Using IoT System for Borrowing and Returning of Teaching Equipment in the Electrical Field

Yutti Chatwaranon[1*], Mallika Chatchawankitkun[2], Sutthikiat Srisathit[3] and Sathisn Yutthanaboon[4]
Faculty of Engineering, Bangkok Thonburi University[1, 2, 3]
Aeronautical Engineering Division Civil Aviation Training Center[4]
e-mail: y.chatwaranon@gmail.com[1] , mallika.chkk@gmail.com[2], sutthikiats17@gmail.com[3], Sathian@catc.or.th[4]
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Abstract

This study focuses on addressing the problem of equipment loss within the electrical engineering department at the Faculty of Electrical Engineering, Bangkok Thonburi University. The research objectives are twofold: (1) to develop and assess an application that utilizes LINE Notify for real-time notifications, integrating data collected through Google Forms; and (2) to create a system for storing borrower information using Google Sheets as the database, which allows for effective tracking and verification of equipment usage. Testing of the system demonstrated that it successfully records equipment borrowing through Google Forms and securely stores this information in Google Sheets for administrative oversight. The system provides timely notifications and detailed updates via LINE Notify, enabling administrators to approve borrowing requests through web browsers and applications. The results indicate that this system effectively mitigates equipment loss and enhances monitoring and management efficiency.

Keywords: Application, LINE Notify, Borrow-Return, IoT, Web Browser.

Introduction

Technology plays a transformative role in contemporary society across various industries, including healthcare, agriculture, and numerous other sectors. Integrating sensor technology into services and management processes has significantly enhanced operational efficiency in these industries. This trend extends to the field of education, where the adoption of technology in diverse tasks has demonstrated the potential to reduce workload and optimize management processes. By leveraging technology in the administration and management of educational resources, institutions can achieve notable improvements in operational efficiency. Education is a cornerstone of human development, providing essential and foundational knowledge. However, with the increasing availability of educational tools and resources, there has been a parallel demand for managing these resources effectively to support student development. A recurring challenge in this area is the loss or mismanagement of tools and equipment, such as screwdrivers, wrenches, and other instruments of varying sizes. This issue, often arising from frequent use in academic and practical settings, leads to significant budgetary strain as institutions are forced to replace lost items regularly. To address this challenge, applying technology to monitor the borrowing and return of equipment presents a viable solution. This research proposes

designing and implementing an equipment borrowing and return management system tailored for the Faculty of Engineering, Department of Electrical Engineering, at Bangkok Thonburi University. The system aims to track and manage the borrowing process efficiently, ensuring accountability and reducing losses. The proposed system leverages Internet of Things (IoT) technology integrated with Google Workspace tools, including Google Forms and Google Sheets, for recording and storing transaction data. Additionally, LINE Notify provides real-time notifications, ensuring that administrators and users receive timely updates about borrowing and return activities. This approach not only facilitates effective monitoring but also enhances transparency and accountability. Institutions can mitigate losses, optimize resource allocation, and support sustainable educational practices by implementing this technology-driven solution.

Literature Review

This research involved a comprehensive review of related studies to identify existing methods and technologies to verify loan and return processes. A review of relevant literature revealed that most prior studies employed information technology systems to improve the efficiency and reliability of loan verification. Notable studies include the following:

Wanthong et al. (2022) this study introduced a borrowing-returning system for managing equipment and research materials in the Information Technology Department at Loei Rajabhat University. The system was developed using PHP, CSS, HTML, and a MySQL database. The research included a satisfaction survey involving 20 users, which revealed that the system successfully facilitated borrowing and returning processes. User feedback indicated a high level of satisfaction with the system's performance.

Wannayos et al. (2021) this research focused on designing, developing, and evaluating an IoT device to facilitate communication between bedridden elderly patients and their caregivers. The study was conducted in Phrom Phiram district, Phitsanulok, Thailand, and involved 60 participants. The device, developed using Arduino IDE, was designed to improve communication efficiency and effectiveness. Results highlighted the device’s success in achieving its purpose, with its keypad functionality enabling continuous communication. Caregivers reported that the device enhanced the quality of 24/7 communication. Hypothesis testing further revealed a strong correlation between the device's efficiency and effectiveness.

