SEARCH IT: SMART ESP32-POWERED ACTIVE RESPONSE COMPANION HARDWARE – INTEGRATED TRACKER

Undergraduate Capstone Project
Submitted to the faculty of the
College of Engineering and Information and Technology
Cavite State University
Indang, Cavite

In partial fulfillment
of the requirements for the degree
Bachelor of Science in Information Technology

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BIOGRAPHICAL DATA

Mr. Keith Brian Coner was born on November 23, 2004, in Molino, Cavite. He is the youngest of two children of Mrs. Glenda L. Coner and Mr. Juanito M. Coner. He has two older brothers, Christian Joy L. Coner and Von Paulo L. Coner. The researcher and his family currently reside in Dasmariñas, Cavite.

He completed his elementary education at The First Uniting Christian School in 2016 and continued his junior high school education at the same institution, finishing in 2020. He pursued his senior high school studies at The First Uniting Christian School as well, taking the Technical-Vocational-Livelihood (TVL) Track, specializing in Information and Communications Technology (ICT). He graduated from senior high school in 2022.

In the same year, he was admitted to Cavite State University, where he is currently pursuing a Bachelor of Science in Information Technology.

BIOGRAPHICAL DATA

Ms. Rafaella P. del Rosario was born on September 23, 2003, in Trece Martires, Cavite. She is the eldest daughter of Mr. Ryant C. del Rosario and Mrs. Morena P. del Rosario. She also has a younger sibling, Rayah P. del Rosario who she shares a close and supportive family bond with. The family currently resides in Salaban, Amadeo, Cavite.

She completed her elementary education at Salaban elementary school in 2016. After that, she pursued her junior high school education at Amadeo Integrated School, where she graduated in 2020. She continued her senior high school at Olivarez College Tagaytay and completed it in May 2022. Moving forward, she got admitted to Cavite State University, Indang in September 2022, where she is currently pursuing the Bachelor’s degree in Information technology.

BIOGRAPHICAL DATA

Ms. Amanda Catherine G. Noveno was born on September 2, 2004 in Antipolo, Rizal. She is the eldest daughter of Mr. Albert P. Noveno and Ms. Consorcia N. Gultian. She has a younger sibling, Alexia Cristine G. Noveno. She currently resides at Palocpoc, Mendez, Cavite.

She completed her elementary education at Palocpoc Elementary School in 2016 and continued her junior high school education at Palocpoc National High School, where she graduated in 2020. In the same year, she continued her senior high school education at Olivarez College Tagaytay under Technical-Vocational-Livelihood - Information and Communications Technology (TVL-ICT) strand and graduated in May 2022. In the same year, she got admitted to Cavite State University - Main campus in September 2022, where he is currently pursuing a Bachelor’s degree in Information Technology.

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She recognizes her friends for their constant support and companionship. Their presence has brought laughter and comfort throughout the journey.

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Above all, the author offers her deepest gratitude to the Lord for His infinite grace, guidance, and blessings. His presence has sustained and guided her through every challenge, making the completion of this study possible.

AMANDA CATHERINE G. NOVENO

ABSTRACT

CONER, KEITH BRIAN L., DEL ROSARIO, RAFAELLA P., NOVENO, AMANDA CATHERINE G. SEARCH IT: SMART ESP32-POWERED ACTIVE RESPONSE COMPANION HARDWARE – INTEGRATED TRACKER. Capstone Project. Bachelor of Science in Information Technology. Cavite State University, Indang, Cavite. September 2026. Adviser: Dr. Mark Philip M. Sy.

Misplacing personal belongings is a common problem that often leads to inconvenience and wasted time. These situations disrupt productivity and may increase reliance on others when searching for lost belongings. To address this issue, a mobile-based system is designed to assist users in locating misplaced objects quickly and efficiently. The goal of the project is to provide a reliable tracking solution that enhances the search method rather than relying on the manual search. This provides real-time proximity detection, visual and audible cues, and secure object management.

The system was thoroughly tested and evaluated using the Agile Development Life Cycle methodology and the ISO 25010 quality standards. Comprehensive assessment involving both technical experts *(μ = 4.63, σ = 0.45)* and non-technical users *(μ = 4.77, σ = 0.46)* demonstrated excellent performance across all key indicators, including functionality, reliability, usability, efficiency, portability, accuracy, and user-friendliness. The results confirm that the system effectively meets its intended purpose and satisfies user needs by delivering accurate locator responses and intuitive interface. Overall, the successful deployment of this technology offers a dependable tool for minimizing misplaced belongings and showcases the potential of integrated hardware-software solutions to improve everyday user experience.

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SEARCH IT: SMART ESP32-POWERED ACTIVE RESPONSE COMPANION HARDWARE – INTEGRATED TRACKER

KEITH BRIAN L. CONER
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An undergraduate capstone outline submitted to the faculty of the Department of Information Technology, College of Engineering and Information Technology, Cavite State University, Indang, Cavite in partial fulfillment of the requirements for the degree of Bachelor of Science in Information Technology with Contribution No. _________. Prepared under the supervision of Mr. Mark Philip M. Sy.

INTRODUCTION

In the daily routine, individuals carry personal belongings that are regularly used, such as keys, a wallet, and a mobile phone. These items are sometimes left unintentionally as people get to move through different places, especially the indoor environment, whether it is the living room, kitchen countertops, or even within the workplace. As stated by Chipolo (2025), most people lose or misplace their belongings at home. It's where we relax and stop paying attention to what we're doing, so it's simple to get distracted and move something to a whole other location than it would normally be. In environments where most of the items are used simultaneously or stored in different locations, misplacement is common and can happen anytime, regardless of the circumstances. In view of Segen et al. (2022), people often experience difficulty recalling the precise locations of objects, highlighting how even brief memory disruption can cause common items to be misplaced. These findings emphasize that misplacement is not necessarily due to carelessness, but rather a natural consequence of limitation. Recognizing these patterns is essential to understanding how frequently such occurrences happen within typical environments.

As individuals faced problems related to the misplacement of personal belongings, research and technological advancements became important. These insights aligned with the United Nations Sustainable Development Goal (SDG 9: Industry, Innovation, and Infrastructure, which promoted innovation and technological advancement to foster economic growth, specifically under target 9.5. As well as SDG 12: Responsible Consumption and Production, which aimed to reduce waste generation and promote sustainable consumption, as outlined in target 12.5. Frequent misplacement of personal belongings was a common occurrence in indoor environments. These incidents often resulted from brief lapses in attention during routine tasks. According to Clark and Donnelly (2024), attentional focus significantly influenced the accurate recall of where objects are placed; individuals were more likely to forget item locations when distracted. Similarly, Brissenden, Tobyne, Osher, and Somer (2025) found that even minor disruptions in attention can alter spatial memory, leading to difficulty retrieving object locations in familiar indoor settings.

The study was conducted at the College of Engineering and Information Technology (CEIT) at Cavite State University - Main Campus. CEIT is one of the university's largest departments, with a diverse population of students enrolled in various programs. The department provides an ideal setting for the study, offering access to a wide range of individuals for data collection and analysis. This diversity ensures the survey gathers meaningful insights from participants with varying experiences, making CEIT the target beneficiary.

A recurring problem among students was the frequent misplacement of personal belongings indoors. According to the researchers' survey, forty-four percent (44%) reported that they often misplace items during the student's daily routine. The item most frequently misplaced is the phone with fifty-four percent (54%), followed by wallets with twenty-six percent (26%). This pattern indicated that disorganized habits, distractions, and a lack of designated storage locations were major contributing factors (See Appendix Figure 1). Alsmadi and Kong (2019) explained that limited memory capacity could lead to frequent item misplacement, especially when individuals are engaged in regular routines in familiar spaces. Parham et al. (2020) also found that individuals often overlook the placement of items in familiar environments due to reduced attention to surroundings.

Another problem observed was the amount of time students spent looking for misplaced items. According to the survey, the majority of the respondents, sixty percent (60%) reported that it typically took five (5) to ten (10) minutes to recover a misplaced item. Additionally, the most common method of recovery was retracing steps, also reported at sixty percent (60%). These responses showed that most students did not immediately remember where the items were placed and instead relied on repeatedly checking places that the students had visited. As shown in Appendix Figure 2, this often resulted in a noticeable amount of time spent on recovery. Yagi, Nishiyasu, Kawasaki, Mitsuki, and Sato (2021) noted that manual searching, such as checking rooms and retracing steps, was often inefficient and time-consuming, especially when individuals relied solely on memory and visual scanning to locate lost objects. Chen, Hsieh, and Chen (2021) also found that repeated checking and scanning of indoor spaces without assistance tools led to longer retrieval times.

The data also showed that many students depended on others when trying to recover misplaced belongings. As per the survey, fifty-eight percent (58%) indicated that respondents sometimes asked friends or family members to help when something was missing. Only forty-two percent (42%) reported that lost belongings were found without assistance. This indicated that a large portion of students relied on others for assistance rather than locating belongings independently. As detailed in Appendix Figure 3, this behavior might have been related to personal routines, item importance, or lack of tracking habits. Șipoș, Ciuciu, and Ivanciu (2022) found that students often involved others in the recovery of misplaced objects when they did not have established methods for organizing or locating items.

To address these challenges, the researchers proposed the development of SEARCH IT: Smart ESP32-Powered Active Response Companion Hardware - Integrated Tracker that used Bluetooth Low Energy (BLE) technology. The system consisted of Search It tags attached to personal belongings and a Search It app that allowed users to label, activate, and locate these tags. When activated, the tags produced sound and light signals while the app provided proximity feedback based on signal strength to guide the user. This solution aimed to reduce misplacement of personal belongings, shorten search times, and reduce dependence on others in locating misplaced belongings.

Objectives of the Study

The main objective of this study was to design and develop SEARCH IT: Smart ESP32-Powered Active Response Companion Hardware - Integrated Tracker, a system that provided an efficient and accessible solution for locating misplaced personal belongings indoors. The system utilized Bluetooth Low Energy (BLE) technology, ESP32 C3 super-mini with integrated passive buzzer module, and an LED light, operated through a mobile application exclusively for Android devices, to help users to locate misplaced belongings, reduce search time and increase independence.

Specifically, the study aimed to:

1. Identify the problems commonly experienced by users in relation to the misplacement of personal belongings indoors, with emphasis on the consequences such as time consumption and reliance on others.
2. Analyzed the problems using fishbone diagrams.
3. Designed the project with the following modules:
   a. Developed tag management module for the customization of tags
   b. Integrated locator actions module to trigger the light and sound features.
   c. Implemented signal processing module for the scanning of BLE signals
   d. Built a Search IT tag that can be attached to objects

4. Tested and improved the system's performance, usability, reliability, compatibility, and portability through user trials and feedback collection.
5. Evaluated the project based on ISO 25010.
6. Prepared an implementation plan for the deployment of the project.

Purpose and Description

The purpose of this project was to develop a SEARCH IT: Smart ESP32-Powered Active Response Companion Hardware - Integrated Tracker, a reliable and user-friendly object-locating system that assisted users, particularly students from Cavite State University – Indang, in finding misplaced belongings efficiently. By integrating Bluetooth Low Energy (BLE) with the ESP 32 C3-mini, buzzer, and LED, the system aimed to provide a responsive tracking solution through a mobile application designed exclusively for Android devices.

The project has the following capabilities:

1. The system allowed users to personalize each tag with a unique name or label and pin.
2. The mobile application included functionality that enabled users to trigger the buzzer and LED light on a tag.
3. The system processed Bluetooth Low Energy (BLE) signals using the Received Signal Strength Indicator (RSSI) to estimate the distance between the user and the tagged item.
4. The project included the development of a compact Search It tag that can be attached to personal belongings such as bags, wallets, or keys.

Time and Place of the Study

The capsule preparation was conducted from March 2025 to December 2025. The title was approved on the 3rd day of April 2025, and the researchers started having the approval sheet signed by the Dean to Thesis adviser and completed it on the 29th of April 2025. The researcher prepares the necessary materials to conduct data gathering, including the questionnaire and the permit to conduct it. The duration started from 30th of April to the 8th of May 2025, where researchers collected data from the respondents. After analyzing and preparing the data needed, the initial defense was held on the 9th day of July 2025. The development of the system is from August to September 2025 and the evaluation phase began in the month of October for technical and non-technical evaluators. The study proceeded with the interpretation and discussion of the result followed by the conclusion and recommendations.

Scope and Limitation of the Study

The purpose of this study was to develop a smart object-locator system called Search It, which aimed to provide a practical solution to the frequent misplacement of personal belongings. The system was designed to reduce the time spent searching for items, enhance independent operation, and improve the overall convenience and efficiency of locating lost or misplaced objects in indoor settings. This was achieved by combining mobile and embedded system technologies that allowed users to interact with physical tags attached to the students' belongings through a mobile application. The system consisted of two major components: the Search It Tag (hardware side) and the Search It App (software side). These components interacted via BLE to allow users to track, locate, and be alerted when they were moving away from the said belongings. The key features of the system were composed of the following modules: tag management module, locator actions module, signal processing module, and Search It tag. In addition, the system was strictly designed for single-user operation, meaning it did not include administrator accounts or multi-user interaction, and one application installation was intended for use by only one individual.

Tag Management Module. This module allowed users to add, rename, and remove objects while maintaining at least one object at all times. It included custom labeling features and the ability to set up a PIN for each tag. Users could update their objects by renaming, changing the description, and could also update their tag PIN. Each tag required authentication before being authorized to perform search actions.

The application used React Native Async Storage, which ensured that all changes made to tags were saved locally on the device.

Locator Actions Module. This module consisted of triggering the LED and passive buzzer module to produce audible sound and visible light, allowing the users to have visual and auditory clues regarding where the object was positioned.

Signal Processing Module. This module consisted of showing available nearby tags, transmitting RSSI values for proximity, and out-of-range notifications. These features enabled users to determine which tag was emitting a signal, know the range based on received signal strength indicator (RSSI), and lastly to inform the user if they were going farther away, not closer.

Search It Tag. This module consisted of the hardware components that were integrated together to create a tag that could be controlled via mobile app; ESP32 C3 super-mini, passive buzzer module, LED light, LiPO battery, and TP4056 charging module.

However, despite the functionality and practical benefits offered by Search It, several limitations were present due to hardware capabilities and design scope. One key limitation was that the system did not support precise, exact pinpoint location tracking. Instead, it relied on proximity detection utilizing the RSSI, which only provided general distance feedback such as very near, near, far, or very far, including its signal strength besides, without indicating the exact location of the tag. This made the system dependent on the user's ability to interpret these proximity levels and locate items using the sound and light produced by the buzzer and LED. Another limitation was the manual nature of the pairing process. Users needed to manually turn on the Bluetooth on their devices and actively initiate the pairing within the app before they could interact with the tags. Additionally, the system allowed pairing and search actions with only one tag at a time, limiting its multitasking capability, and focused on locating one item at a time. Moreover, the Bluetooth signal range of the ESP32 C3 mini–based tags was limited to five (5) meters, depending on environmental factors such as walls or signal interference. The system was intended strictly for indoor use, such as within homes, offices, and classrooms, and was not suitable for outdoor or wide-area tracking. Also, the system was built as a single-user system, focusing solely on one user managing up to three tags. The system supported single-user operation only and allowed one-to-one tag connections, as each tag could pair with only one device at a time due to Bluetooth constraints. Lastly, the system was only compatible with devices that supported Bluetooth 4.0 and above, further narrowing its usability across older smartphones or tablets. Despite these limitations, Search It remained a practical and efficient solution for short-range indoor object tracking. By focusing on simplicity, accessibility, and real-time user feedback, the system successfully addressed the common problem of item misplacement through a reliable and cost-effective approach.

Conceptual Framework of the Study

Building upon the preceding concepts, theories, and findings from relevant literature, along with the presented studies and insights derived from them, a conceptual model is formulated, as illustrated below.

