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Kusot No More: An IoT-Based Flat-Iron Vending Machine for Student Convenience and Safety

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Abstract: This research presents a developmental-experimental study of Kusot No More, an IoT-based flat-iron vending machine designed to provide affordable and accessible ironing services for students in dormitories and shared living spaces. "Kusot," a Filipino/Cebuano term meaning "wrinkled" or "crumpled," reflects the system's purpose of addressing clothing maintenance challenges in student housing environments. The system integrates an ESP-32 microcontroller, MLX90614 infrared heat sensor, multi-coin acceptor, solid-state relay module, and LM2596 buck converter to automate flat-iron operation through a pay-per-use mechanism. A mobile application was developed using MIT App Inventor to display fabric type selection, real-time temperature monitoring, and remaining usage time, enabling users to make informed decisions about proper garment care. The hardware and software components were integrated following the Agile Development Model across five two-week sprints, addressing compatibility, safety features, and user interface requirements. The prototype was evaluated comprehensively by IT experts using the ISO/IEC 25010 Software Quality Model across four dimensions: Functional Suitability, Performance Efficiency, Compatibility, and Reliability. End-users were surveyed using the standardized USE questionnaire to assess Usefulness, Ease of Use, Ease of Learning, and Satisfaction. Results indicated an overall functionality rating of 4.73 (Moderately Functional), with the

system scoring 4.75 in software quality characteristics and 4.84 in usability metrics. The exceptional Ease of Learning score of 5.00 demonstrates effective user interface design. The system demonstrated cost efficiency with total development cost of PHP 11,450 and projected cost recovery within 6-12 months of operation. This study demonstrates how IoT technology can solve everyday practical problems while promoting convenience, safety, and improved garment care for students in institutional settings.

Keywords: Arduino, automation, coin-operated system, distance learning, educational technology, embedded systems, ESP-32, IoT, microcontroller, temperature monitoring, user interface, vending machine

I. INTRODUCTION

Student life in dormitories and boarding houses presents unique challenges, particularly regarding personal grooming and clothing maintenance. "Kusot" is a Filipino/Cebuano word meaning "wrinkled" or "crumpled," commonly used to describe clothes that need ironing. Many students lack access to affordable ironing equipment due to space constraints, cost limitations, and safety concerns associated with personal electrical appliances in shared dormitory settings. The advancement of Internet of Things (IoT) technology has enabled innovative solutions for everyday problems through automation and smart control systems [1][5]. Recent applications of IoT in vending systems demonstrate increased efficiency in payment processing, inventory management, and operational safety [2][3][4]. Enhanced security features through blockchain and payment validation systems have further improved vending machine reliability [6]. This research addresses the need for a safe, affordable, and convenient ironing solution specifically designed for student communities. The Kusot No More system leverages IoT technology to create an automated vending machine that minimizes safety risks while maximizing accessibility and operational efficiency.

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[3]. The integration of microcontrollers such as the ESP-32, combined with reliable sensor technologies, enables precise control and monitoring of appliance operation.
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II. OBJECTIVE OF THE STUDY

The general objective is to develop and evaluate an IoT-based flat-iron vending machine prototype for student dormitories and boarding houses. Specific objectives include:

(1) Develop an IoT-based control system using an ESP-32 microcontroller, heat sensor, relay module, buck converter, and coin acceptor, capable of power regulation, temperature monitoring, and payment validation.
(2) Design and implement a mobile application that displays fabric type options, real-time iron temperature, and remaining usage time to enable informed fabric-care decisions and real-time usage monitoring.
(3) Evaluate the system's usability and software quality using the following frameworks:
(3.1) USE Questionnaire — Assess the system's usability across four dimensions: Usefulness, Ease of Use, Ease of Learning, and Satisfaction (Lund, 2001).
(3.2) ISO/IEC 25010 — Evaluate the system's software quality against four characteristics: Functional Suitability, Performance Efficiency, Compatibility, and Reliability, including their respective sub-characteristics.

