ENCHANCED RFID TECHNOLOGY WITH AI:CASE STUDY OF STUDENT BEHAVIOR ANALYS

WU JIAJIA

ROSILAH BINTI HASSAN

Fakulti Teknologi & Sains Maklumat, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor Darul Ehsan, Malaysia

ABSTRAK

Projek ini memberi tumpuan kepada sinergi sistem RFID dengan Kecerdasan Buatan (AI) untuk mengesan statistik tingkah laku pelajar dalam persekitaran kolej. Ia akan ditempatkan di kawasan yang selesa termasuk perpustakaan, bilik darjah, kafeteria, dan kawasan belajar; para pembaca merekodkan pola trafik pelajar, di mana dan bila mereka masuk dan keluar dari kemudahan tersebut. Sebahagian daripada maklumat ini disusun dalam pangkalan data pusat supaya program AI yang lebih mantap dapat mengenal pasti perubahan bermusim. Dengan menggunakan kluster dan analisis aliran, AI menentukan kemudahan yang disukai pelajar dan kepadatan aktiviti mereka di pelbagai bahagian kampus pada masa tertentu. Maklumat sedemikian, seperti pilihan kawasan kajian, masa makan dan pergerakan terhad kepada kelas, berguna apabila cuba memperuntukkan sumber atau reka bentuk reka letak bangunan. Selain itu, AI boleh mengenal pasti arah aliran dalam pergerakan yang boleh membantu kakitangan melihat sebarang aktiviti yang mencurigakan, dengan itu meningkatkan keselamatan kampus dan tindak balas pantas sekiranya berlaku kecemasan. Projek ini boleh membantu meningkatkan pengalaman pelajar dengan membenarkan pentadbir memperuntukkan sumber yang lebih baik, seperti menukar waktu operasi, mungkin menambah lebih banyak ruang berdasarkan kawasan popular yang biasa diduduki atau menyediakan penyelenggaraan semasa penggunaan di luar puncak. Ini kekal, kerana data tidak dikenali untuk mengelakkan sebarang pengenalan pelajar yang terlibat dan penjejakan data boleh dilumpuhkan. Gabungan RFID dan AI membolehkan sekolah mendapatkan cadangan berasaskan data yang lebih dekat dengan keperluan pelajar dan meningkatkan fungsi sekolah sebagai persekitaran pendidikan.

ABSTRACT

The project focuses on the synergy of RFID system with Artificial Intelligence (AI) to track student's behaviour statistics in a college environment. It will be placed in convenient areas including libraries, classrooms, cafeteria, and study areas; the readers record student traffic patterns, where and when they enter and exit the facilities. Some of this information is compiled in a central database so that more robust AI programs can identify seasonal changes. Using clustering and trend analysis, the AI determines which facilities students prefers and the density of their activity at various parts of campus at any given time. Such information, such as study area preferences, meal times, and movement confined to classes, is useful when trying to allocate resources or design building layouts. In addition, AI can identify trends in

movements that can help staff notice any suspicious activity, thereby improving campus security and rapid responses in case of emergencies. The project could help enhance the student experience by allowing administrators to better allocate resources such as changing operating hours, possibly adding more space based on popular areas that are commonly occupied or providing maintenance during off-peak usage. This remains, as the data is anonymized to avoid any identification of the students involved and data tracking can be disabled. The combination of RFID and AI enables schools to get data-driven recommendations that are closer to the needs of students and improve the functioning of the school as an educational environment.

1.0 INTRODUCTION

As technology is advancing more and more, education institutions themselves are implementing modern changes in the campus environment and students' funnelling. In our case, Radio Frequency Identification (RFID) technology seems to be one of the most effective tools for tracking and controlling the students' activities and the necessary facilities properly (Tyagi et al. 2023). With the help of RFID and spinning adopted with Artificial Intelligence (AI), the schools can discover various tendencies connected with students' activity on the campus and, therefore, the administrators will be able to make decisions that will be efficient usage of the resources and secure environment for learning process as well as more efficient support of the students (Sentíes Maqueda et al. 2023).

This project aims to implement an RFID-based system that traces movement of students to library, class, cafeteria or any other facility in the campus. In its simplest form, by having RFID readers located at strategic places, then every time a student passes through a given section, the system can record an ingress or egress, or passage. Each student also has a unique RFID card that, aside from personalizing, connects each entry and exit with a particular user. Gradually an extensive database of the student activity is created that records patterns of how students navigate through various zones of the campus. This data is analysed by AI algorithms to identify their patterns and trends. The AI system includes the main investigations of the data, for example clustering, association rule and anomaly analyses, which could let the system know the active times of specific area, studying and socializing zones and overall movements throughout campus. Such information enlightens the administrators on how students use a variety of resources for them to change the working hours of the facility, the number of staff as well as the space occupancy (Majeed & Ali 2018). For example, if it is realized that the library experience is busiest either in the morning or afternoon, the school may decide to provide more library spaces at those hours. This will also assist in identifying the right time most dining areas are congested, and therefore, hire sufficient staff to satisfy the student population.