Figure 1 illustrates the conceptual model of the study, the input stage, the process stage, the output stage, and its impact. The input stage involves essential components such as knowledge, software, and hardware requirements. The process stage ensures that the system is built based on the target user. It starts with the requirement analysis, where researchers gather data to identify the problem. Once it is identified, this will involve designing the system from software to hardware components. After that, the development stage is where the actual creation of the system where components and the mobile application are carefully programmed. From there, System testing will be performed to test how each component works together and to ensure that the system works as intended. Afterward, it will undergo a system evaluation to assess feedback from the target users, which will also determine if the system is ready to be deployed or improvements are needed. The resulting output is an object locator that provides a reliable solution for locating misplaced belongings. It effectively reduces the searching time of the user as it provides real-time proximity feedback that guides the user quickly to the object. This also enables users to be independent when searching for misplaced objects, as the user will receive an immediate response through the buzzer and LED lights, making it more helpful, especially for those users who are alone at the moment**.**

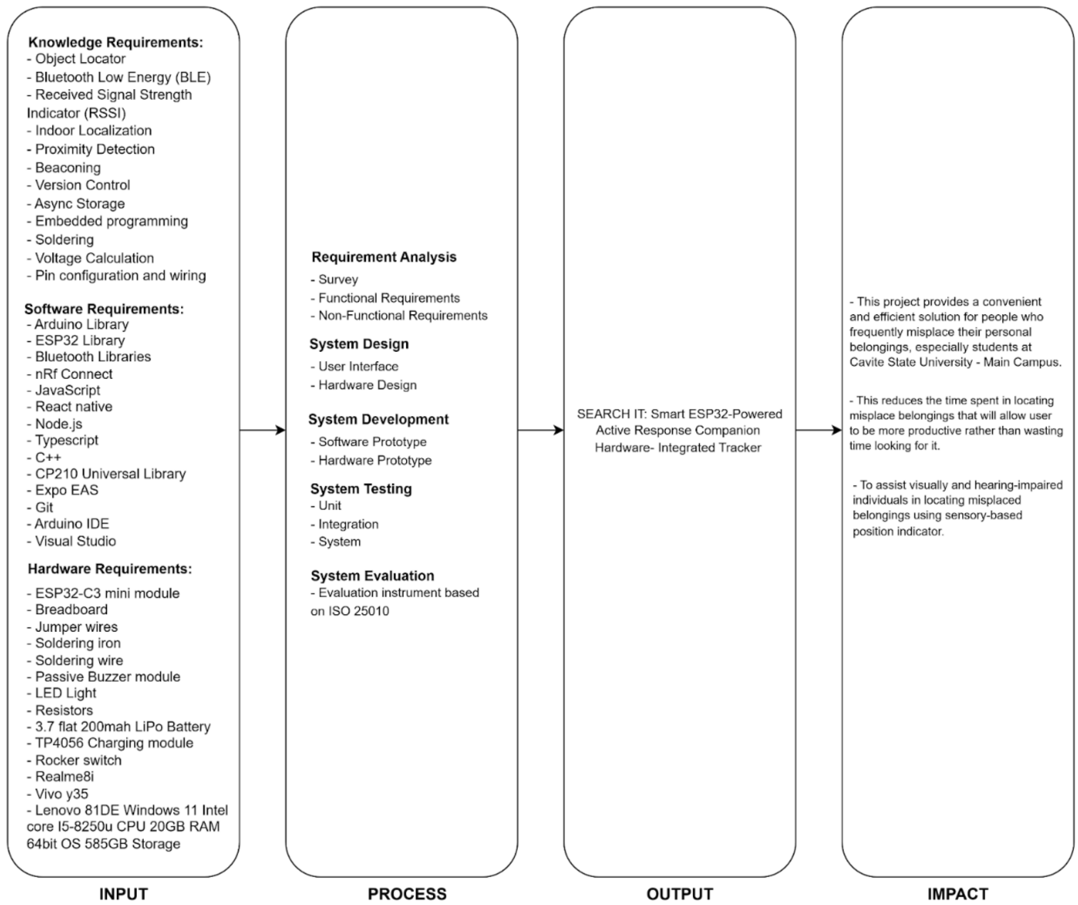


Figure 1**.** Conceptual framework of SEARCH IT: Smart ESP32-Powered Active Response Companion Hardware- Integrated Tracker.

Definition of terms

Buzzer refers to an electronic component which makes a beeping sound when the user presses the button in the app.

Proximity Detection allows the user to determine the location based on proximity whether near, far, weak, or strong signal.

Received Signal Strength Indicator (RSSI) allows the application and tag to communicate the distance between each other by transmitting the signal value

Search Actions features that consist of triggering the buzzer for audible sound and triggering LED for light.

Search It App is the software side of the project which acts as the remote to pair, and perform search actions upon the tag.

Search It tags is the hardware side of the project which consist of ESP32 C3-Super mini microcontroller dev kits with integrated LED light and passive buzzer module that are all enclosed on a casing.

REVIEW OF RELATED LITERATURE

System Technical Background

This section outlines the technical components and underlying technologies that power the system, providing a detailed overview of the hardware and software involved.

ESP32.The ESP32 microcontroller features a Hall effect sensor, capacitive touch sensors, digital to analog converters (ADCs and DACs), independent timers, Bluetooth Low Energy (BLE) connection, and Wi-Fi and Bluetooth capabilities (Cameron, 2023).

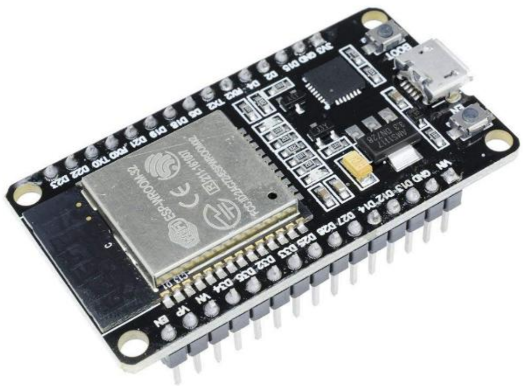


Figure 2. ESP32 Microcontroller

Bluetooth Low Energy. Bluetooth Low Energy (BLE), an emerging technology with remarkable low energy consumption and low-latency data transmissions, has acquired a lot of traction in a variety of application areas, including Wireless Personal Area Network (WPAN) communications, Indoor Positioning, and Home Automation. BLE is being used on both more potent gateway devices and resource-constrained sensor nodes thanks to its many innovative protocol stack characteristics. Since the release of Bluetooth 4.0, BLE beacons have been widely used for proximity detection, mainly because of their energy economy and simplicity of deployment (Yang, Poellabauer, Mitra, & Neubecker, 2023).

BLE Beacon. As stated by Cameron (2023), in order to trigger a response from the device, Bluetooth Low Energy (BLE) beacons send data to nearby smartphones, Android tablets, and other devices. To alert a user to a great offer from a nearby retailer, for instance, a beacon activates a mobile device. Instead of continuously transmitting information, BLE beacons do so in pulses. All that a BLE beacon does is send data; the information is then interpreted by a mobile app. Because of its BLE communication functionality, the ESP32 microcontroller can act as a BLE beacon or as a receiver of messages sent by BLE beacons.

Passive Buzzer Module. A passive buzzer is an electronic device that produces sound when an external electrical signal is applied. It is classified as passive because it lacks an internal oscillator and relies on an external source, such as a microcontroller, to generate the driving signal. The passive buzzer module integrates a passive buzzer with supporting circuitry to facilitate its use with microcontrollers like Arduino. Its operation is based on the piezoelectric effect, in which the application of an electrical signal causes a piezoelectric crystal inside the buzzer to vibrate at a defined frequency, thereby producing audible sound waves. The frequency of the sound corresponds directly to the frequency of the applied signal, allowing control over the pitch of the generated sound by adjusting the signal frequency (SunFounder, 2025).

Arduino IDE. Writing code and uploading it to the board is simple with the open-source Arduino Software (IDE). Any Arduino board can be utilized with this program (Arduino Team, 2024).

Arduino Boards. Arduino boards, as described by the Arduino Team (2024), can process various inputs such as light sensors, button presses, or social media posts, and transform them into outputs like activating an LED, publishing content, or controlling a motor. By programming the board's microcontroller, users can define how it responds to specific inputs.

Arduino ESP32 Board. The ESP32 family of low-cost, low-power microcontrollers has Bluetooth and Wi-Fi built right in. The ESP32 incorporates filters, power management modules, a low-noise receive amplifier, an antenna switch, an RF balun, and a power amplifier (PlatformIO Team, 2024).

Arduino Library. As mentioned by Arduino Team (2024), libraries can be used to expand the Arduino environment. Like the majority of programming platforms, libraries offer additional features for use in drawings, such as data manipulation and hardware interaction.

ESP32 Library. The ESP32 Libraries include a 2.4 GHz Wi-Fi and Bluetooth combination chip that uses low-power 40 nm technology from TSMC (Espressif Systems, 2020). With durability, versatility, and dependability across a broad range of applications and power circumstances, it is engineered to achieve optimal power and radio frequency performance.

Arduino Driver. Using Arduino IDE for the first time will require you to install specific drivers for you to be able to write and upload code to your USP Board. Having said that, your computer can communicate serially with microcontrollers such as the ESP32 or ESP8266 thanks to the CP210x USB chip, which converts a USB connection into a standard serial port. Installing the CP210x USB to UART Bridge Virtual COM Port drivers is necessary in order to program or exchange data with an ESP32/ESP8266 chip (Random Nerd Tutorials, 2024). CP210 Universal Driver for the device to function as a Virtual COM Port and enable host connection with CP210x products, the CP210x USB to UART Bridge Virtual COM Port (VCP) drivers are necessary. The direct access driver can also be utilized by these devices to establish a connection with a host. (Silicon Labs Team, 2024).

React-Native. Facebook created this framework so that native-style apps for iOS and Android may be made using JavaScript, a common language. Facebook first created React Native exclusively for iOS. However, the library can now render mobile user interfaces for both platforms because of its latest support for the Android operating system. (GeeksforGeeks, 2025).

React Native BLE PLX. is a broad library that makes the process of establishing and connecting BLE peripheral in react native applications simpler. This library provides a collection of APIs for scanning, connecting, and communicating with BLE devices. With the help of this library, developers can maximize the features of BLE on their applications. (Akashpoovaragavan, 2024)

JavaScript. is a programming language that enables you to add sophisticated features to websites (Mozilla Contributors, 2024). You can bet that JavaScript is used whenever a website does more than just show you static data. Examples include interactive maps, scrolling video jukeboxes, animated 2D/3D graphics, and timely content updates. It is the third layer of the typical web technologies layer cake, of which we have already discussed HTML and CSS in greater detail in other Learning Area sections.

TypeScript. This is a javascript with additional syntax, formats, and code structure. (W3Schools, 2025).

Node.js Instead of starting a new thread for each request, a Node.js application operates in a single process. Because Node.js libraries are typically designed using non-blocking paradigms, blocking behavior is the exception rather than the rule. Additionally, Node.js's standard library includes a set of asynchronous I/O primitives that prevent JavaScript code from blocking. Rather of pausing the thread and waste CPU cycles waiting for a response, Node.js will pick up where it left off after it completes an I/O activity, such as reading from the network, accessing a database, or accessing the filesystem.This eliminates the need to manage thread concurrency, which might be a major source of errors, and enables Node.js to manage thousands of concurrent connections with a single server. (Node.js, 2024).

C++. Numerous contemporary technologies, including game engines, web browsers, operating systems, financial systems, etc., are built on top of the *C++*

programming language. It was created by Bjarne Stroustrup as an addition to the C programming language. *C*++ offers improved memory and system resource management and is typically used to develop high-performance applications. *C*++ 23 is the most recent version, having been released in 2023. (GeeksforGeeks, 2025).

Expo's EAS. As per Expo (2024) by offering defaults that are suitable for Expo and React Native projects right out of the box and managing your app signing credentials for you (if you want), it makes developing your apps for distribution straightforward and simple to automate. Additionally, it offers first-rate support for the expo-updates library, thoroughly integrates with EAS Submit for app store submissions, and enables sharing builds with your team easier than ever with internal distribution (using ad hoc and/or enterprise "universal" provisioning).

Expo.dev. Is an open-source framework built with react native which makes developing cross-platform mobile applications easier using javascript or typescript. (Expo, 2025)

nRf Connect. A framework of cross-platform tools to support nRF device development. It has numerous applications for testing, tracking, measuring, optimizing, and programming your apps. made to work with our dongles and development kits (Nordic Semiconductor, 2024). The programs will upload the necessary firmware after determining the kit you linked to your PC. The documentation lists the kits that each program supports. This cross-platform tool for checking Bluetooth Low Energy compatibility is simple to use. It includes Bluetooth Low Energy security features, firmware uploads, and the automatic identification of connected development kits.

Visual Studio Code. The blazingly quick source code editor in Visual Studio Code is ideal for daily use. With features like syntax highlighting, bracket matching, auto indentation, box selection, snippets, and more, Visual Studio Code, which supports hundreds of languages, enables you to be productive right away. You can easily browse your code thanks to intuitive keyboard shortcuts, simple modification, and community-contributed keyboard shortcut mappings. Tools that understand more code than just text blocks are often beneficial for serious coding. Rich semantic code understanding and navigation, code refactoring, and IntelliSense code completion are all integrated into Visual Studio Code (Microsoft, 2024).

Git. According to GeeksforGeeks (2024), Git is a distributed version control system that facilitates the management of code changes across time. Every small modification or update you make is tracked, and you can always review earlier iterations or correct errors if necessary.

Github. Developers can store, organize, and track changes to their code with the aid of GitHub, a website and cloud-based service (Kinsta, 2023).

Jumper Wires. The Jumper Wire is a simple yet powerful instrument. It is essentially a flexible insulated wire with male or female connectors that are pre-crimped on both ends. Because these connectors are easy to insert into Arduino boards and breadboards (prototyping boards), soldering is no longer necessary (Ampheo, 2024). Jumper wires come in a variety of colors and lengths. Though colors typically show voltage levels or just aid in circuit visualization and troubleshooting, 20cm (8 inches) and 40cm (16 inches) are the most commonly used lengths. They are the suggested choice for connecting various sensors, modules, and actuators to your Arduino board, and they are also utilized for Arduino prototyping, which allows for rapid prototyping and experimentation.

Dupont Wires. Used to connect components on a breadboard or other prototype or test circuit, or to connect internally with other devices or components without soldering, a jumper wire (also known as a dupont wire) is a type of wire, or a group of wires, with a connector or pin at each end (sometimes without them – just "tinned"). Although they come in a range of colors, jumper wires don't actually indicate anything. The colors serve only as a reminder of what is related (ELEPCB, 2024).

Bread Board. For anyone experimenting and prototyping with electronics, whether they are novices learning the fundamentals or seasoned engineers evaluating circuit designs, breadboards are a necessary tool (Electricity Magnetism, 2024).

Despite their drawbacks, their adaptability, cost, and simplicity of usage make them essential for electronics prototyping. Understanding a breadboard's structure, selecting the appropriate type and size for your project, and accurately inserting and connecting components are all essential to using it efficiently.

Soldering Stand. Despite its simplicity, a soldering iron stand is a highly helpful tool for soldering operations. This stand prevents the hot iron tip from inadvertently injuring your hand or coming into contact with combustible objects (Saif, 2023).

Desoldering Pump. A mechanical tool known as a solder sucker is called a desoldering pump. A printed circuit board's solder can be removed with this tool. It comes in a handy design that includes an unlock button, a head, and a trigger. After removing the existing components from a PCB, desoldering is done to make the board responsive to any components that you wish to add (Absolute Electronics Services, 2020). Desoldering is a repair technique in which defective connections or components are taken out and swapped out for superior ones.

Soldering Iron. One portable tool for constructing or fixing electrical and electronic equipment is a soldering iron. Its heated metal tip melts solder over the components to be linked, forming a solid and reliable connection. Among other things, these instruments are frequently used for working on circuits, wiring, and electrical components (Castillo, 2023).

Related Literature

This chapter presents the relevant writings, studies, and works relevant to the topic. It aims to provide insight into the topic covered by the current study.

Locators. The evacuation system uses the Received Signal Strength Indicator (RSSI) of BLE broadcast collected from precisely placed receivers to track a person's location within a building. It also allows overseeing the movement of evacuees and may even allow implementing the ideal evacuation path based on barriers on the road. Knowing or tracking people's locations is critical so that people can safely exit a facility in the case of a fire, gas leak, or terrorist attack. This is especially true in large structures like factories and offices, where the speed and timing of evacuation are critical to people's safety and life. Nursing homes and medical care facilities, where inhabitants are generally elderly and handicapped, are one sector where such technologies are very useful (Janczak, Walendziuk, Sadowski, Zankiewicz, Konopko, & Idzkowski, 2022).

Based on the study of Vaccari, Coruzzolo, Lolli, and Sellitto (2024), The vast majority of the studies collected looked into IPS in offices, particularly in university offices. Second, industrial settings are another sort of environment that is regularly examined because they are where the majority of logistics activities occur. In contrast, fewer articles conducted testing in supermarkets or hospitals. Currently, the majority of testing is done in offices or university laboratories, which are excellent since there are less sources of interference. The proportion of papers that track each sort of actor, such as Automated Guided Vehicles, Micro aerial vehicles (MAV), Unmanned aerial vehicles (UAV), UAS, people, robots, or manual vehicles like forklifts or shopping carts. According to the responses, the most tracked actor is "Item", followed by "Person".

As reported by Yagi, Nishiyasu, Kawasaki, Matsuki, and Sato (2021), Various types of sensors, including wireless tags, Bluetooth, fixed cameras, and wearable cameras, have been investigated for use in systems that aid users in locating missing objects. Active and passive radio-frequency identification (RFID) tags are commonly used by attaching them to target objects. While RFID tags are useful in interior contexts, they cannot locate an object when removed outside of their search area.

