Final Year Project Report for the Degree of Bachelor of Computer Engineering

SMART CANTEEN PAYMENT SYSTEM

Code No: CMP-490

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United Technical College

Department of Computer Engineering

Affiliated to Pokhara University, Nepal

July 6, 2025

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SMART CANTEEN PAYMENT SYSTEM

Supervised by Er. Sudeep Thapaliya

A final year project report submitted in partial fulfillment of the requirements for the degree of Bachelor of Computer Engineering

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Dedication

This project is dedicated to future engineers' researches, innovators and problem solver who will build upon our work to create a better world. As well as supreme personality of Godhead Sri Krishna who is always accompanied by his devotees.

"Hare Krishna"

Declaration

We hereby declare that the project entitled "SMART CANTEEN PAYMENT SYSTEM" is based on our original work. Related works on the topic by other researchers have been duly acknowledged. We assume all liabilities related to the accuracy and authenticity of the data and any other information included herein.

Names of the Students:

Aman Paudel

Prajjwal Adhikari

Raj Gurung

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Date:

July 6, 2025

Recommendation

This is to certify that the project work entitled “Smart Canteen Payment System” prepared and submitted by Aman Paudel, Prajjwal Adhikari, Raj Gurung and Rozal Dahal in partial fulfillment of the requirements for the degree of Bachelor of Computer Engineering awarded by Pokhara University, has been completed under my supervision. I hereby recommend its acceptance by Pokhara University.

Signature:

Name of the Supervisor: Er. Sudeep Thapaliya

Organization: United Technical College

Date: Jun 6, 2025

Acknowledgements

We have dedicated our efforts to this project. However, it would not have been possible without the kind support and assistance of teachers and individuals. We would like to extend our sincere thanks to all of them.

We are deeply indebted to our project supervisor, Er. Sudeep Thapaliya, for his guidance and constant supervision, as well as for providing necessary information regarding the project. We would like to express our gratitude towards our principal, Prof. Dr. Madhav Prasad Koirala (Ph.D.), and the Head of the Department of Computer Engineering, Er. Sahit Baral, and lecturer Er. Prashan Paudel for their kind cooperation and encouragement.

Our thanks and appreciation also go to Mr. Binod Dhakal, Er. Manoz Sapkota, Er. Pukar Neupane for their contributions to the project; they willingly helped us with their abilities.

Name of the Students:

Aman Paudel

Prajjwal Adhikari

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Date:

Jun 6, 2025

Abstract

The Smart Canteen Payment System is designed to digitize and streamline canteen operations by enabling contactless ordering, automated billing, and real-time sales tracking. At mid-point of development, significant progress has been made in both frontend and backend systems. A functional web-based interface has been developed to support order placement, time-based dynamic menus based on canteen schedules, user authentication, and administrative controls. The backend database successfully manages multiple canteen menus and stores all transaction data. On the hardware side, the PN532 NFC module has been tested with the ESP32 WROOM Devkit V1 microcontroller using UART communication and jumper wire connections. Dummy NFC programs have verified the ability to read tag data, laying the foundation for future integration into the live system. The system also includes a prepaid model where users' balances can be deducted based on scanned NFC tags. Additional modules such as sales analysis, monthly reporting, email-based purchase confirmation, and product management have been implemented. The printing module and full NFC-based authentication are currently in progress. The remainder of the project will focus on completing hardware integration, automating the bill printing process, and performing end-to-end system testing and deployment.

Keywords: *Smart Canteen System, NFC Authentication, ESP32, PN532, Web Application, Time-Based Menu, Prepaid Model, Thermal Printer, Sales Analysis*

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Abbreviation and Acronyms

API	Application Programming Interface
DB	Database
ERD	Entity Relationship Diagram
ESP32	Express if 32
GUI	Graphical User Interface
HTTP	Hypertext Transfer Protocol
ID	Identification
IoT	Internet of Things
NFC	Near Field Communication
POV	Point of View
SPI	Serial Peripheral Interface
SQL	Structured Query Language
UART	Universal Asynchronous Receiver Transmitter
UI	User Interface
UX	User Experience

Chapter 1: Introduction

1.1 Background

Traditional canteen management systems depend on manual operations, leading to inefficiencies such as delayed order processing, errors in billing, and lack of transparency in financial tracking (Khairunnisa, K., Johari, A., Wahab, M., Erdi, M., & Ayob, A., 2009). Recent advancements in IoT and web-based applications offer a unique opportunity to automate and streamline these processes (Sadiku, M., Ashaolu, T. J., Ajayi-Majebi, A., & Musa, S., 2020). By leveraging these technologies, canteens can improve user experience and operational efficiency (Qianyu, 2014).

The proposed system integrates a web application with IoT devices like NFC-enabled ID cards, Raspberry Pi, and real-time data visualization tools (Chee-Chun Wong, Lee-Ying Chong, Siew-Chin Chong, Check-Yee Law, 2023). The inclusion of passkey authentication ensures secure payments and an added layer of accountability (Sharma, 2017). Automated email notifications enhance transparency and keep stakeholders informed about transactions.

1.2 Problem Statement

Canteens relying on manual operations face the following challenges:

- Slow order processing and payment handling.
- Limited visibility into sales and inventory data.
- Difficulty in tracking and auditing transactions.

This project aims to address these issues by developing a web-based canteen system that incorporates automation, visualization, and secure payment mechanisms.

1.3 Objectives

- To design and implement a web-based interface for placing and managing orders.
- To enable NFC-based payment processing linked to student ID cards.
- To develop a visual dashboard to monitor real-time sales and push email notification to stakeholders.

1.4 Motivation and Significance

The inefficiencies of manual canteen systems, such as delayed order fulfillment and lack of accurate records, highlight the need for automation. This project is motivated by the potential to revolutionize canteen management through technology. By integrating IoT and web-based platforms (Khan, M., & Desai, J, 2017), the system will not only reduce operational overhead but also enhance transparency and user satisfaction.