Furthermore, this system also promotes safety in campus since it efficiently utilizes resources on the campus. The mining of student's activities for anomalies can pinpoint cases of forbidden or limited movement within campus, including efforts to access some parts of

the campus after school close. It is closely connected with an early warning system since it notifies staff about anomalies, and, therefore, helps to respond to emergencies or suspicious actions faster. Furthermore, in the case of safety instructions and emergency situations students gather in the specified areas, such information is helpful while planning escape routes and measures for safety management (Velasco 2023).

Issues of privacy and data security are relevant to this work. All the information gathered through the assessments is highly secure to ensure that nothing that is associated with the identity of specific students is exposed. When using the data for creating the assessment reports or for analysis, only the consolidated data is used. Further, students are not allowed to participate if they do not wish to be monitored during the class. These preventions help the project adhere to the provisions of privacy to help establish credibility among the student and the staff. Overall, this RFID based student behaviour analysis system allows schools to build a more effective, safe and proactive campus life. This is because the system renders information and possible intervention to administrators thus enabling schools to take preventive actions. This project not only helps to maintain operational development but also enhances the quality of learning in that regard to see that resources, training, and intervention are meeting the actual behaviours/states of students (Sentíes Maqueda et al. 2023). Figure 1.1 shows the overview of the project.

2.0 LITERATURE REVIEW

Technological advancement and embraces have acted as a basis for replacing traditional appeals on student behaviour analysis in learning institutions for instance embracing Radio Frequency Identification (RFID) and Artificial Intelligence (AI) (Ula et al. 2021). This project brings out the need to gain an insight into students' behaviour to empower improved approaches to engagement and learning (Ishaq & Bibi 2023). However, the conventional techniques of taking attendance, observing activities, and assessing behaviour fail to be systematic, accurate, and real-time at many occasions (Adeniran et al. 2019). RFID technology provides solution to these challenges through the usage of automatic attendance and monitoring of movement of students within a campus. RFID can be put into the student ID cards or wristbands and, in this way, institutions can, gather accurate data without unnecessary interference and thus save a lot of time and energy.

RFID is supported by AI because it captures massive amounts of data, and then AI uses this data to make predictions, detect trends and potential problems like low attendance and disinterest. The collected information assists educators and administrators make proper decisions to enhance students' performance and attendance (Shrivastava et al. 2023). In combination, RFID and AI serve as a breakthrough tool in behaviour assessment to have a holistic approach on student needs (Pss & Bhaskar 2016). The present chapter also systematically presents relevant previous research and techniques in this subject, as well as discusses the drawbacks of prior works, new solutions, and the lack of prior studies (Ishaq & Bibi 2023). That is why, the purpose of this project is to identify possibilities of applying

these technologies to improve the education process and to enhance relation between people which connected with it.

3.0 METHODOLOGY

This project adopts a structured methodology that integrates RFID hardware and AI algorithms to monitor and analyse student behaviour in real time. It begins with collecting data from RFID tags placed on students, which is then transmitted through antennas and readers to a central system. AI models process this data to identify behaviour patterns, detect anomalies, and generate useful reports. The system is tested through simulations to ensure accuracy, reliability, and scalability before real-world deployment.

3.1 Needs Analysis

The proposed system arises from the growing challenges educational institutions face in effectively monitoring student behavior across campus. Traditional approaches such as manual attendance recording and physical supervision are inefficient, error-prone, and lack real-time responsiveness. As shown in Figure 1, the inability to accurately track student movement and engagement has led to critical needs in educational management. These include the need for real-time behavior monitoring, timely detection of abnormal patterns, and data-driven resource allocation. In response, this project introduces a solution that integrates RFID technology with artificial intelligence to automate data collection and analyze behavioral trends. By transforming raw movement data into actionable insights, the system empowers administrators to enhance decision-making, optimize facility usage, and respond proactively to student needs, thereby addressing the root problems identified during the needs assessment.

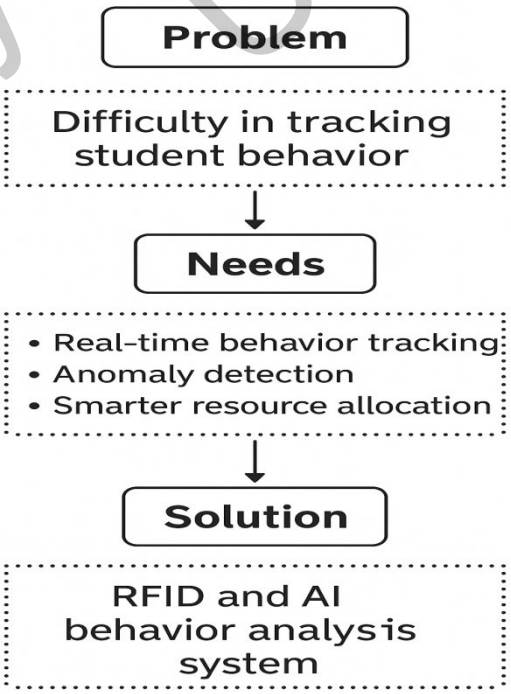


Figure 1: Needs Analysis

3.2 Conceptual Model Design

The conceptual model of the proposed system is structured around a three-layer architecture: Input, Process, and Output, as illustrated in Figure 2. This layered design ensures a systematic flow of data from collection to actionable insights. In the Input stage, RFID technology captures essential data such as student ID, location, and time stamps whenever a student passes through designated areas equipped with RFID readers. This raw RFID data is then transmitted into the Processing stage, where it undergoes a series of analytical procedures. First, the data is collected and validated, followed by AI-driven analysis that detects behavioral patterns and anomalies. Pattern recognition algorithms play a key role in identifying trends over time, such as irregular attendance or unexpected movements.