The author introduces a wearable camera named GO-Finder. It is a registration-free, wearable camera-based technology that helps consumers find misplaced items. It permits identifying an arbitrary number of things based on two main concepts: hand-held Object identification and image-based candidate selection. The user study demonstrated that by utilizing GO-Finder, users may accurately locate missing items while reducing mental burden. Even though the items were registered automatically and without user participation, users were able to identify the target object using the image-based handheld object timeline. Going beyond tracking simply a few selected objects, GO-Finder might be utilized as a practical tool to assist in the recovery of numerous unexpectedly lost objects in everyday life.

As stated by Afyouni, Basalamah, and Tariq (2021), A majority of localization techniques are classified as active systems since they require tags/electronic devices carried by the person being monitored or mounted on objects in order to estimate their position. Intelligent navigation services are excellent instances of pervasive features that will make our homes and workplaces smarter. Recent technological improvements have contributed to the widespread availability of high-speed networks as well as smartphone infrastructure. Among several criteria, recent progress has been made in integrating pervasive computing technologies, such as crowd sensing, with indoor positioning systems. This is especially relevant for apps that help humans do a range of tasks in unfamiliar settings (e.g., airports, malls, college buildings). Dynamic and real-time pathfinding, location-based notifications, and location analytics are all features that can be developed to improve our indoor navigation experience. Various alternatives to GPS data for indoor locating have recently been provided, including WiFi hotspots, Bluetooth, and inertial sensors, among others. The majority of indoor location tracking technologies are known as active systems as they need tracked users to actively participate.

The researchers Bloch and Pastell (2020), proposed a system to track animals in a barn environment. The tags, which were encased in plastic boxes and attached to cow collars with a Velcro belt on one side, determined acceleration and transmitted the results as advertising data (24-byte packets) over the BLE 4.2 protocol. The message transmitting frequency was 5 Hz. The tag messages were received by ten receiving stations, which were single-board computers equipped with Bluetooth antennas (Raspberry Pi 3 B+, Raspberry Pi Foundation, United Kingdom). The stations were packed in hermetic boxes with heat dissipation ribs and set on barn structures with a height of 3-5 meters. They were equally scattered throughout the barn to minimize the maximum distance between tags. The stations logged RSS, tag accelerations, and receiving time. The data was saved in the station's memory and delivered via a router-managed local network using a message queuing protocol (ZeroMQ, iMatix Corporation). A PC received messages from the microcontrollers and saved the raw data as CSV files. The data management programs for the stations were written in both C++ and C#.

A low-cost indoor localization system using BLE tags and receiving stations can monitor a cow's approximate location with an accuracy of 3.27 ± 2.11 m in a barn (10 × 40 m2). It can be utilized in a variety of barn applications, including identifying abnormally long walks during heating, detecting the milking robot queue, and tracking time spent indoors and on pasture.

Al-Maktary and Susanto (2025) discussed that no single tracking technology properly suits all hospital assets tracking requirements. The ideal approach is determined by parameters such as hospital size, asset mobility, operational budget, and deployment environment. RFID is ideal for maintaining hospital goods indoors, whereas GPS permits outdoor mobility tracking. NFC excels in secure, manual applications like patient identification. For healthcare systems with indoor and outdoor tracking needs, a hybrid solution is highly suggested. For instance, integrating BLE for internal equipment tracking. GPS for mobile assets, such as ambulances, provides reliable, scalable, and energy-efficient coverage. RFID can provide detailed indoor monitoring when BLE is not feasible due to interference or infrastructural limitations.

Bluetooth Low Energy (BLE). The implementation of BLE communication functionality is the most important aspect of the Bluetooth transmission system. BLE communication follows the same premise as traditional Bluetooth communication, where a Bluetooth master device utilizes a Bluetooth chip to enable devices to send and receive radio signals over short distances to locate a Bluetooth slave device. The ESP32 Bluetooth BLE communication technology is ideal for IoT devices and sensors because of its low power consumption. The ESP32 supports the entire BLE protocol stack, including the physical layer, link layer, host controller interface (HCI), and general attribute (GATT) protocol modules. The GAP module manages BLE communication tasks such as broadcasting, scanning, and connecting. GATT protocol defines data. BLE devices communicate via several mechanisms, including services, features, and descriptors. The ESP32's BLE library improves the process of developing BLE services, characteristics, and descriptors for developers. The ESP32 Bluetooth BLE communication module provides the features of low power consumption, rapid connection, and simple data transmission making it ideal for IoT applications, sensor data gathering, and remote control scenarios. The broad use of this technology supports the growth of the Internet of Things field (Tie, Chen, & Ma, 2024).

Chandrashekar, Vaishnavi, Neeharika, Suchitha, and Rohith (2025) proposed a Smart Building Management System that uses ESP32 to automate basic house tasks, improving energy efficiency and ease. These sensors automate functions including controlling street lights depending on ambient light, activating inside lights based on motion, opening doors automatically, and monitoring water levels with alarms. The system is powered by the ESP32 microcontroller, a low-power, high-performance processor with built-in Wi-Fi and Bluetooth modules. To enable automation and remote monitoring, the Smart Building Management System employs a variety of sensors (Ultrasonic Sensor LDR (Light Dependent Resistor), PIR (Passive Infrared) Motion Sensor, IR Sensor), actuators (Buzzer, LED light, Servo motor), a microcontroller, and software platforms. The system takes real-time data from sensors, interprets it with the ESP32 microcontroller, and automates actions using actuators. The ESP32 microcontroller, with over 30 GPIO pins, acts as the prototype's central controller. Figure 4 shows how additional components, like LEDs and a buzzer, are linked to digital pins to indicate output.

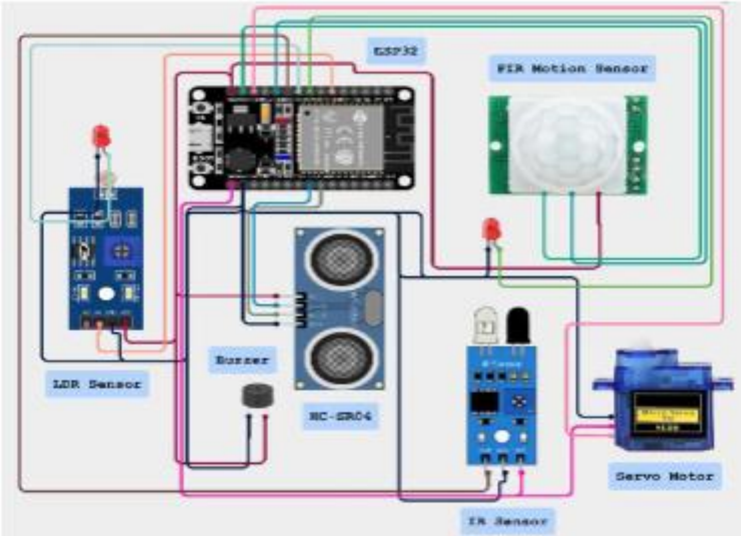


Figure 3. Circuit Diagram of Smart Building Management System (Chandrashekar, Vaishnavi, Neeharika, Suchitha, & Rohith, 2025).

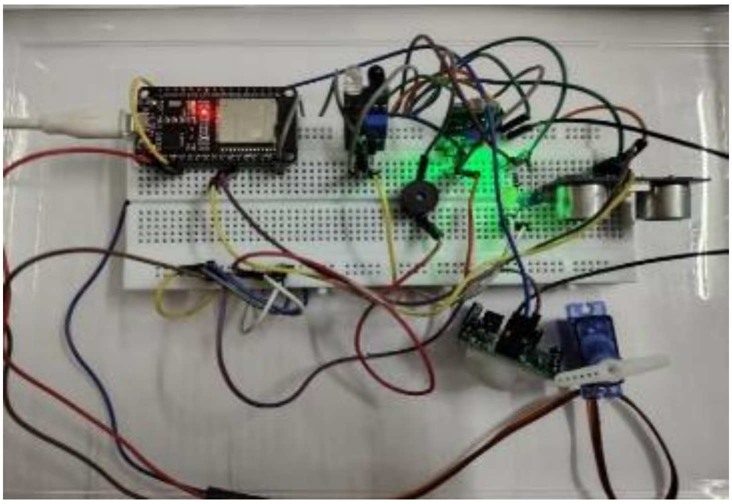


Figure 4. Sensor Integration Test Design (Chandrashekar, Vaishnavi, Neeharika, Suchitha, & Rohith, 2025).

As stated by Nguyen, Le, and Ha (2024) the development of fire and gas monitoring for indoor use allows users to remotely monitor the building's state through a user-friendly dashboard that displays data for all criteria on a single page. When a gathered parameter reaches a certain limit, the homeowner is notified by a buzzer, a red light, and a message sent to his or her mobile phone. Then he can immediately contact the authorities or firefighters, who will respond immediately. One key advantage of this approach is that it counts the number of persons at the fire scene. The IoT device's hardware consists of an ESP32 microcontroller connected to a

SIM900A communication module, a DHT11 temperature sensor, and a MQ2 gas sensor, all of which are readily available in the domestic market. The application software on smartphones enables users to continuously monitor the gas status and temperature in the kitchen. The verification studies reveal that the IoT gadget functions effectively, providing users with continuous information and timely warnings when the gas concentration and temperature in the kitchen surpass the defined limit.

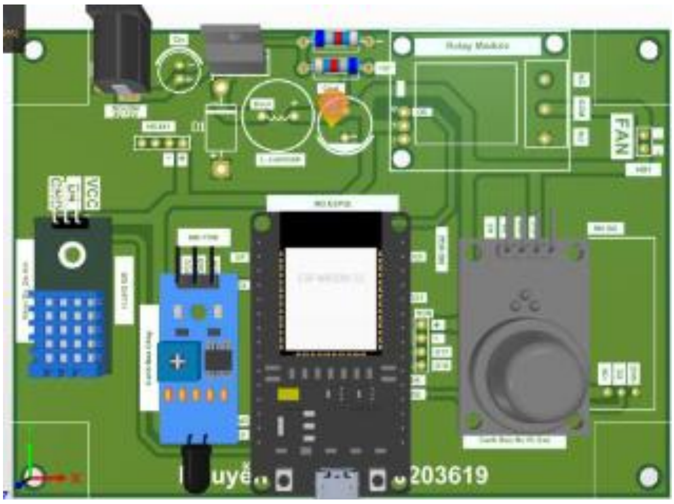


Figure 5. 3D Simulation of Design and Implementation of an IoT System for Indoor Measurement and Monitoring Fire and Gas Warning (Nguyen, Le, & Ha, 2024).

Another study conducted by Aizu and Othman (2021) uses a safe driving system to detect blind spots and drunk drivers. The project uses an ESP8266 microcontroller with alcohol sensor, ultrasonic sensors for distance measurement, LEDs, buzzer, and I2C LCD display. The system uses the Blynk IoT platform to monitor alcohol concentration, distances in the right, left, and rear directions, and a digital sensor state. Real-time data is sent to the Blynk smartphone app for remote monitoring. The LEDs and LCD display visual feedback and alerts for predefined thresholds and sensor conditions. The external serial data parsing technique allows for testing and integration with other devices.

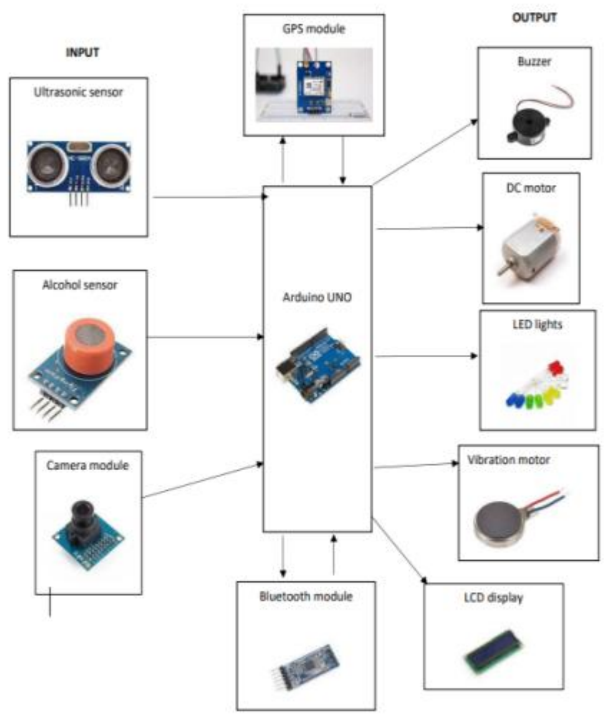


Figure 6. Diagram for the Safe Driving System with IoT (Aizu & Othman, 2021).

A further study investigated by Okpala, Chidiebube, and Emeka (2024), The door access control system which power supply circuit generates regulated voltage, which powers the Esp32-cam and electronic lock. PIR sensors at the entrance door detect infrared radiation from visitors and intruders within its range. It converts infrared input to output data for processing.The written program activates a security camera to take a photograph of someone standing at the entrance door. At the same time, the smartphone owner receives a snapshot notification of the visitor or intruder on their phone for identification purposes. The smartphone user, using a soft touch on the screen, performs the unlock and lock schedule without having to walk to the door. Following the error fixes, the proper power input and output were ensured. The active components were placed on the board sequentially and evaluated for activity and operation. None of the responsive ones were replaced, and the board was configured to receive the control software required for proper operation. The Telegram app was installed successfully on the smartphone. An interface was formed between the Esp32-

cam and the smartphone via WI-FI.The overall assessment revealed that the research met 98% of its proposition. Achieving 100% performance requires only minor adjustments to the test results.

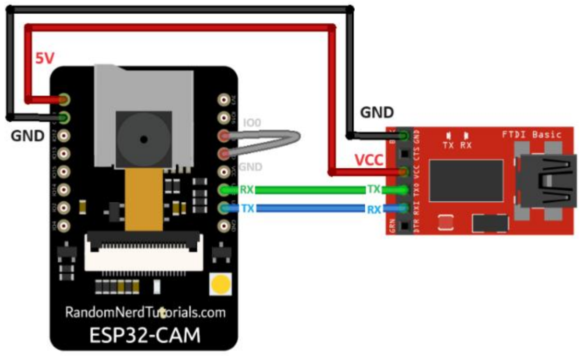


Figure 7. ESP32 Circuit Diagram of the Design and Development of a Cost-Effective Programmable Door Access Control System (Santos, 2025).

The work of Junhirun and Senson (2024) in conducting a testing of ESP32 indoors, uses existing wireless infrastructure, such as Wi-Fi or Bluetooth, to create a system for measuring the strength of signals from fixed reference points. Distances and the object's precise location are calculated using algorithms such as trilateration or fingerprinting. The code configures a WiFi access point (AP) and measures the reference RSSI (Received Signal Strength Indication) for calibration purposes. It then adds several distant ESP32 devices as peers and starts a communication link with them using ESP-NOW. The loop function continuously receives RSSI data from the AP and estimates distance based on signal strength, using calibration settings. It also receives distance data from faraway devices and assigns zones based on predetermined criteria, enabling proximity-based actions or notifications.

The results of testing the indoor localization system developed in a limited 2*3 matrix zone showed overall functionality with occasional failures. The system effectively detects zone transitions and updates the appropriate matrix representation in real time, accurately capturing movement within predefined zones. However, intermittent inconsistencies have been detected, which are primarily due to signal interference or variations in the indoor environment. Despite these occasional faults, the system's performance remains enough for the intended purpose in the limited space. Utilizing extensive calibration methods, we reached a reasonable degree of accuracy with RSSI measurements. Contributes to the advancement of the use of ESP32 in indoor localization solutions that use the RSSI approach.

Proximity Detection. As mentioned by He, Tan, Zhuo, Printz, and Chan (2022), Proximity detection is used to determine whether an IoT receiver is within 5 meters of a signal transmitter. If there is a "proximity" event, or "no proximity" In any case. Without human intervention, such choice allows for several proximity-based services (PBS), such as contact tracing, proximity marketing, and presence of logging check-ins and check-outs. Several signals have been examined for proximity detection, for instance, radio frequency (RF), ultrasound, and LiDAR. Bluetooth Low Energy (BLE) is the most promising technology because of its low cost, low power consumption, reliable coverage range (about 10 meters), and widespread availability in IoT devices. Traditionally, proximity is determined by measuring the received signal strength indicator (RSSI) and associating it with distance, with the assumption that a lower RSSI indicates a longer distance, and vice versa. However, the surroundings and receiver carriage status can significantly impact RSSI, resulting in signal fading, fluctuation, or attenuation. In addition, Flueratoru, Shubina, Niculescu, and Lohan (2022) says that estimating distance between devices can be helpful in finding missing objects, sharing files, enabling smart homes to respond to owner location, and responding to pandemics.

Zadgaonkar and Chandak (2023) discussed the use of BLE Beacons and Machine Learning in locating objects in a warehouse, wherein the proximity method aids in determining the target object's location in relation to a known object. The broadcasting beacon sends a signal to the smart object, and the beacon's location or the symbolic cell's identity offers the target location within the indoor premises. If the RSSI readings exceed the limit, the target object is tagged in the vicinity and designated as localized. Proximity clears indicate that an object is either nearby or close enough to the user.

