researchers. The study may serve as a reference for researchers who plan to explore adaptive learning, AI-based recommendations, learner modeling, mobile LMS development, and related educational technologies.

Educational Technology Development. The study may contribute a practical standalone approach that combines common LMS functions, learner information, adaptive recommendations, and mobile-first features within one platform.

1.5 Significance of the Study

1.6 Definition of Terms

Adaptive Learning Management System. An LMS that adjusts learning content, activities, or recommendations based on learner information and progress.

Artificial Intelligence (AI). A technology component used in the proposed system to process learner information and support personalized learning recommendations through the system's recommendation approach.

Content-Based Recommendation. A recommendation approach that matches a learner's identified learning needs and available learning information with relevant learning materials or activities based on their characteristics.

Personalized Learning Recommendation. A suggested learning material, practice activity, or feedback selected according to a learner's performance and engagement.

Learner Knowledge State. An estimate of a student's current level of understanding or mastery of learning content.

Learning Management System (LMS). A digital platform used to manage learning materials, activities, assessments, assignments, and student progress.

Standalone System. A system that operates independently and does not require direct connection to another institutional information system.

Mobile-First. An approach in which the system is designed primarily for use on mobile devices.

Offline Access. A feature that allows selected learning resources to remain available without an active internet connection and synchronizes relevant data when connectivity returns.

QR-Based Attendance. An attendance feature that uses a QR code to record a student's attendance.

Learner Engagement. The learner's interaction with learning materials, activities, assessments, and other functions of the system.

Progress Tracking. The recording and monitoring of learner performance and completion of learning activities over time.

CHAPTER II

SECTION II — LITERATURE REVIEW

2.1 Introduction to the Review

This chapter presents literature and studies related to the development of a Standalone Adaptive Mobile Learning Management System with AI-Based Personalized Learning Recommendations. The review focuses on Learning Management Systems (LMS), artificial intelligence in education, adaptive learning, personalized learning recommendations, learner data, mobile learning, offline access, software quality, and responsible use of AI. These topics are related to the main functions and goals of the proposed system.

The reviewed sources were selected from 2021 to 2026, following the required five-year period of the study. The sources include peer-reviewed journal articles and official standards or guidance from recognized organizations. The review is used to explain the ideas behind the proposed system and to identify the gap that the present study intends to address.

2.2 Review of Related Literature and Studies

A Learning Management System is a digital platform used to organize learning materials, activities, assessments, assignments, and learner records in one place. An LMS can help teachers manage learning resources and monitor student activities, while students can access learning requirements using digital devices. In the proposed study, these common LMS functions will serve as the basic foundation of the system.

The proposed system will include user accounts, subject and enrollment management, learning materials, assessments, assignment submission, progress tracking, and notifications. These functions will be combined with adaptive recommendations instead of being provided as separate learning tools.

Artificial intelligence is increasingly being studied as part of educational technology. Wang et al. (2024) reviewed a large body of research on AI in education and found that AI applications include adaptive learning, personalized tutoring, assessment, management, and learner profiling. The review also showed that system design and implementation are important areas of AI in education research.

Chiu et al. (2023) also reviewed the opportunities and challenges of AI in education. Their findings show that AI can support learning, teaching, assessment, and administration, but the use of AI also requires attention to issues such as data, implementation, and responsible use. These findings support the use of AI in the proposed system as a support feature rather than as a replacement for teachers.

Adaptive learning is an approach in which the learning content, activity, or support can respond to information about the learner. Instead of giving every learner exactly the same support, an adaptive system can use information such as assessment results, progress, and activity records to determine what may be useful next.

Gligorea et al. (2023) explained that AI and machine learning can support adaptive learning by adjusting learning paths and content according to learner needs. Essa et al. (2023) also reviewed personalized

adaptive learning technologies and showed how learner information can be used in AI-based approaches. These findings are related to the proposed system because learner performance and engagement will be used as inputs for personalized recommendations.