Khamchalor and Songtai (2021) this study focused on synthesizing a framework for utilizing Google Applications to support the evaluation of Level 1 interior electrician skill tests. Feedback from nine experts was collected via questionnaires and analyzed using statistical methods such as percentage, mean, and standard deviation. Results showed high suitability scores for the proposed framework supporting the skill test scoring standard (M = 4.49, SD = 0.47). The framework content received the highest expert rating (M = 4.59, SD = 0.53), indicating its relevance and applicability.

Inthichit et al. (2018) this study assessed the effectiveness, learning achievement, and satisfaction associated with online learning using Google Classroom with the T5 model. The sample consisted of nine Information Management students. Findings revealed an effectiveness index of 74.41%, reflecting a high level of effectiveness. Statistical analysis showed a significant improvement in learning achievement post-intervention ($p < .01$). Additionally, learner satisfaction was rated highly ($M = 4.48$, $SD = 0.59$), indicating that the T5 model facilitated active and effective learning engagement.

These studies demonstrate the potential of leveraging information technology systems, IoT devices, and Google-based applications to enhance educational and management processes. Each study provides valuable insights into the role of technological innovation in improving operational efficiency, user satisfaction, and learning outcomes. The findings from these studies informed the design and development of the borrowing-returning system proposed in this research, emphasizing the integration of IoT and Cloud-based tools to achieve similar improvements in efficiency and satisfaction.

Related Literature

1. Design for filling out information with Google Form

Design for filling out information with Google Form for use in filling out information for borrowing and returning. It is divided into various topics such as first and last name, class year, student ID, etc. Google Form (Google Form) will help collect various information from the sender (Rungkaew, 2021)

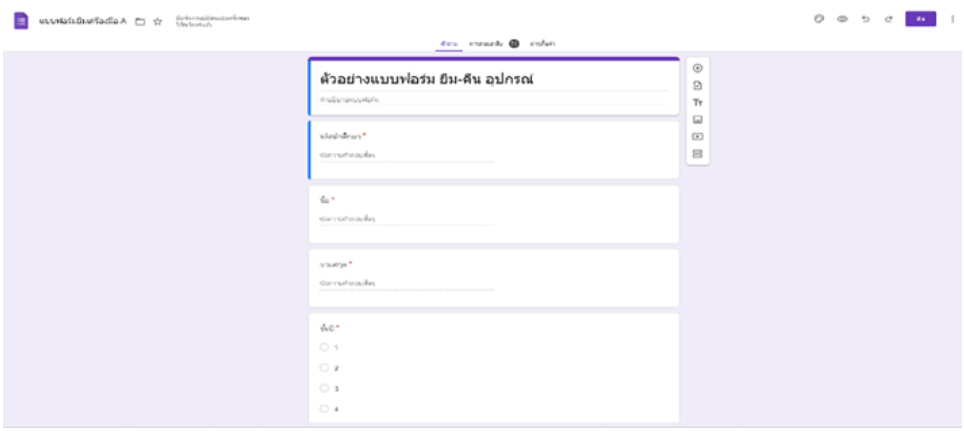


Figure 1 Google Form for borrowing and returning equipment.

2. LINE Notify

LINE Notify is a notification service for LINE used as an aid in notifications Information sent from Google Forms and LINE Notify provides various information in the form of messages. (Wongnoon, 2020)

Figure 2 Line-Notify.

3. Blynk Server

Blynk or Blynk Server is an IoT Cloud that can be installed in many formats and versions, including both smartphones and laptops. There will be 4 main components:

1. Blynk
2. Internet Wi-Fi
3. Client
4. Device.

The working principle of the Client or Application is used to give commands to Blynk Server via Internet Wi-Fi. The server will monitor and provide commands to the device. (Rattananimit et al., 2019)