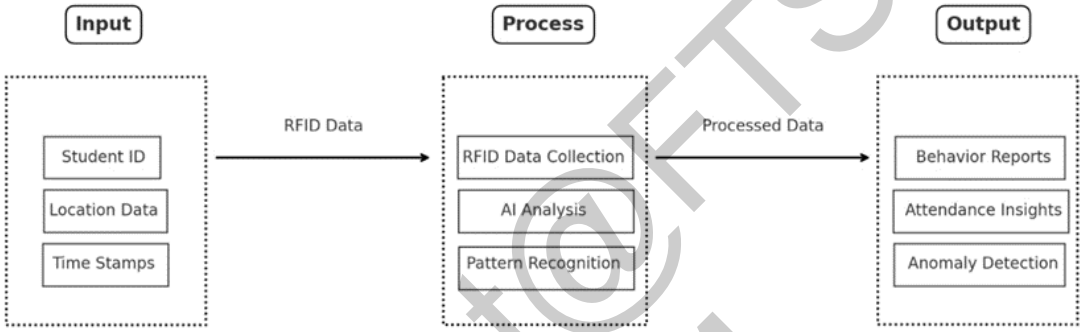


Figure 2: Proposed system

The final Output stage translates the processed data into meaningful information. This includes the generation of behavior reports for administrators and educators, attendance insights for tracking student engagement, and anomaly detection alerts for identifying potential issues such as truancy or unusual activity. This model not only enhances the accuracy and efficiency of behavior monitoring but also supports real-time decision-making in educational environments. The modularity of this architecture ensures scalability, allowing the system to be adapted to various institutional needs and data volumes without compromising performance.

4.0 RESULTS

4.1 Interface Design

As for the project, the login interface is designed to provide users with a secure and user-friendly authentication experience. It features a clean and intuitive layout with a prominent background image of the main building of the Faculty of Information Science and Technology (FTSM), Universiti Kebangsaan Malaysia (UKM), serving as a visual identity element, as shown in Figure 3.Users can log in using their username and password, and they have the option to save their login credentials for convenience. The interface includes essential features such as a large and clearly labeled "Login" button, a "Register" link for new users, and a

"Reset Password" option for users who have forgotten their credentials.The interface is designed with simplicity and usability in mind to ensure smooth navigation for all user types, particularly students and administrators. Its visual clarity and functional accessibility make it suitable for regular academic use.

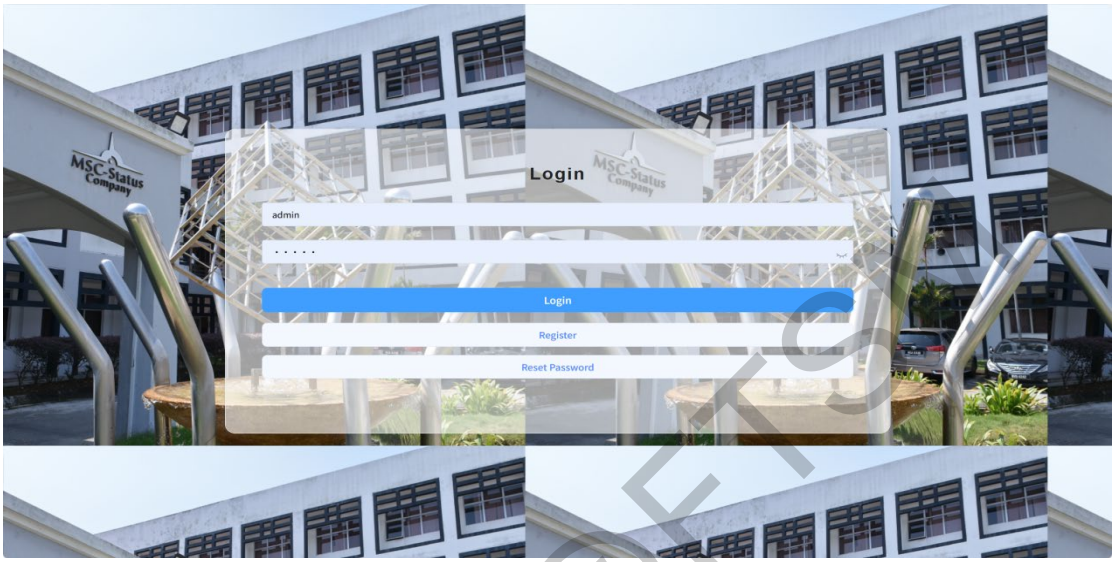


Figure 3 Structure of the LOGIN interface

The registration interface shown in Figure 4 is designed to provide users with a straightforward and intuitive sign-up experience. It includes input fields for username, password, student ID, email, age, gender, and user role selection (such as Student, Teacher, or Admin). This structured approach ensures complete user profile creation during registration.The interface adopts a clean and modern design, with a prominent "Confirm" button to prevent user confusion. The role selection option allows the system to assign appropriate access rights based on the user's identity. The background image featuring the main building of the Faculty of Information Science and Technology (FTSM) at Universiti Kebangsaan Malaysia reinforces institutional branding and credibility.Overall, the design emphasizes usability and clarity, ensuring that even first-time users can register with ease and confidence.