III. MATERIALS AND METHODS

A. *Research Design*

This study employed a developmental-experimental research design, combining system development with empirical evaluation [10]. The developmental component involved designing, building, and testing the IoT-based flat-iron vending machine prototype, while the experimental component assessed system performance through controlled testing with expert evaluators and end-users. This mixed-methods approach enabled both technical validation and user experience assessment [11].

B. *Software Development Life Cycle (SDLC)*

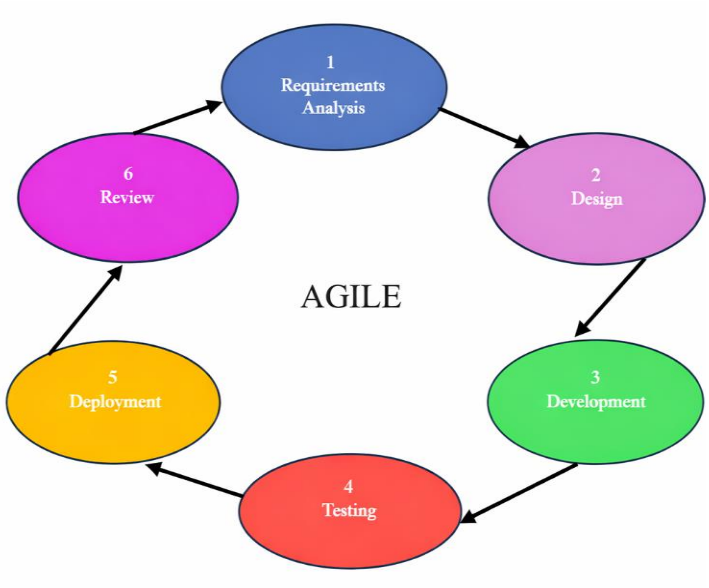

Fig. 1 Agile Development Model

The system was developed using the Agile Development Model [7], which enables iterative hardware-software integration through rapid prototyping and continuous testing [8]. Development progressed through five two-week sprints, addressing hardware compatibility (ESP32, coin acceptor, relay, temperature sensor), safety features (automatic shut-off, timing precision), and user interface design. Sprint testing identified and resolved 12 hardware integration issues and 8 software defects. Figure 1 illustrates the Agile framework applied to this project.

