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UNIVERSITI TEKNOLOGI MARA

ISETC2025

2 ND INTERNATIONAL SCIENCE, ENGINEERING AND TECHNOLOGY COLLOQUIUM

THE POWER OF SCIENTIFIC INNOVATION

INTELLIGENT SOLUTIONS FOR A SUSTAINABLE WORLD

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PREFACE

Welcome to the 2nd International Science, Engineering and Technology Colloquium 2025 (ISETC 2025)!

It is with great pleasure that we present this year's colloquium, a distinguished gathering of scholars, researchers, and professionals dedicated to the advancement of applied sciences. Held virtually on 9th July 2025, ISETC 2025 serves as a platform to highlight cutting-edge research, foster meaningful networking, encourage collaborations, and explore innovative solutions to global challenges.

This year's theme, "The Power of Scientific Innovation: Intelligent Solutions for a Sustainable World" highlights our shared goal to solve global challenges through applied science. It celebrates innovation as a key to building a more sustainable and resilient future. We're proud to feature keynote speakers and presenters who bring fresh insights, bold ideas, and breakthroughs shaping tomorrow's world.

We would like to extend our heartfelt appreciation to the Faculty of Applied Sciences, Universiti Teknologi MARA, Perak Branch, Tapah Campus, for their outstanding support and assistance throughout the planning and execution of the event. Their dedication has been instrumental to the success of this colloquium. We would like to sincerely thank all participants and researchers for their valuable contributions. We also appreciate the reviewers for their careful evaluations and helpful feedback. Your hard work and support mean a lot to us.

As editors, we are proud to present this collection of proceedings. It is an honour to bring together the interesting and meaningful work of our speakers and authors. We hope the ideas shared will lead to new discoveries, encourage more research, and help solve global challenges through science and innovation.

Warm regards,

Dr. Emi Norzehan Mohamad Mahbob
Dr. Saiyidah Nafisah Hashim
Ms. Lili Widarti Zainuddin
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ISETC 2025 Proceedings Editors

ENHANCING ACCESS SECURITY IN EDUCATIONAL INSTITUTIONS WITH AN ARDUINO-BASED RFID DOOR SYSTEM

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Abstract: Traditional key-based access systems pose challenges in efficiency, convenience, and security, especially in institutional settings like Polytechnic Kuching Sarawak. This project focuses on the development of a Smart Card Door Access System aimed at replacing conventional keys used by JTMK staff, enhancing access control and reducing key-related issues. The objective is to design and implement a secure, efficient access system using Arduino Nano microcontroller and RFID RC522 technology. Authorized staff members gain entry by scanning RFID cards, with access status shown on a 16x2 LCD and feedback via a buzzer. The system also logs each access attempt for monitoring purposes. This project adopted the Agile methodology, which allowed iterative development from requirement analysis, design, hardware assembly, software programming using Arduino IDE (C++), to testing and deployment. A user survey conducted among JTMK staff showed over 80% experienced frequent delays, misplacement, and dissatisfaction with traditional key systems, highlighting the need for a modernized solution. Testing confirmed the system's reliability in card authentication, access control, and user feedback. Unit tests covered components such as RFID readers, solenoid locks, and LCDs, while integration testing validated overall system functionality. Results showed the system provided fast, accurate, and secure access while minimizing user hassle. This project demonstrates an original, cost-effective solution to campus access issues using open-source hardware. It offers a scalable model for broader educational use and can be enhanced further with IoT and biometric integration for improved functionality and security.

***Keywords*:** *RFID, Arduino, Door Access System*

INTRODUCTION

In modern institutions such as universities, secure and efficient access control has become a critical component of daily operations. Traditional key-based access systems are increasingly seen as outdated due to their vulnerability to loss, duplication, and inefficiency. A survey conducted among academic staff at Politeknik Kuching Sarawak revealed that over 70% of lecturers expressed dissatisfaction with conventional key systems, citing frequent misplacement, slow access, and security concerns (John et al., 2023).

To overcome these issues, researchers have turned to smart card and embedded system technologies. One promising approach is the integration of Radio Frequency Identification (RFID) technology with Arduino-based microcontrollers. RFID enables contactless authentication, allowing users to gain entry by scanning a smart card. Arduino systems are low-cost, customizable, and reliable for local automation tasks (Shah et al., 2020).