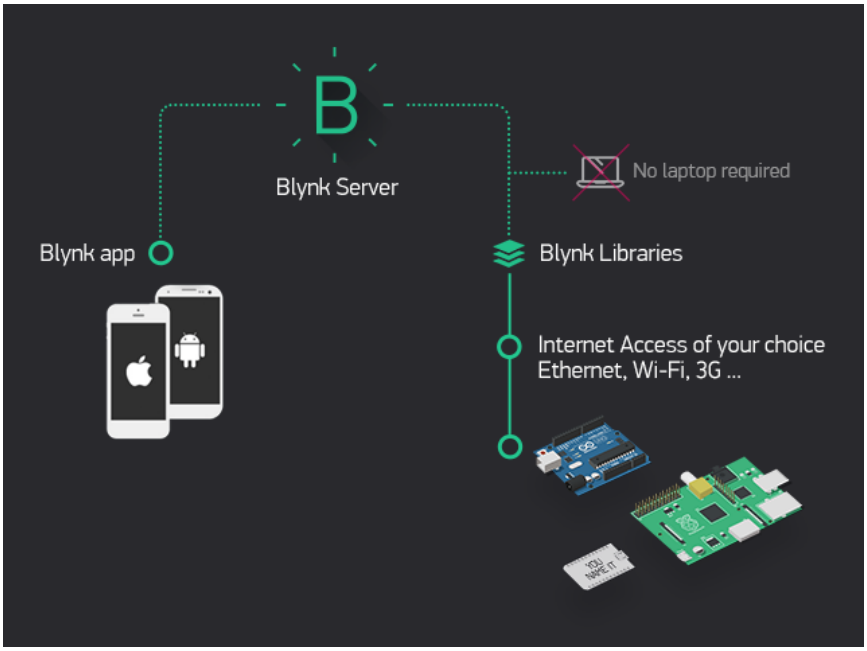


Figure 3 Blynk.

4. Magnetic Contactor

Magnetic contactor or electromagnet that works using 12 V direct current. When an electrical current is applied, an electromagnet is activated to prevent the opening and closing of the equipment storage box.

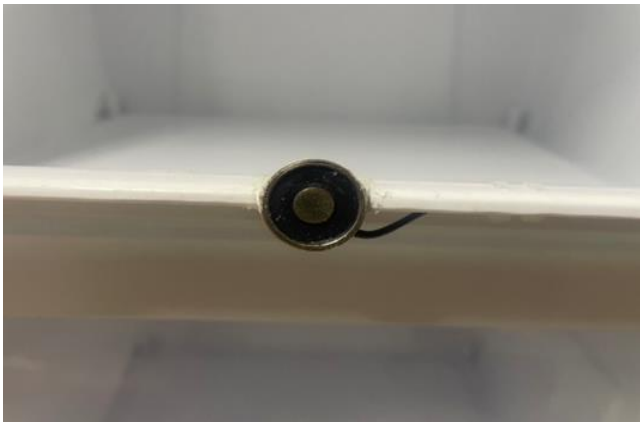


Figure 4 Magnetic Contactor.

5. ESP8266 Wi-Fi

ESP8266 Wi-Fi is Node-MCU, a platform to help build the Internet of Things (IoT). It can be programmed in Lau language, making it easier to use. It comes with a Wi-Fi module (ESP8266), which is the key to connecting to the internet or programming into the ESP8266 to automatically receive sent data without the administrator pressing it. (Ariyapim & Deephang, 2021)

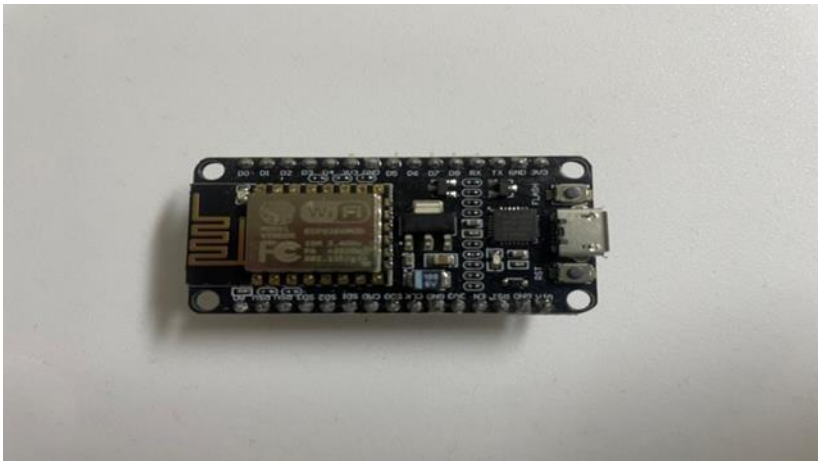


Figure 5 ESP8266 Wi-Fi

6. Internet of Things (IoT)

Internet of Things or IoT are various electronic devices that can link or send data to each other via the internet. The Internet of Things is used to receive information, which allows the administrator to unlock the box via phone and use Blynk Server to unlock it automatically.