The proposed solution has significant implications for modernizing institutional canteens, ensuring timely service, and providing stakeholders with actionable insights. This combination of functionality and transparency sets a new standard for canteen operations.

1.5 Scope of Work

The scope of this project includes the following:

- Development of a responsive web interface for user interaction.
- Integration of NFC readers to facilitate cashless transactions.
- Implementation of a real-time visual dashboard to display key performance metrics.

- Automated email notifications for order summaries and monthly expenditure reports.
- Rigorous testing to ensure compatibility across hardware components (Computer, NFC devices).

Chapter 2: Related Works

2.1 Overview of Existing Systems

1. **Online Canteen Management System**

   According to (Bhavani, August,2022), the Online Canteen Management System digitized food ordering through web-based menus and payment integration, streamlining order preparation and administrative management. Users can log in using their institutional email IDs to place orders, which are directly queued for preparation. Administrators manage menu updates, transactions, and user profiles using a secure, encrypted database.

2. **Cashless & Online QR-Code-Based Canteen System**

   Similarly, (Tejaswini Sharma, Swati Jha, Shubhi Gupta, Vishakha Singh, Shipra Gautam, 2021) introduced a Cashless & Online QR-Code-Based Canteen System to address contactless transactions. Their system employed QR codes for menu access, real-time order updates, and UPI-based payments. Users scan QR codes to access a web platform, where they can browse the menu, place orders, and pay via UPI or e-wallets. Notifications keep users updated about their order status.

3. **Cashless Canteen Management System**

   The RFID-Based Cashless Canteen System by (M. Ambika, Saravana Kumar R, Sandhya S Nair, Ranjith Kumar S, 2020) utilized RFID cards for cashless payments and integrated encryption for secure transactions. This system integrates RFID cards for cashless transactions, enabling users to recharge cards and make payments seamlessly. Orders placed online or at the counter are

displayed in real-time in the kitchen. Security is ensured through encryption and SSL protocols.

4. **Development and Evaluation of a Comprehensive Web-Based Canteen Food Ordering System**

   (Sushank Pandey, Rayaan Quraishi, Aditya Salian, Swapnil Bhagat, 2024) developed a Comprehensive Web-Based Canteen Food Ordering System focusing on real-time inventory updates and centralized dashboards. This system focuses on automating food ordering and inventory management in educational and workplace cafeterias. It allows users to browse menus, place orders, and pay online. Admins have access to a centralized dashboard for monitoring operations and generating reports.

5. **QR Food Ordering System with Data Analytics**

   Finally, (Chee-Chun Wong, Lee-Ying Chong, Siew-Chin Chong, Check-Yee Law, 2023)developed a QR Food Ordering System designed to automate the ordering process in restaurants and provide insightful business analytics. Customers scan a QR code on their table to access a digital menu and place orders, which are automatically processed for billing. The system allows restaurant administrators to manage the menu, generate QR codes, and analyze sales data through visualized charts. It utilizes machine learning to forecast demand, enhancing decision-making and resource allocation.

2.2 Comparison of Features

1. **Online Canteen Management System**

   Features:

   - Web-based e-menu for easy access to food options.

- Online payment integration streamlining order processing.
- Real-time notifications to kitchen staff for immediate order updates.

Drawbacks:

- Limited scalability for large institutions.
- Lacks parental notifications and multi-factor authentication for added security.

2. **Cashless & Online QR-Code-Based Canteen System**

Features:

- QR-code-based contactless ordering for a seamless user experience.
- UPI and e-wallet payment options enhance convenience.
- SMS notifications provide real-time order updates.

Drawbacks:

- Relies heavily on QR-code technology, which can be unreliable if codes are damaged.
- Scalability issues when handling high user volumes.

3. **Cashless Canteen Management System**

Features:

- RFID-based cashless payments simplify transactions.
- Encrypted payment processing ensures secure operations.
- Real-time order display in the kitchen improves workflow efficiency.

Drawbacks:

- Susceptible to operational issues from lost or damaged RFID cards.
- Lacks multi-device support, parental notifications, and comprehensive reporting tools.

4. **Comprehensive Web-Based Canteen Food Ordering System**

Features:

- Scalable web-based platform for managing high transaction volumes.
- Real-time inventory updates streamline stock management.
- Centralized admin dashboard for efficient monitoring and reporting.

Drawbacks:

- Requires advanced infrastructure, which may not be feasible for smaller canteens.
- Lacks multi-factor authentication and does not provide parental notification features.

5. **Food Ordering System with Data Analytics**

Features:

- QR-code-based ordering for a contactless dining experience.
- Automated billing to reduce human error.
- Data analytics integration for visualized insights on sales and customer behavior.
- Machine learning for demand forecasting and strategic decision-making.

Drawbacks:

- Requires a reliable internet connection and mobile devices for all users.
- High initial setup cost due to the integration of data analytics and machine learning.
- Potential learning curve for restaurant staff to fully utilize the analytics dashboard and forecasting features.

2.3 Gaps in Existing Systems

Despite their contributions, these systems fail to:

- Combine IoT hardware (e.g., NFC readers) with web-based functionality in a cost-effective way.
- Provide robust visualization tools for tracking sales, expenditures, and real-time data.
- Automate notifications to stakeholders to enhance transparency and accountability.

2.4 Significance of Proposed Work

This project addresses these gaps by:

- Developing an integrated system that combines IoT and web-based technologies.
- Offering a comprehensive dashboard for real-time and historical data visualization.
- Automating communication through email notifications to improve stakeholder engagement.

Chapter 3: Methodology

3.1 Requirements Gathering

- Conducted surveys and consultations to identify user requirements.
- Define hardware specifications (Mirco Controllers, PC, Thermal Printer, NFC reader) and software needs (Flask, MySQL).

3.2 System or Model Design

- Develop modular components for order management, payment processing, and data visualization.
- Prototype the user interface using Figma or similar tools.

