

# iScan Campus: Revolutionizing Lab Asset Management Using RFID Technology

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## Abstract

One of the rapidly developing trends in the modern world is the Internet of Things (IoT) – the concepts that define the use of physical objects for communication according to their function and context in the commercial, healthcare, transport, and home environments. Challenges arising from manual inventory management are well felt in learning institutions, especially where there is a lot of equipment in use each time such as computer laboratory. These challenges are mitigated in this project by suggesting an iScan Campus RFID-based inventory management system that rests on established accuracy, efficiency, and accountability in the inventorying management section. The system is installed with RFID tags and readers; thus, it provides efficient time-based tracking and management of equipment, thereby reducing equipment loss and optimizing the use of resources. The research employs the Agile software development approach that makes the development of the system flexible and able to accommodate changes in the requirements. The study therefore strongly supports the possibility of radio frequency identification technology as an effective tool for automated system of inventories, hence more deployment in similar events.

## 1. Introduction

Radio Frequency Identification (RFID) is an advanced technology that has transformed inventory management through the wireless or non-contact use of radio frequencies to identify objects [1]. It eliminates the need for paperwork or direct contact, offering operational advantages and real-time tracking convenience. In academic environments, especially in university laboratories, inventory management typically relies on traditional systems, where most processes are manual, contributing to inefficiency in managing inventories, particularly equipment [2]. One major challenge of using a manual inventory system in the lab is the risk of inaccuracies in data recording, which can create confusion when tracking assets. Additionally, manual systems are more susceptible to unauthorized access, compromising the integrity of the equipment. During peak times, delays in issuing equipment can hinder operations and reduce productivity. These issues affect the laboratory's operational efficiency, highlighting the need for improved inventory management strategies. To address these shortcomings, research has increasingly focused on implementing RFID-based systems for laboratory inventory management.

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By placing RFID tags on equipment and using RFID readers for wireless data transmission, this technology enables tracking of equipment availability and location without requiring line-of-sight visibility [3]. This proposed RFID-based system can alleviate these challenges by providing real-time updates on inventory status, improving equipment utilisation efficiency, and generating detailed reports to support management decisions [3]. The system review includes specifications, implementation, and evaluation of an RFID system for inventory control in educational institution laboratories, showcasing its potential to enhance laboratory management functionality.

## 2. Literature Review

As laboratories become more advanced, effective inventory management has become increasingly essential. RFID technology has proven to be a game-changer, surpassing traditional barcode systems that are often slow and inaccurate. Table 1 highlights the advantages of RFID compared to barcodes. RFID technology has significantly matured, transforming handheld scanners by offering benefits such as enhanced data management and real-time tracking capabilities [4]. Additionally, several systems with similar functions to the one proposed here have been developed, as shown in Table 2.

**Table 1** Differences between RFID and barcode

RFID	Barcode
Faster reading, as they can be read simultaneously.	It can only be read individually.
No line sight is required in reading RFID tags.	Barcode labels must be visible to the scanner to be read.
It can deal with rough and dirty environments because tags can be integrated into the packaging materials.	They cannot be read if they are dirty or damaged.
Read automatically, resulting in no labour costs.	Read manually and thus incur labour costs. Automated scanning demands standardisation of barcode location.

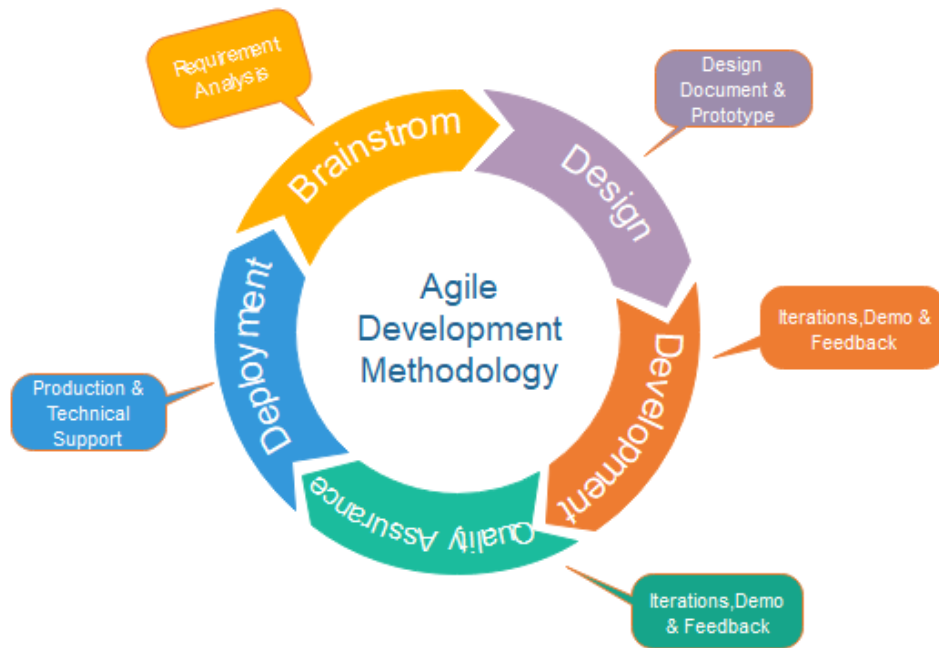
**Table 2** Comparison between existing systems