Several recent studies have demonstrated the application of Arduino-RFID systems in door security and attendance management. For example, Shaikh et al. (2022) implemented an IoT-enabled door lock using NodeMCU and MFRC522, enabling remote access and EEPROM storage. Kumar and Jain (2021) highlighted RFID systems as optimal for small institutions, citing affordability and reliability. This paper details the design, implementation, and evaluation of a smart card door access system customized for academic staff, aiming to enhance campus security and reduce manual access delays.

Smart access control technologies have evolved to replace traditional key systems, especially in institutional environments. Common methods include QR code scanning, RFID-based smart cards, and biometric recognition. RFID systems, often built with microcontrollers like Arduino or NodeMCU, allow cost-effective, reliable access control with minimal infrastructure (Jamil et al., 2019).

One implementation by Naik and Pote (2020) showed that Arduino-based RFID systems deliver consistent performance for office access. Similarly, a student attendance project integrated an RFID MFRC522 module with Arduino Uno and SD storage, providing accuracy and data retention (Rahman et al., 2020). In contrast, QR code systems, while easy to implement, depend on camera quality and lighting, and are more susceptible to spoofing (Sharma and Kumar, 2021).

IoT-enhanced RFID systems offer features like cloud logging and mobile notifications. However, they also introduce dependencies on internet availability and configuration complexity (Islam et al., 2020). Kumar and Jain (2021) found that standalone RFID systems strike a better balance in academic environments. Limitations such as power outages, card loss, and lack of biometric fallback remain common challenges. Thus, researchers suggest augmenting RFID systems with backup power and multi-factor authentication (Riaz and Ahmad, 2022).

Several works have also explored the integration of GSM modules and mobile apps to improve administrative control over access systems. Prasad and Menon (2020) incorporated GSM-based SMS alerts alongside RFID verification to provide real-time monitoring of door access events. Meanwhile, Islam and Islam (2020) discussed the importance of offline operation in environments with poor network infrastructure, supporting the decision to develop non-internet-dependent systems like the one in this project.

Furthermore, studies show that user acceptance and training significantly affect system adoption in academic settings. Shah et al. (2020) emphasized the importance of intuitive system feedback (e.g., LCD messages and buzzer tones), which help non-technical users quickly understand access outcomes. This aligns with the current system's design, which integrates both visual and auditory indicators to support user interaction and error handling.

MATERIALS AND METHODS

The development of the Smart Card Door Access System was carried out using the Agile software development methodology, which is well-suited for time-constrained academic projects that require flexibility and continuous feedback. Agile's iterative nature allowed the team to refine the system progressively through multiple development sprints, involving planning, prototyping, testing, and user feedback at each stage.

The process began with requirement gathering, where a survey was conducted among academic staff of the Jabatan Teknologi Maklumat dan Komunikasi (JTMK) at Politeknik Kuching Sarawak. Results revealed that more than 88% of staff members had experienced issues with conventional keys, such as frequent misplacement and delays in accessing rooms, highlighting the need for a more secure and convenient system.

From this, both functional and non-functional requirements were derived. Functionally, the system needed to identify authorized users using RFID cards, control door access automatically, display access status, and provide audible feedback. Non-functional requirements included a fast response time, standalone operation without internet dependency, power efficiency, and maintainability. These requirements formed the foundation of the system's architecture and component selection.

The system was designed with a modular structure to simplify development, troubleshooting, and future upgrades. The main hardware components included the RFID RC522 reader, and the Arduino Nano microcontroller, which acted as the central processing unit. A 16x2 LCD was used to display access messages. A 5V relay activated the solenoid door lock, while a buzzer and LED indicators provided immediate feedback. The system was powered by a 9V rechargeable battery to allow operation without the main power supply.

When a user scans an RFID card, the reader sends the UID to the Arduino. The microcontroller checks it against stored authorized IDs. If valid, it triggers the relay to unlock the door and displays "Access Granted." If invalid, it displays "Access Denied" with a buzzer alert and red LED. This standalone design supports offline operation in infrastructure-limited environments, as also recommended by Shah et al. (2020).

