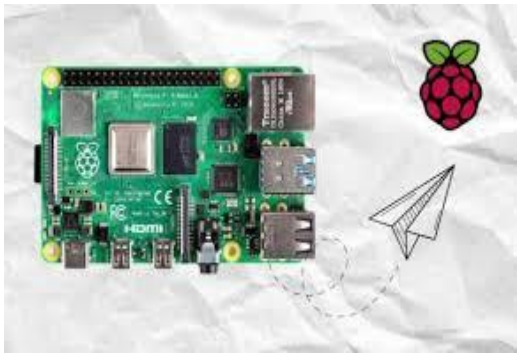

SMART OFFLINE
LMS USING
RASPBERRY PI

ABSTRACT

Online Learning Management Systems (LMS) are widely used in universities, but they require a stable internet connection, which is not always available in rural or restricted environments. This project introduces a Smart Offline LMS hosted on a Raspberry Pi (RPI), designed to deliver quizzes and learning materials without internet access. The Raspberry Pi acts as a local server, creating a Wi-Fi network that allows only authorized student laptops to connect and access the LMS platform. Students complete quizzes through this system, with their results collected, ranked, and displayed on a leaderboard. An additional feature is focus detection, which monitors whether students remain attentive during assessments, helping to discourage unfair practices such as copying. Because the system does not use external internet signals or mobile data, students are also prevented from browsing unrelated websites during exams. This offline, secure, and low-cost solution ensures continuous digital learning and fair assessment. It has potential applications in rural education, disaster recovery classrooms, training environments, and anywhere reliable internet connectivity is unavailable.



INTRODUCTION

In modern education, Learning Management Systems (LMS) play a vital role in delivering course materials, conducting assessments, and managing student performance. These platforms are widely used in schools, universities, and training institutions to provide a structured and interactive learning environment. However, the majority of existing LMS platforms depend heavily on a continuous internet connection, making them inaccessible or impractical in areas with limited or unreliable connectivity.

This dependency creates a significant challenge for institutions located in rural or remote regions, or in environments where the internet is restricted for security or cost-related reasons. Moreover, during examinations or quizzes, unrestricted internet access can pose the risk of unfair practices, as students may browse unrelated websites or online tools that provide unauthorized assistance.

To address these challenges, our project proposes a Smart Offline LMS built on a Raspberry Pi (RPI) platform. The Raspberry Pi functions as a local server, hosting the LMS and allowing students to connect via a Wi-Fi network. Unlike conventional systems that require an external Internet Service Provider (ISP), this setup works completely offline, ensuring secure and uninterrupted access to educational content. Only the laptops connected to the RPI Wi-Fi can access the LMS site, while external browsing is disabled, thereby eliminating distractions and opportunities for misconduct.

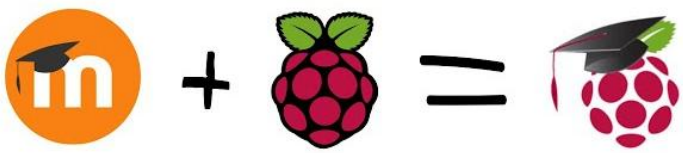
The system has been tested with multiple student laptops connected simultaneously. During quizzes, students receive questions from the

RPI server, submit their answers, and have their scores automatically processed. A leaderboard is generated in real-time to display student rankings, encouraging motivation and healthy competition. Additionally, the system integrates a focus detection feature, which monitors student attention during assessments. If a student looks away from their laptop screen, the system identifies this as a possible sign of copying or distraction.

This approach offers several benefits: it is low-cost, portable, and scalable, making it highly suitable for educational environments that lack stable internet. It also ensures fair assessment through restricted access and focus monitoring, while maintaining the convenience of a digital learning environment.

In summary, the Smart Offline LMS project aims to provide an affordable, secure, and accessible solution for classrooms, particularly in settings where internet connectivity is unreliable or unavailable. By combining the flexibility of digital learning with the practicality of offline deployment, the system has the potential to enhance teaching and assessment across a wide range of educational contexts.

Setup Offline Classroom with Moodlebox



Related Work

Online Learning Management Systems

Learning Management Systems (LMS) are widely used in higher education to deliver courses, assessments, and digital learning materials. Popular platforms such as Moodle, Blackboard, and Google Classroom provide interactive features that support online quizzes, assignments, and communication between students and instructors. However, these platforms are heavily dependent on internet connectivity. In regions with poor or no internet access, their use becomes difficult or even impossible. This creates an accessibility gap for students in rural or restricted areas.