C. *System Architecture*

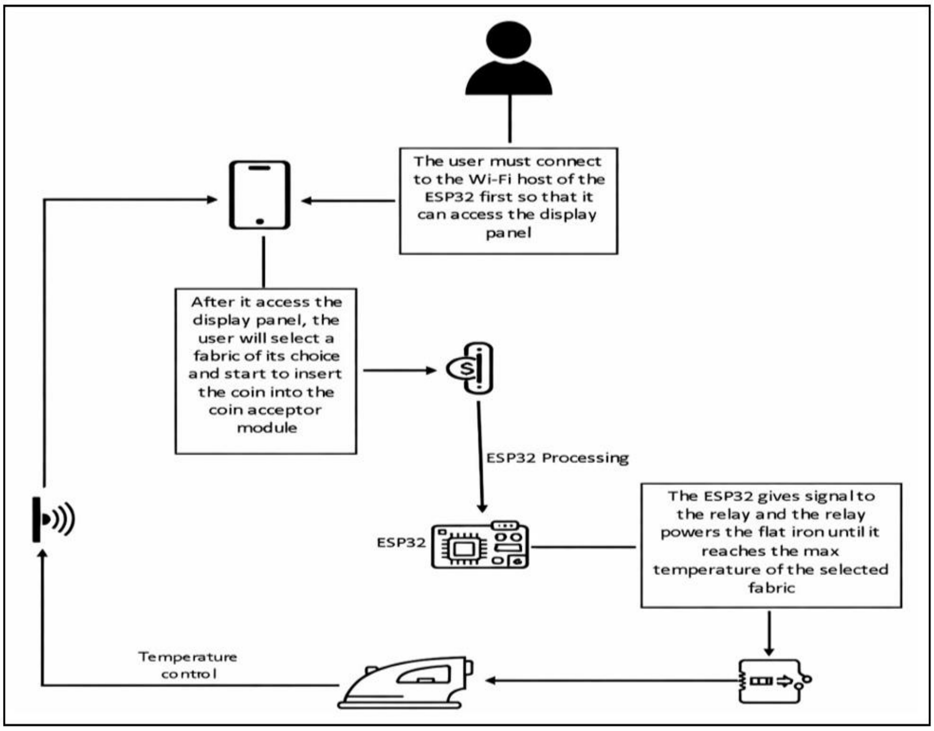

Fig. 2 System Architecture of Kusot No More

Figure 2 illustrates the Kusot No More system architecture, showing the interaction between the user, mobile application, ESP-32 microcontroller, and hardware components. Users select fabric type and monitor temperature through the mobile application, which communicates with the ESP-32 via Bluetooth. The ESP-32 processes coin acceptor inputs to validate payments, controls the flat iron through a solid-state relay on GPIO pin 25, and manages temperature monitoring via the MLX90614 sensor using I2C communication. Real-time temperature data is displayed on both the LCD screen and mobile application, ensuring users maintain appropriate iron temperature for selected fabric types.

D. Block Diagram

The system block diagram (Figure 3) illustrates the functional relationships between nine primary components arranged in three layers: power distribution (main power supply, buck converter), processing and control (ESP32, coin acceptor, infrared temperature sensor), and output interfaces (digital display, solid-state relay, single relay, flat iron). The ESP32 microcontroller receives input from the coin acceptor and temperature sensor, processes payment and thermal data, and controls the display and relay modules to manage flat iron operation. Arrows indicate signal flow: coin pulses and temperature readings input to the ESP32, while control signals output to the display and relays.