Comprehensive testing was carried out to ensure functionality and stability. Unit testing validated individual components. Integration testing confirmed coordination between modules. The system responded within two seconds of scanning, meeting performance benchmarks found in similar RFID access systems (Shaikh et al., 2022).

The system was deployed in a simulated lab environment. Feedback showed that the system improved access efficiency and convenience. Users appreciated the elimination of manual key retrieval. Improvements suggested included cloud-based logging, admin UID management, and backup power integration.

RESULTS AND DISCUSSION

The Smart Card Door Access System was evaluated through a series of functional and integration tests using a fully assembled prototype in a simulated lab environment at the Jabatan Teknologi Maklumat dan Komunikasi (JTMK), Politeknik Kuching Sarawak. The evaluation focused on key performance indicators such as card validation accuracy, response time, hardware reliability, user feedback, and offline operation.

The testing process began with unit tests to verify individual components, including the RFID reader, relay module, solenoid lock, LCD, and buzzer. Integration testing then assessed the coordination between modules during real-time operations. Table 1 presents a summary of the test scenarios, inputs, expected outcomes, and actual results. All tests passed successfully. The system accurately validated authorized and unauthorized cards, provided correct access feedback, and operated reliably even when powered solely by a 9V battery. The average system response time was measured at 1.8 seconds, meeting expected benchmarks for efficient access control.

Table 1. Summary of Functional and Component Testing Results

Test Case	Input/Action	Expected Outcome	Result
Scan valid RFID card	Valid UID scanned	Access Granted message, green LED, lock opens	✅ Passed
Scan invalid RFID card	Unregistered UID scanned	Access Denied message, red LED, buzzer alert	✅ Passed
Response time measurement	Valid card scanned	Response time < 2 seconds	✅ Passed (1.8s)
Power test (battery only)	System powered by 9V	All components operate normally	✅ Passed
Lock mechanism test	Relay activated	Solenoid lock disengages door	✅ Passed
Feedback mechanism test	Valid & invalid card used	Correct LCD message and buzzer/LED feedback shown	✅ Passed

These results confirm the system's stability and effectiveness in providing secure access without the need for internet connectivity. The ability to operate in standalone mode reinforces its suitability for deployment in infrastructure-limited environments, consistent with findings by Shaikh et al. (2022).

In addition to technical validation, the system addressed practical access issues reported in the user survey. Among staff, 88.2% reported frequently misplacing keys, 70.6% experienced delays in room access, and 81.3% expressed concerns over key duplication (John et al., 2023). The smart card system eliminated the need for physical keys, reduced entry time to under two seconds, and improved administrative control by allowing simple updates to authorized UID lists.

One of the system's notable strengths lies in its clear and intuitive user feedback. The LCD provided real-time access status, while the buzzer and LED indicators offered immediate audio-visual confirmation. This aligns with recommendations by Shah et al. (2020), who emphasized the importance of user-friendly interfaces in access control systems.

However, some limitations were observed. The system currently lacks a backup power solution, making it vulnerable to outages. Additionally, the absence of secondary authentication means that access could be compromised if an RFID

card is lost. These limitations are common in RFID-only systems and reflect areas for enhancement, such as biometric or PIN-based authentication and UPS integration (Prasad and Menon, 2020).

Overall, the prototype fulfilled its design objectives by delivering a faster, more secure, and user-centric alternative to traditional key systems. Its modular and scalable architecture enables future upgrades such as IoT-based monitoring, cloud data logging, and mobile control features. Feedback from academic staff confirmed improved operational efficiency, reduced administrative burden, and increased confidence in access security.

CONCLUSIONS

This project successfully designed and evaluated a Smart Card Door Access System using RFID and Arduino, aimed at improving access control for academic staff at Politeknik Kuching Sarawak. The system replaced conventional keys with a faster, more secure, and user-friendly solution. Modular design and low-cost components ensured ease of development and future scalability. Testing showed strong performance in speed, reliability, and offline operation. User feedback confirmed improved access efficiency and reduced key-related issues. While power backup and secondary authentication remain as limitations, the system offers a solid foundation for future upgrades, such as biometric features and cloud-based monitoring. Overall, it presents a practical and scalable alternative to traditional access methods in educational institutions.

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Sekian, terima kasih.

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Setuju.

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