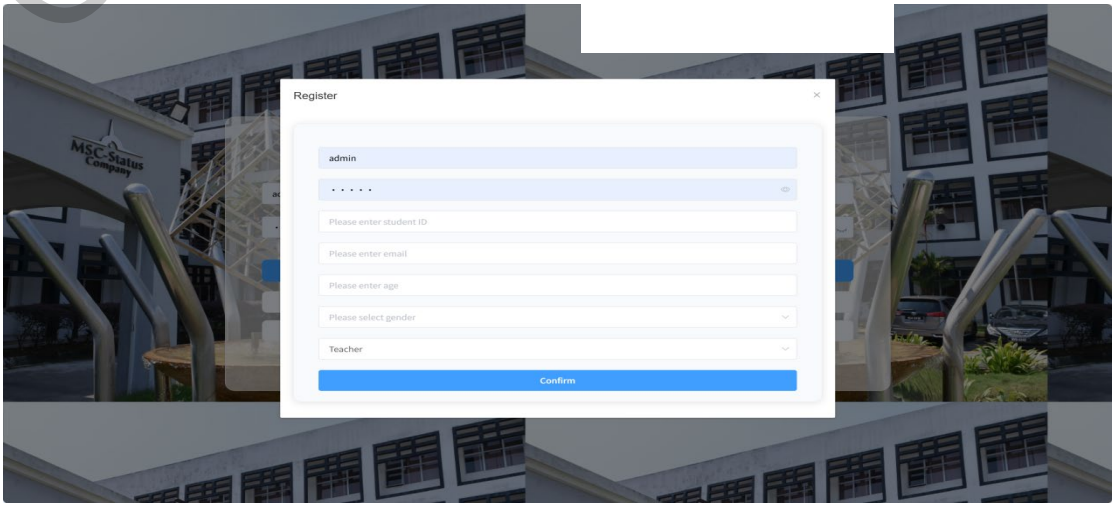


Figure4 Structure of the Register Interface

The Dashboard Interface in Figure 5 to 7.To enhance data transparency and facilitate monitoring, the system provides a series of visual reporting components on the dashboard. As shown in Figure 4.6, a line chart titled Card Usage Trend illustrates the daily card swipe frequency over a period of time. This helps users and administrators identify behavior patterns and detect sudden changes in usage habits.Figure 6 presents a pie chart summarizing the distribution of card usage across different locations, including Classroom, Library, Canteen, and Study Area. This visual representation provides insights into space utilization, supporting more effective facility planning and resource allocation.Additionally, Figure 7 shows a daily learning time graph, which calculates and displays each user's total learning time per day based on their first and last swipe-in records in learning zones (e.g., Classroom and Library). This feature offers a data-driven overview of students' study engagement and supports personalized feedback and academic supervision.

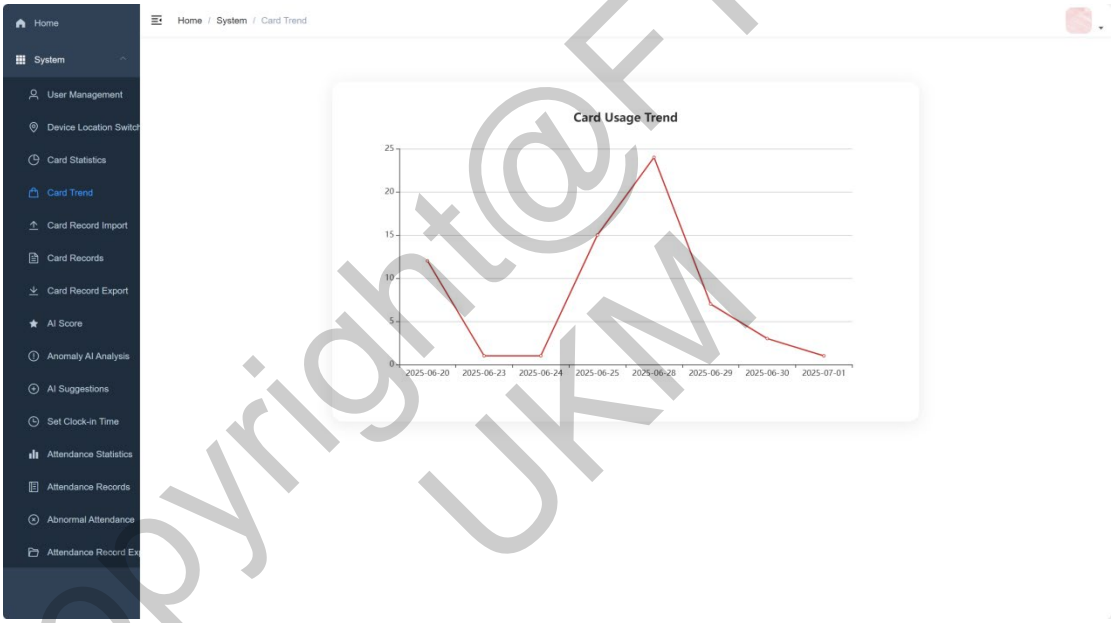


Figure 5 Card Usage Trend

Figure 6 Card Statistics

Figure 7 Daily Learning Time

Figure8 illustrates the Student Personal Interface .Sidebar offers a well-structured and intuitive navigation menu. It integrates key modules such as card usage statistics, usage trends, detailed card records, AI-generated behavior scores, anomaly analysis, personalized suggestions, and attendance reports. This layout enables students to efficiently monitor their academic behavior, access AI insights, and manage their attendance data—all within a user-friendly and visually organized interface.