System	Strength	Weakness
RFID Based Improving Supply Chain Traceability [4]	<ul style="list-style-type: none"> <li>Reduces product loss.</li> <li>Enhances distribution efficiency.</li> <li>Integrates with current systems.</li> </ul>	<ul style="list-style-type: none"> <li>High initial setup cost.</li> <li>Needs careful integration.</li> <li>RFID tag tampering risk.</li> </ul>
The Intelligent Inventory Management System Based on RFID [7]	<ul style="list-style-type: none"> <li>Streamlines inventory.</li> <li>Track equipment status.</li> <li>Covers wide area for tracking.</li> </ul>	<ul style="list-style-type: none"> <li>Needs stable network.</li> <li>Limited by number of readers/tags.</li> </ul>
RFID Based Lab Inventory Management System [1]	<ul style="list-style-type: none"> <li>Detailed reports, user-friendly.</li> <li>Real-time monitoring.</li> <li>Work with current systems.</li> </ul>	<ul style="list-style-type: none"> <li>Limited read range.</li> <li>Stable power needed.</li> <li>High initial cost.</li> <li>Compatibility issues.</li> </ul>

## 3. Methodology

A significant number of practices connected with the agile process are embedded into the iScan Campus project to react to changing requirements and enable rapid development. It is worth noting that agile methodologies can be adaptive, participative, and incremental, which are valuable in projects involving technologies that still need to define key areas of application and that produce complex contexts [5]. Specifically, in this project, the agile approach fosters responsiveness to change, engages stakeholders, and easily incorporates new and radical technologies. The agile approach allows progress to be continuously evaluated and provides an opportunity to fine-tune a design until the user fully appreciates it. It enables the project team to demonstrate steps in its evolution, known as sprints, showing how the new solution is improved [6]. By organizing the development process into stages like brainstorming, design, development, testing, and deployment, the project ensures that every aspect of the process is refined and transformed during cycles. This approach results in flexible work, team

cooperation, and, ultimately, the creation of a worthwhile product that adds value to the user's life. In Fig. 1, the agile methodology is illustrated below.



**Fig. 1** Agile Methodology

### 3.1 Brainstorming Phase

During the planning phase, the project team evaluates and compares the specifications, pricing, availability, and compatibility of the hardware and software. This phase involves identifying the appropriate frameworks and technological implementations for the system. User behaviours are analysed to enhance the user experience, and hardware standards are established. Various tasks are defined, assigned, and scheduled, and resources are allocated to support all project activities. An essential step in project management is clearly outlining the project, its objectives, and specifications, and assigning responsibilities, timelines, and methods for achieving each goal.

### 3.2 Designing Phase

This project involves developing a prototype to demonstrate a solution for RFID-based inventory management, focusing on real-time tracking of laboratory equipment. The hardware design aims to create a functional inventory management system, using components such as the ESP8266, MFRC522 reader, breadboard, and jumper wires for connections. Fig. 2 illustrates the circuit and use case diagrams of the prototype.

The ESP8266 microcontroller is the primary device in this project, running the necessary code through Arduino IDE software to operate the system. Once programmed, the ESP8266 directs the MFRC522 reader to scan RFID tags, enabling accurate monitoring and efficient inventory management. The data collected by the MFRC522 reader is processed by the ESP8266 and transmitted to a central system, allowing users to visualise and manage inventory in real-time.

Simultaneously, stakeholders are working on enhancing the website's user experience (UX) and graphical user interface (GUI). This phase involves creating mock-ups and visually appealing models to ensure user-friendly interaction. A use case diagram, shown in Fig. 2, outlines the website's functionality as the design progresses. Development tools for the website include Visual Studio Code, XAMPP, and phpMyAdmin.

