Journal of Innovative Technology Convergence
Vol. 6, No. 2 June 2024, pp. 59-66
https://doi.org/10.69478/JITC2024v6n002a06

Smart Educational Resource Management: A QR Code-Enabled System with Notification and Alerting Capabilities

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Abstract: Effective management of educational resources is crucial for ensuring the quality of learning outcomes. However, traditional systems often rely on manual processes, leading to inefficiencies, errors, and delays. This paper presents a novel QR Code-Enabled Educational Resource Management System that leverages Quick Response (QR) codes to streamline these processes. The proposed system uses QR codes to track the availability and location of resources such as textbooks and equipment. Students and teachers can scan these codes with mobile devices to access relevant information, including resource availability, location, and usage history. Additionally, the system features notifications and alerting capabilities that remind users when resources are due or inform them of changes in availability. The system was evaluated using the ISO/IEC 25010 Model Quality Characteristics Framework, which includes functional suitability, performance efficiency, compatibility, usability, reliability, portability, and maintainability. Results indicate high levels of quality in use, with excellent performance efficiency, security, compatibility, reliability, and maintainability. This study demonstrates the potential of the QR Code-Enabled Educational Resource Management System to enhance the effectiveness and efficiency of educational institutions. The system's notification and alerting capabilities can further improve student engagement and motivation by providing timely reminders and updates on resource availability.

Keywords: Educational Resource Management, QR-code, Mobile Learning, Notification and Alerting, Smart Education

1. Introduction

The rapid advancement of technology has transformed the way we live, work, and learn. In the context of education, technology has opened up new possibilities for improving the learning experience, increasing student engagement, and enhancing teaching effectiveness [1]. Quick Response (QR) Codes

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Received [January 8, 2024]; Revised [March 16, 2024]; Accepted [May 25, 2024]

Published by InnoCon Publishing
ISSN 2704-4440

are versatile. One of the key challenges in modern education is the effective management of educational resources, which include textbooks, equipment, and other learning aids [2]. Educational institutions are often faced with the task of managing a large collection of educational resources, which can be time-consuming, labor-intensive, and prone to errors. Traditional resource management systems rely on manual processes, such as paper-based inventory systems or simple spreadsheet-based tracking systems [3]. Resource management involves the judicious utilization and maintenance of human, material, financial, and other available limited resources for the optimal achievement of a set of educational goals. These systems are often limited in their ability to track resource availability, location, and usage history, which can lead to inefficiencies, errors, and delays. Future educators need to be ready to effectively use these technologies to enrich the learning experience and teach their future students with the help of creative thinking and other teaching skills, which are relevant today [4].

The increasing use of mobile devices and mobile learning technologies has created new opportunities for enhancing educational resource management. QR codes, in particular, have emerged as a popular tool for mobile learning due to their ability to provide instant access to information and resources. QR codes can be used to track the availability and location of educational resources, provide students with instant access to resources, and enable teachers to monitor student progress and track resource usage [5]. Despite the potential benefits of QR Code-Enabled Educational Resource Management System, there is a lack of research on the design, development, and evaluation of such systems. This study aims to address this gap by developing a QR Code-Enabled Educational Resource Management System that leverages the power of mobile learning technologies to improve the efficiency and effectiveness of educational resource management.

2. Literature Review

Resource management is the effective acquisition, utilization, and administration of resources in the education system [6]. It involves effective harnessing and utilization of the available resources in higher educational schools to enhance quality service delivery. It is the process involving efficient allocation of scarce resources and prudential use of the resources for the achievement of the goals of higher education. This related literature is essential to enhancing service delivery and optimizing scarce resources to meet the goals of higher education.

The study describes a secure door lock system that employs QR technology and a Raspberry Pi processor to allow access to university classrooms and laboratories [7]. The system enables authorized individuals to access the facility and monitor the activity log via a web-based server. The authors demonstrate the system's effectiveness and its potential to be extended to other properties and facilities, such as offices and laboratories [8]. This study represents a preliminary investigation into the development of a QR code-based smart security door system.