The author concludes that a based object localization system for real-world industrial warehouse management applications. This innovation makes it simple to locate raw materials in warehouses, reducing order picking time from 11 minutes to 2.2 minutes. The position accuracy observed is less than 1.4 meters. Preliminary testing findings reveal that the proposed work is a low-cost, robust system with good location accuracy. The results reveal an average location error of 1.3 m and accuracy of 1.4 m, which is lower than most of the algorithms provided using a normal traditional propagation model and systems where only target beacons were used as raw data rather than neighborhood beacons. Moreover, the work of Mackey, Spachos, Song, and Plataniotis (2020) concludes that filtering techniques have the potential to significantly enhance proximity accuracy. The experimental results showed an improvement of up to 40% over the smoothed results, with proximity error ranges as low as 0.27 m when the beacon was within 3 m of the receiver. BLE beacons are a promising solution for PBS since they are inexpensive, simple to deploy, and have low energy requirements. The use of Bayesian filtering can enhance efficiency while incurring minimal overhead.

Received Signal Strength Indicator (RSSI)-based proximity monitoring is a well-known signaling method for determining indoor location. It is easy and cost-effective since it employs low-cost, off-the-shelf hardware. It represents the measured power of the received signal. RSSI values are measured in dBm, which stands for decibels milliwatt. It is represented in a negative form; higher RSSI values indicate a stronger signal, and vice versa (Philippopoulos, Koutrakis, Tsafaras, Papadopoulou, Sigalas, Tselikas, Ougiaroglou, & Vassilakis, 2025).

As stated by Janczak *et. al,* (2024), The signal from the found object normally does not contain information about its location; therefore, it is critical to determine the values that may be monitored and used to estimate the location of the object. The following are the most common applications of this property:

a. Monitoring the RSSI signal level. The distance from the transmitter can be calculated using signal propagation loss.
b. Analysis of the time differences between signal arrivals from a transmitter and multiple receivers (Time Difference of Arrival, TDoA). When the position of at least two receivers and the time difference of signal arrival are known, the object location can be calculated.
c. An examination of the angle of signal arrival (Angle of Arrival, AoA). It is utilized in UWB (Ultra-Wideband) location systems and is based on locating the signal source using the amplitude and amplitude-phase methods. The need to use longer antenna systems is certainly a downside of this strategy.
d. Using the Doppler method, which is the analysis of the received and transmitted signal frequencies, also known as FDoA (Frequency Difference of Arrival). This strategy is commonly utilized in open environments with moving items.
e. Hybrid approaches, such as Doppler shift and AoA, Doppler shift and RSSI, TDoA and AoA, ToA and RSSI, or AoA and RSSI, are used to locate objects. Data fusion is also a common method.

Among the alternatives discussed above, the RSSI approach combined with the Bluetooth technology known as BLE (Bluetooth Low Energy) is the most cost-effective and simple to implement. BLE technology is one of the most universal systems for transmitting information over short distances. It has a great application potential due to the widespread availability of electronic modules that support this standard, low energy consumption, and the ability to collect and process data using a smartphone (most of which have built-in BLE transceivers).

As discussed by Wilford, Pu, Zhou, Khalid, and Tahir (2022), the RSSI fingerprinting architecture, generally considered an upgraded version of the RSSI technique, takes into account both the preliminary offline calibration phase and the secondary localization online phase. The key distinction is that it focuses on pre-recording the Signal strength levels obtained from detectable RF transceivers such as Base Stations (BTS) (for GSM signals), Access Points (AP) (for Wi-Fi signals), and Frequency Modulation (FM). Fingerprinting requires significant time and effort to build an offline database, which relies on indoor dimensions to calibrate RPs and location candidates. Each RP fingerprint is an average of total RSSI samples received within a specific time window. This approach has problems that are not limited to environmental changes, such as demarcating the indoor area, which may modify the fingerprint connection to each location, requiring the update of the fingerprint database.

Giuliano, Cardarilli, Cesarini, Nunzio, Fallucchi, Fazzolari, Mazzenga, & Vizzarri (2020) evaluated an indoor localization system based on BLE in a museum environment, using RSSI to estimate the position of visitors' devices and delivering signals to BLE receivers strategically placed throughout the museum. Using a feed-forward neural network and a nonlinear least squares algorithm, the results demonstrated an accuracy of less than 1 m. However, there was no quantification of position prediction performance, and the pilot site is limited to a single room and not associated with a specific institution. On the other hand, Spachos and Plataniotis (2020) examined the positioning of BLE beacons in an IoT-based interactive smart museum. Kalman filters applied on the visitor's smartphone were utilized to improve RSSI accuracy without the use of the cloud. Experimental results showed that the placement and density of BLE beacons determine detection accuracy. However, all experiments were carried out in a laboratory setup.

RSSI-based positioning accuracy can be greatly impacted by environmental factors such as shadowing, multipath fading, non-line of sight, time changing, and interference from nearby devices. To address variability and inconsistency in RSSI-based indoor positioning systems, many algorithms have been developed. Machine learning techniques such as ANN, KNN, and DNN algorithms have been proposed

(Ainul, Wibowo, Djuwari, & Siswanto, 2021). Machine learning (ML) has been extensively used to overcome the inherent complexity of BLE/RSSI-based indoor localization, as well as the limitations of classical filtering techniques. ML models are largely dependent on the quality and diversity of training data, which limits generalization across contexts. This effectively means that data collection and model training must be performed with each new room arrangement and museum architecture. Furthermore, ML algorithms frequently require large, labeled datasets for training, which can be time-consuming and expensive to collect/process, and their real-time application in IoT, or resource-constrained situations, might be difficult due to high computing demands (Philippopoulos *et.al,* 2025)

Indoor Positioning. Due to the fact that Global Positioning System (GPS) technology has disadvantages in enclosed settings, indoor localization solutions are becoming increasingly important. While GPS is still commonly used for navigation, its accuracy is greatly degraded indoors or in closed locations. Given the increasing societal and technological demand for precise localization and movement tracking in such contexts, the development of indoor positioning systems (IPSs) has emerged as a significant research topic. Among various technologies, Bluetooth Low Energy (BLE) beacons have emerged as one of the most promising solutions for indoor location applications (Skypalova, Boros, Lovecek, and Vel'as, 2025).

Indoor positioning systems are a collection of hardware and software solutions used to wirelessly determine the location of people or objects within buildings. A variety of technologies can be used to monitor and track the location and movement of persons and entities. Satellite, magnetic, inertial, acoustic, optical, radio frequency (Wi-Fi, Bluetooth Low Energy technology, radio frequency identification, and ultra-wideband), and visual sensors are available depending on the operating principle.

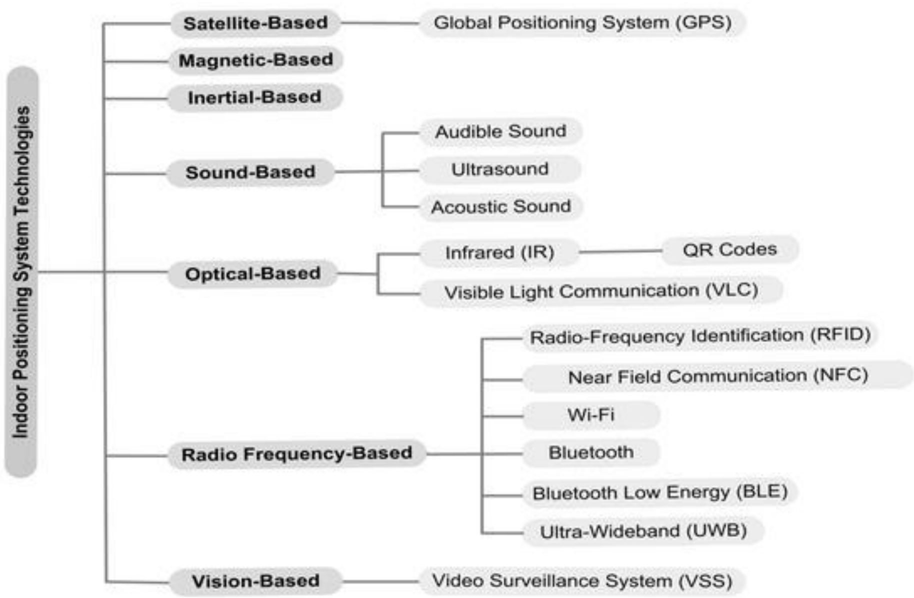


Figure 8. Technologies for Indoor Positioning (Skypalova, Boros, Lovecek, and Vel'as, 2025).

The majority of the localization methods listed above can be used both indoors and outdoors. GPS technology can be used in outside areas where there is a signal. Indoor use is limited due to signal obstruction through building structures. Ultrasound, RFID, and NFC systems can be used primarily inside. GPS, IR, VLC, RFID, Wi-Fi, Bluetooth, BLE, UWB, and a VSS are examples of technologies that enable real-time item and person tracking. Some technologies only allow transmitting and receiving devices to communicate within a certain range. Short-range technologies include ultrasonic systems, infrared, near-field communication (NFC), and QR codes. The size of a QR code determines its range. The larger the QR code, the more the reading gadget can scan it from a distance. RFID technology, like Wi-Fi and VSS, enables devices to receive broadcast signals as far as 50 m. At high frequencies, the propagation slope is higher, implying that signal destruction occurs faster as distance increases. This indicates that technologies with a steeper propagation slope may be more susceptible to impediments and distance. Bluetooth, UWB, and BLE technology have shorter communication ranges than Wi-Fi and VSS. However, a communication range of about 20-40 m is enough for monitoring and tracking the movement of individuals and entities inside. Tracking refers to the ability of technology to determine its position in space. RFID, NFC, Wi-Fi, and QR code location technologies only provide information on an entity's presence or absence in a particular space. Monitoring is achievable based on information about an entity's presence time in a specific space.

Bluetooth-based indoor positioning is a system based on RSSI that employs Bluetooth low energy (BLE) technology. As a result, this positioning technology offers the advantage of being low-cost and easy to use. Bluetooth positioning technology is based on sensing signal strength to locate, with low power consumption and a short range. This locating method requires Bluetooth LAN access points indoors. The most significant advantage of a Bluetooth-based indoor positioning system is the ease of interaction with mobile devices. As long as the mobile terminals enable Bluetooth capability, the positioning system can determine their location (Xu, Miao, & Zheng, 2021).

To compute the positioning accuracy of the tested terminal, Bluetooth and WIFI are utilized as test APs for signal transmission, and an electronic map is employed to depict the terminal's location. At the moment, the tested terminals are mostly mobile phones that are commonly used.

a. Creation of a Wi-Fi-based indoor positioning performance testing program. The test program can detect the positioning accuracy and response time of a Wi-Fi-based indoor positioning system based on IoT intelligent communication terminals, as well as perform statistics and analysis of the positioning results, enabling the automatic detection function to be realized.
b. Creation of a Bluetooth-based indoor positioning performance test program. The test program can detect the positioning accuracy and response time of a Bluetooth-based indoor positioning system based on IoT intelligent communication terminals, as well as perform statistics and analysis of the positioning results, allowing for automatic detection.

c. Wi-Fi and Bluetooth test programs are being used to develop indoor integrated positioning. The test program measures the accuracy and response time of indoor integrated positioning using Wi-Fi and Bluetooth, analyzes the results, and implements automatic detection. Additionally, the test results show that integrated positioning and single positioning can be compared and investigated.

The increasing interest in IPS arises from their ability to provide significant benefits and enable a wide range of application cases. In industrial intralogistics, for example, IPS can track goods and operators, allowing businesses to make informed decisions based on real-time data. Businesses, for example, can optimize their processes, detect bottlenecks, and increase overall efficiency by visualizing flows. Furthermore, the location data generated from these systems can be utilized to establish ideal routes, ensuring that intralogistics operations run on schedule and within budget (Vacarri *et. al*, 2024).

Spachos *et al*. (2020) presented an indoor positioning system that uses the proximity and localization features of BLE beacons to improve the user experience in museums by automatically supplying cultural content relevant to artifact observation. On the other side, Safwat, Shaaban, and Al-Tabbakh (2023) employed KNN and WKNN to match collected RSSI readings with the RSSI of an unknown place to estimate the user's location, achieving low localization errors even in the presence of obstructions, reflections, and interference. Alternatively, Wu, Guo, Han, and Baris (2024) addressed the problem of high Bluetooth signal fluctuation and significant localization error during indoor navigation by using the Kalman filter (KF) to reduce the effect of random perturbations on the true Bluetooth signal, using the maximum likelihood method to infer the pedestrian's posi tional coordinates, and using multiple beacon nodes to improve the localization accuracy.

Agile System Development Life Cycle. It is a flexible and iterative approach to software development that encourages continuous collaboration, rapid delivery, and change adaptability. This model improves client satisfaction by providing regular delivery and the capacity to respond rapidly to changing needs. Agile SDLC is ideal for dynamic projects where requirements are likely to change and early and frequent delivery of product increments are essential (Geeks For Geeks, 2024).

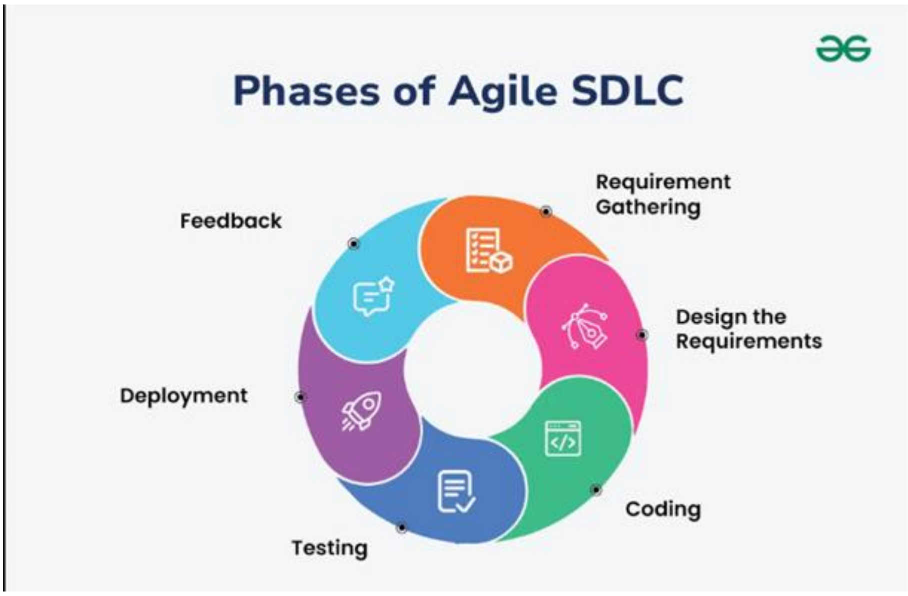


Figure 9. Phases of Agile SDLC (Geeks for Geeks, 2024)

Requirement. Collaboration with stakeholders occurs throughout requirement gathering to understand and prioritize project needs that are focused on that provide value. This step includes approaches for successful communication, such as user stories and workshops.

Design and Requirements. In design, the requirement step converts collected requirements into actionable tasks by breaking them down into smaller, more manageable portions. In this step, developers create visual representations of the solution, such as wireframes or prototypes, in order to get early input and assure alignment with stakeholder expectations.

Coding. During the coding phase, the development team builds the program in short, iterative cycles known as sprints. Each sprint aims to produce incremental, useful increments of the product. Developers build code, integrate it into the main source, and commit changes on a regular basis in order to find and address errors as soon as possible.

Testing. Each iteration includes testing to ensure that the software is of high quality and functional. Unit tests are created to validate individual components, whereas integration tests ensure that various pieces of the system work together as planned. User Acceptance Testing (UAT) entails end users testing the software in real-world scenarios to confirm that it satisfies their requirements.

Deployment. Deployment entails regularly and reliably releasing software increments to production. Automated deployment technologies simplify the process, allowing for rapid and consistent releases. Monitoring the deployment process and system performance assists in quickly identifying and resolving any difficulties.

Feedback. Continuous progress in Agile relies heavily on feedback. Stakeholders and end users contribute input through surveys, direct communication, and usage data. This feedback is used to modify requirements, prioritize improvements, and identify opportunities for enhancement.

Related Studies

This section presents an overview of previous research relevant to the study.

Design and Implementation of an RSSI-Based Bluetooth Low Energy Indoor Localization System. This study presents a low-complexity indoor localization system using BLE beacons and RSSI-based distance estimation. It employs a weighted k-Nearest Neighbors (k-NN) algorithm to determine object positions and utilizes the nRF52832 microcontroller known for its low power consumption. The system was tested in a furnished room and achieved an average localization error of 0.72 meters. Designed for energy efficiency, it can operate for over a year on a small coin battery, making it a practical solution for long-term indoor positioning applications.