Raspberry Pi in Education

The Raspberry Pi (RPI) is a low-cost, portable, and energy-efficient single-board computer that has gained significant popularity in educational settings. It is often used as a server in small-scale projects, classroom experiments, and digital laboratories. Because of its affordability and ability to host lightweight web applications, the Raspberry Pi provides a promising foundation for building offline educational platforms. Several studies and projects have demonstrated its effectiveness in supporting classroom learning without relying on expensive infrastructure.

Eye-Tracking and Focus Detection in E-Learning

Student engagement is a critical factor in the effectiveness of e-learning systems. Recent research has explored the use of eye-tracking and focus detection technologies to monitor student attention during lessons or assessments. By analyzing eye movements or facial orientation, these systems can detect when a learner becomes distracted or disengaged. This technology has

potential applications in improving fairness and integrity during online or digital examinations, reducing the chances of copying or cheating.

Research Gap

Although online LMS platforms are widely available, they fail to address environments where internet access is limited or unavailable. At the same time, while Raspberry Pi has been successfully used in classrooms and focus detection has been explored in e-learning research, a combined system that integrates offline accessibility, fairness, and security is lacking. There is currently no complete solution that:

- Functions entirely offline without an Internet Service Provider (ISP).
- Provides quiz hosting, result processing, and automatic ranking.
- Includes focus detection to discourage unfair practices.

This project aims to bridge this gap by developing a Smart Offline LMS using Raspberry Pi that incorporates assessment delivery, leaderboard ranking, and student focus monitoring in a secure and internet-independent environment.

System Design and Architecture

System Overview

The proposed Smart Offline LMS system is designed to function entirely without external internet access. At the core of the system is a Raspberry Pi (RPI), which hosts the Learning Management System and behaves as a local server. Students connect to the RPI through a Wi-Fi hotspot, and only authorized laptops within this local network can access the LMS. Unlike traditional LMS platforms that rely on an Internet Service Provider (ISP), this design ensures that the system is self-contained, secure, and fully operational offline.

System Components

- **Raspberry Pi (RPI):** Functions as the server computer. It hosts the LMS platform, manages quiz data, processes student submissions, and generates rankings.
- **Wi-Fi Hotspot:** The Raspberry Pi creates a closed Wi-Fi network that allows laptops to connect directly without using mobile data or an ISP.
- **Student Laptops:** Students use their laptops to connect to the RPI server, access quizzes, submit answers, and view their results.
- **Local LMS Interface:** The interface provides a user-friendly platform for quizzes, submissions, and displaying leaderboard rankings.
- **Focus Detection Module:** Tracks whether a student is paying attention during the quiz. If a student looks away, the system flags potential distraction or misconduct.