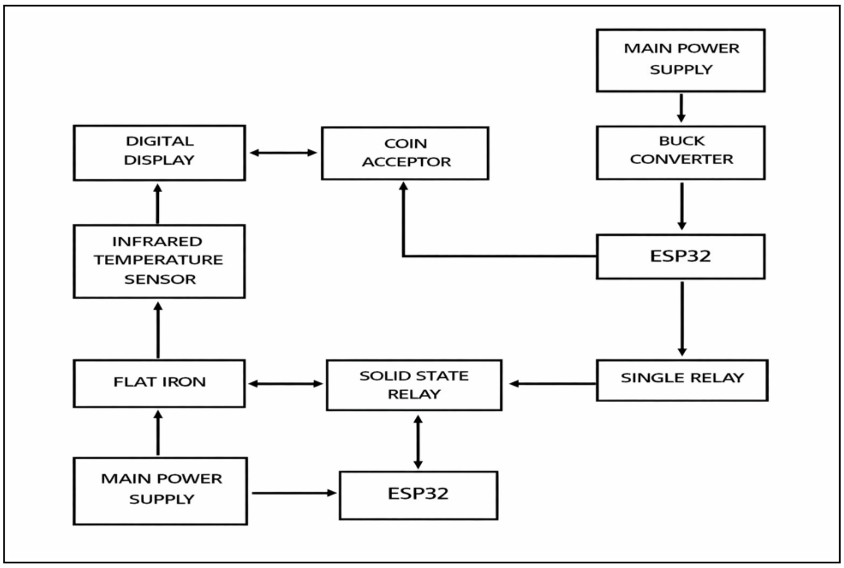

Fig. 3 Block Diagram of Kusot No More System

E. Hardware Components and Specifications

The Kusot No More system integrates seven primary hardware components, as illustrated in the 3D circuit representation (Figure 4). The ESP32-WROOM-32 microcontroller serves as the central processing unit, operating at 240 MHz with dual-core Xtensa LX6 architecture and integrating IEEE 802.11 b/g/n Wi-Fi and Bluetooth 4.2 BR/EDR/BLE capabilities for wireless communication. Temperature monitoring is achieved through the MLX90614ESF-BAA infrared sensor, which performs non-contact surface temperature measurement with ±0.5°C accuracy across a range of 0-300°C, communicating via I2C protocol at address 0x5A. Power control utilizes a 5V single-channel relay module with optocoupler isolation, rated for 10A switching capacity at 250V AC, connected to GPIO pin 25 of the ESP32. The LM2596 buck converter regulates the 12V DC input from the power supply, providing stable 5V/3A output to power the ESP32 and peripheral modules with >92% efficiency. Payment validation is handled by a multi-coin acceptor module configured to recognize Philippine 5-peso and 10-peso denominations, generating pulse signals on GPIO pin 4 upon successful coin validation. The primary power source comprises a 12V/5A (60W) switching AC-DC adapter. Electrical safety compliance is ensured through a 40A circuit breaker visible in the upper section of Figure 4, along with proper grounding connections to prevent electrical hazards.

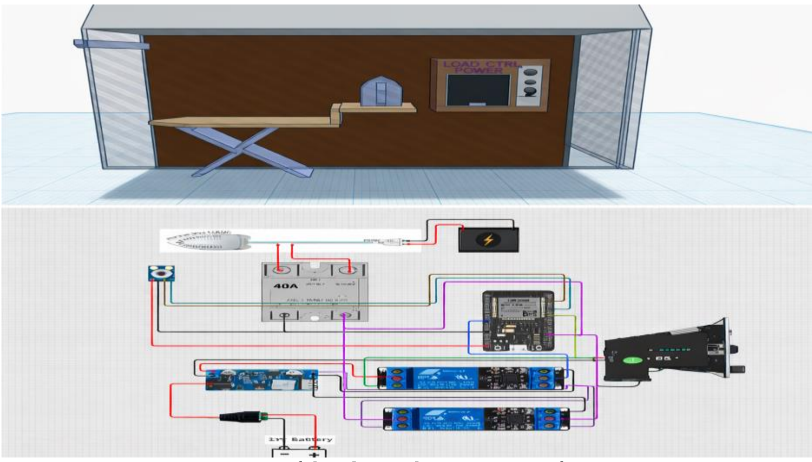

Fig. 4 3D Representation of the Electrical Circuit Design for Kusot No More

F. *Software Development and Mobile Application*

System firmware was developed using Arduino IDE 2.3.2 in C++ language, implementing payment processing, relay control, and temperature monitoring modules on the ESP32 microcontroller. The mobile application, developed in [specify framework], provides four key interfaces: fabric selection with preset temperature profiles (acetate, silk, rayon, wool, cotton, linen), real-time temperature display updated every 2 seconds, countdown timer, and safety notifications. Users connect via WiFi network "KnM Vendo Machine" (password: 12345678) and access the web interface at 192.168.4.1. Figure 5 illustrates the complete eight-step user guide, from WiFi connection through fabric selection and payment to system operation.

Fig. 5 User's Guide for Kusot No More System Operation

G. *Data Collection and Evaluation Methodology*

Figures Expert Evaluation: Eight IT experts and engineers (3 computer engineers, 2 electrical engineers, 3 IT using a 5-point Likert scale (5 = Strongly Agree, Strongly Satisfied, Excellent, 4.00 – 4.99 = Agree, Slightly Satisfied, Moderately Functional, 3.00 – 3.99 = Neutral, Undecided, Satisfied, Functional, 2.00 – 2.99 = Disagree, Slightly specialists) evaluated the prototype using the ISO/IEC 25010 Software Quality Model, assessing Functional Suitability, Performance Efficiency, Compatibility, and Reliability. User Evaluation: Sixty student users and fourteen teacher-advisers completed the USE Questionnaire (Lund, 2001) assessing Usefulness, Ease of Use, Ease of Learning, and Satisfaction Dissatisfied, Slightly Functional, 1.99 – 1.99 = Strongly Disagree, Strongly Dissatisfied, Not Functional). Implementation Timeline: Development occurred across 8 weeks (June-July 2025) including requirements analysis, system design, hardware assembly, testing, deployment, and evaluation.