Personalized learning recommendations are suggestions of learning materials, practice activities, or feedback based on information about a learner. In the proposed system, recommendations will be connected to learner performance and engagement. For example, when a learner has difficulty with a topic, the system may recommend a related learning material or practice activity.

The use of recommendations is supported by recent AI-in-education research. Wang et al. (2024) identified adaptive learning and personalized tutoring as major areas of AI in education. Essa et al. (2023) also discussed the use of learner-related information in personalized adaptive learning. These studies support the idea of using learner data as a basis for selecting learning support.

Adaptive learning depends on useful learner information. Assessment scores, completed activities, progress records, and interaction with learning materials can provide information about a learner's current condition. The proposed system will use only the learner information needed within its approved scope.

This approach is consistent with the findings of Essa et al. (2023), which describe learner information as an important part of personalized adaptive learning. The proposed system will use available performance and engagement information to identify areas where a learner may need additional learning support.

Mobile learning allows students to access learning resources through smartphones and other mobile devices. This can be useful for higher education students because learning is not always limited to a desktop computer. Rangel-de Lazaro and Duarte (2023) reviewed mobile learning applications in online higher education and described mobile learning as a flexible and useful part of higher education.

A 2021 systematic review by Al-Emran et al. also examined mobile learning in higher education and identified factors that affect the use of mobile devices for learning. These findings support the mobile-first direction of the proposed system. The system will place important learning functions, including learning materials, assessments, progress, and recommendations, within a mobile-oriented platform.

A developed software system should not only provide the required functions but should also be checked for quality. ISO/IEC 25010:2023 provides a product quality model that can be used as a reference for software requirements and evaluation. The standard includes quality characteristics that can help developers and evaluators examine software quality.

For this study, software testing will focus on whether the major functions work correctly. User evaluation will focus mainly on usability, effectiveness, and user satisfaction, consistent with the objectives of the study. Other software quality areas may be included in the evaluation questionnaire when they are relevant to the final system and approved research instrument.

Agile Scrum is an iterative approach in which software is developed in smaller parts and improved through repeated development cycles. Hron and Obwegeser (2022) reviewed how Scrum is adapted in software development and found that Scrum is used in different development settings and can be adjusted based on project needs.

The proposed study will use Scrum because the system contains several connected modules, including user accounts, subjects, learning content, assessments, progress tracking, recommendations, notifications, offline access, and QR-based attendance. Developing these modules through several sprints allows the researchers to test and improve the system step by step.

Educational systems that depend on learner data must consider fairness, privacy, and access. Baker and Hawn (2022) discussed algorithmic bias in education and warned that AI-driven systems may disadvantage certain groups when data and algorithms are not carefully designed and evaluated. Apata et al. (2026) reviewed AI in higher education in relation to Sustainable Development Goals (SDG) 4 and 10 and pointed to concerns about infrastructure, privacy, and unequal access. These concerns apply to the proposed system because its recommendations depend on learner information. The researchers will therefore limit data

collection to what the study requires, protect evaluation responses, and consider access and fairness during development and evaluation. The system is also aligned with SDG 4, Quality Education, because it explores technology that provides more responsive and accessible learning support.

2.3 Conceptual Framework

The conceptual framework of the study follows the Input-Process-Output (IPO) model. The framework describes how the resources and requirements of the proposed system will be transformed through system development and adaptive recommendation processes into a functional learning platform and measurable evaluation results.

Input. The inputs include learner information, student and subject records, enrollment information, learning materials, assessment results, assignment performance, engagement information, system requirements, and mobile-learning requirements. These inputs provide the information needed by the LMS and the AI-based recommendation module.

Process. The process includes requirements analysis, system design, database and interface development, implementation of LMS functions, collection and processing of learner performance information, generation of personalized recommendations, functional testing, system evaluation, and refinement. The recommendation process will use available learner information to identify suitable learning materials, practice activities, or feedback.

Output. The expected outputs are a functional standalone Adaptive Mobile Learning Management System, personalized learning recommendations, mobile learning features, and evaluation results describing usability, effectiveness, and user satisfaction.