The website's front end is built with HTML and CSS for layout and design, while JavaScript provides interactivity. For database management, phpMyAdmin is used to expand and manage the database, while PHP and MySQL handle back-end functionality, ensuring seamless operation.

With the hardware design and website interface finalized, the project now moves into the development phase, where the RFID-based system will be seamlessly integrated with the web platform. This integration will enable real-time inventory management, providing a fully functional, efficient, and user-friendly system for tracking laboratory assets.

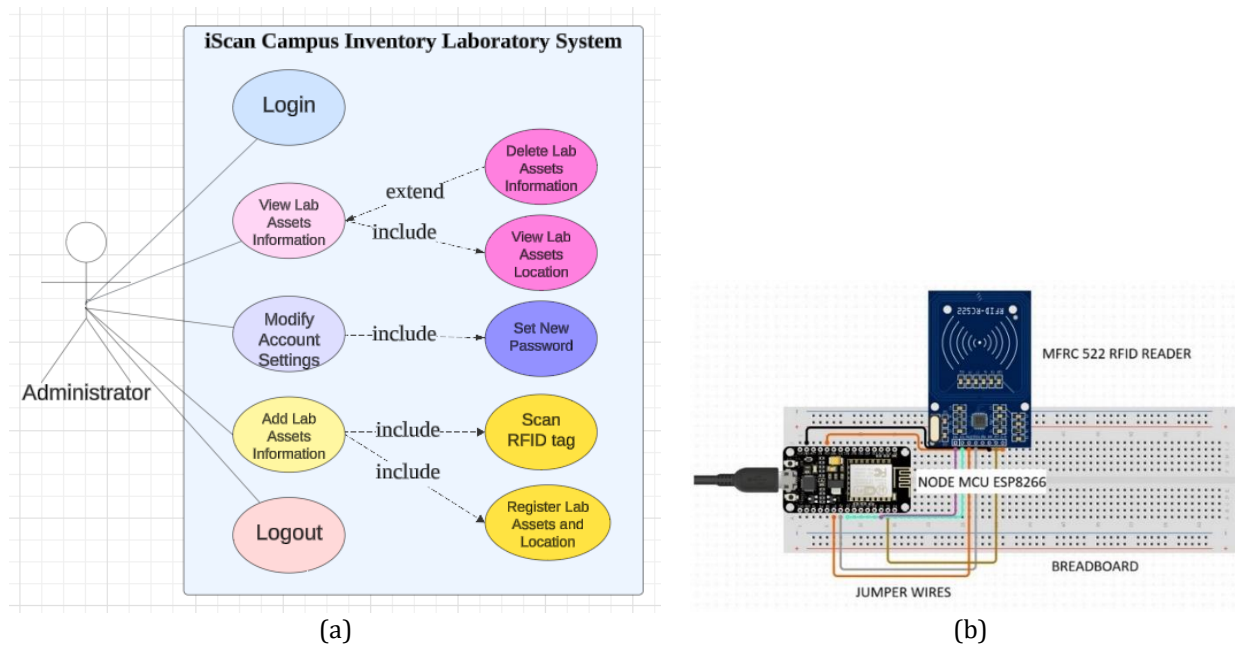


Fig. 2 Example of the project diagram (a) Circuit diagram; (b) Use case diagram

### 3.3 Development Phase

The primary intended deliverables of the development phase, regardless of its duration across one or more stages, include documentation of both functional and non-functional requirements, detailed design documentation for all project components, test plans, and deployment of software code, purchased technology, or other components of the solution prepared for testing, control assessment, and other pre-implementation activities. This involves defining the expected operational requirements during development for computing platforms, hardware, networks, infrastructure, operation, maintenance, and support.

This product has an RFID reader, specifically the MFR522 model, which is capable of reading data from Near Field Communication (NFC) tags, and it also incorporates an ESP8266 module to ensure that the iScan Campus establishes a connection with a laptop or PC of the user so that the monitoring and control aspects can be incorporated. IoT devices are defined as smart objects, and their usefulness in the current world is highlighted. Likewise, similar to most IoT devices such as ID card scanners, the iScan Campus makes the job more convenient for users since it stores data through computers instantly. Concerning that, the iScan Campus also plays an important role in the security of laboratory inventory items. In conclusion, this section stresses the benefits of the iScan Campus in terms of convenience and enhanced security.