The following diagram illustrates the system flow of the Smart Canteen System, highlighting the interaction among key components and the database for seamless operation.

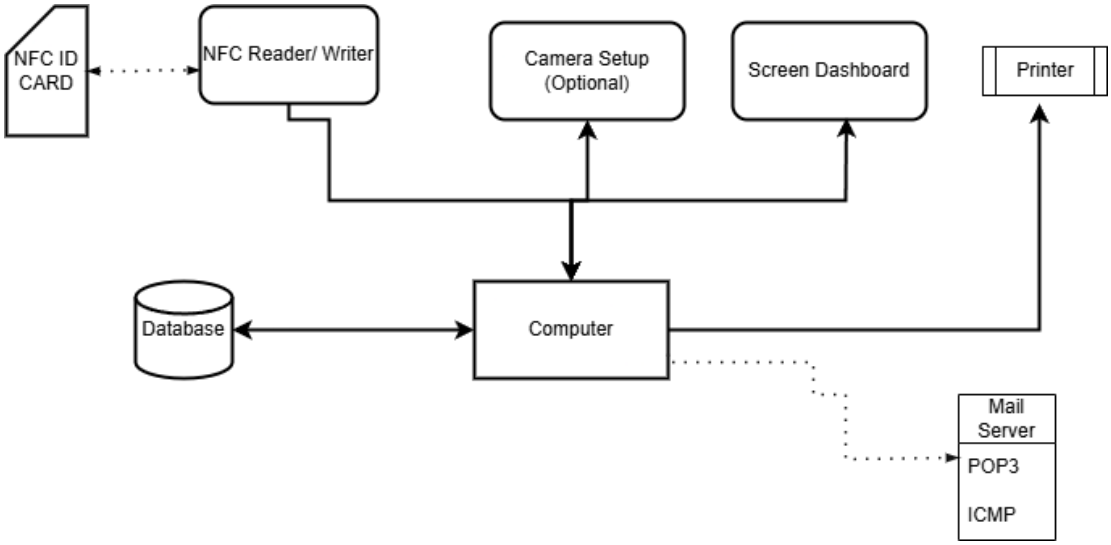


Figure 3.1: System Architecture

3.3 Technology Stack

- **Backend:** Python (Flask/Django), PHP
- **Frontend:** HTML, JavaScript, Tailwind CSS
- **Database:** MySQL
- **Design:** Draw.io, Easy EDA, Fritzing
- **Hardware:** Computer, ESP32 Devkit v1, PN532 V3 Module, NFC Tag

3.4 Development Process

- Use Agile methodology for iterative development and continuous testing.
- Employ Git for version control and collaborative development.