2.4 Synthesis

The reviewed literature and studies establish that AI, machine learning, adaptive learning, recommendation systems, learner modeling, and intelligent educational components can support personalized learning. Across the reviewed works, learner information is an important foundation because an adaptive system needs evidence of performance, progress, interaction, or knowledge to determine what type of support may be appropriate. This provides the conceptual basis for using learner performance and engagement information in the proposed system.

The reviewed studies also indicate that personalized recommendations can be used to select learning resources, activities, assessments, or pathways according to changes in learner information. Li et al. (2023) and Ruan et al. (2025) provide direct support for recommendation approaches in adaptive learning, while Su et al. (2023) demonstrates the importance of considering changes in learner knowledge over time. Together, these studies support the proposed cycle in which learner activity generates information, the system processes that information, and the resulting recommendation guides a subsequent learning activity.

The literature further shows that adaptive learning should be considered alongside practical platform requirements. Mobile access, offline support, notifications, and classroom-management functions can improve the usefulness of an LMS, while privacy, algorithmic bias, infrastructure, and equitable access must be considered during development. The proposed study therefore treats AI as one component of a larger learning environment rather than as an isolated algorithm.

Overall, the reviewed literature supports a system that combines conventional LMS functions with AI-based personalized recommendations. At the same time, the researchers recognize that the proposed system has a defined technical scope. It is intended to support students and teachers and will not replace instructors or establish long-term academic effects. The literature therefore guides the design and evaluation of the

platform, while the actual research findings will determine its observed usability, effectiveness, and user satisfaction.

Although existing literature has established the value of AI, adaptive learning, personalized recommendations, learner modeling, and mobile learning, these areas are often examined separately or within specialized learning environments. Some studies focus primarily on recommendation algorithms, while others concentrate on pedagogical agents, knowledge tracing, adaptive assessment, or broad AI applications. This creates a practical opportunity to integrate these concepts into one complete learning-management platform.

A major gap addressed by the present study is the integration of AI-based personalized recommendations with the complete set of functions expected from a standalone LMS. A practical platform must manage users, subjects, enrollments, learning materials, assessments, assignments, and progress in addition to producing recommendations. The proposed study addresses this implementation gap by developing one standalone system in which these functions are connected to an adaptive recommendation component.

Another gap concerns the combination of adaptive learning with mobile-oriented continuity features. Mobile learning provides flexible access, but learners may experience unstable or limited connectivity. The proposed system therefore combines mobile-first design with selected offline access and synchronization, push notifications, and QR-based attendance. These features address practical learning and classroom needs within the defined scope of the system.

Finally, the study addresses an evaluation gap by evaluating the integrated platform as a complete system in terms of usability, effectiveness, and user satisfaction. The study will not claim that the system automatically produces long-term academic improvement. Instead, it will determine how intended users experience the platform, whether its major functions operate as intended, and what areas require refinement. The research gap is therefore addressed through the development and evaluation of a standalone, mobile-oriented LMS that integrates standard LMS functions, learner information, AI-based personalized recommendations, and selected mobile learning features.

CHAPTER III

RESEARCH METHODOLOGY

SECTION III — METHODOLOGY

3.1 Research Design

This study uses a Descriptive-Developmental Research Design and Quantitative Approach. The developmental aspect focuses on the systematic design, development, testing, and refinement of the proposed Standalone Adaptive Mobile Learning Management System with AI-Based Personalized Learning Recommendations. The development component will transform the identified learner, instructional, and system requirements into a functional mobile learning platform.

The descriptive part of the study is concerned with describing the evaluation of the developed system by the intended users. After interacting with the system, the respondents will evaluate selected characteristics such as usability, functionality, performance, reliability, compatibility, and satisfaction. The descriptive component will allow the researchers to summarize the respondents' assessment using numerical data and appropriate descriptive statistics.

The study will use a quantitative approach because the evaluation data will be collected through a structured questionnaire with scaled responses. The questionnaire will provide measurable information regarding the respondents' assessment of the system. Frequency, percentage, and weighted mean or mean, as appropriate to the approved instrument, will be used to summarize the responses.