Role of Raspberry Pi as Local Server

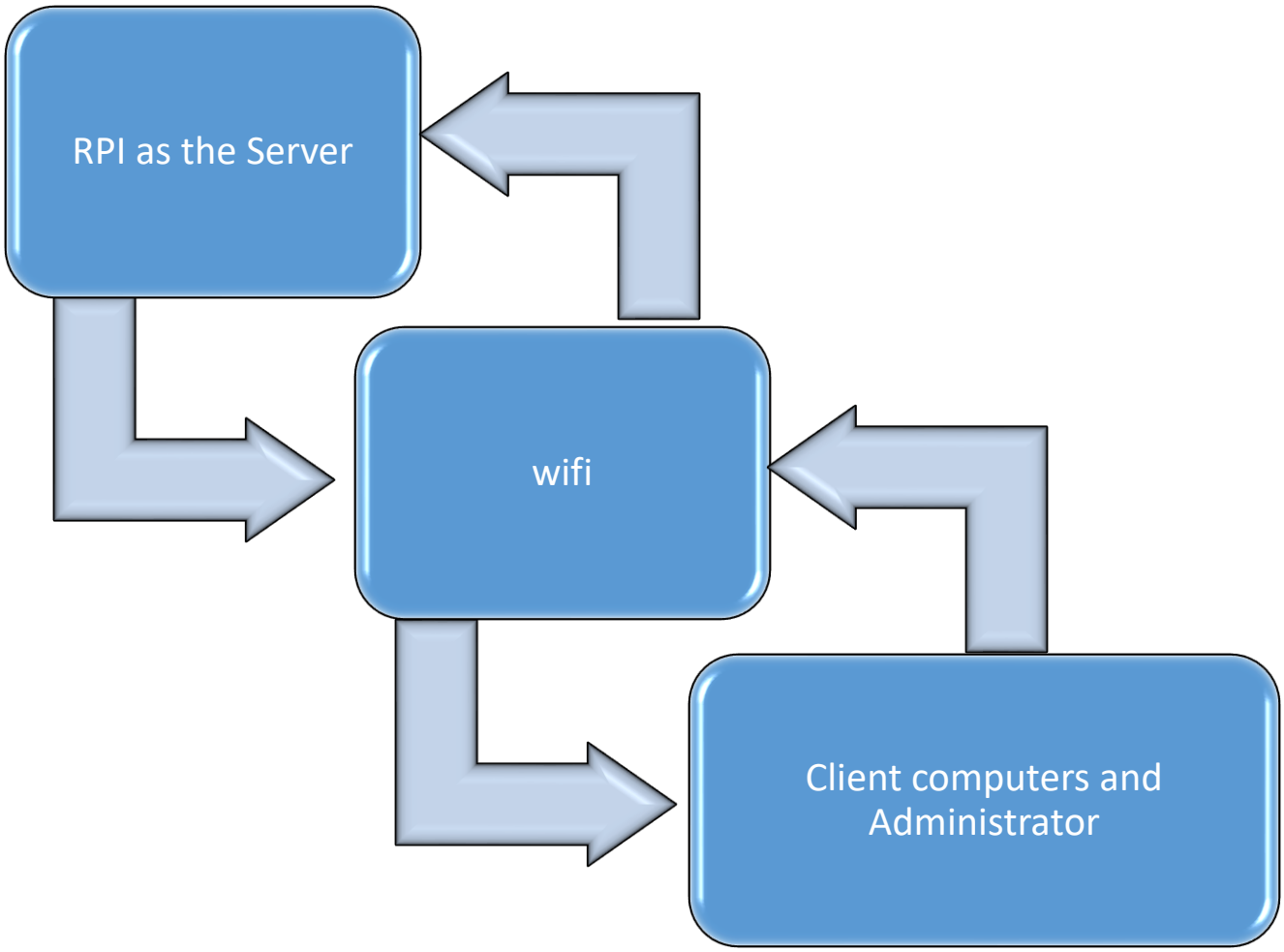
The Raspberry Pi replaces the need for a web-hosted server by running the LMS internally. This means:

- The LMS is available only within the closed Wi-Fi network created by the RPI.
- Students cannot access external websites (such as social media or AI tools) while connected.
- The RPI processes all requests (quiz delivery, submissions, and ranking) locally.

Data Flow of the System

The operation of the system can be explained step by step:

1. **Quiz Distribution** – The instructor uploads quiz questions to the LMS hosted on the RPI.
2. **Student Access** – Students connect their laptops to the RPI Wi-Fi and log in to the LMS.
3. **Answer Submission** – Students complete the quiz and submit their responses.
4. **Result Processing** – The RPI processes the submissions, calculates scores, and updates the database.
5. **Leaderboard Generation** – A leaderboard is automatically generated and displayed, ranking students by performance.
6. **Focus Detection Check** – During the quiz, the system monitors student attention. If a student looks away from the laptop, the RPI flags the behavior.


RPI as the Server
wifi
Client computers and Administrator

Implementation Details

Hardware Setup

- **Raspberry Pi:** The core of the system is a Raspberry Pi (Model 4B), which functions as the local server. It is chosen for its affordability, portability, and ability to host lightweight applications.
- **Student Laptops:** Four laptops were used during testing. Each laptop connected to the Raspberry Pi over the local Wi-Fi network.
- **Wi-Fi Setup:** The Raspberry Pi was configured to act as a Wi-Fi hotspot. Only authorized laptops within the range of this hotspot were able to access the LMS. No external internet connection or ISP was required.

Software Setup

- **Operating System:** Raspberry Pi OS (Linux-based) was installed as the base system.
- **Local LMS Platform:** The learning management system was installed directly on the Raspberry Pi, enabling quizzes, assignments, and result storage.
- **Database:** A lightweight SQL-based database (MariaDB/MySQL) was used to store quiz questions, student submissions, and performance data.
- **Server Configuration:** Apache/Nginx was used to serve the LMS platform locally to connected laptops.

Key Features Implemented

1. **Quiz Hosting and Result Collection**

- Quizzes are prepared by the instructor and hosted on the RPi-based LMS.
- Students attempt quizzes through their laptops and submit responses.
- Results are collected, processed, and stored in the database.