Objectives.

To develop an IoT system for borrowing and returning teaching equipment in electrical engineering.

Research Methodology

1. The equipment storage box

The equipment storage box stores various equipment such as digital multimeters, screwdrivers, pliers, etc. The equipment storage box contains four pairs of LED bulbs to display the results. Four electric magnets are used to prevent the opening and closing of the equipment loan-return cabinet. Four magnetic switches send signals to (Blynk Server) for data storage. QR Code is used to fill in information and control the system (Controls system).

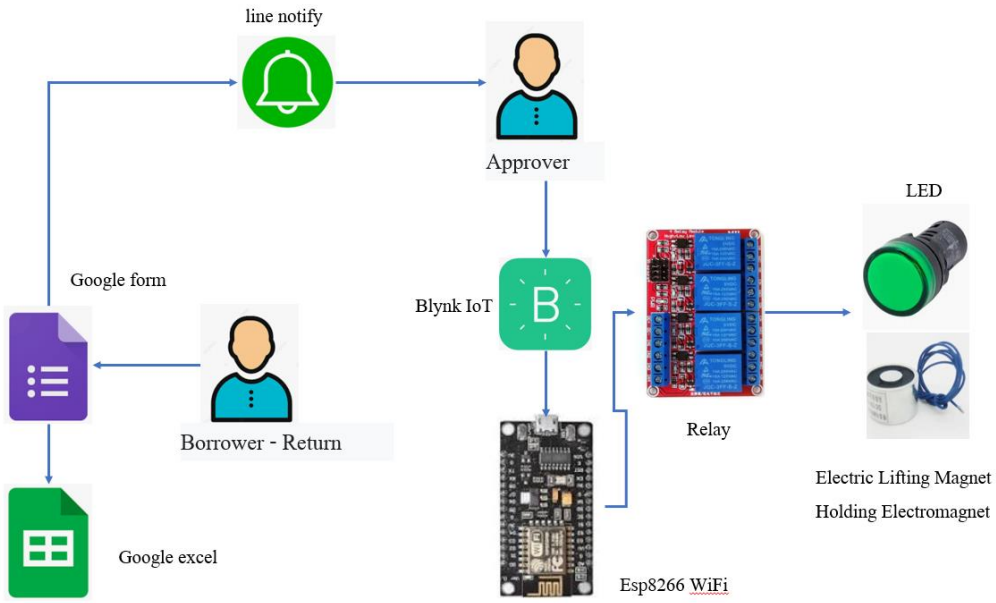


Figure 6 Building methods and procedures.

From Figure 6, there is a method for borrowing equipment in the camera and approval, along with working principles, methods for turning the camera on and off, and collecting data for verification

Figure 7 Equipment storage box.

2. Controls system

Controls system, which uses IoT technology to help receive data from (Blynk Server) and uses ESP8266 for approval. Users can borrow equipment by scanning a QR Code and filling out a Google Form, which will receive a notification via Line Notify.

Figure 8 Control cabinet

3. The control cabinet

The equipment installed inside the control cabinet consists of:

1. Power supply DC 12 V serves to convert AC 220 V alternating current into DC 12 V direct current to supply to devices such as voltage reduction modules (Step-down), Node MCU (NodeMCU ESP8266), and Relay module.

2. The voltage reduction module (Step-down) converts voltage from AC 220V to DC 5V.

3. Node MCU model ESP8266 (NodeMCU ESP8266) controls various input-output ports. It can also be linked to a wireless internet network, which can be used to program with (Blynk Server) to control equipment borrowing and returning cabinets.

4. A 4-channel relay module (4 Relay Modul) serves as a module used to control the operation of electrical loads, both direct current (DC) and alternating current (AC). It is like various light switches that use voltage to turn on and off, such as magnetic contactors, LED bulbs, and magnetic switches etc.

4. The program

The program is divided into 3 steps.

Step 1 for those who borrow and return equipment, creating a form for borrowing and returning.