The research design is appropriate because the study does not only describe an existing condition; it also involves the creation of a software product followed by systematic testing and evaluation. The development and evaluation activities will be conducted in stages so that findings from testing and user feedback can be used to refine the proposed system before the final evaluation. This approach is consistent with iterative software development and defined software quality evaluation practices (Schwaber & Sutherland, 2020; ISO/IEC 25010:2023).

3.2 System Development Methodology

The study will adopt the Agile Scrum approach in the development of the Standalone Adaptive Mobile Learning Management System with AI-Based Personalized Learning Recommendations. Scrum is an iterative framework for developing and sustaining complex products. It organizes work into manageable increments and supports regular inspection and adaptation of the work being developed (Schwaber & Sutherland, 2020).

The development of the proposed system will be organized into several sprints. The initial sprint will focus on requirements analysis, project planning, database planning, and interface design. The succeeding sprints will cover the implementation of user accounts, subject and enrollment management, learning materials, assessments and assignments, progress monitoring, AI-based recommendations, notifications, offline synchronization, and QR-based attendance. Testing and refinement will be conducted throughout the development process so that problems can be identified and corrected before the succeeding sprint.

The Scrum approach is appropriate for the study because the proposed system contains several interconnected modules that may require changes during development. An iterative process allows the researchers to develop the system incrementally, receive feedback, and improve functions before moving to the next development cycle (Schwaber & Sutherland, 2020).

The planned sprint sequence is presented below.

Sprint | Main Activities | Expected Result

Sprint 1 | Requirements analysis, project planning, database planning, user roles, initial interface design | Approved system requirements and initial prototype

Sprint 2 | User accounts, login, profile, subject and enrollment management | Working account and enrollment modules

Sprint 3 | Learning materials, learning modules, assessments, and assignments | Working learning and assessment modules

Sprint 4 | Progress monitoring, learner-data processing, content-based recommendation module, recommendation matching and display | Working progress tracking and personalized recommendation functions

Sprint 5 | Notifications, offline access and synchronization, QR-based attendance | Working mobile-support features

Sprint 6 | Integration, functional testing, user testing, refinement, final preparation | Integrated and evaluated system

Scrum Framework

The Scrum framework provides an iterative and incremental approach for developing the proposed system. It organizes the development process into Sprints, allowing the researchers to develop system features, conduct testing, receive feedback, and refine the system throughout the development process (Schwaber & Sutherland, 2020).

Scrum Elements

Scrum Roles | Scrum Artifacts | Scrum Events

3.3 Requirement Specification and Analysis

This section presents the functional and non-functional requirements of the proposed Standalone Adaptive Mobile Learning Management System with AI-Based Personalized Learning Recommendations. The requirements are based on the objectives of the study and the intended functions of the system. They provide the basis for system architecture, database design, interface development, programming, testing, and evaluation.

The functional requirements identify what the system must do, while the non-functional requirements describe the expected quality and operational characteristics of the system. The requirements will be reviewed during development and may be refined when testing identifies necessary changes within the approved scope of the study.

Functional requirements describe the specific functions that the standalone Adaptive Mobile LMS is expected to perform.

No. | Requirement | Description

1 | User Account and Login | The system shall allow students and authorized staff to access accounts and log in using valid credentials.

2 | Profile Management | The system shall allow authorized users to view and update appropriate profile information.

3 | Subject Management | The system shall allow authorized staff to create, update, and manage subjects in the standalone system.

4 | Enrollment Management | The system shall allow authorized users to assign and manage student enrollment in subjects.

5 | Learning Materials | The system shall provide lessons, learning materials, and activities for enrolled subjects.

6 | Assessment | The system shall provide quizzes or other assessments and record learner results.

7 | Assignment Submission | The system shall allow students to access assignments and submit required outputs.

8 | Progress Tracking | The system shall record and display learner progress, completed activities, assessment results, and related performance information.

9 | AI-Based Recommendation | The system shall analyze available learner performance and engagement information to generate personalized learning recommendations.