2. **Leaderboard Generation**
    - After each quiz, the system automatically ranks student performance.
    - A real-time leaderboard is generated, allowing students to compare their scores.
3. **Eye-Tracking / Focus Monitoring**
    - The system includes a monitoring feature to detect whether students are attentive during the quiz.
    - If a student looks away from the screen, the system marks this as potential distraction or copying.
4. **Restricted Access**
    - Since the RPi acts as a closed local server, students cannot access external websites (e.g., search engines, ChatGPT, or social media) while connected.
    - This ensures fairness, security, and a distraction-free examination environment.

Results and Observations

System Demonstration

The Smart Offline LMS was successfully deployed on a Raspberry Pi, with four student laptops connected via the local Wi-Fi network. Students were able to access the LMS site, log in, attempt quizzes, and submit their responses. The system processed the answers and displayed results in real time.

- **Quiz Interface:** The laptops displayed the LMS interface where students could attempt multiple-choice and short-answer quizzes.
- **Leaderboard:** After quiz completion, the Raspberry Pi generated a leaderboard ranking students based on their scores.
- **Focus Detection:** The monitoring module highlighted when a student's attention moved away from the laptop screen, providing an indication of possible copying or distraction.

(Screenshots of the LMS interface, leaderboard, and focus detection output should be attached here.)

Working Demo

During testing, the system workflow functioned as expected:

1. Instructor uploaded a quiz to the Raspberry Pi server.
2. Students connected to the RPi Wi-Fi and attempted the quiz on their laptops.
3. Answers were submitted and automatically processed.
4. The leaderboard updated in real time, providing clear and fair rankings.

5. Focus detection flagged instances of distraction.

Comparison with Online Systems

Compared to conventional online LMS platforms, the Smart Offline LMS demonstrated several advantages and some limitations:

Advantages:

- Operates entirely offline – no internet or ISP required.
- Prevents access to unrelated websites (e.g., ChatGPT, social media) during assessments.
- Low-cost, portable, and suitable for remote or rural areas.
- Provides real-time leaderboard and focus monitoring for fairness.

Limitations (compared to online systems):

- Limited to the number of devices that can connect to the Raspberry Pi simultaneously.
- Storage and performance constraints due to hardware limitations.
- Lacks cloud-based backup and large-scale scalability.

Observations

The testing confirmed that the proposed system:

- Successfully delivered quizzes and collected results offline.
- Enhanced exam integrity by limiting external access and monitoring focus.
- Provided a reliable and secure offline alternative to conventional LMS solutions.

Importance of the Project

The Smart Offline LMS project carries significant importance in the context of modern education, especially where connectivity and fairness are critical challenges.

1. **Functionality in Poor Internet Areas**
    - Many rural and remote schools and universities face difficulties in accessing stable internet.
    - This system ensures that digital learning and assessments can continue without depending on an ISP.
2. **Low-Cost Educational Solution**
    - Using a Raspberry Pi as the central server drastically reduces infrastructure costs.
    - Institutions can deploy the system without expensive networking or server hardware.
3. **Portability and Scalability**
    - The Raspberry Pi setup is lightweight and portable, making it easy to carry between classrooms or institutions.
    - The system can be scaled to connect multiple laptops in small to medium-sized classrooms.
4. **Fair Assessment and Integrity**
    - Restricted Wi-Fi access prevents students from browsing unrelated websites (e.g., ChatGPT, social media).

- Focus detection adds an extra layer of fairness by discouraging copying and ensuring students remain attentive.

5. **Enhanced Classroom Control**
    - Teachers and examiners gain more control over assessments, as all quiz delivery, submission, and result processing happens through a closed local server.
    - This promotes discipline and reduces malpractice during examinations.

Overall, the project provides a secure, affordable, and practical alternative to online LMS platforms. By enabling uninterrupted digital learning in poor internet environments and ensuring fair evaluation, the Smart Offline LMS contributes to making education more accessible, reliable, and equitable.

Applications

The Smart Offline LMS system has a wide range of applications in educational and specialized environments where internet connectivity is limited, unavailable, or needs to be restricted for security reasons.