A Low Cost Indoor Positioning System Using Bluetooth Low Energy. This study presents a BLE-based indoor positioning system developed for monitoring daily living patterns, particularly for individuals with dementia or disabilities. The system utilizes multiple sensors installed in different home locations to capture raw RSSI data from BLE beacons attached to users. Two methods—trilateration and fingerprinting—are proposed to determine indoor location and track users. Experiments conducted in various home environments demonstrate the system's ability to accurately track user locations and infer health statuses.

Bluetooth Low Energy based Indoor Positioning System using ESP32. This paper discusses the implementation of a BLE-based indoor positioning system using ESP32 microcontrollers. The system employs ESP32-Node Microcontroller Unit devices to create a network of Bluetooth devices for indoor navigation. By analyzing RSSI values from BLE beacons, the system triangulates the source to identify device positions within a building. The study highlights the feasibility of using low-cost ESP32 devices for accurate indoor positioning.

Design and Implementation of Indoor Positioning System using Bluetooth Low Energy. This research outlines an indoor positioning system, applying RSSI data and triangulation techniques for enhanced accuracy. Conducted in a one (1) to three (3) meter range, the system attained a mean positioning error approximately one (1) meter. The study emphasizes BLE’s superiority over RFID and Wi-Fi in indoor environments and demonstrates how it can be applied for precise, real-time tracking across smart spaces such as buildings and campuses.

Estimating Indoor Occupancy Through Low-Cost BLE Devices. This study introduces a low-cost, Bluetooth Low Energy (BLE)-based system for estimating indoor occupancy by analyzing variations in signal strength. The method relies on Received Signal Strength Indicator (RSSI) fluctuations from multiple BLE devices to infer the presence and number of people within a given environment. The system does not require expensive infrastructure and is designed to be energy-efficient, leveraging the inherent low-power characteristics of BLE communication. Experimental results demonstrate that the solution accurately detects occupancy levels, showcasing its viability for real-time, cost-effective monitoring in smart buildings and indoor environments.

Table 1. Comparison and Contrast of Related Studies.

TITLE OF RELATED STUDIES	FEATURES	METHODOLOGY	SOFTWARE	FINDINGS AND RESULTS OF THE STUDY
Design and Implementation of an RSSI-Based Bluetooth Low Energy Indoor Localization System (Cortesi, Dreher, & Magno, 2023)	BLE beacons, RSSI, k-NN algorithm, low-power microcontroller (nRF52832)	Experimental setup using k-NN for indoor positioning in a 7.2×7.2 m environment	Custom firmware on nRF52832	Achieved a mean error of 0.72 meters and long battery life, making it ideal for continuous indoor localization.

Table 1. Continuation

A Low Cost Indoor Positioning System Using Bluetooth Low Energy (Bai, Ciravegna, & Bond, 2020)	BLE tags, RSSI data from sensors, real-time location tracking	Experimental analysis using trilateration and fingerprinting in home-like environments	Custom software for data logging and analysis	Accurately tracked user location; effective in monitoring people with disabilities or dementia in indoor settings
Bluetooth Low Energy Based Indoor Positioning System Using ESP32(Sophia et al., 2021)	ESP32 Microcontroller Unit, BLE, RSSI triangulation	Experimental BLE positioning using NodeMCU ESP32	Arduino IDE and ESP32 BLE libraries	Showed effective low-cost BLE tracking with stable indoor positioning capabilities.
Design and Implementation of Indoor Positioning System using Bluetooth Low Energy (Hu et al., 2020)	Bluetooth 5.0, RSSI	Accuracy evaluation within 1-3 meters indoor range using RSSI-based localization	BLE-compatible software stack	Achieved 1 meter average localization error; showed BLE's superiority over Wi-Fi and RFID for indoor systems.

Table 1. Continuation

Estimating Indoor Occupancy Through Low-Cost BLE Devices (Demrozi et al., 2021)	BLE occupancy tracking	RSSI variation analysis for presence detection	RSSI-based occupancy analysis framework	Achieved 97.97% accuracy in estimating occupancy using BLE signal strength variations

Synthesis

Different studies explore distinct advancements in technology; it demonstrates the effectiveness of Bluetooth Low Energy (BLE) technology in addressing indoor positioning challenges through affordable and scalable solutions. Despite varying hardware platforms and algorithmic approaches, these studies collectively emphasize the role of BLE and RSSI-based methods in real-time object and user localization.

The study *"Design and Implementation of an RSSI-Based Bluetooth Low Energy Indoor Localization System"* uses a weighted k-Nearest Neighbors algorithm and low-power BLE modules (nRF52832) to achieve high localization accuracy in indoor environments, with minimal power consumption suitable for extended deployment. Meanwhile, *"A Low Cost Indoor Positioning System Using Bluetooth Low Energy"* focuses on user tracking in home settings, especially for healthcare applications involving dementia or disability monitoring, using trilateration and fingerprinting methods. Lastly, *"Bluetooth Low Energy Based Indoor Positioning System Using ESP32"* showcases a cost-effective approach using ESP32 microcontrollers to triangulate object positions indoors, making it viable for widespread IoT applications. *"Design and Implementation of Indoor PositioningSystem using*

Bluetooth Low Energy" demonstrates the use of Bluetooth 5.0 and RSSI triangulation to achieve a one (1) meter average positioning error. Conducted within a one (1) to three (3) meter range testbed, the study emphasized BLE's improved accuracy and scalability over RFIP and Wi-Fi, reinforcing its utility for precise indoor tracking in smart environments. *"Estimating Indoor Occupancy Through Low-Cost BLE Devices"* expanded the application of BLE by using signal strength variation (RSSI) to infer real-time occupancy levels without compromising privacy or requiring complex infrastructure. This approach achieved nearly 98% accuracy, underscoring BLE's utility not only for localization but also for environmental sensing and smart building management.

In conclusion, these studies underline the growing relevance of BLE in creating low-cost, accurate, and energy-efficient indoor positioning systems. Each approach provides unique insights into algorithm design, hardware integration, and application focus—from smart health monitoring to scalable smart infrastructure.

METHODOLOGY

This chapter outlines the methodological approach used in the study, describing the key processes undertaken from data collection to development, testing, and evaluation.

Requirement Analysis

This section explains the requirement process which involves identifying functional and non-functional requirements to develop a system that meets the user needs.

The initial phase of the study involved obtaining an approved letter from the dean to permit the researchers to conduct the study. The study surveyed fifty (50) students using random sampling from the College of Engineering and Information Technology (CEIT) at Cavite State University – Indang. To gather the necessary data, researchers used a survey questionnaire consisting of twenty-five (25) well-structured questions. This method provides participant's insights, habits, and challenges related to misplacement.

At that time, there were no technical solutions to address the misplacement of belongings, particularly in an indoor environment. The lack of a system led to a manual search or re-tracking of places to check whether they have left it. The situation leads to several problems, such as frequently misplaced belongings in an indoor step-up, excessive time spent in locating objects that affects productivity or the ability to complete a scheduled task, and users frequently relying on others for assistance in finding misplaced belongings, which affected the independence.

Figure 10 shows that the user would first add object details (object name, description, PIN, assign tag) and the app would return tag key–value counts. The confirmed object details were stored in key–value storage, and the tags were also assigned to the registered objects. After that process, the tag would then show its RSSI, and the user would be able to determine the proximity of 3 tags based on its

RSSI. Next, the user would choose their desired tag/object to pair with. Once they initialized pairing, the tag would then exit its deep sleep mode and would show and advertise its device name, which would be seen on the user's device and would be available to them. Then the user would use GAP connect (Generic Access Profile) to initialize pairing with the ESP32, and once connected, the user device queried GATT services from the ESP32, and the ESP32 responded with GATT attributes (services, characteristics, descriptors). After being paired successfully, the light and buzzer actions were now displayed, allowing the user to choose which one they wanted to trigger. Either of the two operations would both start with the triggering on the client side, and the app would then use the BLE write command custom characteristics to activate the pins of the desired search operations. Both also returned proximity either sound proximity or visual proximity.

Considering these difficulties, the SEARCH IT: Smart ESP32-Powered Active Response Companion Hardware–Integrated Tracker was proposed as a practical solution. The system was an integrated BLE technology that emitted a signal that could be detected by the mobile phone. When the user triggered the button via mobile phone, it made an audible alert and flashed a light to easily track down the misplaced belongings. In such a way, the system reduced the time spent searching while minimizing the need for assistance from others.

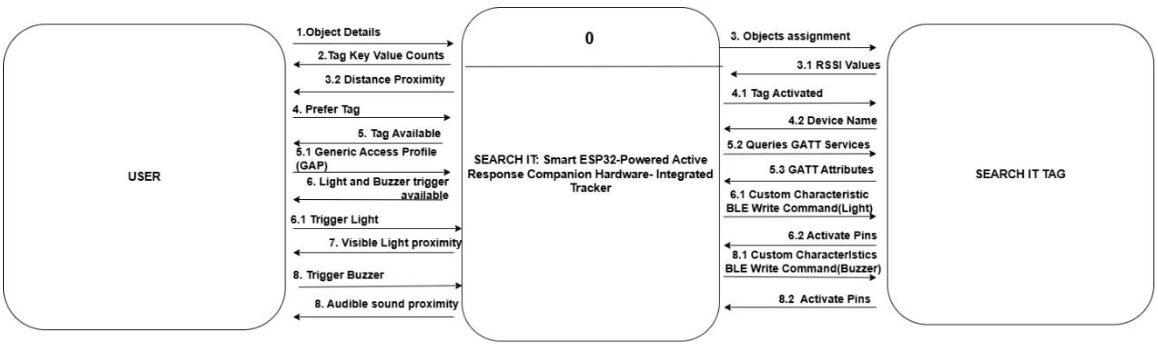


Figure 10. Context diagram of SEARCH IT: Smart ESP32-Powered Active Response Companion Hardware - Integrated Tracker.

Figure 11 shows a Bluetooth-based wireless control system where a mobile phone communicated with an MCU (Microcontroller Unit) via Bluetooth to control output devices like a buzzer and an LED. The mobile phone served as the transmitter, sending control commands through a mobile app or terminal over Bluetooth. The Bluetooth module, which typically included both transmission (TX) and reception (RX) capabilities in one unit (e.g., HC-05 or ESP32), received these commands and forwarded them to the MCU using the Universal Asynchronous Receiver/Transmitter (UART) protocol. The MCU, which could be an ESP32, Arduino, or STM32, processed and parsed the received commands, then determined which output device to activate. Depending on the command—such as "BEEP" for the buzzer or ON/OFF for the LED—the MCU triggered the corresponding output.

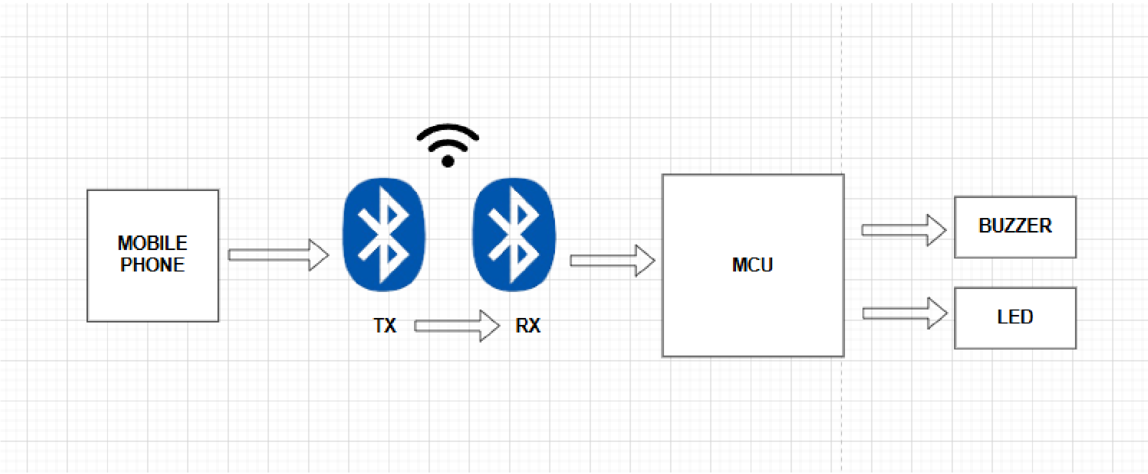


Figure 11. Block diagram of SEARCH IT: Smart ESP32-Powered Active Response Companion Hardware – Integrated Tracker.

Figure 12 shows that the Search It tag consisted of TP4056, Passive buzzer, ESP32-C3 Supermini, 2 Pin Rockerswitch, 220 Ω resistors, and a flat 3.7 V, 200 mAh LiPo rechargeable battery components. The 3.7 V, 200 mAh LiPo battery fed its positive terminal to the B+ pin of the TP4056 charging module and its negative terminal to the B- pin, enabling safe charging and protection. The TP4056's regulated output was taken from OUT+ and OUT-, where OUT+ was routed through the two-pin rocker switch to serve as the system's switched supply line. When the rocker switch was engaged, the switched OUT+ line distributed power simultaneously to the 5V input pin of the ESP32-C3 Supermini and to the VCC pin of the passive buzzer. The OUT- line was tied directly to system ground and connected to the ESP32-C3 GND pin as well as the buzzer's GND terminal, forming a common reference. The GPIO pin 5 from the ESP32-C3 (as indicated by the yellow signal line in the schematic) interfaced with the buzzer's I/O pin, allowing PWM or digital control of acoustic output. Additionally, an indicator LED was driven from another GPIO of the ESP32-C3. The LED's anode was connected through a 220 Ω current-limiting resistor to the selected GPIO pin 4, while the LED's cathode returned to the common ground. This ensured proper current regulation and prevented over-driving the LED. Overall, the interconnections established a stable power domain managed by the TP4056 module while enabling the ESP32-C3 to control peripheral components through dedicated signal lines.

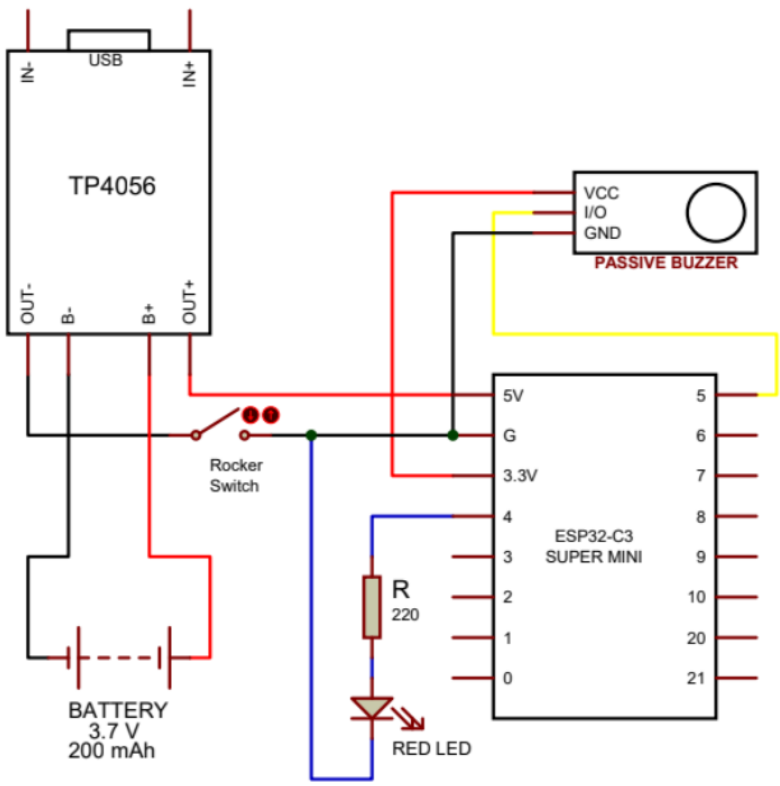


Figure 12. Schematic Diagram of SEARCH IT: Smart ESP32-Powered Active Response Companion Hardware – Integrated Tracker.

Figure 13 shows that the flowchart began with the process of initializing the tag management modules on the app right after it was installed and opened, and all happened at the backend. Then the specific module allowed and required the user to add objects and it was 3 iterations; once completed, it loaded the signal processing module, which allowed the application to show RSSI on the registered objects even when they were not yet paired. The user chose which object they wanted to pair with, and the user turned on the Bluetooth on their phone so once the pairing was initialized, it loaded the locator actions module which consisted of triggering the buzzer and LED light. The user chose which actions based on what they preferred and what they needed at that specific time. Either way, they could do both at the same time. Triggering a buzzer produced audible sound while triggering light produced visible light.