3.5 Hardware Circuit Designs

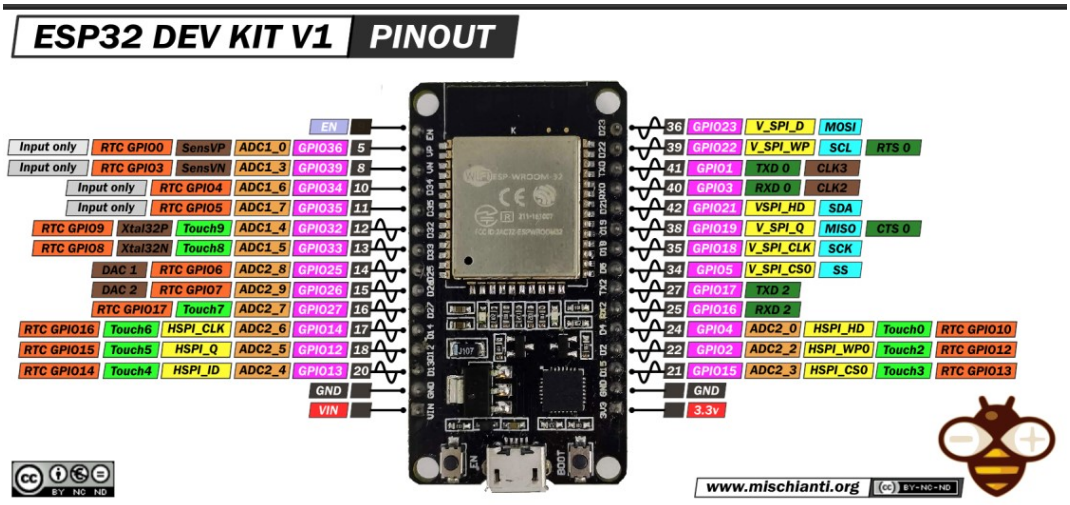


Figure 3.2: ESP 32 Pin Diagram

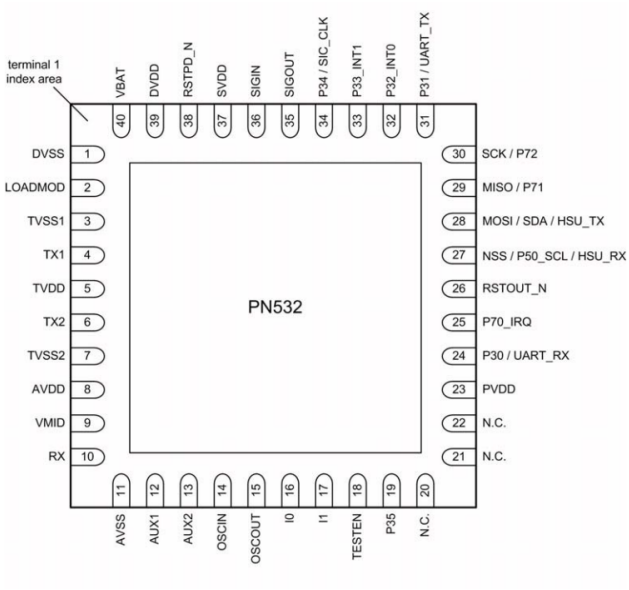


Figure 3.3: PN532 V3 Module Pin Diagram

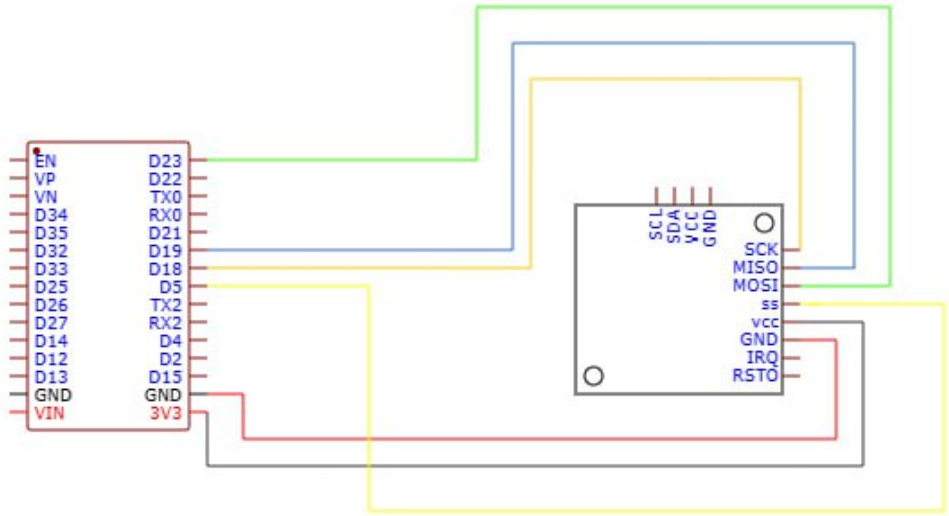


Figure 3.4: ESP32 to PN532 Schematic Diagram

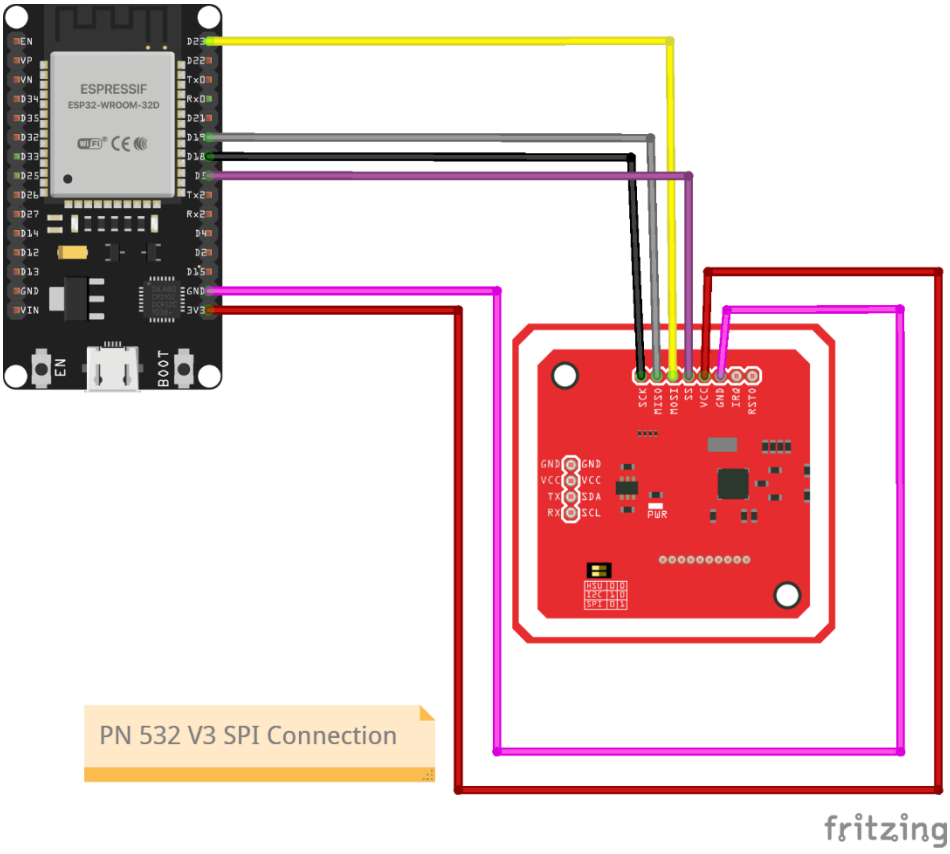


Figure 3.5:ESP32 to PN532 SPI Wiring

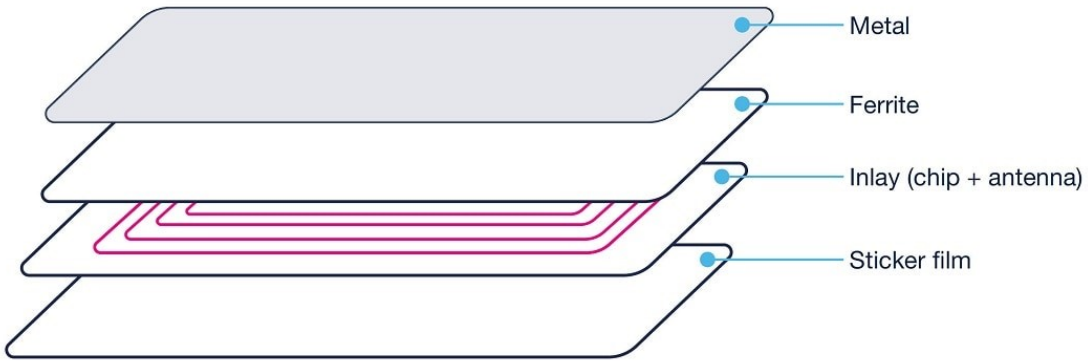


Figure 3.6: NFC Layers

Chapter 4: Result and Discussions

4.1 System Outcomes

The Smart Canteen Payment System has been successfully developed and tested, delivering on the core objectives envisioned at the start of the project. The following key modules and features have been implemented:

1. **Web Application Functionality**: A robust web-based system has been created with separate interfaces for students and canteen staff. The platform facilitates user authentication, dynamic menu viewing, transaction history, and administrative operations. Both the frontend and backend leverage modern frameworks ensuring scalability and maintainability.
2. **Canteen Menu Scheduler Based on Time:** A dynamic scheduler is implemented to display menu items based on predefined time slots (breakfast, lunch, dinner). This is controlled through database rules and eliminates manual adjustments by canteen staff.
3. **NFC Hardware Integration:** The PN532 NFC module has been interfaced with the ESP32-WROOM DevKit V1 via UART, successfully reading card UIDs. Dummy data programs were tested extensively to confirm stable hardware communication, forming the basis for secure student identification.
4. **Prepaid Balance Management:** Each NFC card is linked to a unique student record with an associated balance. Transactions automatically deduct amounts from this balance, simulating a virtual wallet system. Balance updates are reflected immediately in both the database and the user dashboard.
5. **Sales Tracking and Monthly Reporting:** The admin dashboard provides comprehensive transaction tracking, with real-time daily sales summaries and downloadable monthly expenditure reports. This supports informed decision-making and transparent financial oversight.

6. **Email Notification System:** For each completed transaction, automated emails are sent to students (and optionally parents) detailing the purchased items and the remaining balance. This enhances accountability and keeps stakeholders informed.
7. **Printing System (Semi-Automated):** A semi-automated receipt printing module is in place. Bills are generated via backend triggers and formatted for thermal printers. Full automation (auto-print on successful transaction) is under final testing.

4.2 Discussions

The development and testing of the system have led to several observations and important insights:

- **Reliability of NFC Reads:** While the PN532-ESP32 combination proved effective in reading card data, stable communication required careful handling of UART settings and debounce logic. Occasional misreads were mitigated through software retries.
- **Advantages of Time-Based Menus:** Implementing menu schedules significantly reduced manual intervention and errors. Canteen staff no longer needed to activate or deactivate menu items manually, which also minimized ordering mistakes.
- **User Engagement and Transparency:** The automated email system not only improved transparency but also helped build trust among students and parents, offering a detailed trail of purchases and balances.
- **Semi-Automated Printing:** Although the printing module generates receipts correctly, achieving fully unattended printing is sensitive to printer driver configurations. This is an area marked for minor post-project refinement.

- **Data Accuracy and Real-Time Sync:** Ensuring real-time updates between NFC hardware reads and backend balance deductions was a primary technical challenge. This was addressed by atomic transaction operations and careful API design, maintaining data consistency across the system.

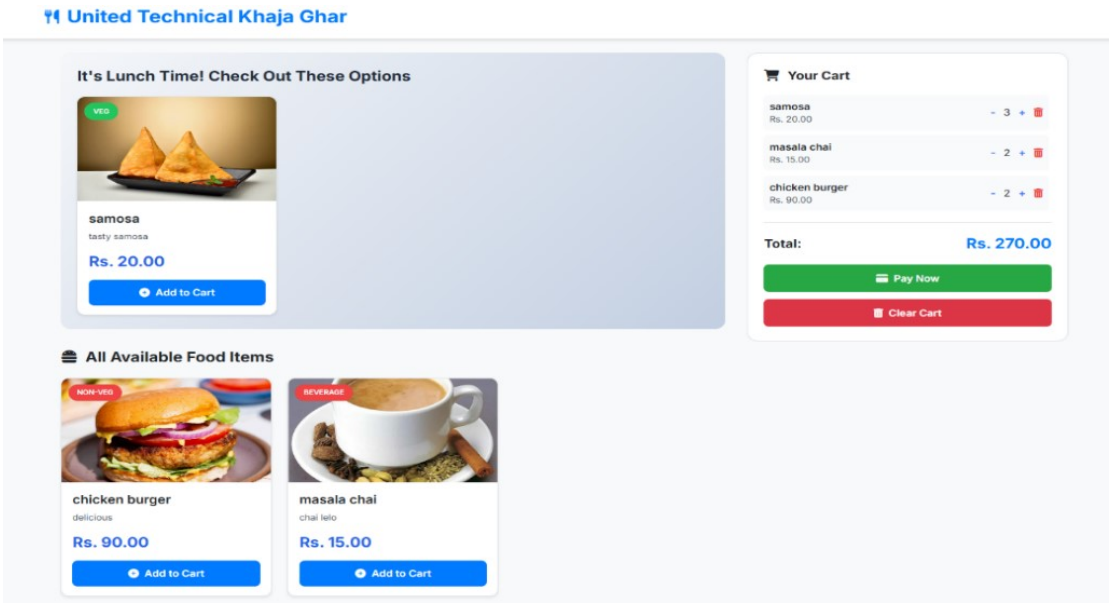
4.3 Overall Impact

The project successfully modernizes canteen management by introducing secure, cashless transactions, automated notifications, and data-driven insights. By reducing manual effort and integrating IoT components, the system provides a scalable blueprint for smart canteen management in educational or commercial settings.

4.4 Deployment and User Testing

The final step involves deploying the complete system on a live test environment. This will include onboarding a few real users (students and staff), collecting feedback, and performing usability testing before a wider rollout.