Each piece of hardware is collected, including the ESP8266, breadboard, MFR522 reader, RFID tags, wires, and software such as Arduino IDE. Sensors and other electronic components will be interfaced with the ESP8266 through the breadboard. The RFID reader will capture the laboratory inventory asset information from the scanned RFID tags and forward it to a database for storage. Consequently, appropriate code must be written to ensure that the data is stored correctly and that the system operates as required without any issues. For instance, the system must create an identification for each laboratory asset and the specific lab room associated with that asset. The code must be uploaded to the ESP8266 using the Arduino IDE software. After the code is written, it will be uploaded to the physical board, and once all components are connected, iterative testing will be conducted to ensure that both the components and the code function as expected.

### 3.4 Testing Phase

In this stage, the emphasis is on evaluating the specific performance characteristics of the product, as well as its compatibility and usability profiles, in addition to confirming and identifying any defects or complications. The testing phase of iScan Campus, an Internet of Things (IoT) system designed to detect missing or misplaced lab equipment in educational settings, will also involve a detailed assessment of its efficiency in practice. This includes validating RFID technology for asset tracking regarding affordability, reliability, and efficiency in identifying and monitoring moving assets, as well as establishing the dependability of the notification system and the overall user-friendliness of the RFID system. Additionally, the testing phase in Agile methodology involves constant interaction among developers, testers, and end users to conduct testing, allowing for the detection of any existing problems and enabling the team to work on fixing them. This approach helps gather continuous feedback on the

expectations of the iScan Campus system's users, ensuring that their needs and expectations are met while delivering quality and reliability.

### 3.5 Deployment Phase

In the context of the iScan Campus project, the deployment phase is a critical step as it transitions the system from development to the actual usage environment. The focus during this phase is to ensure that the iScan Campus system functions as intended within the educational institution's network. This involves consulting with stakeholders to coordinate the deployment process, which includes installing various hardware devices such as RFID readers and sensors, setting protocols for network communication, and configuring software applications for specific devices. Finally, the deployment phase may require user training to inform staff and administrators about the functions and capabilities of the iScan Campus system.

## 4. Results and Discussion

The testing of the iScan Campus Inventory Laboratory System was holistic, covering functionality, usability, interface, database integrity, performance, and security. The team developed a System Testing Evaluation Form to facilitate this process, allowing evaluators to answer "Yes" or "No" for each given criterion. The initial testing occurred on the Admin Login Page, where testers logged in and underwent the validation processes using their entered credentials. This was a crucial step in ensuring effective authentication processes and access control mechanisms. Next, RFID tags were scanned before and after data entry by asset ID, asset name, and location to verify the correctness of registration by both the system and database, with timestamps recorded as accurately as possible at that moment, as shown in Fig. 3 (a). The user data page, depicted in Fig. 3 (b), enabled administrators to examine all inventory records, ensuring that all operations, data entries, and button clicks were executed correctly and synchronized appropriately with the back-end database. Consequently, Fig. 4 presents the prototype of the hardware components integrated with the system, effectively demonstrating the successful combination of both elements.

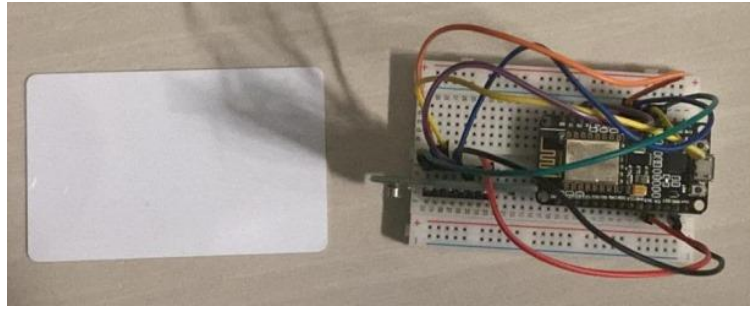


(a)



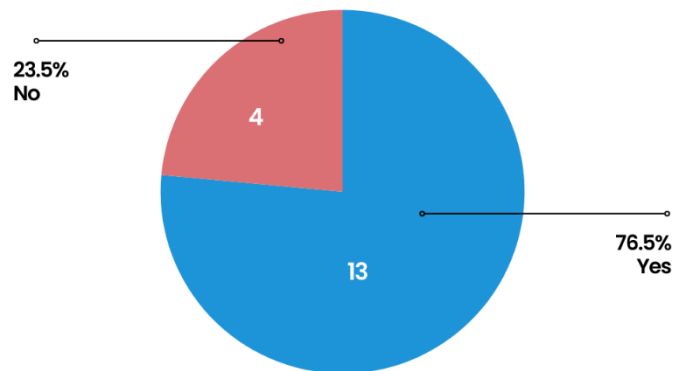
(b)

**Fig. 3** System interfaces (a) Assets registration form; (b) User data page



**Fig. 4** *Prototype of hardware components*

During the test run of the application, a few system constraints were observed, which did not have an issue warning or any type of notification or reminder for ensuring updating the asset information, which may be helpful for their everyday management. In addition, the non-responsiveness of the system by some devices and browsers due to local hosting has brought into focus compatibility issues that need to be ironed out. The other issue that arose was that between the hardware (RFID tags and readers) and the software components in the integration, which shows possible technical problems that need to be further researched and ironed out.