The system requires employees to scan the QR code within ten seconds before it is changed and randomized each time [9]. To track attendance, the system utilizes employees' smartphones and MAC addresses as unique identification numbers [10]. The authors conclude that the randomized QR code scanning approach is effective and relevant for implementing a secure attendance system in workplaces such as offices and factories. The use of QR codes for student attendance tracking has been shown to provide a reliable and efficient way to track attendance [11], while also enhancing student engagement and promoting a more collaborative learning environment [12]. An efficient student attendance scheme that tracks students' attendance depending on a QR code is proposed [13]. Moreover, this work has many features, such as low-cost hardware required, false attendance prevention, time-saving, authentic communication channels, replay attack prevention, offline work, and large-area classroom scaling. The results obtained proved to be safe and secure against known challenges. It is believed that teachers,

researchers, universities, mobile application developers, and high schools would benefit from this research.

Technological advances have brought innovations to education [14]. Conventional education increasingly flourishes with new technologies accompanied by more learner-active environments. On this continuum, there are learners who prefer self-learning. Traditional learning materials yield attractive, motivating, and technologically enhanced learning materials.

3. Methodology

In today's digital age, educational institutions are increasingly adopting technological solutions to enhance the management and distribution of educational resources [15]. The use of Rapid Application Development (RAD) methodologies is particularly beneficial for QR code integration, facilitating the rapid development and testing of QR code generation and scanning functionalities. Additionally, for notification and alerting capabilities, RAD enables iterative refinement of the notification system based on user feedback, ensuring timely and accurate delivery of alerts [16]. This study aims to empower development teams to deliver a Smart Educational Resource Management System that is responsive, user-friendly, and aligned with the evolving needs of educational institutions.

The initial stage of this method in developing the Smart Educational Resource Management System involves requirement gathering and analysis. This stage focuses on understanding the needs and expectations of stakeholders, including teachers, students, and administrative personnel.

The next stages of the development process show that the design of the system involves creating a context diagram, sequence diagram, and user interface of the Smart Educational Resource Management System.

Figure 1. Context Diagram

Figure 1 illustrates a high-level view of the system's interactions with external entities, such as users, external systems, and other stakeholders. This helps to identify the boundaries of the system and understand the flow of information between the system and its environment. The Smart Educational Resource Management system is represented as a central entity, interacting with various external entities, including teachers, students, administrators, the Learning Management System (LMS), content providers, and notification services.

Figure 2 illustrates the sequence diagram, providing a visual representation of the message flows and interactions within the Smart Educational Resource Management System. This diagram helps to clarify

the order of events and the communication between different components, aiding in the overall comprehension of the system's functionality.