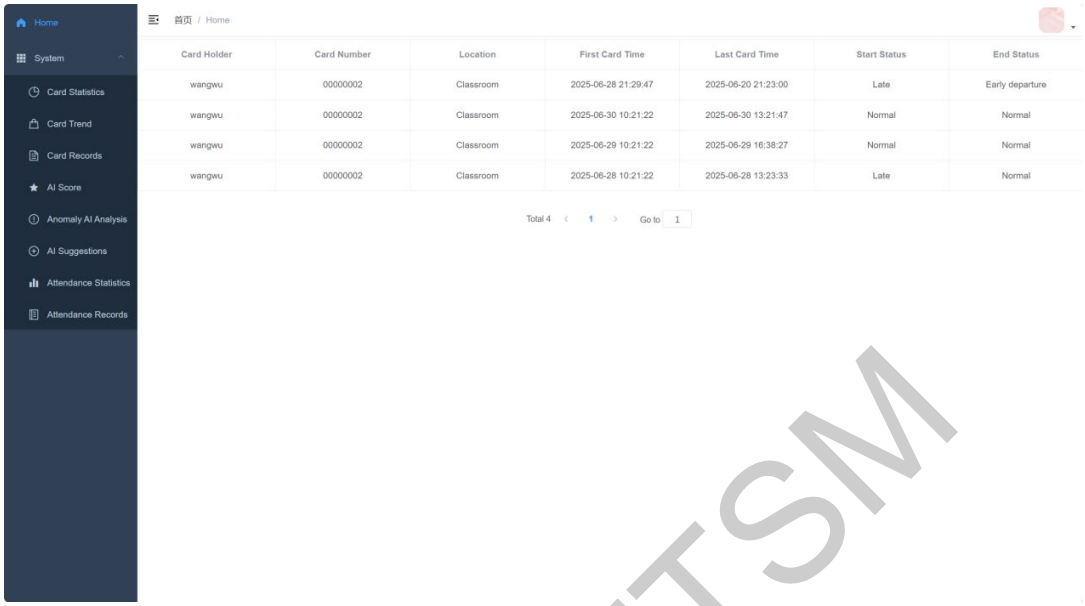


Figure 8 Student Personal Interface

Figures 9 and 10 highlight the system's intelligent monitoring capabilities for behavioral irregularities.Figure 9 shows the Anomaly AI Analysis interface, where a chatbot-powered AI engine evaluates swipe patterns and explains possible violations, such as impossible simultaneous location entries or excessive rapid swipes.Figure 10 presents the Abnormal Attendance interface, which summarizes late arrivals, early departures, or incomplete check-ins within a selected time frame. These tools greatly enhance administrative oversight and proactive detection of attendance issues..