TABLE I
Scoring Range of Likert Scale of the Survey

Scale	Range	Verbal Interpretation
5	5.00	Strongly Agree / Strongly Satisfied / Excellent
4	4.00 - 4.99	Agree / Slightly Satisfied / Moderately Functional
3	3.00 - 3.99	Neutral/Undecided / Satisfied / Functional
2	2.00 - 2.99	Disagree / Slightly Dissatisfied / Slightly Functional
1	1.00 - 1.99	Strongly Disagree / Strongly Dissatisfied / Not Functional

IV. RESULTS AND DISCUSSIONS

A. System Performance Metrics

TABLE II
Hardware and Application Performance Components

Component/Feature	Rating	Status
ESP-32 Control System	**4.67**	**Moderately Functional**
Heat Sensor Accuracy	**4.33**	**Moderately Functional**
Buck Converter Performance	**5.00**	**Excellent**
Coin Acceptor Reliability	**5.00**	**Excellent**
Temperature Display	**4.33**	**Moderately Functional**
Remaining Time Display	**5.00**	**Excellent**

Table II presents the performance evaluation results of the individual hardware components and mobile application features. Eight IT experts conducted standardized testing over a two-week period. Evaluation criteria included functional reliability, operational accuracy, and user interaction quality.

1) Hardware Component Performance

The **buck converter** obtained a mean rating of 5.00 (Excellent), demonstrating stable voltage regulation from a 12 V input to a regulated 5 V/3 A output under all testing conditions. No voltage instability or thermal abnormalities were observed during continuous operation of up to four hours. The **coin acceptor** also achieved a mean rating of 5.00 (Excellent). It successfully validated 100% of test insertions for PHP 5 and PHP 10 denominations. Pulse signal transmission to GPIO Pin 4 resulted in zero false readings and no missed detections across 200 test transactions. The ESP-32 control system received a mean rating of 4.67 (Moderately Functional). The microcontroller exhibited stable system performance with minor Wi-Fi connectivity delays during peak usage. The dual-core processor effectively managed concurrent operations, including temperature monitoring, payment validation, and relay control, without observable performance degradation. Optimization of the Bluetooth communication protocol is recommended to improve mobile application synchronization speed. The heat sensor achieved a mean rating of 4.33 (Moderately Functional). The MLX90614 infrared sensor produced temperature readings within ±2 °C of calibrated reference measurements. The non-contact sensing mechanism prevented interference with iron operation. Additional calibration is recommended to achieve the manufacturer-specified accuracy of ±0.5 °C.

2) Mobile Application Feature Performance

The remaining time display feature obtained a mean rating of 5.00 (Excellent). The countdown timer remained accurately synchronized with the relay control mechanism. Evaluators reported clear display visibility and intuitive interpretation of time allocation. The temperature display feature received a mean rating of 4.33 (Moderately Functional). Real-time temperature updates occurred at two-second intervals as designed. However, evaluators recommended increasing font size and incorporating color-coded temperature zones (safe, caution, and danger) to enhance readability, particularly for users with visual impairments.

Overall, the system achieved a composite mean score of 4.72 out of 5.00, indicating high functional reliability and system robustness. Identified issues require incremental optimization rather than structural redesign.

Fig. 6 Kusot No More IoT-Based Flat-Iron Vending Machine Prototype

Figure 6 shows the completed Kusot No More prototype featuring a wooden enclosure housing the IoT-based control system. The flat iron is mounted on top of the vending machine cabinet. The front panel displays the coin acceptor mechanism with clear coin slot markings for PHP 5 and PHP 10 denominations. The ESP-32 microcontroller, relay modules, buck converter, and temperature sensor are housed within the enclosure, providing automated control of the flat iron through the pay-per-use system. The compact design measures approximately 30cm x 25cm x 40cm, making it suitable for dormitory hallway installation while maintaining portability for maintenance access.