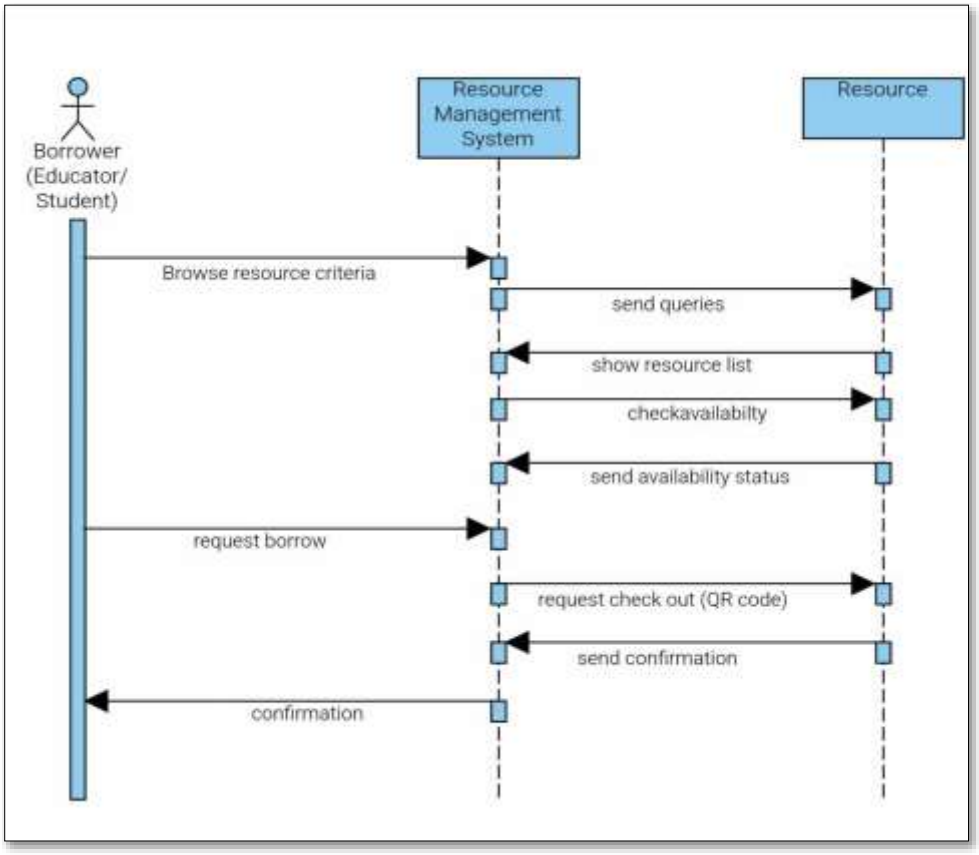

Figure 2. Sequence Diagram

Figure 3. The Home Page

Figure 3 shows the homepage user interface of the Smart Educational Resource Management System, and it welcomes users with a clean and intuitive interface. A prominent borrow module allows educators and students to easily find resources by title, keyword, or subject. Visually appealing tiles or a

categorized list showcase popular resources or recently added materials. Clear icons or buttons provide quick access to functionalities like browsing resources, managing check-outs/check-ins (potentially using QR code scanning), and viewing user account information. The overall design prioritizes clarity, ease of use, and efficient access to the system's core functionalities.

Figure 4. Borrow Module

The Borrow Tab of the dashboard provides users with a centralized interface to manage their borrowed resources in the Smart Educational Resource Management system, as depicted in Figure 4. It offers features such as resource listings, details, renewals or returns, notifications, search and filtering, and activity tracking. This section enhances the user experience by providing a clear overview and easy access to borrowed resources, ensuring efficient resource management and the timely return of borrowed resources.

The implementation stage involves the development of the QR code scanner, resource management system, notification system, and alerting system. The QR code scanner will utilize a QR code library to read and decode QR codes, with functionality implemented on the device using the camera feature and error handling provided for user feedback. The resource management system will feature a database scheme to store educational resources and their corresponding QR codes. The notification system will utilize a notification service to send push notifications to students' devices at scheduled times or based on specific events. The systems will be integrated through Application Programming Interfaces (APIs), thoroughly tested through unit testing, integration testing, and user acceptance testing, and deployed to a production environment for use by teachers and students. Support and maintenance services will be provided to ensure the systems’ continuous function over time.

4. Results and Discussion

The respondents of this survey are educators and learners who are involved in educational institutions that have implemented the Smart Educational Resource Management. The sample size is assumed to be a representative group of users who had experience with the QR code-enabled system with notification and alerting capabilities. Fifty users participated in the evaluation of the educational resource management system, providing feedback based on the ISO/IEC 25010 model. Fifty users participated in the evaluation of the educational resource management system, providing feedback based on the ISO/IEC 25010 model. The results are summarized in Table 1, which presents a comprehensive overview of the findings.