Output A: Screenshots of Web App



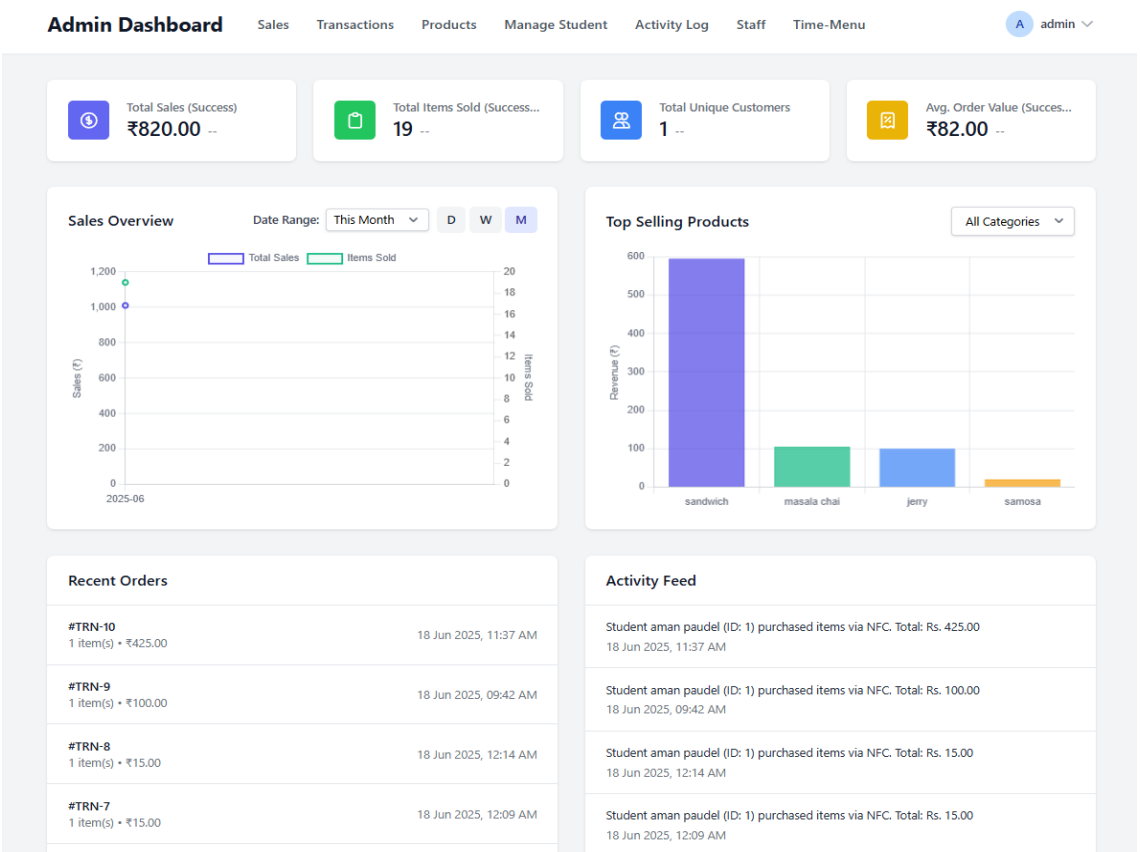


Figure 4. 1: User Interface

Output B: Circuit Diagram (PN532 to ESP32 SPI)

This section presents the wiring and connection diagram between the PN532 NFC module and the ESP32-WROOM Devkit V1 using SPI communication. It illustrates VCC, GND, TX, and RX connections with labels and jumper cable layout.

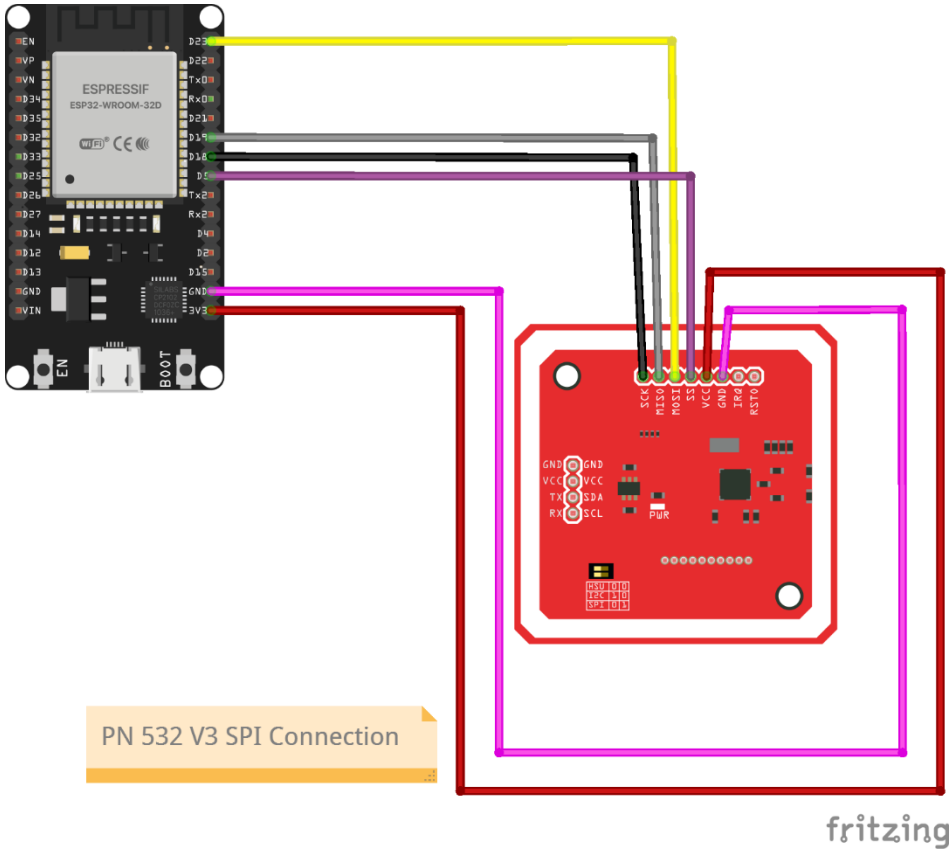


Figure 4. 2: ESP32 to PN532 SPI Connection

Output C: Sample Email, Bill Format, or Transaction Log

Included here are examples of generated email alerts sent to students/parents upon successful transactions, the formatted bill template used for order receipts, and backend logs of transaction data with timestamps.

