

Affiliated to Pokhara University

## UNITED TECHNICAL COLLEGE



**A Major Project Mid Defense  
on  
SMART CANTEEN PAYMENT SYSTEM  
Code No: CMP-490**

**For partial fulfillment of final Year/Semester in Computer Engineering**

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## 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.

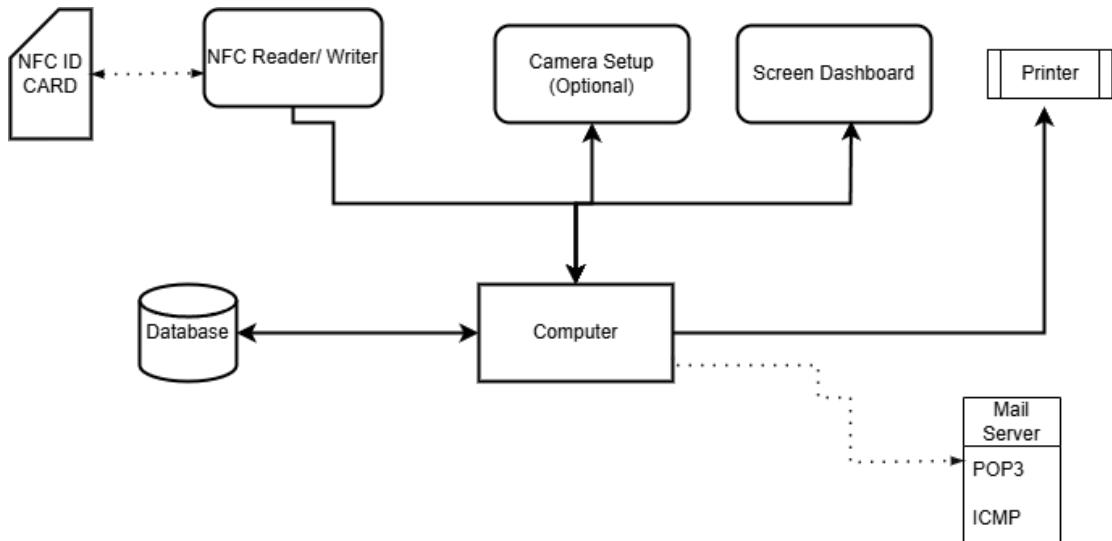


Figure 3.1: System Architecture

### 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

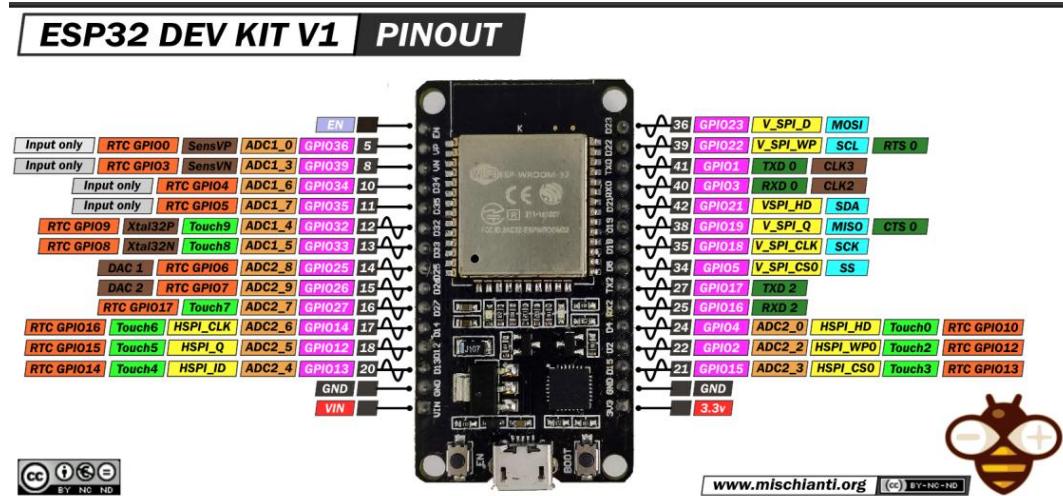


Figure 3.2: ESP 32 Pin Diagram

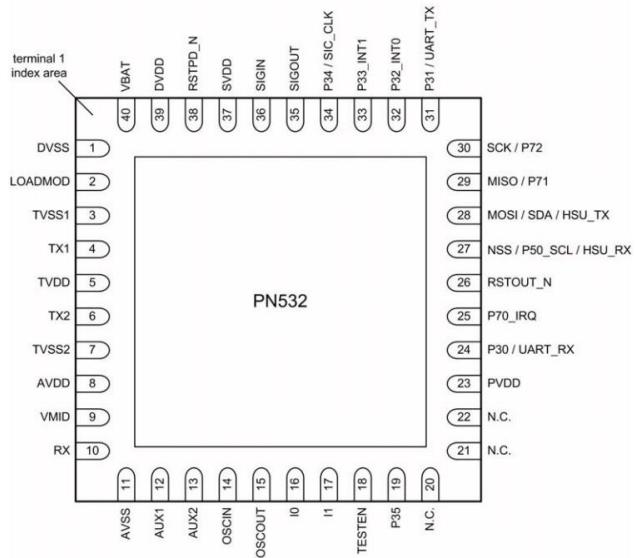


Figure 3.3: PN532 V3 Module Pin Diagram

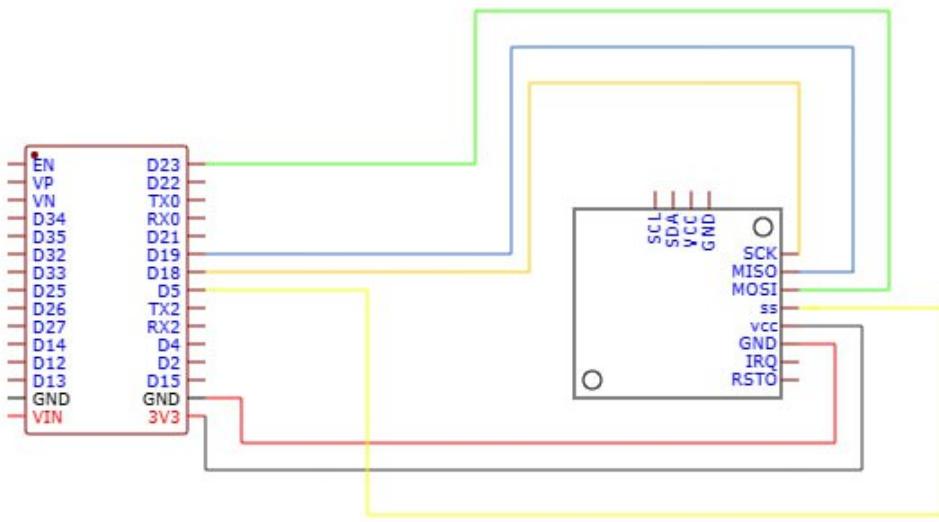


