K. E. Society's

Rajarambapu Institute of Technology, Rajaramnagar

(An Autonomous Institute)

Synopsis

Environmental Science Project

Program	: Electronics and Telecommunication Engineering
Academic Year	: 2025-26
Course Name & Code	: Environmental Science (SH2174)
Class	: S.Y. B. Tech (Semester-III)
Proposed Title	: Smart Incentivized Dustbin with IoT-enabled Cloud Dashboard for Campus Waste Management

Name of the students in project group:

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Project Guide **Project Co-ordinator** **Head of Department**

1. INTRODUCTION:

Waste management in educational institutions is often neglected by students due to lack of awareness and motivation. Improper disposal of waste not only affects cleanliness but also harms the environment. This project proposes a smart incentivized dustbin designed for college campuses, which detects waste deposits, records disposal events, and provides instant QR code rewards to students through a TFT display. The system is integrated with RFID for student identification and a cloud dashboard that maintains a leaderboard of student contributions. By combining IoT technology with gamification, the project aims to encourage responsible waste disposal habits, promote sustainability, and create an engaging eco-friendly culture among students

2. PROBLEM STATEMENT:

Traditional dustbins do not motivate students to use them effectively, resulting in littering and poor waste segregation. There is a need for a system that not only ensures proper disposal but also tracks participation, provides incentives, and generates measurable data for campus authorities.

3. RELEVANCE:

The project addresses two critical aspects: environmental sustainability and behavioral change. By rewarding students for responsible actions, the system increases participation in waste management practices. It also provides real-time data to the institution for monitoring cleanliness and planning effective waste collection. The project is scalable to other institutions, public places, and smart city environments, contributing to long-term sustainability goals.

4. LITERATURE REVIEW :

- Najafpour et al., (2009) studied Biological Treatment of Antibiotic Plant Effluent in an UASFF bioreactor. Their research highlighted the role of innovative systems in improving waste treatment efficiency.
- Sharma & Patel (2021) explored IoT based Smart Waste Management System using Ultrasonic Sensor and NodeMCU, showing the feasibility of sensor-based level detection and cloud data logging.
- Singh et al., (2022) proposed Gamification in Waste Management Systems in IJRASET Journal, demonstrating that rewards and points can significantly increase user engagement in sustainability practices.
- Al-Masri et al., (2019) developed an IoT-enabled Smart Waste Bin that integrates ultrasonic sensors with a GSM module to alert authorities when bins are full, proving IoT’s effectiveness in urban waste monitoring.
- Ramesh & Kavitha (2020) in their study on RFID-based Smart Bin Systems demonstrated how RFID can be used to link waste disposal activities to individual users, providing accountability and personalized data.
- Chaudhary et al., (2021) proposed QR Code-based Incentive Models in Smart Campus Systems, which showed that integrating QR vouchers with routine tasks (like waste disposal) improves student participation in sustainability programs.

- Li et al., (2022) presented Real-time Waste Analytics Using Cloud Dashboards, highlighting how cloud databases and visualization tools can help institutions manage resources effectively and encourage data-driven decision making.
- Patel & Shah (2023) reviewed Smart City Waste Management Frameworks, pointing out that combining IoT, gamification, and dashboards can not only improve cleanliness but also create behavioral change in communities.

5. OBJECTIVES:

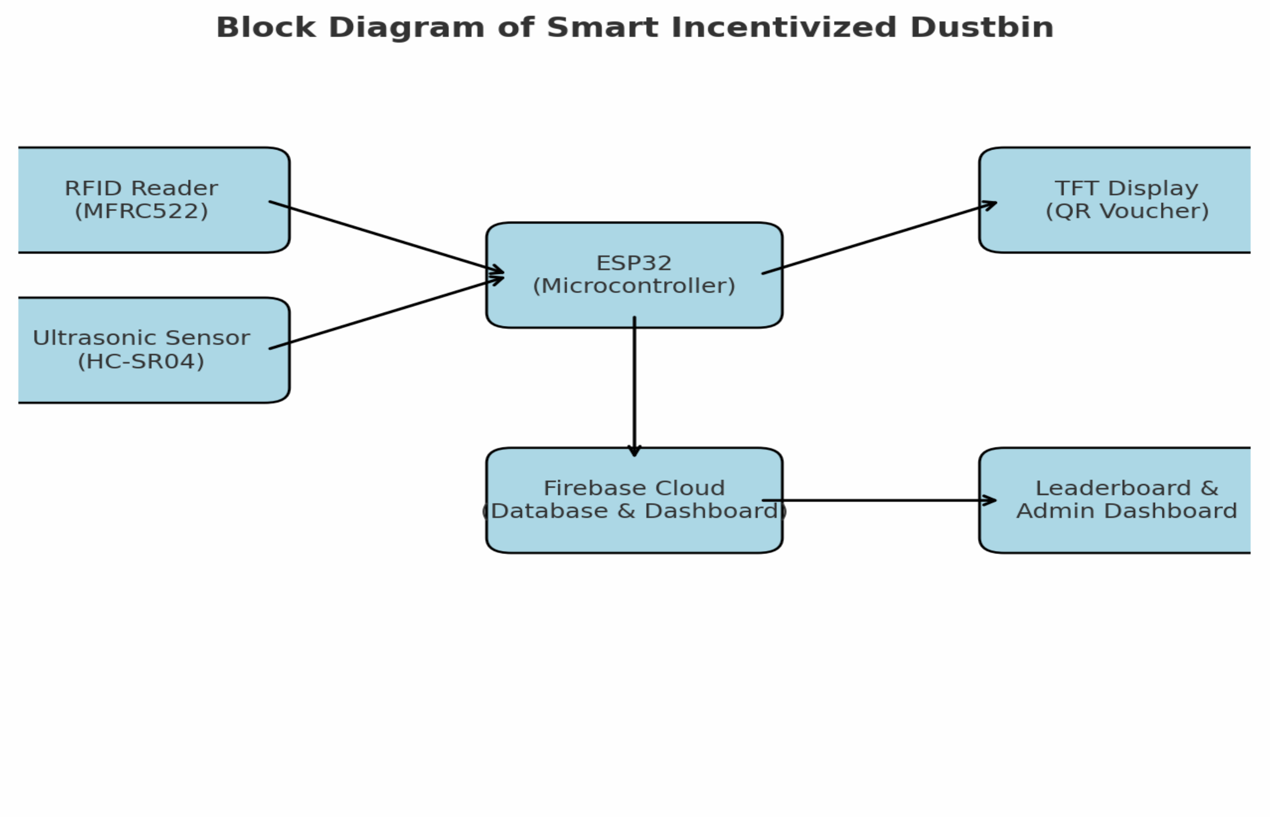
- To design and implement a smart dustbin that detects waste disposal and monitors fill levels.
- To develop a reward-based system that generates QR vouchers for students upon waste disposal.
- To link student identity (via RFID) with disposal data and maintain a campus-wide leaderboard.
- To integrate a cloud-based dashboard for administrators to track waste collection and student participation.