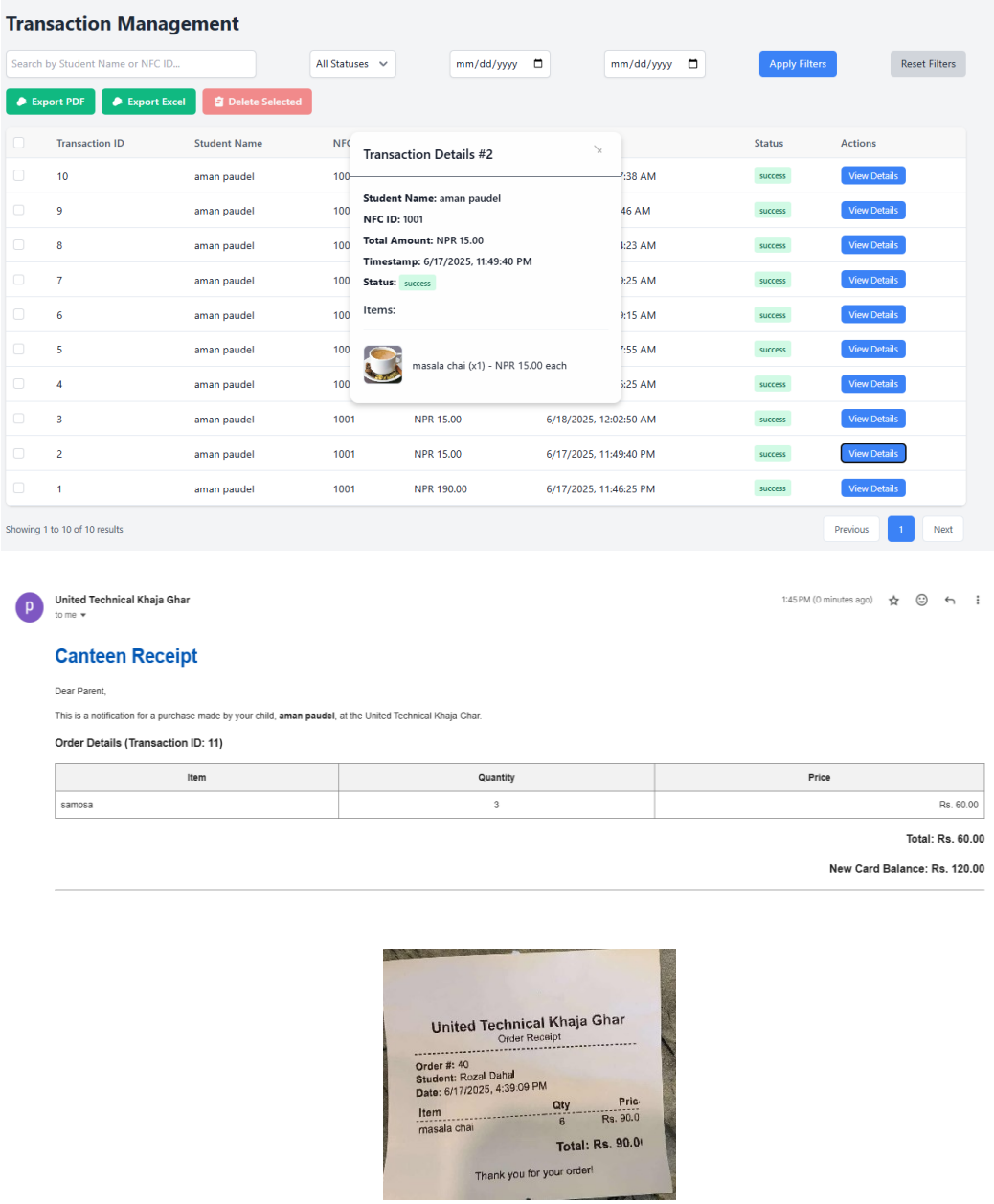


Figure 4. 3: Email, Transaction Log and Receipt

Chapter 5: Challenges and Risk Analysis

5.1 Hardware Communication Issues

During NFC module integration with ESP32, intermittent communication failures were observed. UART-based connections faced challenges with baud rate mismatches, signal noise, and inconsistent reads. Ensuring reliable reads from the PN532 module required extensive testing and hardware debounce strategies.

5.2 Power and Wiring Constraints

Temporary setups using jumper wires were prone to lose connections and voltage drops, especially while powering both NFC and ESP32 from the same source. Care had to be taken to manage power distribution without damaging components, particularly during continuous reads.

5.3 Real-time Sync and Data Accuracy

Real-time synchronization between NFC transactions and backend databases introduced risks of data duplication or missing logs if network latency or server unavailability occurred. Ensuring atomic transactions and retry mechanisms became necessary to guarantee integrity.

5.4 Risk Mitigation Strategies

To address the above challenges, several strategies were adopted:

- Implemented retry and debounce logic on ESP32 reads
- Separated power sources for stability
- Introduced local logging in ESP32 as backup
- Validated backend endpoints using mock data
- Scheduled regular testing checkpoints to verify system integrity
- SPI Based connection was more stable and reliable for communication

Chapter 6: Future Scope and Potential Enhancements

6.1 Cloud-Based Deployment for Scalability

One of the most promising directions for the Smart Canteen Payment System is transitioning from a local or institution-bound setup to a **cloud-based architecture**. Hosting the backend on cloud platforms would enable:

- Centralized data management for multiple campuses or branches.
- Easier scalability to handle growing user bases without overhauling the infrastructure.
- Robust backup, disaster recovery, and automatic failover to improve reliability.
- Real-time data analytics accessible from anywhere, supporting informed decision-making across all levels of management.

This approach also facilitates integrations with other institution-wide services, creating a unified digital ecosystem.