10 | Recommendation Display | The system shall display recommended lessons, practice activities, learning materials, or feedback to the learner.

11 | Notifications | The system shall provide learning-related notifications and reminders.

12 | Offline Access and Synchronization | The system shall support selected learning functions during offline use and synchronize appropriate data when connectivity returns.

13 | QR-Based Attendance | The system shall provide QR-based attendance for supported learning sessions.

14 | Administrative Management | The system shall allow authorized administrators to manage users, subjects, enrollments, content, assessments, and system information.

Non-functional requirements describe the quality, performance, and operational characteristics expected from the proposed system. The evaluation categories will be aligned, where applicable, with software quality concepts in ISO/IEC 25010:2023, which provides a product quality model for specifying and evaluating software quality (ISO/IEC 25010:2023).

No. | Requirement | Description

- 1 | Usability | The interface should be clear, understandable, and easy to navigate so that users can complete learning tasks with minimal difficulty.
- 2 | Functional Suitability | The system should provide the functions required for user management, learning, assessment, progress tracking, recommendations, and administration.
- 3 | Performance Efficiency | The system should respond to user actions within a reasonable time under normal operating conditions.
- 4 | Reliability | The system should operate consistently during normal use and minimize unexpected errors or loss of user data.
- 5 | Compatibility | The mobile application should operate on the supported devices and software environments identified during requirements analysis.
- 6 | Security | The system should restrict protected functions and learner information to authorized users through access controls.
- 7 | Maintainability | The system structure and source code should be organized so that authorized developers can correct errors or make approved improvements.
- 8 | Data Accuracy | Student, subject, enrollment, assessment, assignment, progress, and recommendation data should be recorded and processed consistently.

The Level 0 Data Flow Diagram presents the proposed system as one main process and shows the major external entities that interact with it. The primary external entities are the Student, Instructor/Teacher, and Administrator. These users provide or request information through the standalone Adaptive Mobile LMS. The system processes account information, learning content, assessments, learner performance, recommendations, and administrative information.

External Entity | Data Sent to System | Data Received from System

Student | Login information, profile information, learning activity responses, assessment answers, assignment submissions, attendance data | Learning materials, assessment results, progress information, personalized recommendations, notifications, attendance confirmation

Instructor/Teacher | Subject information, learning materials, assessments, assignments, learner-related management information | Learner performance information, submissions, progress records, and authorized recommendation information

Administrator | User records, subject and enrollment information, system management data | User/account status, subject and enrollment records, system reports and administrative information

The Level 1 Data Flow Diagram decomposes the main system process into major subprocesses: user and access management, subject and enrollment management, learning content management, assessment and assignment management, learner progress processing, AI-based recommendation processing, and administrative management. Major data stores include user records, subject and enrollment records, learning content, assessment and assignment records, learner performance records, and recommendation records.

Process | Main Data Input | Main Data Output

1.0 User and Access Management | Account credentials and profile information | Authenticated user session and user records

2.0 Subject and Enrollment Management | Subject information and enrollment requests | Subject and enrollment records

3.0 Learning Content Management | Lessons, materials, and activities | Available learning content

4.0 Assessment and Assignment Management | Quiz items, assignments, answers, and submissions | Scores, feedback, and submission records

5.0 Learner Performance Processing | Assessment results, assignment results, activity completion, engagement information | Updated learner performance and progress records

6.0 AI Recommendation Processing | Learner performance, assessment results, activity completion, engagement information, and available learning content | Personalized learning recommendations based on identified learning needs and relevant learning materials

7.0 Administrative Management | User, subject, enrollment, and system information | Updated administrative records and system information

The Entity-Relationship Diagram describes the major data entities and their relationships within the standalone system. The database is expected to contain records for users, subjects, enrollments, learning materials, assessments, assessment results, assignments, submissions, learner progress, recommendations, notifications, and attendance. The ERD will guide the creation of the database structure and help maintain relationships among learner, subject, content, assessment, and recommendation records.