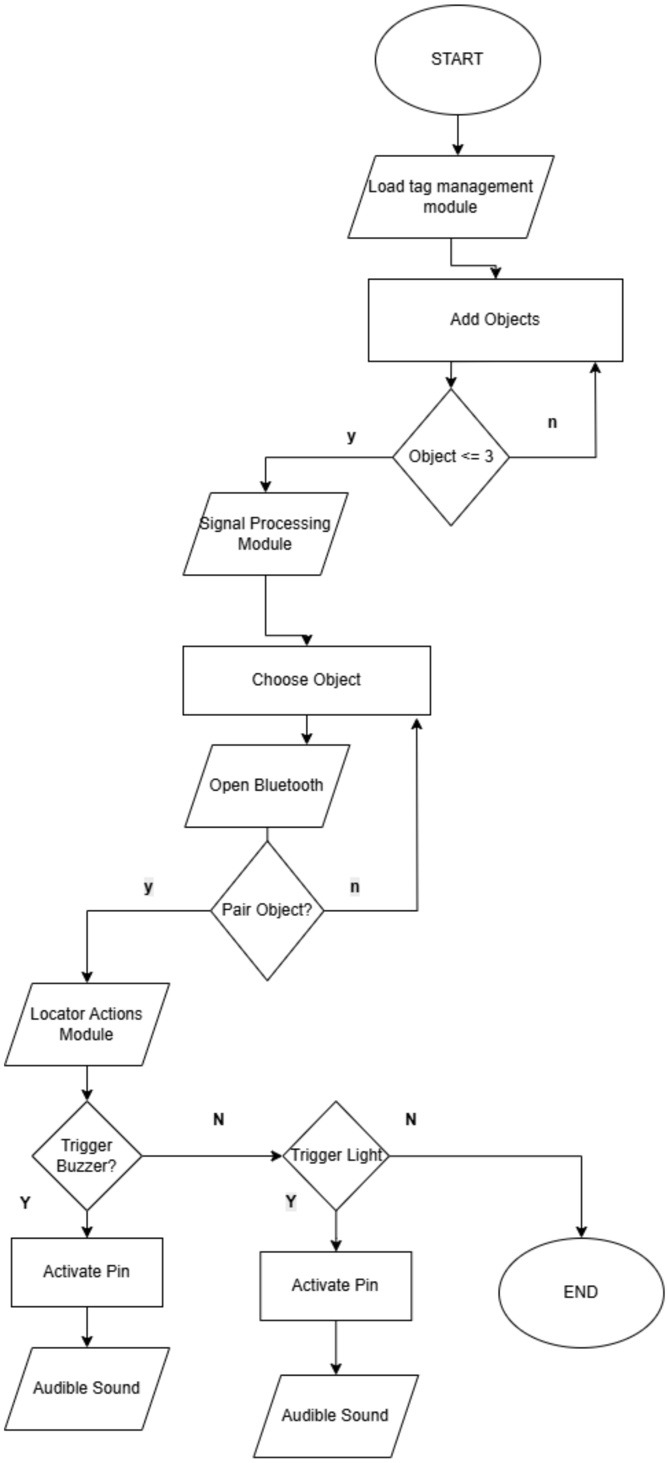


Figure 13. Flowchart of SEARCH IT: Smart ESP32 Powered Active Response Companion Hardware – Integrated Tracker.

Functional Requirement

This section describes the core features of Search It and how the system must perform to meet user requirements.

The Search It tag could be attached to personal belongings and allowed a custom label based on the object. The registered tags were controlled remotely by the Search app, which enabled users to pair and perform Search actions to assist users in finding misplaced belongings. By utilizing the BLE connectivity, it established a secure and stable connection between the app and the tag. The RSSI visual feedback was provided to determine the proximity of misplaced belongings, whether it was near, far, or weak. Since BLE had a limited range of up to five (5) meters, the user was notified when it went further than this to recognize that the user was moving farther away instead of getting closer. In addition, the system consumed less power as it only activated when the user triggered its search actions on the mobile app. Both the mobile app and Search It tags were compatible with Android operating systems to ensure accessibility for the user. Furthermore, the system was designed for single-user operation, where only one individual could use, manage, and control all registered tags and objects within the application.

Table 2. Functional requirements of the system.

MAIN FUNCTION(S)	DETAILED REQUIREMENTS / DESCRIPTION(S)
Tag Management Module	• The user was able to add a maximum of three (3) objects on the app. • The app allowed the user to rename or edit registered object details. • The app allowed removal or deletion of registered objects but required at least one (1) object on the list.

Table 2. Continuation.

	• The app required the user to include a pin on registering each specific object. • Every change on the object details was saved even if the application was restarted. • The assigned tags on each specific object had authentication for security. • The system operated under single-user mode, where only the individual managed all objects and tags within the application.
Locator Actions Module	• The app was able to trigger a passive buzzer module and emit audible sound. • The user was able to trigger the LED light using the app and produce visible light. • The user was able to trigger both the LED light and passive buzzer module at the same time.
Signal Processing Module	• Search It was able to display RSSI values of tags even if not paired. • The Search It app returned RSSI values after being paired, showing proximity. • The app had a disconnected modal or alert, allowing the users to be aware that they were no longer searching within five (5) meters or if they accidentally turned off their Bluetooth. • The app and the tag had a stable BLE connection as long as they were within range.

Table 2. Continuation.

Search It Tags	• Each tag should consist of ESP32 C3-Supermini, passive buzzer module, LED light, 3.7 200MAH LiPo battery, and a TP4056 charging port all integrated together. • Tags should be attachable around specific objects.

Non-Functional Requirement

This section describes how the system should behave when a specific action is performed.

The user interface had a simple design to easily navigate features like adding, renaming, and removing objects; pairing; and triggering the buzzer as well as the LED light. This also helped users who had no technical background or were elderly to simply use the Search It app. The app launched within two (2) seconds after the icon was tapped, and the user was able to easily operate the Search It app and use the Search It action to control the tags. The connection between the app and tags was stable without delay, allowing the visual feedback to be responsive based on the movement of the user. The buzzer and LED light worked once the user pressed the button. Each tag could be customized with a unique name and PIN for security. PIN input was required before performing actions such as pairing, renaming, removing, or changing the tag PIN to ensure that only the authorized user had access to the tag. In addition, the app displayed a notification out of bounds when the user was beyond a five (5) meter range. In terms of performance, it was noted that the user could register or rename an object in less than a second. The buzzer activated within one (1) to two (2) seconds, and an LED light blinked every zero point five (0.5) second once the button was pressed to ensure a proper user experience. The Bluetooth signal strength was stable for five (5) meters indoors and paired one Search It tag at a time. Aside from that, the tags entered a deep sleep when inactive to conserve power, and notifications out of bound alerted when the user's connection was lost beyond a reasonable range. To test the reliability, it was considered that the app saved registered tags in the Asynch storage module, which provided key-value storage for small data. The app also allowed users to perform search actions without any errors and provided a stable connection between the app and tags. Visual feedback returned accurate values to ensure the reliability of the system. Features like the buzzer and LED light functioned without any delay to help the user locate the misplaced object. The app provided a clear error message when disconnected from the tags and reconnected within three (3) to five (5) seconds. On top of that, tags consistently entered deep sleep mode without losing data or affecting the performance of the search. For compatibility, the layout of the app was responsive across different screen sizes and worked without the internet. In addition, the app worked exclusively for Android and supported Bluetooth version 4.0 or higher to adapt to modern smartphones. In terms of portability, the user could easily install and uninstall the app without error, and it ran smoothly on different platforms. In addition, the app used minimal battery power when in use. To maintain the lightweight nature of the system, the researcher used a small size for internal hardware without occupying too much space to maintain a discreet design.

Table 3. Non-functional requirements of the system.

MAIN FEATURES	DETAILED REQUIREMENTS / DESCRIPTION(S)
Usability	• The Search IT app had a simple UI and easy to follow workflow. Key features such as the adding, renaming, and removing of objects; triggering buzzer, and triggering LED light should be easy to follow and understand.

Table 3. Continuation.

	• The user easily operated the Search It app and used Search action to control the Search It tags. • Search It tag and app had stable connection to avoid delays or reconnection. • The app should showed notifications out of bounds when beyond five (5) meters to clearly guide the user. • The interface was structured for single-user access, ensuring that only one individual operated the system
Performance	• The Search It app allowed users to manage (add/rename/remove) the object locators in less than a second. • The app was able to locate misplaced belongings within four (4) minutes or less. • Bluetooth signal strength was stable within a reasonable range, ensuring that the user can trigger the search actions (buzzer and LED) from a distance of up to five (5) meters
Reliability	• The Search It tag saved registered tags correctly without losing data. • The Search It app allowed users to perform Search It action without any errors or interruption. • Single-user restriction ensured data consistency and prevented multi-user conflicts. • PIN-protected actions consistently blocked unauthorized access.

Table 3. Continuation.

Compatibility	• The Search It app displayed properly across different screen sizes without layout issues. • The Search It app was supported Bluetooth 4.0 or higher to ensure compatibility with modern smartphones. • The system was supported by Android devices.
Portability	• The app was designed to use minimal battery power. • The integration of ESP32, Buzzer, and LED was compact and lightweight. • The case that holds the internal hardware (ESP32 C3-Mini, buzzer, and LED) was discreet, maintaining the overall lightweight and non-bulky design.

System Design

This part discusses the overall structure of the system which involves how software and hardware should be properly designed to ensure all components work together.

After defining the purpose and requirements of the system, the researchers proceeded to design and employ the structure of the system. This stage focused on planning how the system would work and how its components would interact. It covered both the overall structure of the system and detailed steps needed for its process. The design phase included the development of the logical design, physical design, and user interface design to ensure that the system is well-organized and easy to use.

Figure 14 shows the first screen the users saw after installing the application.

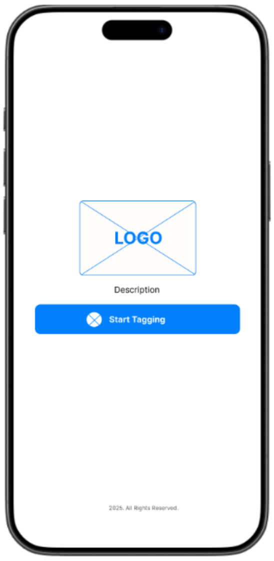


Figure 14. Initial Landing Wireframe.

Figure 15 displays the page that allowed the user to add the object. This allowed the user to add information about the object, assign tag, and assign PIN.

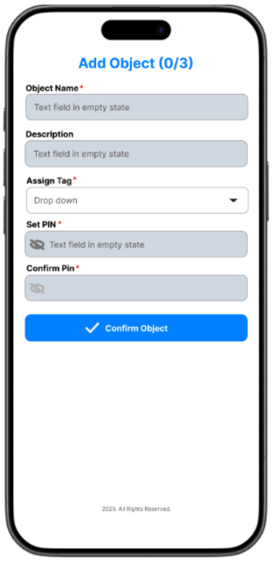


Figure 15. Add Object Wireframe.

Figure 16 presents the objects added by the user together with the instruction icon. On this page, users could add up to three (3) objects, edit the object's information, and view whether a tag was connected to the object or none. A pair button will appear if one object was selected.

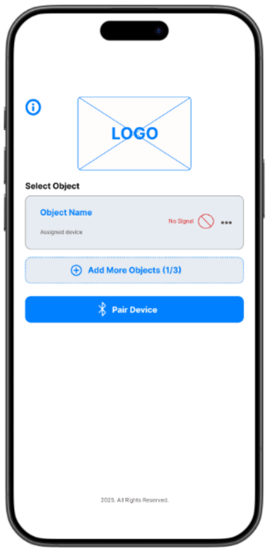


Figure 16. List of Added Objects Wireframe.

Figure 17 illustrates the enter PIN modal that appeared once the user clicked the Pair button. This modal required the user to input the PIN assigned during object creation to proceed with Bluetooth pairing.

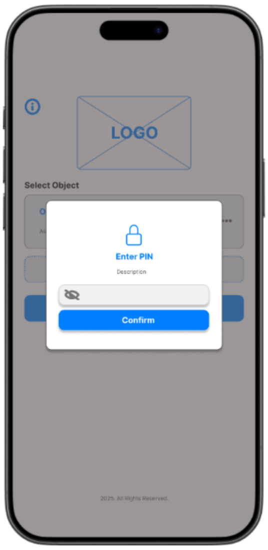


Figure 17. Enter PIN Wireframe.

Figure 18 shows the Incorrect PIN modal that appeared when the entered PIN did not match the assigned PIN. This protected access to the object connection process.

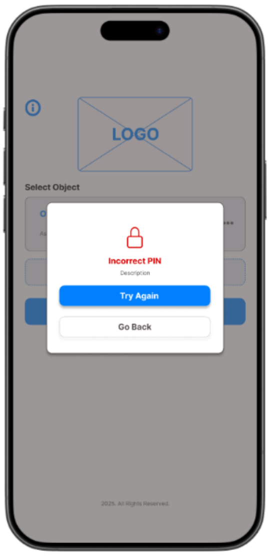


Figure 18. Incorrect PIN Wireframe

Figure 19 represents the scanning process. This modal appeared after the user entered the correct PIN, indication that the application was searching for available tags nearby.

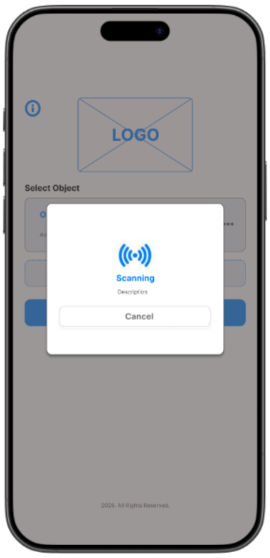


Figure 19. Scanning Wireframe.

Figure 20 displays the modal indicating that the application had successfully pared with the tag. This confirmed that both devices were connected and ready for use.

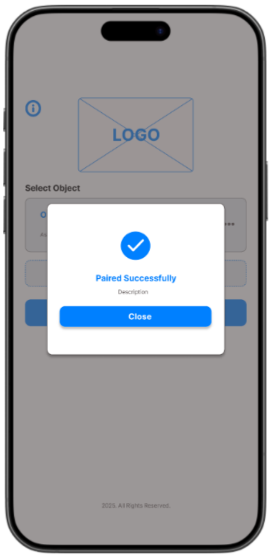


Figure 20. Paired Successfully Wireframe.

Figure 21 illustrates the object page. This screen showed the distance, RSSI value, and control buttons for the buzzer and LED. These features assisted users locating their tagged belongings.

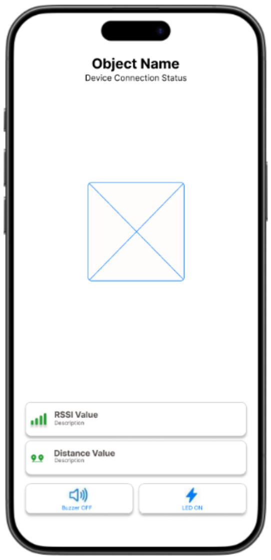


Figure 21. Object Page Wireframe.

Figure 22 shows the connection lost warning. This notification appeared when the tag disconnected from the phone due to distance or obstruction.

Figure 22. Connection Lost Warning Wireframe.

System Development

This section outlines the process of developing the system which includes planning, designing, coding, deployment, and feedback to deliver a reliable solution to the user.

The system development for the Search It followed the structured approach of Agile System development life cycle such as Requirement gathering, Design and Requirements, Coding, Testing, Deployment, and Feedback. After the requirement gathering where researchers identify the needs of users through the use of a survey. The system design included a wireframe of the system to visualize how it was built. Researchers proceeded with the development of the system, starting with a working version of the system. This puts all the basic features that showed that both the software and hardware were working properly. The ESP32 C3-mini microcontroller was programmed through Arduino IDE and C++, which involved initializing Bluetooth connection on the ESP32 and carrying out trigger actions in a buzzer and LED light when the signal was received through the Search It app. Along with that, React-Native, Node.js, TypeScript, and JavaScript were used to create the app. React Native BLE libraries allow communication between the software and hardware components; this sends commands through the app and then triggers the Search Actions using

Bluetooth, which also includes the RSSI feature to locate the proximity of the object. The Async Storage Module is a key-value storage that enables users to register and rename Search It tags without needing a database, since the data is saved in local phone storage. Platforms such as Expo.dev and an Android phone were used for testing. Next, this focused on the functionality and performance of the system. Features were examined to ensure that the system works properly based on the user's requirements. The system undergoes unit testing to ensure that every function works individually. Next was integration testing, to make sure that the software and hardware systems work as a whole. When everything worked as expected, the researchers proceed to system evaluation, including real-life situations, especially in the indoor step-up whether the app can send a signal to trigger both the buzzer and LED light to locate misplaced belongings. This also includes technical issues such as connectivity errors or lag between devices. In this step, user feedback was an essential part of ensuring that the system aligns with its project goal and serves its target user. The deployment phase was where the researchers released a working system for the user. For software deployment, applications were released exclusively for Android and include instructions on setting up for the user. In Hardware deployment, hardware components were integrated as one that is enclosed in a customized 3D print case to protect internal hardware. Lastly, the feedback collected became the basis for the researchers to adjust the functionality to ensure that the final product meets the target user. Both software and hardware were refined to improve the performance of the system. After making adjustments, it undergoes integration testing, user feedback, and refinement until the system meets user requirements.