Figure 3.4: ESP32 to PN532 Schematic Diagram

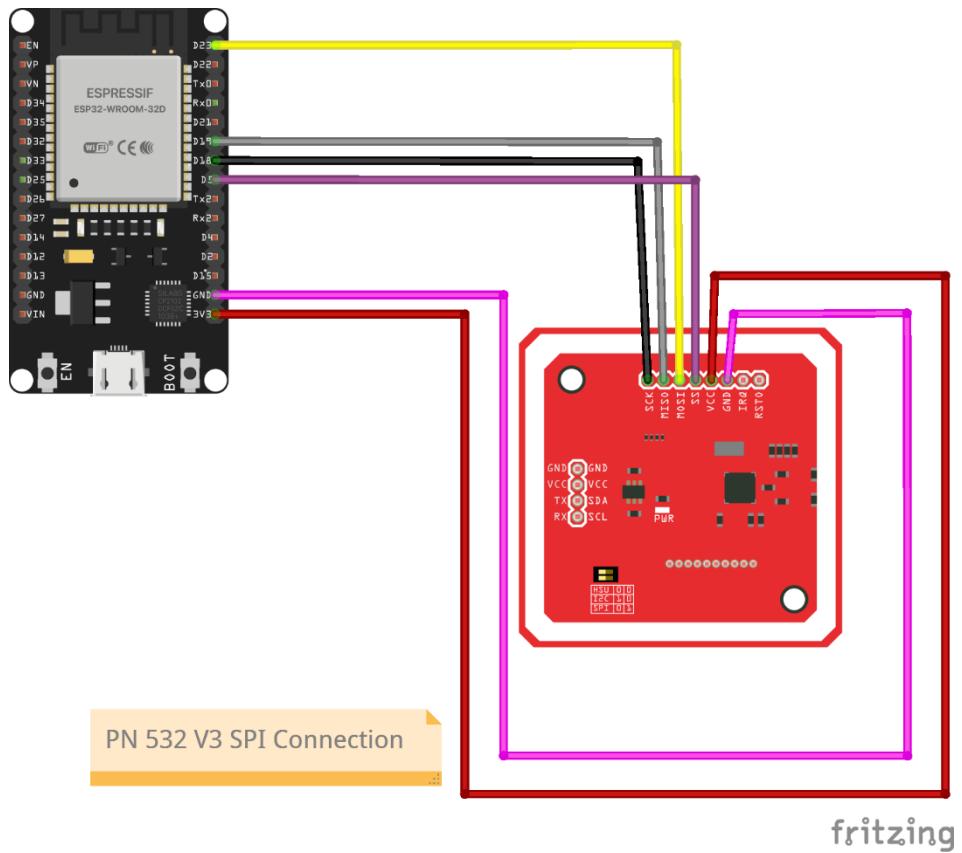


Figure 3.5:ESP32 to PN532 SPI Wiring

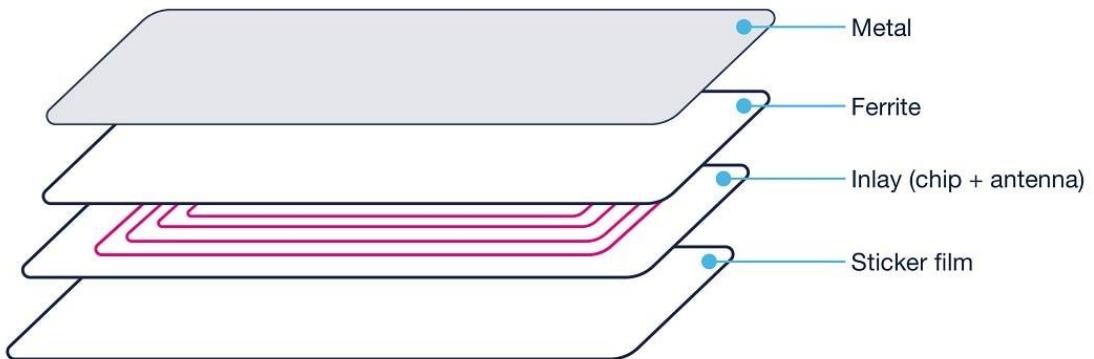


Figure 3.6: NFC Layers

## **Chapter 4: Result and Discussions**

### **4.1 Expected Outcomes**

- A fully functional web-based canteen system that facilitates secure transactions and user interactions.
- NFC-enabled payments allowing students to pay using their assigned NFC cards, replacing manual cash handling.
- Automated email notifications to students and parents for every successful transaction, ensuring real-time updates and transparency.
- Time-based canteen menu scheduling, dynamically adapting the available menu according to breakfast, lunch, or dinner time slots.
- A user-friendly dashboard for staff and admin users to:
  - Monitor real-time sales
  - View daily, weekly, and monthly reports
- Integrated prepaid balance model, enabling students to top up and spend digitally.
- Automated or semi-automated bill printing system for in-premise verification and order processing.
- Sales analytics and report generation, offering insights for operational decisions and audits.

### **4.2 Achieved Outcomes**

#### **◆ Web Application Functionality**

- Frontend and backend have been fully developed using modern technologies. Interfaces for student login, canteen staff login, menu display, and order history are functional.