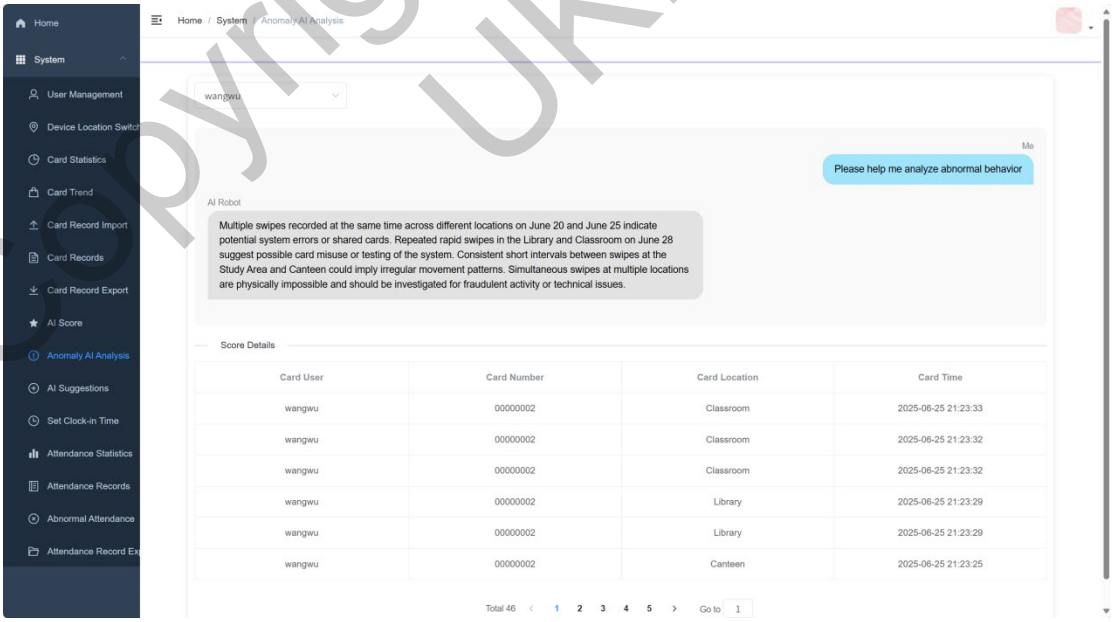


Figure 9 AI-Based Anomaly Detection Interface

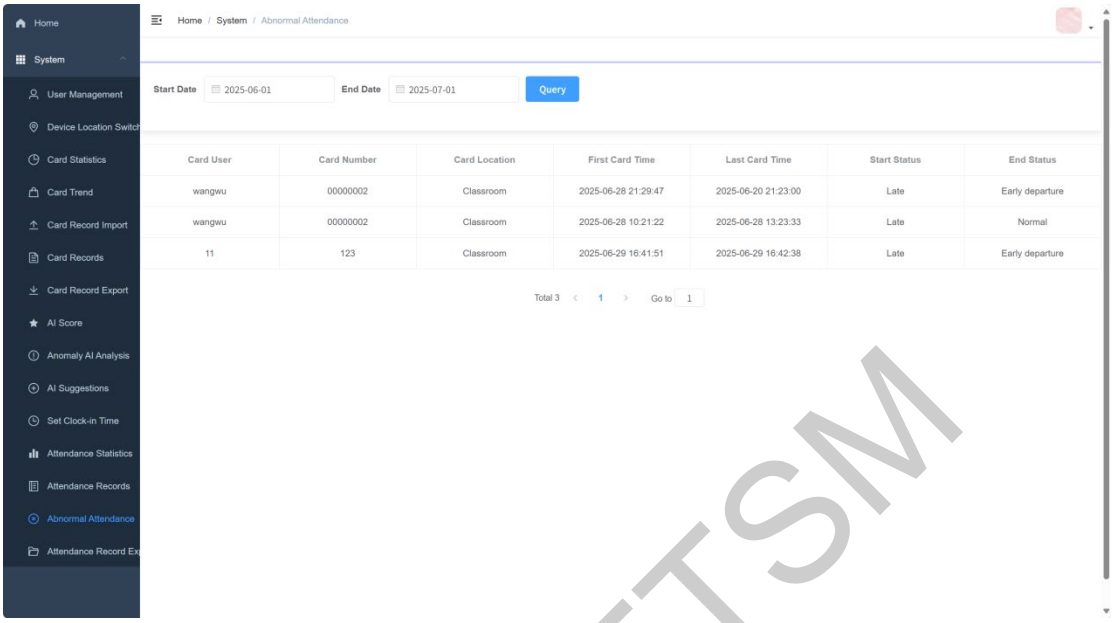


Figure10 Abnormal Attendance Record Interface

4.2 Testing Data

To validate the core functionalities of the system—including user management, RFID tracking, and attendance behavior analysis—a series of test data entries were created and uploaded. The system was tested using sample user profiles, RFID card entries, and check-in/out records to simulate real-world scenarios.

Figures 11 shows the User Management interface where test users were added. The dataset includes various roles such as Students, Teachers, and Admins, with fields like Username, Password, Name, Gender, Age, Email, and RFID.

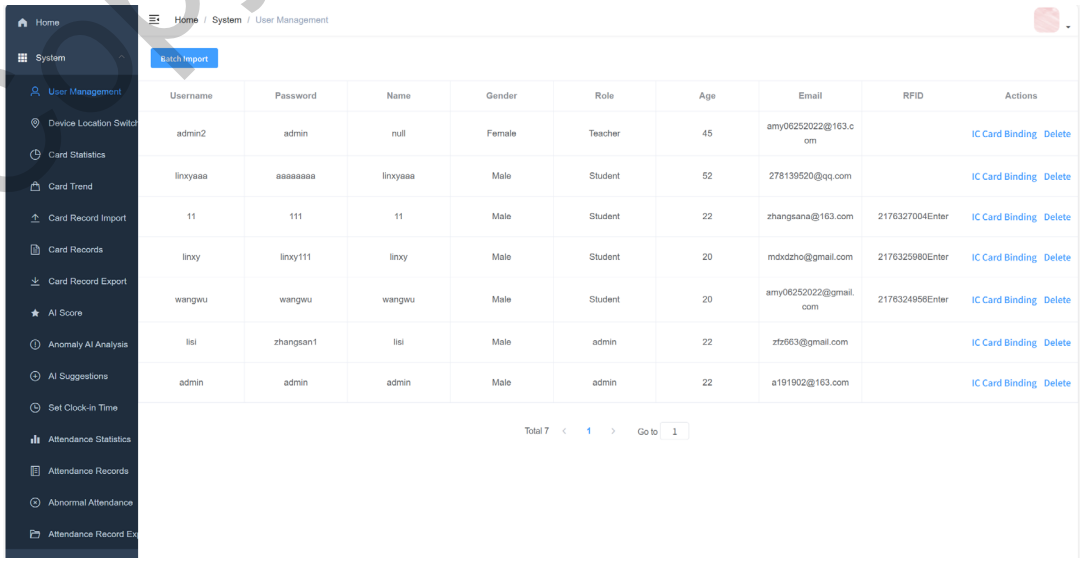
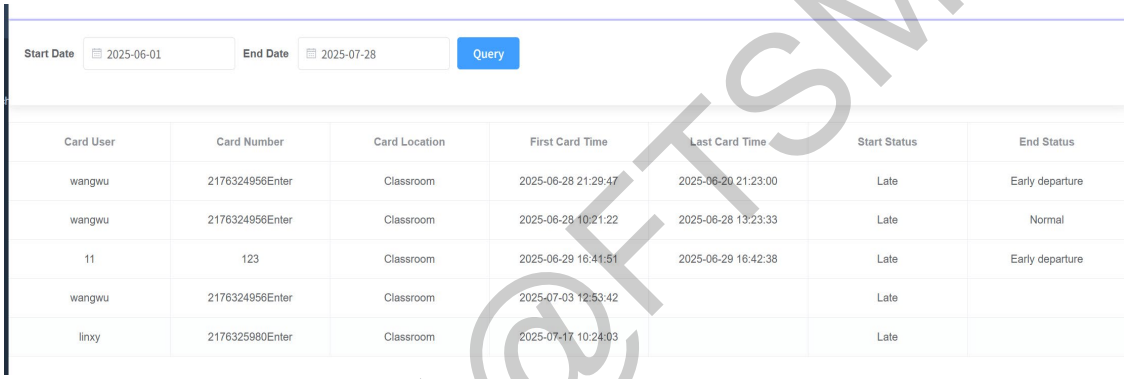