B. User Satisfaction Results

TABLE III
User Satisfaction and Usability Assessment Results

Quality Characteristic	Mean Score	Interpretation
Usefulness	**4.75**	**Agree**
Ease of Use	**4.73**	**Agree**
Ease of Learning	**5.00**	**Strongly Agree**
Satisfaction	**4.86**	**Agree**
Overall Usability	**4.84**	**Agree**

As shown in the table, the system achieved high usability scores across all quality characteristics. Usefulness (4.75), Ease of Use (4.73), Satisfaction (4.86), and Overall Usability (4.84) all received "Agree" ratings. The exceptional "Ease of Learning" score of 5.00 indicates the interface effectively communicates operation to first-time users, achieving a "Strongly Agree" rating. The overall composite usability score of 4.84 demonstrates high user contentment.

C. Expert Evaluation Results

TABLE IV
ISO/IEC 25010 Software Quality Model Evaluation Results

Quality Characteristic	Mean Score	Interpretation
Functional Suitability	**4.67**	**Slightly Satisfied**
Performance Efficiency	**4.89**	**Slightly Satisfied**
Compatibility	**4.84**	**Slightly Satisfied**
Reliability	**4.58**	**Slightly Satisfied**
Overall System Quality	**4.75**	**Slightly Satisfied**

Functional Suitability (4.67) indicates the system meets specified functions adequately. Performance Efficiency (4.89) demonstrates fast response times and sustained usage capability. Compatibility (4.84) shows excellent co-existence and operability. Reliability (4.58) achieved 5.00 for availability but 4.33 for fault tolerance. The overall 4.75 score demonstrates the system meets professional quality standards for deployment.

D. Discussion

1) System Effectiveness: The 4.73/5.00 overall functionality rating indicates successful prototype development. Perfect scores for buck converter and coin acceptor suggest robust electrical design. The 4.33 heat sensor rating indicates an area for improvement through sensor recalibration.

2) User-Centered Design Success: The exceptional "Ease of Learning" score of 5.00 indicates the interface effectively communicates operation to first-time users. The high composite usability score of 4.84 proves the system successfully balances automation with user transparency.

3) Economic Viability: The PHP 11,450 development cost yields approximately PHP 0.30 cost-per-use when amortized. At PHP 5-10 per use, the system reaches cost recovery within 6-12 months, after which revenue becomes profit. This viability supports adoption by dormitory operators.

V. CONCLUSIONS

The Kusot No More IoT-based flat-iron vending machine successfully addresses a practical problem faced by students in dormitory settings. The system achieved functional effectiveness ratings of 4.73/5.00, demonstrating reliable component integration, user-friendly interface design, and safe operation through automated controls. Expert evaluation confirmed the system meets professional quality standards across four ISO/IEC 25010 dimensions, while end-user testing revealed high satisfaction (4.84/5.00) particularly in ease of learning (5.00) and overall usability. The system proves economically viable for dormitory implementation, with projected cost recovery within 6-12 months of operation and subsequent profitable revenue generation. Safety improvements achieved through automated flat iron control significantly reduce fire and electrical hazards compared to personal appliances in student rooms.

RECOMMENDATION

Based on the findings and the conclusion made the following recommendation are being proposed;

1. For Dormitory Implementation: Institutional adoption is recommended with pilot deployment in one dormitory building followed by expansion based on operational experience and revenue performance. Administrative oversight of daily maintenance and coin collection procedures is essential.
2. For Technical Enhancement: Future versions should incorporate heat sensor recalibration to achieve ±0.5°C accuracy, user-selectable ironing duration, refund mechanisms, and battery backup systems to enable operation during power outages.
3. For Data Collection: Implementation of cloud-connected logging systems would enable tracking of usage patterns, temperature data, and revenue generation without compromising offline reliability, providing valuable data for system optimization.
4. For Scaling: Development of a dual-iron cabinet design would accommodate higher-traffic locations while maintaining the single-station simplicity that contributes to interface ease of learning.
5. For Curriculum Integration: The prototype presents an excellent case study for IT and engineering students, demonstrating practical application of IoT principles, systems integration, and user-centered design. Educational institutions should incorporate similar projects into capstone requirements.

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