#### **◆ Canteen Menu Scheduler Based on Time**

- Dynamic menu rendering implemented using time-based rules stored in the database.
- ◆ **NFC Hardware Testing**
- NFC card (PN532) successfully interfaced with ESP32-WROOM Devkit V1 via UART. Dummy programs tested for read/write functionality and UID retrieval.
- ◆ **Prepaid Balance Model**
- A balance system for each NFC card has been implemented and tested. Balance deductions are triggered on simulated transactions.
- ◆ **Sales Tracking and Monthly Report Module**
- Admin panel provides real-time transaction summaries. Monthly expenditure summaries are generated using backend queries.
- ◆ **Email Notification System**
- Email alerts are triggered upon successful transactions and sent to the student's and/or parent's registered email addresses.
- ◆ **Printing System (Semi-Automated)**
- Bill templates and backend print triggers are implemented. Printing is currently semi-automated and under refinement for full integration.

### **4.3 Pending Tasks**

- Hardware and Software Integration
- NFC based login and balance verification
- Fully Automated Printing of Receipt
- Testing Report from user POV.

## **4.5 Integration Plan for NFC → Web Backend**

Although NFC has been tested separately, final integration into the web application remains. This involves establishing a secure communication pipeline between the ESP32 and the backend API for authenticating cards and deducting balances in real time.

## **4.5 Final Testing and Debugging**

A comprehensive testing phase is planned which will include:

- Unit tests for backend logic
- Integration tests for NFC and transaction logging
- Real-time use-case simulations in a canteen environment

## **4.6 UI Polish and Error Handling**

Minor UI inconsistencies and lack of feedback messages need attention. Error handling for failed transactions, card errors, or system timeouts will be refined to enhance user experience.

## **4.7 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**

This section includes representative screenshots from the developed web-based canteen management system and successful NFC connection. Screens show student dashboard, admin panel etc.

## United Technical Khaja Ghar

**It's Lunch Time! Check Out These Options**



**samosa**  
 tasty samosa  
**Rs. 20.00**  
[Add to Cart](#)

**Your Cart**

samosa	Rs. 20.00	- 3 + <span style="color: red;">■</span>
masala chai	Rs. 15.00	- 2 + <span style="color: red;">■</span>
chicken burger	Rs. 90.00	- 2 + <span style="color: red;">■</span>
<b>Total:</b>		<b>Rs. 270.00</b>
<a href="#" style="background-color: #28a745; color: white; padding: 5px 10px; border-radius: 5px;">Pay Now</a> <a href="#" style="background-color: #dc3545; color: white; padding: 5px 10px; border-radius: 5px;">Clear Cart</a>		

**All Available Food Items**



NON-VEG

**chicken burger**  
 delicious  
**Rs. 90.00**  
[Add to Cart](#)



BEVERAGE

**masala chai**  
 chai lelo  
**Rs. 15.00**  
[Add to Cart](#)

 Total Sales (Success)  
**₹820.00 ..**

 Total Items Sold (Success...  
**19 ..**

 Total Unique Customers  
**1 ..**

 Avg. Order Value (Success...  
**₹82.00 ..**

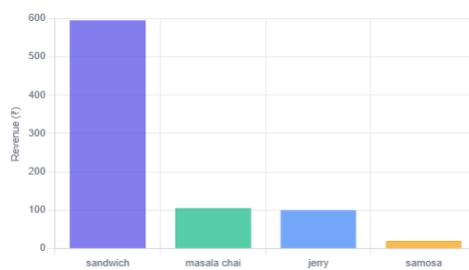
**Sales Overview**

Date Range:



The chart shows Sales (₹) on the Y-axis (0 to 20) and PGS (units) on the X-axis (0 to 20). A blue line represents Total Sales, starting at 1,000 and ending at 1,200. A green line represents Items Sold, starting at 10 and ending at 18. A legend indicates: Total Sales (blue line), Items Sold (green line).

**Top Selling Products**



The chart shows Revenue (₹) on the Y-axis (0 to 600) and Product names on the X-axis. The products and their approximate revenue are: sandwich (~580), masala chai (~100), jerry (~80), and samosa (~20).