1. **Rural Education**
    - Provides access to digital learning in remote areas where internet connections are poor or unavailable.
    - Enables schools in underdeveloped regions to adopt modern learning techniques at a low cost.
2. **Disaster Recovery Classrooms**
    - In the aftermath of natural disasters, internet and communication networks are often disrupted.
    - The offline LMS can be deployed quickly to ensure continuity of education during recovery periods.
3. **Secure University Examinations**
    - Prevents students from accessing unauthorized online resources during assessments.
    - Ensures fairness and integrity by operating within a closed local server environment.
4. **Workshops, Hackathons, and Training Camps**
    - Offers a reliable platform for conducting short-term courses, competitions, or events in temporary setups.
    - Eliminates the need for large-scale networking infrastructure.

5. **Military and Off-Grid Training Environments**
    - Useful in defense, military, or field training operations where internet access is restricted for security reasons.
    - Allows controlled learning and assessment environments even in isolated or classified locations.

By addressing the challenges of connectivity, cost, and fairness, the Smart Offline LMS provides a flexible solution that can be applied in multiple contexts. Its adaptability makes it an ideal tool for both academic institutions and specialized fields that require secure, portable, and independent learning systems.

Challenges and Limitations

Although the Smart Offline LMS provides several advantages in terms of accessibility, cost, and fairness, there are some challenges and limitations that must be acknowledged:

1. **Hardware Limitations**
    - The Raspberry Pi has limited processing power and memory.
    - Only a certain number of laptops can connect simultaneously before performance issues arise.
2. **Accuracy of Eye-Tracking / Focus Detection**
    - Focus detection depends on camera quality and environmental factors such as lighting.
    - False positives or missed detections may occur, reducing accuracy in real classroom conditions.
3. **Limited Storage on Raspberry Pi**
    - The onboard storage is restricted compared to larger servers.
    - This limits the amount of quiz data, results, and learning materials that can be stored at one time.
4. **Scalability Compared to Cloud-Based Systems**
    - While suitable for small to medium classrooms, the system cannot yet match the scalability of cloud-based LMS platforms.

- Cloud systems can handle thousands of users and large databases, whereas the Raspberry Pi setup is better suited for localized use.

Despite these challenges, the system remains a practical, low-cost, and effective offline solution. With further improvements—such as expanding hardware capacity, refining focus detection, and integrating hybrid cloud support—the limitations can be gradually overcome.

Future Enhancements

While the current version of the Smart Offline LMS demonstrates strong functionality in delivering offline learning and fair assessment, several improvements can be made in future versions to increase usability, scalability, and security.

1. **Support for Mobile Devices**
    - Extend system compatibility beyond laptops to include smartphones and tablets.
    - This will make the platform more accessible for students who do not have personal computers.
2. **Biometric Authentication**
    - Introduce secure login methods such as **face recognition** or **fingerprint scanning**.
    - Ensures identity verification and prevents impersonation during quizzes and exams.
3. **AI-Based Cheating Detection**
    - Enhance the focus detection feature by integrating artificial intelligence to monitor behavior.
    - Detects suspicious activities such as multiple faces on screen, use of mobile devices, or unusual movements.
4. **Multi-Classroom Support**
    - Enable one Raspberry Pi server to handle multiple classrooms or groups simultaneously.
    - Useful in larger institutions that want to deploy the system in different locations at once.

5. **Cloud Synchronization (When Internet is Available)**
    - Allow the Raspberry Pi to synchronize data with a central cloud server whenever internet connectivity is restored.
    - Provides backup, large-scale data storage, and easier access for teachers and administrators.

These future enhancements will transform the Smart Offline LMS into a more robust, secure, and scalable educational platform, ensuring that it can adapt to diverse teaching environments while maintaining its offline-first approach.

Conclusion

The development of the Smart Offline LMS using Raspberry Pi has successfully demonstrated that digital learning and fair assessments can be conducted without reliance on the internet. By hosting the LMS on a Raspberry Pi and connecting student laptops through a local Wi-Fi network, the system ensures secure quiz delivery, result collection, leaderboard generation, and focus monitoring, all within a closed and controlled environment.

This project proves that an offline, fair, and low-cost LMS is not only feasible but also highly practical for real-world applications. It addresses the challenges faced by rural and remote education systems, ensures fairness during examinations by preventing external browsing, and provides teachers with greater control over the learning environment.

Overall, the Smart Offline LMS serves as a reliable alternative to traditional online platforms. It highlights how affordable hardware and open-source software can be integrated to create an innovative solution that enhances accessibility, fairness, and classroom management. With further improvements and scalability, the system has the potential to play a significant role in shaping the future of equitable and inclusive digital education.