System Testing

The Search It object locator system underwent rigorous testing to ensure its functionality, usability, and reliability. The test was designed to evaluate the system against predefined functional and non-functional requirements.

Usability Testing

The user interface was evaluated to ensure it has a simple user interface and was easy to navigate. Buttons such as “Add Object”, “Rename”, “Remove”, “Trigger Buzzer”, and “Trigger LED” were tested for clarity and ease of use. The applications layout was examined to confirm that it was user-friendly, especially for users with no technical background. The system’s feedback mechanisms such as modal popups and visual proximity indicators were assessed for clarity.

Performance Testing

The system’s performance was assessed under different indoor conditions to confirm its responsiveness and stability. The time between triggering the buzzer, LED light and the actual response was measured, targeting activation within one (1) to two (2) seconds. The stability of Bluetooth connectivity was evaluated within the five (5) meter range. The LED’s visibility was tested under normal indoor lighting conditions to ensure it can be seen from three (3) to five (5) meters, with blinking verified every 0.5 seconds intervals.

Reliability Testing

Reliability tests were focused on ensuring consistent system behavior over repeated use. Multiple connectivity trials were conducted to verify stable and reliable Bluetooth communication between the mobile application and each tag. The system’s ability to reconnect within three (3) to five (5) seconds after disconnection are tested. The reliability of proximity feedback, buzzer activation, and LED visibility was also validated during extended usage and repeated trigger to confirm dependable performance.

Compatibility Testing

The compatibility of the system was evaluated across a range of devices and platforms. The mobile application was tested on Android devices to ensure it functions smoothly on different operating systems. Furthermore, the application was capable of functioning without an internet connection, ensuring continuous usability in offline environments. Devices with Bluetooth 4.0 or higher are used to confirm proper compatibility.

Portability Testing

The physical components including the ESP32 C3-Mini, buzzer, and LED are compact and lightweight, ensuring it won't add unnecessary bulk when attached to personal belongings. These components were integrated into a discreet and space-efficient enclosure that supports ease of daily use without compromising its functionality.

System Evaluation

The Search IT system evaluation included several components to ensure thorough and formal assessment of its quality, effectiveness, and user satisfaction.

Signed Approval Letter

A signed approval letter from the Dean of the College of Engineering and Information Technology validated the study, ensured institutional support and recognized the relevance of the system in addressing common issues related to misplaced personal belongings.

Evaluation Framework

The evaluation followed the ISO 25010 Software Quality Model, focusing on the following attributes:

a. **Usability** evaluated how intuitive and user-friendly the system was for the intended users. The interface was evaluated based on its layout, simplicity, and ability to be understood and used by individuals regardless of their technical background. Key features such as object pairing, rename, and activation of buzzer and LED were examined for clarity and ease of use.

- **b. Performance** measured the system's responsiveness and efficiency. This includes the speed of tag activation, RSSI feedback, reconnection after being disconnected, and modal display, with the goal of achieving quick response time within one (1) to two (2) seconds and maintaining stable Bluetooth connectivity within the expected range of five (5) meters.
- **c. Reliability** focused on the system's ability to operate consistently over time. Evaluations included repeated tests on tag detection, accurate signal strength reporting, stable Bluetooth connection, and the ability to reconnect within three (3) to five (5) seconds after disconnection.
- **d. Compatibility** assessed the system's performance across multiple platforms and devices. The mobile applications were tested on Android systems and were verified for proper functioning with various Bluetooth 4.0 and above versions.
- **e. Portability** evaluated the ease of use and deployment in various settings. The hardware components (ESP32 C3-Mini, buzzer, and LED) were lightweight and compact, allowing them to be attached to personal items without adding bulk. The app was tested for efficient performance while consuming minimal battery.

Statistical Analysis

Statistical analysis was conducted to interpret the response gathered from the System Evaluation Questionnaire. The analysis focused on the computation of the mean, standard deviation, and percentage distribution, which served as the basis for determining the overall perception of the respondents toward the system.

The **mean** was used to obtain the average rating of the respondents on each item. This showed the general level of agreement regarding the system's functionality, reliability, usability, efficiency, portability, and accuracy. The

standard deviation measured the variability of the responses. A low standard deviation indicates that the ratings were closely aligned, while a high standard deviation showed that responses vary across users. The **percentage** was used to determine the proportional distribution of respondents, specifically the number of technical and non-technical evaluators who participated.

The researchers used a pointing system to acquire the level of agreement of the respondents on the questions in the survey questionnaire. The points to be used are:

Table 4. Options in Survey Questionnaire.

SCORE	INTERPRETATION
5	Excellent
4	Very Good
3	Good
2	Fair
1	Poor

The interpretations of the mean scores followed the Likert scale used in the evaluation:

Table 5. Likert scale

RANGE OF WEIGHTED MEAN	INTERPRETATION
4.51 – 5.00	Excellent
3.51 – 4.50	Very Good
2.51 – 3.50	Good
1.51 – 2.50	Fair
1.50 and below	Poor

These interpretations were used to classify how respondents evaluated the different system attributes.

On the other hand, the following statistical procedures were used to analyze the data to be gathered from the System Evaluation Questionnaire. The results of the statistical procedure determined the general perception of the respondents on the system.

Formulas for Statistical Analysis

Sample mean is the average score of the respondents on a given variable.

Formula:

$$\underline{x} = \frac{\sum_{i=1}^{n} X_i}{n}$$

Where:

$\underline{x}$ = mean

X_i = representation of each observation from respondents

n = total number of respondents

Sample standard deviation measures the spread or variability of the scores in the given variable.

Formula:

$$s = \sqrt{\frac{\sum_{i=1}^{n} (X_i - \bar{x})^2}{n-1}}$$

Where:

$\underline{x}$ = mean

X_i = representation of each observation from respondents

n = number of respondents

s = sample standard deviation

Percentage determined the frequency counts and percentage distribution of personal related variables of the respondents.

Phased Testing and Feedback Collection

Phased testing and feedback collection ensured the system's functionality and user satisfaction. The evaluation process followed a phased approach to testing and feedback. First, the hardware setup was conducted where the ESP32 C3-Mini, buzzers, and LED lights were configured to ensure they function properly. Once the hardware was ready, users received brief orientation sessions to help users understand how to use the mobile application. Specifically, on how to pair the tags, view proximity feedback, and activate the buzzer and LED features. After this, pilot testing was conducted in indoor settings like home, classrooms or study areas to simulate real use comments, and suggestions were gathered through feedback forms. This feedback was reviewed and analyzed to identify potential issues or areas for enhancement. Necessary adjustments were made to improve the system's overall performance and user experience before its full implementation.

System Implementation

The implementation of the Search It system at Cavite State University- Main Campus began with the deployment of both the hardware and software components. The hardware setup included the assembly and integration of the ESP32 C3-Mini, buzzer, and LED light into compact tag enclosures that were attached to personal belongings. The mobile application, developed to support Android platforms, was to establish a secure Bluetooth connection with each tag to enable proximity-based tracking and alert features.

Prior to full deployment, the researchers conducted a system demonstration to guide the students in its effective use, including device pairing, buzzer activation, and interpreting RSSI feedback. Pilot testing was conducted in controlled environments to evaluate system performance, and feedback was collected to refine the design and functionality.

After refining the system based on user feedback, full deployment proceeded. Users were provided with finalized hardware units and access to the mobile application.

RESULTS AND DISCUSSION

This chapter contains the interpretation of the data analysis or statistical method applied in the investigation. The subsequent information is presented in the respective tables and analyzed accordingly.

System Development

The development for the Search It followed the structured approach of Agile System development life cycle, such as Requirement gathering, Design and Requirements, Coding, Testing, Deployment, and Feedback.

The researchers identified the needs of the user through the use of a survey among fifty (50) students of CEIT in Cavite State University, Indang. The system design included a wireframe to visualize how the application will look; it was created using the Figma software application. Other software applications include Draw.io for creating diagrams (Figure 10 and 11), and the flow of the system (Figure 13).

The development of the system started with the working version, where all the basic features were integrated properly for testing. Regarding the software and hardware used for the system, this included the ESP32 C3-mini microcontroller that was programmed through the Arduino IDE and C++, which involved initializing the Bluetooth connection on the ESP32 and carrying out trigger actions in a buzzer and LED light when the signal was received through the Search It app. Along with that, React Native, Node.js, TypeScript, and JavaScript were used to create the app. React Native BLE libraries allowed communication between the software and hardware components; this sent commands through the app and then triggered the Search Actions using Bluetooth, which also included the RSSI feature to locate the proximity of the object. The Async Storage Module was a key-value storage that enabled users to register and rename Search It tags without needing a database, since the data was saved in local phone storage.

For the testing, the system underwent unit testing to ensure that every function worked individually (Appendix 4). Next was integration testing (Appendix 5), to make sure that the software and hardware systems worked as a whole. After everything worked as expected, the researchers proceeded to system evaluation, including real-life situations—especially in the indoor setup—to determine whether the app could send a signal to trigger both the buzzer and LED light to locate misplaced belongings. This also included technical issues such as connectivity errors or lag between devices. In addition, user feedback was an essential part of ensuring that the system aligned with its project goal and served its target user. Platforms such as Expo.dev and an Android phone were used for testing.

The deployment phase was where the researchers released a working system for the user. For software deployment, applications were released exclusively for Android and included instructions on setting up for the user. In hardware deployment, hardware components were integrated as one and were enclosed in a customized 3D-printed case to protect the internal hardware.

Lastly, the feedback that was collected was used as the basis for the researchers to adjust the functionality to ensure that the final product met the target user. Both software and hardware were refined to improve the performance of the system. After making adjustments, the system underwent integration testing, user feedback, and refinement until the system met user requirements.

System Overview

The Search IT: Smart ESP32-Powered Active Response Companion Hardware-Integrated Tracker aimed to reduce misplacement of personal belongings, shorten search times, and reduce dependence on others in locating misplaced items.

Figure 23 shows the mobile application's initial user interface that appeared after installation to ensure the user experience was not overwhelming and to clarify that this action was required before proceeding to the next steps. It had a simple interface with the logo, application name, and paragraph with a visible start tagging button.

Figure 23. Initial Landing Page.

Figure 24 shows the Add Object Page, which can be accessed in two ways: (1) when the application was freshly installed, where the user was allowed to add at least one object to begin using the application, and (2) when the user was on the Registered Objects Page, where they could add additional objects as long as the total did not exceed three (3) objects. This page contained a form with required fields such as the object name, description, a drop-down menu for selecting the tag to assign (e.g., Tag 1, Tag 2, Tag 3), and fields for setting and confirming a six-character PIN to ensure authorized use. These components helped organize the user's items and maintained secure and efficient tagging within the application.

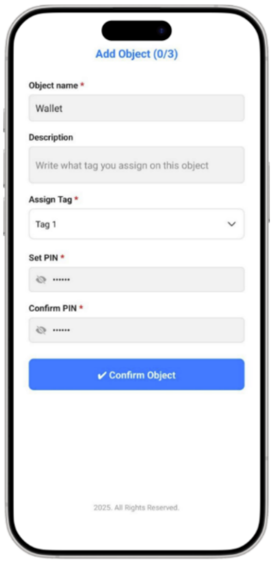


Figure 24. Add Object Page.

Figure 25 shows that after adding an object, the permission-required modal popped up. It asked the user for permission to use the application with Bluetooth and Location. Once the user clicked the Continue button, it proceeded. After the Proceed button, the grant-permission modal popped up. It displayed a text asking the user to allow the application to use Bluetooth and Location permissions. By clicking the Grant button, it proceeded to the next step.

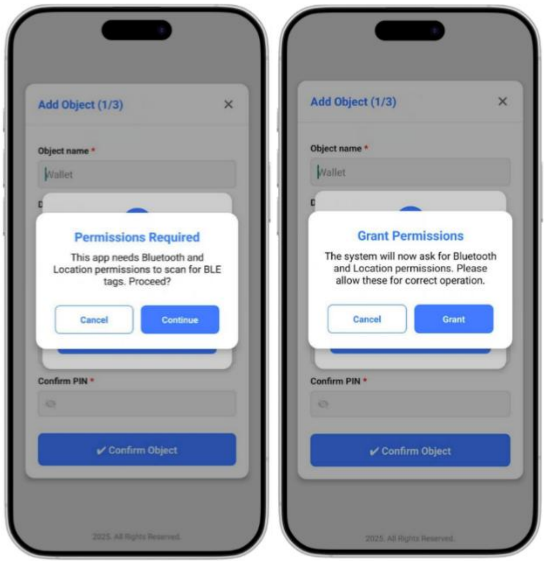


Figure 25. Permission Required and Grant Permission Modal.

Figure 26 shows that after granting the use of Bluetooth and Location, the allow location modal popped up. It allowed the user to pick whether to use the device's location while using the application, only this time, or to not allow. After allowing access to the device's location, the allow-connection modal popped up. It allowed the user to pick whether to allow the application to connect and find nearby devices the user wanted to connect to on the application.

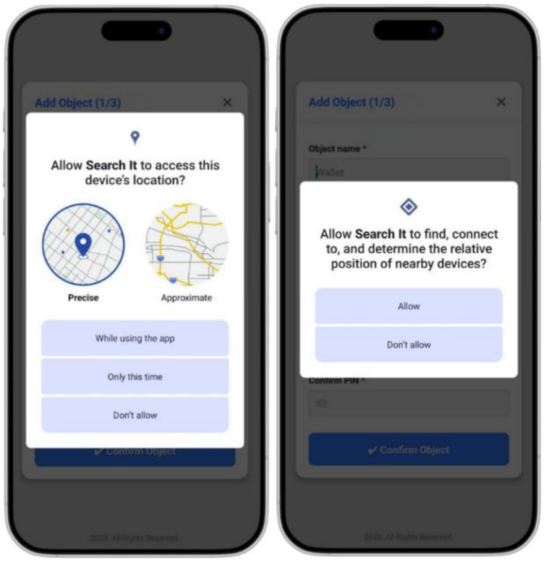


Figure 26. Allow Location and Connection Modal.

Figure 27 shows the Added Successfully Modal. Once an object was successfully added, this modal popped up to ensure the user that their progress was saved and that they could proceed to the next page of the application after clicking Close.

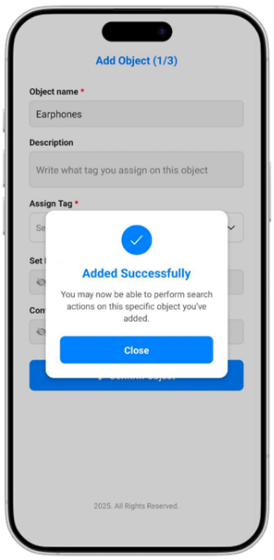


Figure 27. Added Successfully Modal.

Figure 28 shows the Registered Objects Page. This user interface appeared after finishing the addition of the object's process and allowing the application's requirements. It had a simple interface with the logo, instruction icon, list of registered objects, and Add More Objects button. It also displayed if there was a connected tag to the object and its signal. The three (3) dotted icon on the right side allowed the user to edit specific details of the object, such as object name, description, and password. When the user added more objects, a Remove button appeared beside the signal icon, allowing the user to remove an object. The red trash bin icon represented this button, which allowed the user to delete a specific object from the application. When tapped, the user was required to enter the PIN to confirm deletion. This action removed the selected object along with its assigned tag information, making the slot available for adding a new object if needed. This feature helped users manage their list efficiently and maintain only the objects they wanted to track. When the user clicked a specific object, the Pair Device button appeared, and upon hovering over the object name, it changed its color to make it clear to the user that they selected this specific object.

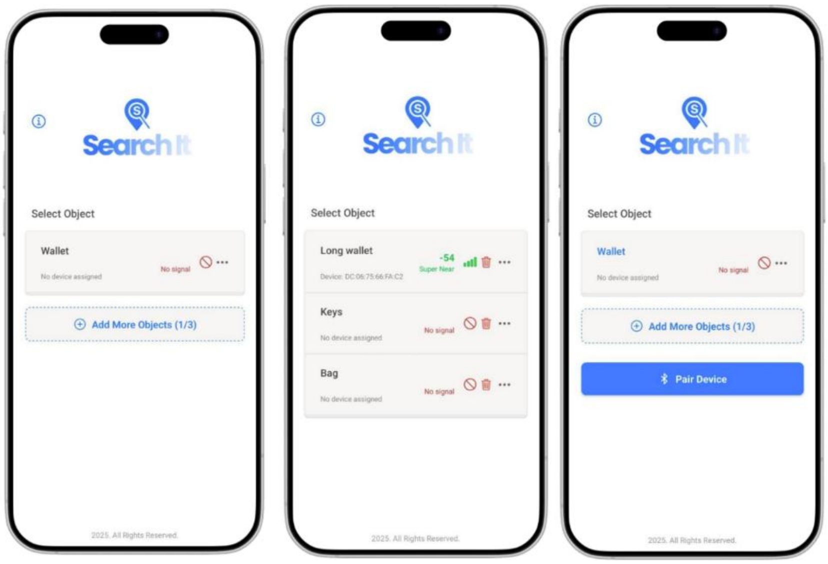


Figure 28. Registered Objects Page.