Figure11 User Management

In Figure 12, the system’s ability to record and analyze student attendance behavior is demonstrated through test data collected between June 1 and July 28, 2025. The interface displays filtered records showing each user's card number, location, and their first and last card swipe times during each visit. For example, the user "wangwu" consistently checked in at the classroom location using card number "2176324956Enter" with recorded behaviors such as late arrivals and early departures. Similarly, the user "11" also exhibited irregular behavior with a late check-in and early check-out, marked accordingly by the system. These data entries validate that the system can accurately associate RFID scans with time-based behavioral patterns and classify attendance status such as "Late", "Normal", or "Early departure" automatically.



Card User	Card Number	Card Location	First Card Time	Last Card Time	Start Status	End Status
wangwu	2176324956Enter	Classroom	2025-06-28 21:29:47	2025-06-20 21:23:00	Late	Early departure
wangwu	2176324956Enter	Classroom	2025-06-28 10:21:22	2025-06-28 13:23:33	Late	Normal
11	123	Classroom	2025-06-29 16:41:51	2025-06-29 16:42:38	Late	Early departure
wangwu	2176324956Enter	Classroom	2025-07-03 12:53:42		Late	
linxy	2176325980Enter	Classroom	2025-07-17 10:24:03		Late	

Figure12 Card Record Analysis

Figure 13 presents a comprehensive view of the attendance records generated by the system using test data from multiple users. The table captures detailed RFID card activity, including the cardholder’s name, card number, location, first and last card swipe times, as well as system-generated start and end status indicators. The entries reflect a range of attendance behaviors: for example, "linxy" and "wangwu" frequently appear with a "Late" status at the start of the session, and users like "11" and "wangwu" occasionally show "Early departure" at the end. Meanwhile, records from "zhaoliu" are marked with "Normal" status throughout, illustrating standard behavior. This dataset confirms that the system effectively distinguishes between normal and abnormal attendance, detects repeated patterns, and ensures data consistency across multiple users and entries in real-time.

Card Holder	Card Number	Location	First Card Time	Last Card Time	Start Status	End Status
linxy	2176325980Enter	Classroom	2025-07-17 10:24:03		Late	
wangwu	2176324956Enter	Classroom	2025-07-03 12:53:42		Late	
11	123	Classroom	2025-06-29 16:41:51	2025-06-29 16:42:38	Late	Early departure
wangwu	2176324956Enter	Classroom	2025-06-28 21:29:47	2025-06-20 21:23:00	Late	Early departure
zhaoliu	0000003	Classroom	2025-06-30 10:21:22	2025-06-30 13:21:47	Normal	Normal
wangwu	2176324956Enter	Classroom	2025-06-30 10:21:22	2025-06-30 13:21:47	Normal	Normal
wangwu	2176324956Enter	Classroom	2025-06-29 10:21:22	2025-06-29 16:38:27	Normal	Normal
wangwu	2176324956Enter	Classroom	2025-06-28 10:21:22	2025-06-28 13:23:33	Late	Normal

Figure13 Full Attendance Log

5.0 CONCLUSION

The new combination of advanced student tracking systems with artificial intelligence creates a major step forward for schools. Old ways to watch student attendance and behaviour depend on manual steps that easily fail and cannot serve many students. Our system fixes these problems by combining RFID tools for smooth tracking with AI to produce reliable predictive results.

RFID technology tracks students across the campus in real time so attendance data stays always correct. Comparing to standard procedures like rollcall or manual entry RFID tags track student behaviour automatically to eliminate staff workload and data entry mistakes. By using artificial intelligence algorithms, the system helps educators and administration become smarter through data insights beyond simple recording. AI analysis tools detect behavioural changes in students by monitoring attendance patterns and movement between classes. They identify trends that show students are lost or sliding toward disengagement so schools can act quickly.