6.2 Extending NFC Applications Beyond the Canteen

The existing NFC module, currently configured for canteen payments, can be seamlessly adapted to a broader range of institutional uses:

- **Transportation:** Students could tap their NFC cards to board campus shuttles or public transport systems, with fares automatically deducted.
- **Library Services:** NFC cards could be used for book checkouts, fine payments, or even access control to reading rooms.
- **Retail and Stationery Purchases:** Integration with on-campus shops would allow cashless purchases of books, supplies, or uniforms.

- **Attendance Tracking:** Tapping an NFC card at classroom entrances could automate attendance records, reducing manual entry errors and administrative overhead.

This consolidated NFC identity system would simplify operations and provide a single card for multiple services, enhancing user convenience.

6.3 Enhancing Security with Biometric Verification

In future iterations, the system could replace or complement PIN-based transaction confirmations with **biometric authentication**, such as:

- **Fingerprint scanning at NFC kiosks** for secure, quick identity verification.
- **Face recognition modules** linked to transaction points for seamless payments and attendance.

This would not only increase security by eliminating PIN sharing or misuse but also create a frictionless user experience.

6.4 Leveraging AI and Machine Learning

Integrating AI and ML technologies could transform the system from a transactional platform into a **predictive and intelligent assistant**:

- **Menu Optimization:** Machine learning models can analyze historical sales data, weather patterns, academic calendars, and local events to recommend what the canteen should prepare each day, reducing waste and improving satisfaction.

- **Health Tracking:** By linking purchases to students' health profiles, the system could flag unhealthy buying patterns or help nutrition teams tailor menu offerings.
- **Dynamic Pricing or Promotions:** AI could suggest discounts during off-peak hours to balance kitchen loads and reduce leftovers.

Such innovations would turn the canteen from a simple service outlet into a proactive contributor to students' well-being and operational efficiency.

6.5 Broader Vision

Ultimately, the Smart Canteen Payment System can evolve into a **comprehensive smart campus solution**, integrating finance, transportation, health, and academic services through a unified platform. By leveraging cloud scalability, multi-service NFC applications, biometric security, and AI-driven insights, institutions can provide a seamless, data-rich environment that benefits both administrators and end-users.

Chapter 7: Conclusion

The Smart Canteen Payment System, at its current stage, establishes a solid foundation for transforming conventional canteen operations through digital innovation. The successful development of both the web application's frontend and backend, along with validated NFC hardware, marks significant progress toward realizing the project's objectives. Key features such as time-based menu scheduling, automated sales tracking, and real-time email notifications have already delivered tangible improvements in efficiency and transparency.

This project stands as a practical example of integrating IoT and software systems to create a secure, streamlined, and user-centric canteen management solution. The adoption of NFC technology minimizes human error, accelerates transactions, and enhances convenience for students, staff, and administrators alike. Furthermore, the system's modular architecture ensures that it remains scalable and adaptable across diverse institutional settings.

Although components like complete NFC-to-backend integration and fully automated receipt printing are still under final development, the groundwork laid so far is both robust and promising. With upcoming efforts focused on integration, thorough testing, and deployment, the project remains well-positioned to achieve all intended outcomes.

Ultimately, the Smart Canteen Payment System not only fulfills immediate institutional needs but also serves as a scalable model for similar implementations elsewhere, contributing meaningfully to the broader transition toward smart, data-driven service infrastructures.

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Appendices

Appendix A: Database ERD Diagram

This section contains the Entity-Relationship Diagram (ERD) that visualizes the structure of the database, including primary tables such as student, transaction, NFC card, and food, along with their relationships and attributes.

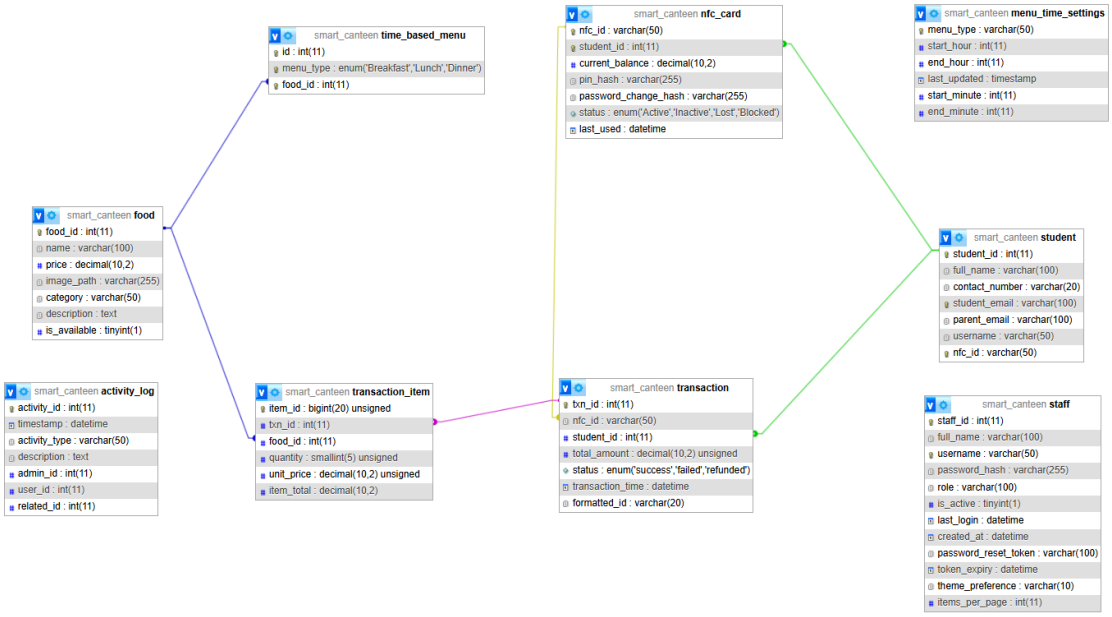

Figure Appendix: 1: Entity Relation Diagram

Appendix B: Source Code

Source code of this project and other screenshot is available in www.github.com/prajjwallive