**Recent Orders**

#TRN-10 1 item(s) • ₹425.00	18 Jun 2025, 11:37 AM
#TRN-9 1 item(s) • ₹100.00	18 Jun 2025, 09:42 AM
#TRN-8 1 item(s) • ₹15.00	18 Jun 2025, 12:14 AM
#TRN-7 1 item(s) • ₹15.00	18 Jun 2025, 12:09 AM

**Activity Feed**

Student aman paudel (ID: 1) purchased items via NFC. Total: Rs. 425.00  
18 Jun 2025, 11:37 AM

Student aman paudel (ID: 1) purchased items via NFC. Total: Rs. 100.00  
18 Jun 2025, 09:42 AM

Student aman paudel (ID: 1) purchased items via NFC. Total: Rs. 15.00  
18 Jun 2025, 12:14 AM

Student aman paudel (ID: 1) purchased items via NFC. Total: Rs. 15.00  
18 Jun 2025, 12:09 AM

Figure 4. 1: User Interface

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## 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.

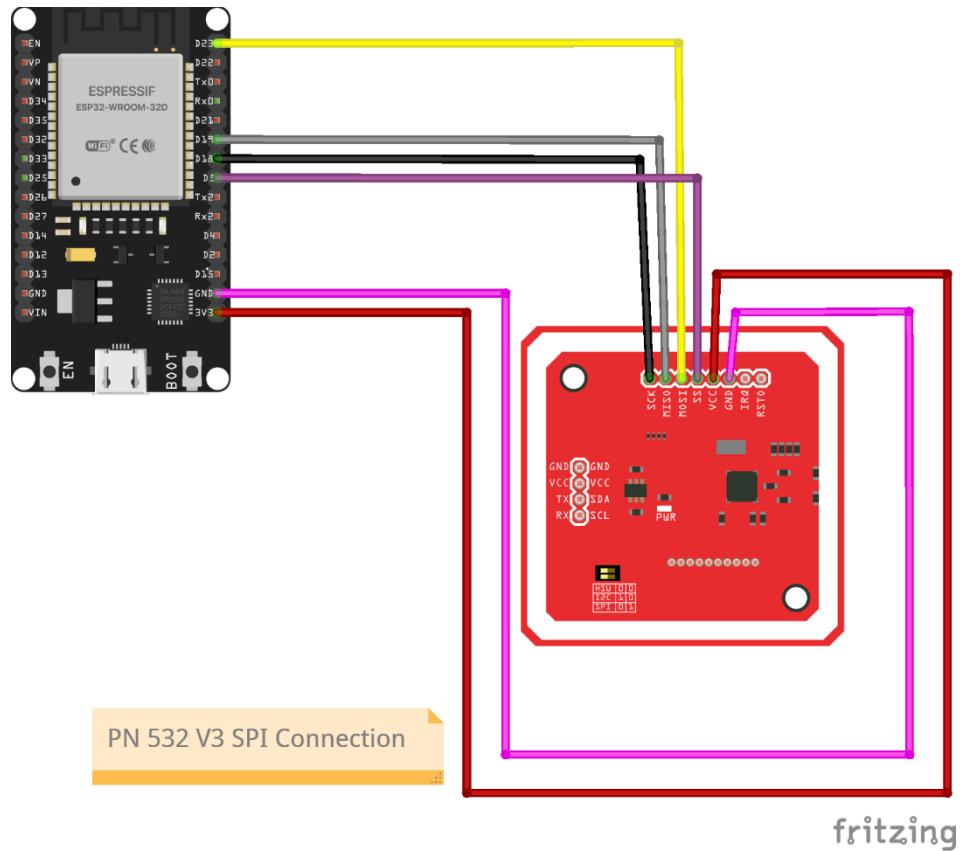


Figure 4. 2: *ESP32 to PN532 SPI Connection*

## 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.

**Transaction Management**

Transaction ID	Student Name	NFC	Timestamp	Status	Actions
10	aman paudel	100	6/17/2025, 11:49:40 PM	success	<a href="#">View Details</a>
9	aman paudel	100	6/17/2025, 11:49:46 AM	success	<a href="#">View Details</a>
8	aman paudel	100	6/17/2025, 11:49:51 AM	success	<a href="#">View Details</a>
7	aman paudel	100	6/17/2025, 11:49:56 AM	success	<a href="#">View Details</a>
6	aman paudel	100	6/17/2025, 11:50:01 AM	success	<a href="#">View Details</a>
5	aman paudel	100	6/17/2025, 11:50:06 AM	success	<a href="#">View Details</a>
4	aman paudel	100	6/17/2025, 11:50:11 AM	success	<a href="#">View Details</a>
3	aman paudel	1001	6/18/2025, 12:02:50 AM	success	<a href="#">View Details</a>
2	aman paudel	1001	6/17/2025, 11:49:40 PM	success	<a href="#">View Details</a>
1	aman paudel	1001	6/17/2025, 11:46:25 PM	success	<a href="#">View Details</a>