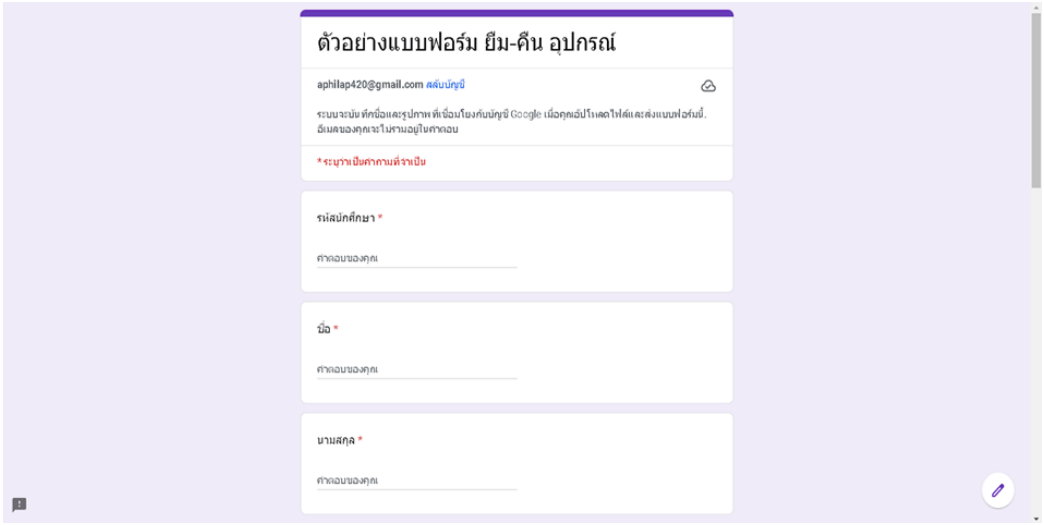


Figure 9 Form in Google Form.

From Figure 9, when the person borrows/returns the equipment, they must filter the details in the Google Forms system. The system will notify the loan details and return via the LINE Notify system so that the approver can receive the information.

Step 2 for those who approve the borrowing-return of equipment: Using LINE Notify to help give approval notifications.

Figure 10 Notifications in LINE Notify

Step 3 This part is approval through the Blynk program or through a web browser by pressing approval, which has the following process.

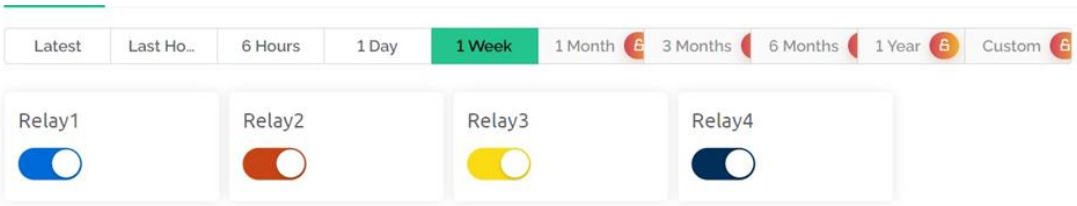


Figure 11 Press the button for approval.

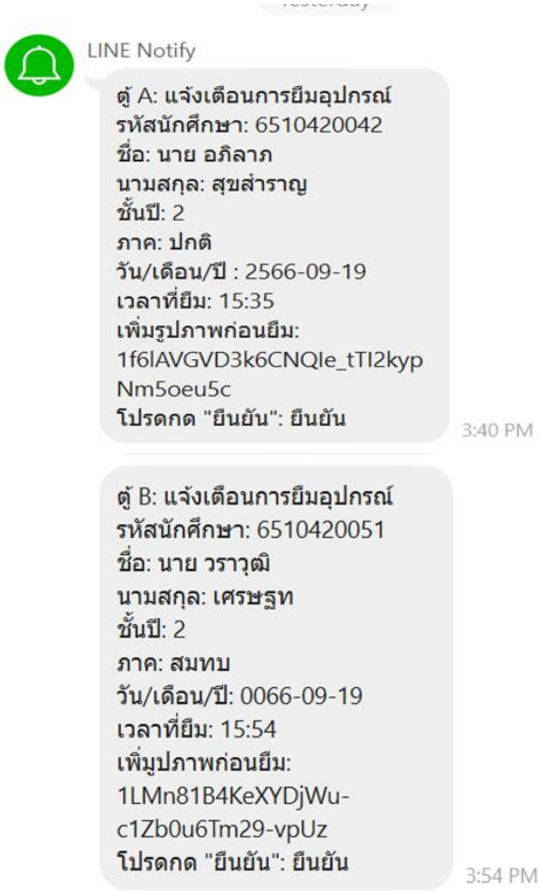
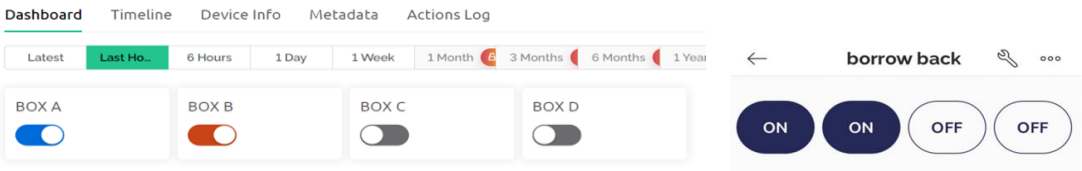