Entity | Key Information | Main Relationship

User | User ID, name, email, password/access information, role | A user may have enrollments, submissions, progress records, recommendations, notifications, and attendance records.

Subject | Subject ID, subject name, description, status | A subject may have many enrollments, learning materials, assessments, and assignments.

Enrollment | Enrollment ID, user ID, subject ID, date/status | Connects students to subjects.

Learning Material | Material ID, subject ID, title, content, type | Belongs to a subject and may be recommended to learners.

Assessment | Assessment ID, subject ID, title, type, schedule | Belongs to a subject and contains assessment items or activities.

Assessment Result | Result ID, assessment ID, user ID, score, date | Stores learner assessment performance.

Assignment | Assignment ID, subject ID, title, instructions, due date | Belongs to a subject and may have student submissions.

Submission | Submission ID, assignment ID, user ID, file/response, score/status | Stores student assignment submissions.

Progress | Progress ID, user ID, subject ID, completion, performance | Summarizes learner progress within a subject.

Recommendation | Recommendation ID, user ID, material/activity ID, reason/status, date | Stores personalized recommendations generated from learner information.

Notification | Notification ID, user ID, title, message, status | Stores learning reminders and system notifications.

Attendance | Attendance ID, user ID, subject/session ID, date, status | Stores QR-based attendance records when the feature is used.

The system flowchart shows the overall process of the Standalone Adaptive Mobile LMS. It starts when the user launches the system and proceeds to account authentication. After successful login, the user is directed to the appropriate dashboard based on the assigned role. Students can access enrolled subjects, learning materials, assessments, assignments, progress information, recommendations, notifications, and supported mobile features. Instructors or authorized staff can manage learning content, assessments, assignments, and learner-related information. Administrators can manage users, subjects, enrollments, and other system information.

For the adaptive recommendation process, the system collects available learner performance and engagement information from completed learning activities, assessment results, assignment performance, and related interactions. The recommendation module processes the available information and matches results with appropriate learning materials or activities. The resulting recommendations are displayed to the learner. When the learner completes additional activities, updated performance information can be used in the next recommendation cycle.

The system also updates progress records after applicable learning activities, assessments, and assignments. Notifications may be generated for learning reminders or system events. If offline access is supported for a particular function, the system temporarily stores permitted data and synchronizes the data when the device reconnects to the network.

3.4 System Design Specification

This section provides the logical and physical design specifications of the proposed Standalone Adaptive Mobile Learning Management System with AI-Based Personalized Learning Recommendations. The logical specification describes how users navigate the system, how the modules interact, and how information moves through the major functions. The physical specification describes the software, hardware, database, mobile environment, and other technical resources required to develop and operate the system.

The logical specification describes the structure and functional behavior of the system from the user's perspective. The design is organized around the main modules of the proposed LMS: account and access, dashboard, subjects and enrollment, learning materials, assessment and assignment, progress monitoring, AI-based recommendations, notifications, offline synchronization, QR attendance, and administration.

A. AI-Based Recommendation Logic

The AI-based recommendation component will use a content-based recommendation approach to generate personalized learning recommendations. The recommendation process will consider learner performance and engagement information available within the system, including assessment results, activity completion, learning progress, and other applicable interaction data. These learner indicators will be compared with the characteristics and subject areas of available learning materials and activities.

The recommendation process will first identify learning areas in which the learner may require additional support based on available performance and progress information. The system will then match the identified learning needs with relevant learning materials, practice activities, or feedback available in the learner's enrolled subjects. The resulting recommendations will be presented to the learner through the recommendation module.

As the learner completes additional activities and assessments, the system will update the learner's performance and progress information. The updated information may then be used in subsequent recommendation cycles. The recommendation component is intended to provide learning support and will not replace teacher instruction or human decision-making.

B. User Interface and UX Design

The user interface is designed to provide a simple mobile-first learning experience. The student dashboard will present enrolled subjects, current progress, recent activities, and

recommended next learning activities. Navigation will use clear labels and consistent controls so users can move between learning materials, assessments, progress, and recommendations without unnecessary steps.