Showing 1 to 10 of 10 results

**Canteen Receipt**

Dear Parent,

This is a notification for a purchase made by your child, aman paudel, at the United Technical Khaja Ghar.

**Order Details (Transaction ID: 11)**

Item	Quantity	Price
samosa	3	Rs. 60.00

Total: Rs. 60.00

New Card Balance: Rs. 120.00



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: Conclusion**

The Smart Canteen Payment System, at its current stage, demonstrates a strong foundation for transforming traditional canteen operations through digital innovation. The successful development of the web application backend and frontend, combined with separate NFC hardware validation, signifies a substantial progression toward the project's objectives. Features like time-based menu scheduling, sales tracking, and email notifications have already added tangible value to the system.

This project exemplifies the integration of IoT and software systems to deliver a secure, efficient, and user-centric canteen management experience. The use of NFC technology streamlines transactions, reduces human error, and enhances convenience for both users and administrators. Moreover, the system's modular design ensures scalability and adaptability to different institutional environments.

While certain components such as complete NFC-to-backend integration and full system deployment remain under development, the groundwork laid thus far is robust and promising. With the remaining phases focused on testing, refining, and deployment, the project is well on track to meet its final goals.

Ultimately, the Smart Canteen Payment System not only addresses immediate institutional needs but also lays a scalable blueprint for broader application in similar contexts, contributing to the ongoing shift 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.

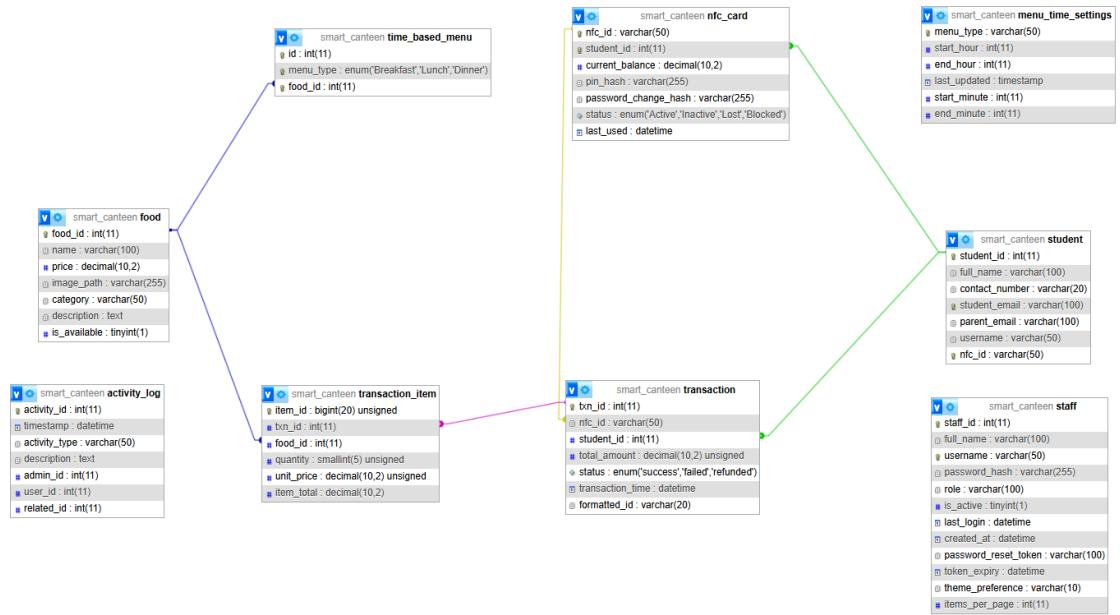


Figure Appendix: 1: Entity Relation Diagram