**Fig. 5** *Results of system testing*

The pie chart in Fig. 5 illustrates the results of an evaluation survey, showing that 76.5% of respondents (13 responses) provided affirmative feedback, while 23.5% (4 responses) indicated negative responses. This result suggests that the application has generally achieved its functional goals, though there are areas for improvement. Key enhancements should focus on introducing notification features and improving cross-platform compatibility to boost user experience.

## 5. Conclusion

Therefore, there is much potential for RFID technology to improve laboratory inventory processes for institutions like iScan Campus in the future. In addition to eliminating the weaknesses of manual processes in tracking and managing equipment through RFID tags and readers, the system also lays down processes to further improve the efficiency and effectiveness in the operations. Functions provided by RFID imply that equipment location and status can be tracked in real-time, hence any delay in the retrieval of any equipment may result in wastage of a lot of time, hence improving the productivity of laboratories. Further, through regular inventory and utilization reports generated by the system, the administrators and educators can gain favourable information for strategic planning and decisions of the institution efficiently. Prospects for future enhancements include developments like writing tags that have a longer lifespan, read ranges that deliver higher accuracy, and cloud capabilities within the RFID systems contribute to the increased reliability of such a system. These developments will probably address existing perceived limitations such as costs of installation, risks of data loss that should make RFID-based solutions a functional tool for augmenting laboratory management at iScan Campus and other settings.

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## Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of the paper.

## Author Contribution

The authors confirm contribution to the paper as follows: **study conception and design, data collection, analysis, and interpretation of results:** Adil Mohd Hafiz, Nora Syafira Abd Gani, Nur Syasya Fatimah Othman; **manuscript preparation:** Adil Mohd Hafiz, Nora Syafira Abd Gani, Nur Syasya Fatimah Othman, Shelena Soosay Nathan. All authors reviewed the results and approved the final version of the manuscript.

## References

- [1] H. Hazura, B. Mardiana, S. Fauziyah, M. Zahariah, A. R. Hanim, and N. Z. Siti, "RFID Based Laboratory Management System," in 2009 International Conference on Computer Technology and Development, Kota Kinabalu, Malaysia, 2009, pp. 289-291. doi: 10.1109/ICCTD.2009.176.
- [2] R. Evelyn and J. R. Darwin, "Development of an Automated Laboratory Assets Inventory Control With Security System," in 2019 International Conference on Computational Intelligence and Knowledge Economy (ICCIKE), Dubai, United Arab Emirates, 2019, pp. 501-504. doi: 10.1109/ICCIKE47802.2019.9004395.
- [3] A. K. Govind and R. P. Chaudhari, "RFID Based Lab Inventory Management System," in 2017 International Conference on Information, Communication, Instrumentation and Control (ICICIC), Indore, India, 2017, pp. 1-3. doi: 10.1109/ICOMICON.2017.8279154.
- [4] M. Yaser, A. A. M. Musaab, and B. D. Nasarudin, "RFID Based Improving Supply Chain Traceability," in 2013 IEEE International Conference on RFID-Technologies and Applications (RFID-TA), Johor Bahru, Malaysia, 2013, pp. 1-6. doi: 10.1109/RFID-TA.2013.6694543.
- [5] S. Apoorva, B. Sukriti, and S. Shipra, "Scrum model for Agile methodology," in 2017 International Conference on Computing, Communication and Automation (ICCCA), 2017. doi: 10.1109/CCAA.2017.8229928.
- [6] H. Faisal, U. R. Ammar, S. A. Khawaja, W. Kanwal, and A. Muhammad, "The influence of Agile Methodology (scrum) on Software Project Management," in 2019 20th IEEE/ACIS International Conference on Software Engineering, Artificial Intelligence, Networking and Parallel/Distributed Computing (SNPD), 2019. doi: 10.1109/SNPD.2019.8935813.
- [7] X. Jing and P. Tang, "Research and Design of the Intelligent Inventory Management System Based on RFID," in 2013 Sixth International Symposium on Computational Intelligence and Design, Hangzhou, China, 2013, pp. 8-11. doi: 10.1109/ISCID.2013.117.