The instructor or authorized staff interface will focus on content and learner management. It will provide access to subjects, learning materials, assessments, assignments, and learner performance information. The administrator interface will provide management functions for accounts, subjects, enrollments, and system information.

C. System Navigation

Module | Primary Functions

Login and Account | Authentication, account access, profile, and role-based access

Dashboard | Summary of subjects, activities, progress, notifications, and recommendations

Subjects | View and manage enrolled subjects and subject information

Learning Module | Access lessons, materials, activities, and recommended content

Assessment and Assignment | Complete quizzes, assessments, activities, and assignment submissions

Progress | View scores, completion status, mastery/performance information, and learning history

Recommendation | View AI-based recommended materials, activities, or feedback

Notifications | Receive learning reminders and relevant system notices

Mobile Support | Use supported offline functions, synchronization, and QR attendance

Administration | Manage users, subjects, enrollments, content, assessments, and system information

The physical specification identifies the technology environment needed to implement the proposed standalone system. The final technologies may be adjusted according to the approved development environment and available resources, but the system will maintain the requirement that core student, subject, learning, assessment, and recommendation records are managed by the standalone platform rather than depending on an external institutional LMS.

Component | Proposed Specification

Client Device | Android and/or iOS mobile device supported by the final application build

Development Computer | Laptop or desktop computer capable of running the selected development tools, database server, and testing environment

Application Layer | Mobile application interface and business logic for authentication, learning, assessment, progress, and recommendations

Database Layer | Relational or appropriate structured database for users, subjects, enrollments, content, assessments, performance, progress, recommendations, and related records

AI Recommendation Layer | A content-based recommendation component that processes learner performance and engagement information and matches identified learning needs with relevant learning materials or activities. Recommendation processing will occur through the online system, while selected previously generated recommendations and permitted learning data may remain available during offline use and synchronize when connectivity returns.

Connectivity | Internet connection for synchronized functions and data exchange; selected offline functions may operate without continuous connectivity

Testing Environment | Supported mobile devices/emulators, development tools, database tools, and test accounts

Security Controls | Authentication, role-based access, input validation, protected data handling, and controlled administrative access

3.5 Implementation

Implementation will involve converting the approved system design and requirements into a working standalone Adaptive Mobile LMS. The researchers will implement the system modules according to the planned Agile Scrum sprints. Development will include database creation, interface implementation, core LMS functions, learner-data processing, AI-based recommendation functions, mobile features, integration, and testing.

During implementation, the researchers will first establish the database and user access functions. The subject, enrollment, learning content, assessment, assignment, and progress modules will then be implemented and connected. The recommendation module will use the learner information available within the system to identify suitable learning materials or activities. Mobile-specific features such as notifications, supported offline access and synchronization, and QR-based attendance will be integrated according to the approved scope.

After individual modules have been implemented, integration testing will be conducted to verify that data move correctly between related modules. Problems discovered during testing will be documented, corrected, and retested. The implementation will proceed through iterative improvements until the system meets the approved functional requirements and is ready for user evaluation.

3.6 Testing and Evaluation

Testing and evaluation will be conducted to determine whether the developed system performs its intended functions and meets the identified quality requirements. Testing will first focus on individual functions and module integration. User evaluation will then be conducted with the selected respondents using the approved evaluation instrument. The evaluation will consider interaction capability, functional suitability, performance efficiency, reliability, compatibility, security, and user satisfaction as applicable to the final instrument and study objectives.

The software evaluation criteria will be guided by the relevant concepts of ISO/IEC 25010:2023. The standard provides a product quality model that can support requirements specification and software product evaluation (ISO/IEC 25010:2023).

Testing Area | Procedure | Expected Result

Login and Access | Test valid and invalid credentials and role-based access | Authorized users can access appropriate functions; invalid access is rejected.

User Management | Create, update, and manage test user accounts | User records are saved and retrieved correctly.

Subject and Enrollment | Create subjects and assign test students | Subjects and enrollments are stored and displayed correctly.