6. METHODOLOGY:

1. System Design with ESP32 as the Core
    - The ESP32 microcontroller is chosen as the central unit because it has built-in WiFi, making it suitable for IoT applications.
    - The dustbin will be equipped with:
        - Ultrasonic Sensor (HC-SR04): to measure the fill level of the bin by detecting the distance between the sensor and the waste.
        - RFID Reader (MFRC522): to authenticate students by scanning their ID cards and link waste disposal events to their identity.
        - TFT Display (2.4”–2.8”): to generate and show a QR code voucher or reward message immediately after a successful disposal event.
    - Additional components such as a buzzer and LED indicators will provide instant feedback to the user.
2. Cloud Integration with Firebase
    - The ESP32 will connect to Firebase using WiFi.
    - Each event (student ID, timestamp, bin ID, waste level) will be uploaded to the cloud in real time.
    - Firebase will handle:
        - Storing records of all disposal events.
        - Reward logic (assigning points or vouchers based on usage).
        - Leaderboard data (maintaining student rankings).
    - Cloud Functions or simple database rules will automate the process of updating points and generating voucher links.
3. Dashboard Development

- A web-based dashboard will be developed using HTML, CSS, JavaScript, and Chart.js for data visualization.
- This dashboard will allow administrators to monitor:
  - Fill levels of each bin in real time.
  - Number of disposal events per student.
  - Leaderboard ranking of most active students.
- The dashboard will be hosted on Vercel, making it accessible on both desktop and mobile devices without extra setup.

4. Testing and Validation
   - Prototype testing will be done within a controlled campus environment.
   - Key tests include:
     - Accuracy of waste level detection.
     - Reliability of RFID-based student identification.
     - Correct QR voucher display and scanning.
     - Smooth synchronization with Firebase.
   - After technical validation, student engagement will be evaluated by checking how often students use the bin when incentives are offered.
   - Feedback will be collected to refine the reward system and improve usability.
5. Scalability Considerations (Future Scope)
   - Once validated, the same setup can be scaled across multiple bins on campus.
   - Data from different bins can be combined to provide overall campus waste analytics.
   - Sponsor integrations (canteen vouchers, stationery discounts) can be added to make the reward system more attractive and self-sustainable.



7. SYSTEM REQUIREMENTS WITH JUSTIFICATION

- Hardware Requirements: ESP32 (Wi-Fi enabled controller), MFRC522 RFID reader, HC-SR04 ultrasonic sensor, TFT display, power supply, and enclosure. These components are low-cost, readily available, and suitable for prototype development.

- Software Requirements: Arduino IDE for coding, Firebase for cloud storage, and HTML/JavaScript with Chart.js for dashboard visualization. These are open-source or free-to-use platforms, ensuring affordability.

8. PROJECT OUTCOMES

- A functional prototype of a smart incentivized dustbin.
- A cloud-integrated dashboard showcasing waste levels and student leaderboards.
- Increased student awareness and participation in campus cleanliness drives.
- Potential for deployment in hackathons, research publications, and scaling to smart cities.

9. REFERENCES:

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10. APPROXIMATE EXPENSES:

Components	Cost (INR)
ESP32 Dev Board	800
RFID Reader (MFRC522)	350
RFID Cards/Tags (set)	200
Ultrasonic Sensor HC-SR04	120
TFT Display (2.8”)	950
Buzzer + LEDs + Wires	150
Power Adapter/Module (lithium ion battery	300

Total: ~ 3370 INR