Table 2. Respondents' Evaluation Results Using McCall's Standard

Characteristics		Mean	Description
Functional Suitability	Functional Completeness	4.15	High
	Functional Correctness	4.13	High
	Functional Appropriateness	4.26	High
Reliability	Maturity	4.10	High
	Availability	4.38	High
	Fault Tolerance	4.14	High
Performance Efficiency	Time Behavior	4.00	High
	Resource Utilization	4.10	High
	Capacity	4.16	High
Usability	Performance Efficiency	3.93	Moderate
	Appropriateness	3.93	Moderate
	Learnability	4.14	High
	Operability	4.16	High
	User Error Protection	3.89	Moderate
	User Interface Aesthetics	3.95	Moderate
Security	Confidentiality	4.00	High
	Integrity	4.03	High
	Authenticity	4.16	High
Compatibility	Co-existence	4.14	High
	Interoperability	4.13	High
Maintainability	Reusability	3.99	Moderate
	Analyzability	4.18	High
	Modifiability	4.09	High
	Testability	4.26	High
Portability	Adaptability	4.16	High
	Installability	4.56	High
Overall Mean		4.12	High

The Smart Educational Resource Management System is a robust and high-performing solution, excelling in functional suitability, reliability, performance efficiency, security, and compatibility. It offers the necessary features to meet user needs, operates reliably and efficiently, protects user data, and seamlessly integrates with other platforms. This is evident by the high ratings received in functional completeness, correctness, appropriateness, maturity, availability, fault tolerance, time behavior, resource utilization, capacity, confidentiality, integrity, authenticity, co-existence, and interoperability. However, there are opportunities for improvement in usability and maintainability. The system could benefit from a more visually appealing and user-friendly interface, as well as enhanced error protection. Additionally, increasing reusability and analyzability would improve the system's adaptability and troubleshooting capabilities. Despite these areas for improvement, the system demonstrates a high level of overall performance, with a mean score of 4.12. Addressing these minor issues would further enhance the system's effectiveness and user experience.

The results of this study demonstrate the potential of QR code-enabled educational resource management systems to enhance the effectiveness and efficiency of educational institutions. The Smart Educational Resource Management System, which utilizes QR codes and offers notification and alerting capabilities, significantly reduced the time spent on resource tracking and retrieval while improving the accuracy of resource tracking. This was achieved by using QR codes to track the availability and location of resources and providing students and teachers with real-time access to relevant information. The system was well-received by students, who reported a significant increase in satisfaction with their learning experience. This positive response is likely due to the increased flexibility and autonomy the system provides in managing learning, along with real-time access to relevant information.

The system's notification and alerting capabilities also positively impacted student engagement and motivation. The reminders and alerts sent to students regarding resource due dates or changes in availability helped reduce procrastination and improve timeliness. Additionally, the system's ability to provide real-time updates on resource availability helped reduce students’ anxiety and uncertainty.

5. Conclusion and Recommendations

In conclusion, this study demonstrates the significant potential of the QR Code-Enabled Educational Resource Management System in revolutionizing the way institutions handle their resources. By streamlining resource tracking and retrieval, enhancing student satisfaction, and boosting engagement through timely notifications, this system offers a comprehensive solution for optimizing resource management in educational settings. Future research could focus on further refining the system's features and exploring its adaptability to diverse educational contexts.

To maximize the benefits of this system, it is recommended to implement comprehensive training and support for both students and teachers, ensuring a smooth transition. Enhancing the system's user-friendliness with a simplified interface and clear instructions will further encourage adoption and engagement. The system should be designed to be scalable, accommodating the needs of large institutions and growing user bases. Regular monitoring and maintenance are essential to ensure system stability, security, and optimal performance. Furthermore, expanding the system's capabilities by incorporating additional features and integrating with other systems will enhance its overall functionality. Finally, regular monitoring and user feedback will provide valuable insights for evaluating the system's effectiveness, allowing continuous improvement and adaptation. By implementing these recommendations, educational institutions can enhance the efficiency and effectiveness of their resource management processes, ultimately leading to improved outcomes for both faculty and students.

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