The main success of this project rests in maintaining personal privacy and security. Our system uses multiple security tools to protect personal data and make it available only to authorized users. When privacy issues alarm students and parents the systematic approach to ethical security builds reliable foundations for updating education with technology. The system protects student privacy through legal requirements and robust data protection measures.

The project tested today's technology standards to show it delivers better results than typical control systems. The improved RFID system works well for institutions of all sizes because developers created it to grow with institutions when they need to add more capabilities. Because it works reliably with many users and provides simple controls the system meets educational institution requirements at every level.

By developing this project reveals the value of adopting modern technology to help students succeed while feeling better. Students who show risk signs get highlighted by the system so educators can provide adaptive help to help them succeed. The system uses data to see when students stop attending class or stay uninvolved so help teams can react before problems develop. The system collects useful information that helps administrators design better long-term plans to develop students.

This project leads education technology forward with efficient secure solutions that show proper ways to tackle real world problems. The system provides better results through RFID and AI together while helping faculty understand student information to make smart choices for the school. By creating a solid foundation our system prepares technology to guide education development into the future.

By combining RFID technology with AI analysis this system offers a secure way to both track student behaviour and boost student learning effectiveness. This system makes attendance monitoring simpler while examining behaviour to help institutions design better teaching spaces. Our project brings technology and education together so schools can use modern methods for teaching.

REFERENCES

Aldowah, H., Rehman, S.U., Ghazal, S. & Umar, I.N. 2017. Internet of Things in higher education: a study on future learning. In *Journal of Physics: Conference Series* (Vol. 892, No. 1, p. 012017). IOP Publishing.

Al_Janabi, S. 2020. Smart system to create an optimal higher education environment using IDA and IOTs. *International Journal of Computers and Applications* 42(3): 244-259.

Adeniran, T. C., Sanni, Y., Faruk, N., & Olawoyin, L. A. (2019). Design and implementation of an automated attendance monitoring system for a Nigerian university using RFID. *African J. Comput. ICT*, 12(2), 72-89.

Ishaq, K. & Bibi, S. 2023. IoT based smart attendance system using RFID: A systematic literature review. *arXiv preprint arXiv:2308.02591*.

Keau, C.S., On, C.K., Hijazi, M.H.A. & Singh, M.M. 2021. Smart-Hadir-Mobile Based Attendance Management System. *International Journal of Interactive Mobile Technologies* 15(14).

Majeed, A. & Ali, M., 2018. How Internet-of-Things (IoT) making the university campuses smart? QA higher education (QAHE) perspective. In *2018 IEEE 8th Annual Computing and Communication Workshop and Conference (CCWC)*, pp. 646-648.

Pss, S., & Bhaskar, M. (2016, January). RFID and pose invariant face verification based automated classroom attendance system. In 2016 *International Conference on Microelectronics, Computing and Communications* (MicroCom) (pp. 1-6). IEEE.

Sentíes Maqueda, A., Olais-Govea, J.M., Cuellar-Reynaga, D.A., Rosales Salas, E.J., Torres Zafra, E., Flores Sayavedra, Y.Y., Aguilar-Mejía, J.R. & Reynaga-Peña, C.G. 2023. Application of RFID Technology to Create Inclusive Educational Resources. In *International Conference on Human-Computer Interaction*, pp. 405-416.

Shrivastava, A., Suji Prasad, S. J., Yeruva, A. R., Mani, P., Nagpal, P., & Chaturvedi, A. (2023). IoT Based RFID Attendance Monitoring System of Students using Arduino ESP8266 & Adafruit. io on Defined Area. Cybernetics and Systems, 1-12.

Tan, P., Wu, H., Li, P., & Xu, H. (2018). Teaching management system with applications of RFID and IoT technology. Education Sciences, 8(1), 26.

Tholeti, P., Thirumalesh, B., Anu, B. & Valiveti, H.B. 2023. Facial and Behavioural Analysis for Classroom Management using Computer Vision. In *2023 2nd International Conference on Applied Artificial Intelligence and Computing (ICAAIC)*, pp. 827-833.

Tianbo, Z. 2012. The internet of things promoting higher education revolution. In *2012 Fourth International Conference on Multimedia Information Networking and Security*, pp. 790-793.

Tyagi, S., Gupta, V., & Mehndiratta, V. 2024. Building Smart Campuses: Integrating AI in Higher Education. In *Recent Trends in Artificial Intelligence Towards a Smart World: Applications in Industries and Sectors*, pp. 399-431.

Ula, M., Pratama, A., Asbar, Y., Fuadi, W., Fajri, R., & Hardi, R. (2021, April). A new model of the student attendance monitoring system using rfid technology. In *Journal of Physics: Conference Series* (Vol. 1807, No. 1, p. 012026). IOP Publishing.

Velasco, R.M.A. 2023. IoT Security Solutions for Students' Laboratory with RFID-based Attendance Authentication. *International Journal in Information Technology in Governance, Education and Business* 5(1): 41-50.

Wu jiajia (A191902)
Prof. Madya Dr. Rosilah Hassan
Fakulti Teknologi & Sains Maklumat
Universiti Kebangsaan Malaysia