Learning Content | Open lessons, materials, and activities | Learning content loads and is accessible to authorized users.

Assessment | Answer assessment items and submit responses | Results are recorded and calculated according to configured rules.

Assignment | Submit test assignment and review status | Submission information is recorded and status is displayed correctly.

Progress Tracking | Complete activities and inspect progress | Progress records are updated and displayed consistently.

AI Recommendation | Use test learner profiles with different performance information | The system produces recommendations based on configured recommendation rules and available learner data.

Notifications | Trigger applicable reminders or notices | Notifications are generated and displayed to the intended user.

Offline and Synchronization | Use supported offline functions and reconnect the device | Permitted offline data is retained and synchronized correctly when connectivity returns.

QR Attendance | Scan valid and invalid test QR codes | Valid attendance is recorded and invalid/duplicate scans are handled appropriately.

Security | Test unauthorized access and invalid input | Protected functions and data remain restricted and invalid input is handled safely.

Usability | Ask respondents to perform representative learning tasks | Users can complete the tasks and provide evaluation ratings through the questionnaire.

The evaluation will follow a structured procedure. First, the researchers will secure the required permission and coordinate with the participating institution. Second, the selected respondents will be oriented about the purpose of the study and the basic functions of the system. Third, respondents will use selected features of the system, such as accessing learning materials, completing assessments or activities, viewing progress, and checking personalized recommendations. Fourth, respondents will answer the approved evaluation questionnaire. Finally, the researchers will compile, analyze, and interpret the responses and use the findings to identify possible refinements to the system.

The evaluators will consist of selected higher education students who represent the intended users of the proposed system. Where approved by the institution and relevant to the evaluation, instructors or school personnel may also provide feedback regarding system functions and usability. The final number of evaluators and sampling procedure will be determined after coordination with the institution and approval of

the research protocol.

The primary data-gathering instrument will be a structured Likert-scale questionnaire prepared by the researchers and reviewed for alignment with the study objectives. The questionnaire will contain statements covering relevant software quality and user evaluation criteria. A task checklist may also be used during functional testing to document whether required functions operate as expected.

For data analysis, frequency and percentage will be used for applicable respondent information and response distributions. Mean or weighted mean will be used to summarize scaled evaluation responses, depending on the final approved questionnaire and statistical plan. The results will be presented by evaluation category. The researchers will use the numerical findings together with documented testing observations and user comments to identify areas for system refinement. No claim of effectiveness beyond the scope of the evaluation will be made solely from user ratings.

Scale | Range | Interpretation

5 | 4.21–5.00 | Strongly Agree

4 | 3.41–4.20 | Agree

3 | 2.61–3.40 | Neutral

2 | 1.81–2.60 | Disagree

1 | 1.00–1.80 | Strongly Disagree

Before conducting the evaluation, the researchers will secure the necessary permission from the school or participating institution. Participation will be voluntary, and respondents will be informed about the purpose of the study, the activities involved, and the intended use of the collected information. Respondents will not be required to provide unnecessary personal information.

Learner information, evaluation responses, and system records used for the study will be handled only for approved research purposes. Access to collected data will be limited to authorized researchers or personnel. Results will be reported in an aggregated manner when appropriate so that individual respondents are not unnecessarily identified. The researchers will also apply appropriate access controls and data-handling practices within the developed system.

The expected output of the study is a functional Standalone Adaptive Mobile Learning Management System with AI-Based Personalized Learning Recommendations. The system is expected to integrate user and access management, subject and enrollment management, learning materials, assessments, assignment submission, progress monitoring, AI-based personalized recommendations, notifications, supported offline synchronization, and QR-based attendance within one standalone platform.

The study is also expected to produce quantitative evaluation results describing the perceived usability, functionality, performance, reliability, compatibility, and user satisfaction of the developed system, based on the final approved evaluation instrument. The results will provide a basis for identifying areas for refinement and may serve as a reference for future studies involving adaptive learning, AI-based recommendations, mobile learning management systems, and standalone educational platforms.

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