Figure 12 Notification via LINE system to the approver.

Once the notification has been received, the approver can approve the loan through the IoT system in both channels: through a web browser or an application, as shown in Figure 12.



(a) (b)

Figure 13 Approval via both channels (a) web browser (b) application

Figure 13 is approved in 2 ways: through a web browser or application. At the same time, this information will be stored in Excel format containing details about borrowing equipment. Returning the device will also be a notification via Google Forms, as shown in Figure 14.

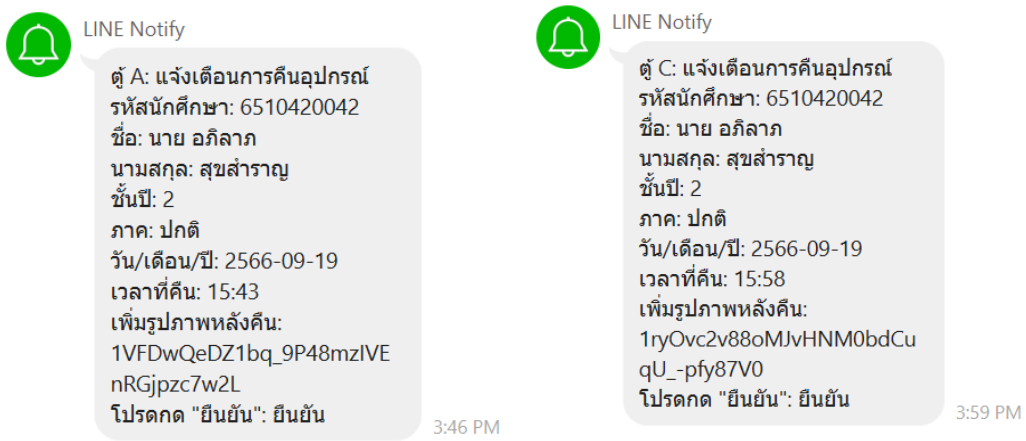


Figure 14 Returning the devices.

When returning equipment, the returner must notify the person who approved the return of the equipment, the time when the equipment was returned, and in which box to inspect it. Data is stored in Excel with details on borrowed and returned equipment that are captured using Excel online for verification anywhere.

Results

The experiment uses electronic devices, the IoT system, and the Google application to fill out loans and return the information with Google Forms. The system can work efficiently and immediately sends approval request information through the LINE Notify system to administrators. In addition, the approver can approve it in both ways: Through a web browser or application. The borrowing and returning information will be stored in Google Excel, including

student ID, student name, year, and pictures of borrowed and returned equipment. This test used data from students of all years in the electrical field.

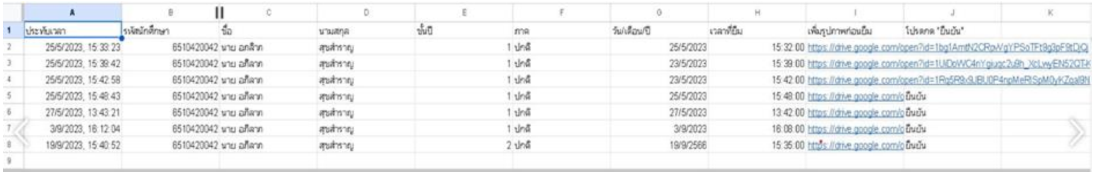


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Figure 15 Information on borrowing and returning equipment.

Conclusion

This research focuses on developing a system to manage the borrowing of teaching equipment in electrical engineering, aiming to prevent losses during usage and enable equipment tracking through a robust inspection system. The objective is to address inefficiencies in traditional borrowing and returning equipment by incorporating modern technology, specifically IoT (Internet of Things) systems, into the process. IoT technology, leveraging the internet and sensor systems, provides a more efficient and reliable solution for equipment management.

Historically, equipment borrowing and return processes relied on manual record-keeping, where personnel checked loans and maintained documentation. This approach was time-consuming, prone to errors, and required constant human oversight. Approvers often needed to be physically present to confirm and unlock equipment, leading to delays and operational inefficiencies. Recognizing these challenges, this research aimed to modernize the process by integrating IoT and Cloud-based systems.

The proposed system utilizes Google Workspace tools, including Google Forms for data input, Google Sheets for data storage and tracking, and LINE Notify for real-time notifications. When equipment is borrowed, the system records the transaction details, including visual evidence (photographs), in Google Sheets. Notifications are sent via LINE Notify, ensuring timely updates for borrowers and approvers. This streamlined approach eliminates unnecessary steps, reduces the need for continuous manual oversight, and enhances overall efficiency.

Experimental results demonstrated the system's effectiveness in reducing the complexity of the borrowing and return process. Loan approvals are completed within an average of 3–5 minutes, significantly faster than traditional methods. Additionally, the system enables a single teacher or staff member to oversee the entire process, minimizing resource requirements while maintaining accuracy and reliability. Including photographic evidence further enhances accountability and ensures a transparent borrowing process.

This research highlights the potential of IoT and Cloud-based systems to transform traditional equipment management practices, providing a scalable and efficient solution for

educational institutions. The proposed system improves workflow efficiency by reducing procedural steps and increasing automation. It also establishes a model for integrating technology into resource management across various domains.

Discussion

The results of testing the loan recovery system integrated with IoT technology demonstrated significant improvements in the efficiency and effectiveness of managing borrowed equipment. The system utilizes information technology, including Cloud-based tools and sensors, to streamline the inspection and tracking processes. By leveraging the freely accessible Google Workspace platform, the system incorporates Google Forms to filter and record loan and recovery data, which is then stored and organized in Google Sheets. Notifications regarding loan statuses are sent in real-time through LINE Notify, allowing stakeholders to monitor and approve transactions remotely via any internet-enabled device.

This IoT-enabled system records borrowing and recovery activities comprehensively, providing detailed information for borrowers and administrators. It facilitates transparent monitoring, enabling efficient equipment tracking and reducing the likelihood of mismanagement or loss. The integration of Google Sheets allows for easy access to historical data, supports accountability, and enables administrators to generate reports for auditing purposes. The system's flexibility and scalability apply to domains beyond electrical engineering, such as managing borrowing and returning processes for sports equipment, library books, or other institutional resources. Its Cloud-based infrastructure ensures the system remains cost-effective and widely accessible, making it suitable for educational institutions, sports facilities, and public libraries.

The experimental results demonstrated that the IoT-enhanced loan recovery system reduces operational complexity and enables real-time approval and monitoring, significantly enhancing user experience. The ability to approve and inspect loans from any location with internet connectivity improves administrative efficiency and convenience. This approach can serve as a model for other institutions seeking to modernize their resource management systems, contributing to broader efforts to integrate digital technology into traditional workflows.

Suggestions

1. The current borrowing-returning system lacks the assignment of serial numbers to devices, which can lead to errors in verifying and tracking equipment information.
2. Borrowing and returning in this system requires approval from designated personnel via the IoT system, but delays may occur if the approver is preoccupied or forgets to approve.
3. Since the system relies on IoT technology, internet connectivity plays a crucial role in determining the efficiency and timeliness of the approval process.
4. Future development will address these issues by incorporating an image detection system to assist in equipment recovery. Additionally, equipment will be categorized, loan

numbers assigned, and organized within a database to simplify and enhance the verification and management of equipment loans and returns.

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