Figure 29 shows the Instructions Modal. The image displayed the application's user guide, which provided simple, step-by-step instructions for pairing the tag, renaming an object, and managing or removing tags. The guide outlined how users could connect the device through Bluetooth, confirm pairing through audible and visible cues, and update or disconnect a tag when needed. Overall, this modal served as a quick reference to help users understand and operate the application easily.

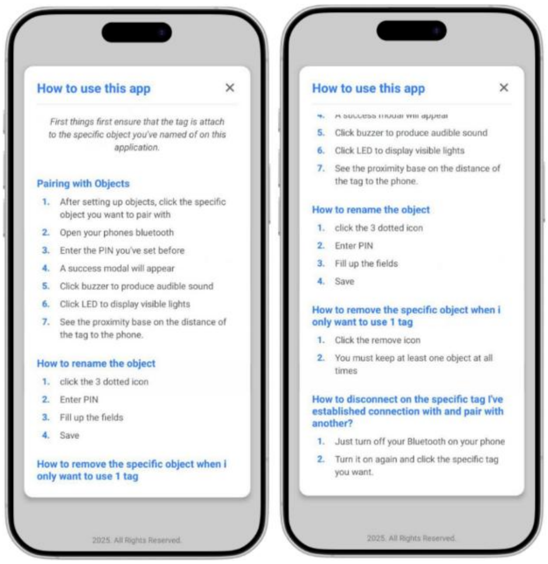


Figure 29. Instructions Modal.

Figure 30 shows the Enter PIN Modal. This modal appeared in multiple scenarios: (1) If the user clicked the three (3) dotted icons on the right side, ensuring they were the authorized user who wanted to edit object details or change the password. (2) If the user wanted to connect the object to a tag to avoid unauthorized tag pairing requests. (3) If the user wanted to remove an object.

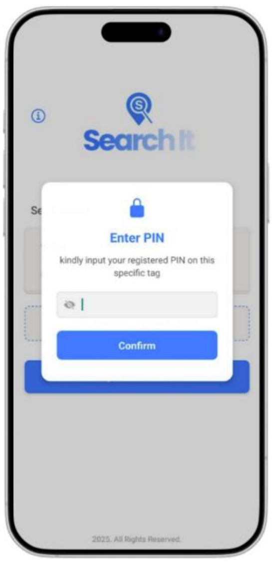


Figure 30. Enter PIN Modal.

Figure 31 shows the Scanning and Paired Successfully Modal. This modal appeared after clicking the Pair Device button and verifying the PIN to let the user know that the mobile application was already scanning for the specific tag advertised by the BLE signal. This lasted for at most 10 seconds if the app didn't detect any signal, but it took only 2–3 seconds if the signal was available. The Paired Successfully modal appeared after successfully establishing a connection between the mobile application and the specific tag, letting the user know that they could already perform locator actions.

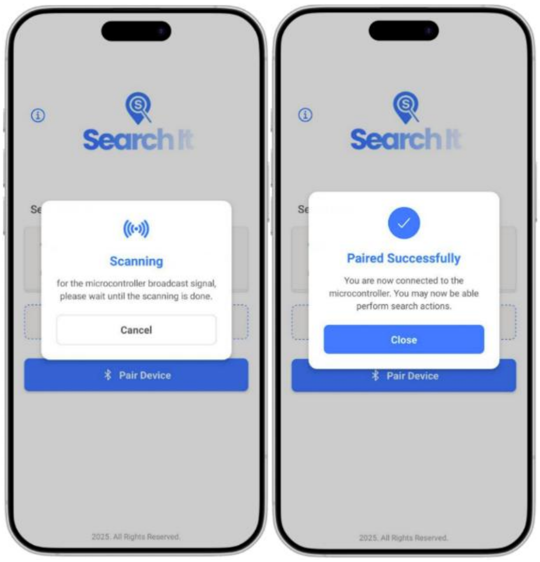


Figure 31. Scanning and Paired Successfully Modal.

Figure 32 shows the Specific Object Page. This screen displayed the buttons the user could click to perform locator actions. These consisted of two significant features: the first showed RSSI in real-time on the application, determining whether the object was super near, near, far, or super far based on proximity. The second consisted of two different outputs, both considered locator actions: the buzzer, which triggered the pin on the tag to produce an audible sound, and the LED button, which produced visible light.

Figure 32. Specific Object Page.

Figure 33 shows the Edit Object Details modal. On the Registered Objects Page, the three (3) dotted icon beside the specific object triggered this modal after clicking it and successfully verifying the PIN, ensuring the user was authorized before making changes. The form consisted of the object name (required), description (optional), and password and confirm password fields (required). The actions of the buttons were as follows: clicking Update Tag Details saved the changes, and the Go Back button returned the user to the existing object screen.

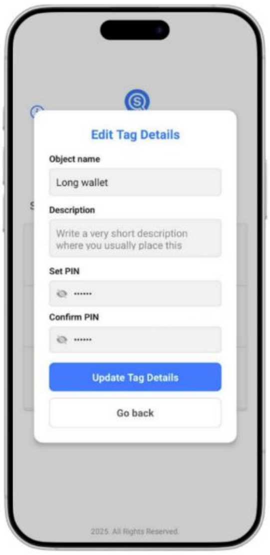


Figure 33. Edit Object Details.

Figure 34 shows the Incorrect PIN Modal. This modal popped up upon incorrect input of passwords, presenting two buttons: Try Again and Go Back. Clicking Try Again reopened the Enter PIN modal, while the Go Back button returned the user to the existing objects screen.

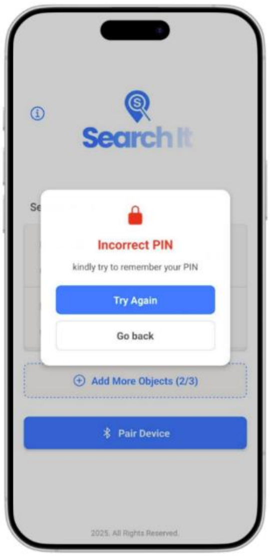


Figure 34. Incorrect PIN Modal.

Figure 35 shows the Connection Lost Modal. This modal appeared in either of two scenarios: (1) when the user accidentally turned off Bluetooth on their device, or (2) when the user was out of range of the specific tag, with the BLE signal perimeter being five (5) meters. Both scenarios triggered this modal, but the issues could be resolved by turning on Bluetooth and clicking the Go Back button, then repeating the pairing process.

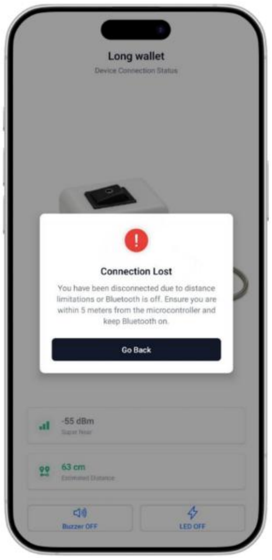


Figure 35. Connection Lost Modal.

Software Testing

For system evaluation, an assessment based on ISO 25010 was used. The evaluation covered the following quality characteristics: functionality, reliability, usability, efficiency, portability, and accuracy. Both technical and non-technical aspects contributed to the overall assessment.

A total of one hundred ten (110) respondents participated in the evaluation. It was composed of ten (10) technical evaluators and one hundred (100) non-technical users. The respondents rated the system using a scale of five (5) to one (1). A rating of five (5) indicates “Excellent”, meaning the system fully meets or exceeds expectations. A rating of four (4) is interpreted as “Very Good”, signifying that the system fully satisfies all requirements. A score of three (3) is considered “Good”, meaning it meets required functions. A rating of two (2) is “Fair”, indicating that the system falls short of expectations, while rating of one (1) represents “Poor”, showing that the system does not meet several key requirements.

To determine the overall interpretation, the mean score of each criterion was computed and compared to the range of weighted mean values. A weighted mean of 4.51 to 5.00 is interpreted as Excellent, 3.51 to 4.50 as Very Good, 2.51 to 3.50 as Good, 1.51 to 2.50 as Fair, and 1.50 and below as Poor.

Technical Evaluation

The table 6 shows the system performance in terms of system functionality rated by technical evaluators. The Tag management system effectively registers and manages tags ($\mu = 4.6$, $\sigma = 0.24$) which falls under the category of "Excellent". The LED lights were successfully activated through the use of application ($\mu = 4.7$, $\sigma = 0.45$) as well as the buzzer ($\mu = 4.8$, $\sigma = 0.4$) which is both interpreted as "Excellent". Moreover, the application displays nearby tags and proximity status correctly ($\mu = 4.6$, $\sigma = 0.48$) which denotes "Excellent". Overall, the system functionality effectively performs and delivers accurate output ($\mu = 4.67$, $\sigma = 0.48$) which is rated as "Excellent".

Table 6. Result of the Evaluation of Technical Participants for System Functionality.

INDICATOR	MEAN	STANDARD DEVIATION	INTERPRETATION
Tag Management	4.6	0.24	Excellent
LED Activation	4.7	0.45	Excellent
Buzzer Activation	4.8	0.4	Excellent
Proximity Display	4.6	0.48	Excellent
Average	4.67	0.39	Excellent

The table 7 presents the result of assessment in terms of reliability based on technical evaluators. The application registered tags correctly without losing the data ($\mu = 4.6$, $\sigma = 0.48$) which denotes "Excellent". Along with that, the application also performs Search It actions (buzzer, LED lights) without any error ($\mu = 4.7$, $\sigma = 0.45$) which is interpreted as "Excellent". The security of the system consistently blocks unauthorized users ($\mu = 4.5$, $\sigma = 0.5$) which falls under the category of "Very Good". To sum up, the system handles the process accurately ($\mu = 4.6$, $\sigma = 0.47$) which is considered as "Excellent".

Table 7. System Reliability Performance Based on the Technical Evaluators.

INDICATOR	MEAN	STANDARD DEVIATION	INTERPRETATION
Data handling accuracy	4.6	0.48	Excellent
Process Stability	4.7	0.45	Excellent
Access Control Reliability	4.5	0.5	Very Good
Average	4.6	0.47	Excellent

The table 8 outlines the summary of the system's usability based on the feedback of technical evaluators. The application is easy to understand and visually straightforward and can easily navigate features smoothly without confusion ($\mu = 4.7$, $\sigma = 0.45$) which are both interpreted as "Excellent". The design also provides clear and well-organized visuals ($\mu = 4.6$, $\sigma = 0.48$) which denotes "Excellent". Generally, the application provides an efficient and user-friendly experience to its users ($\mu = 4.66$, $\sigma = 0.46$) which falls under the category of "Excellent".

Table 8. Technical evaluation for System's Usability.

INDICATOR	MEAN	STANDARD DEVIATION	INTERPRETATION
Interface Clarity	4.7	0.45	Excellent
Feature Navigation	4.7	0.45	Excellent
Clear Visual Design	4.6	0.48	Excellent
Average	4.66	0.46	Excellent

The table 9 provides an overview of system efficiency assessed by technical evaluators. The system responds quickly to features clicked by the user in the application ($\mu = 4.7$, $\sigma = 0.45$) which is interpreted as "Excellent". The Search It action responds in time ($\mu = 4.6$, $\sigma = 0.48$) and performs smoothly without noticeable delay ($\mu = 4.6$, $\sigma = 0.48$) which both denotes "Excellent". Overall, the system's efficiency was assessed as “Excellent” (μ = 4.6, σ = 0.48) reflecting the fast response time across all functions.

Table 9. Technical Assessment in terms of System’s Efficiency.

INDICATOR	MEAN	STANDARD DEVIATION	INTERPRETATION
Fast Feature Response	4.7	0.45	Excellent
Quick Search Process	4.6	0.48	Excellent
Smooth System Performance	4.6	0.48	Excellent
Average	4.63	0.47	Excellent

The table 10 provides a summary of the system evaluation based on portability assessed by technical evaluators. The Search It tags is considered as lightweight that is easy to handle and to carry around (μ = 4.7, σ = 0.45), the tag also allows to be attached in any kind of personal belongings (μ = 4.7, σ = 0.45) which are both interpreted as “Excellent”. The battery performance is assessed as reliable with minimal time of charging (μ = 4.6, σ = 0.48) which is denoted as “Excellent”. Generally, the portability of the system achieved an “Excellent” rating (μ = 4.66, σ = 0.48) indicating that the system is highly portable.

Table 10. Assessment of System’s Portability

INDICATOR	MEAN	STANDARD DEVIATION	INTERPRETATION
Lightweight Design	4.7	0.45	Excellent
Flexible Attachment	4.7	0.45	Excellent
Battery Performance	4.6	0.48	Excellent
Average	4.66	0.46	Excellent

The table 11 illustrates the evaluation of technical evaluators with regards to the system's accuracy. The system proximity detection provides mostly precise readings, but it remains reliable for practical use ($\mu = 4.5$, $\sigma = 0.5$) which is considered as "Very Good". The battery responds timely and consistently when activated ($\mu = 4.6$, $\sigma = 0.48$) and LED lights provide clear visual feedback which remains visible indoors ($\mu = 4.7$, $\sigma = 0.45$) both are denoted as "Excellent". The accuracy of the system is rated as "Excellent" ($\mu = 4.6$, $\sigma = 0.47$) which ensures that the system can be depended on the real-world settings.

Table 11. Technical Evaluation of System Accuracy.

INDICATOR	MEAN	STANDARD DEVIATION	INTERPRETATION
Distance Accuracy	4.5	0.5	Very Good
Buzzer Response	4.6	0.48	Excellent
LED Operation	4.7	0.45	Excellent
Average	4.6	0.47	Excellent

The table 12 shows the overall results assessed by technical evaluators with an average mean score of 4.63 and standard deviation of 0.45 which fall under the category of "Excellent". It suggests that the system not only meets but goes beyond expectation as it maintains a high level of performance across all indicators. These findings indicate that the system is suitable for practical use and can help users to minimize the misplacement.

Table 12. Overall Average Assessed by Technical Evaluators.

SCORE	MEAN	STANDARD DEVIATION	INTERPRETATION
Functionality	4.67	0.39	EXCELLENT
Reliability	4.6	0.47	EXCELLENT
Usability	4.66	0.46	EXCELLENT
Efficiency	4.63	0.47	EXCELLENT
Portability	4.66	0.46	EXCELLENT
Accuracy	4.6	0.47	EXCELLENT
Average	4.63	0.45	EXCELLENT

Non-Technical Evaluation

The table 13 presents the result of assessment in terms of functionality from non-technical users. It indicates that the system performs the intended purpose (μ = 4.84, σ = 0.3666) which is interpreted as “Excellent”. In addition, the system produces accurate and precise results (μ = 4.83, σ = 0.4484) that is interpreted as “Excellent” and provides features needed to satisfy user requirements (μ = 4.71, σ = 0.5881) which is also denoted as “Excellent”. Overall, the system got an “Excellent” rating for effectively performing its intended use and meeting user needs.

Table 13. Result of the Evaluation of Non-Technical Users for Functionality

INDICATOR	MEAN	STANDARD DEVIATION	INTERPRETATION
The system performs its intended functions consistently	4.84	0.37	EXCELLENT
The system produces accurate and exact results.	4.83	0.45	EXCELLENT
The system provide the key features needed to satisfy users' requirements	4.71	0.59	EXCELLENT
Average	4.79	0.47	EXCELLENT

The table 14 outlines the summary of system assessment for reliability based on the feedback of the non-technical users. The system has the ability to complete the task correctly without error (μ = 4.82, σ = 0.4494) which is denoted as "Excellent". Moreover, the system maintains consistent performance when used multiple times (μ = 4.74, σ = 0.5407) and properly recovers from minor interruptions (μ = 4.72, σ = 0.5491) which are both denoted as "Excellent". The system received an "Excellent" rating as it operates consistently and handles minor issues (μ = 4.76, σ = 0.4997).

Table 14. Feedback from Non-Technical Users Regarding System Reliability.

INDICATOR	MEAN	STANDARD DEVIATION	INTERPRETATION
The system completes tasks without errors or malfunctions.	4.82	0.41	EXCELLENT
The system operates reliably when repeatedly used.	4.74	0.54	EXCELLENT
The software recovers properly from minor issues or interruptions.	4.72	0.55	EXCELLENT
Average	4.76	0.5	EXCELLENT

The table 15 provides an overview of system evaluation in terms of usability assessed by non-technical users. This shows the users are able to understand and efficiently complete the task ($\mu = 4.83$, $\sigma = 0.4014$) which is interpreted as “Excellent” and users find the system’s interface easy to use ($\mu = 4.74$, $\sigma = 0.4821$). The usability of the system received an “Excellent” rating, as it allows users to interact smoothly while completing the task ($\mu = 4.79$, $\sigma = 0.4418$.

Table 15. Non-technical Users’ Evaluation of System Usability

INDICATOR	**MEAN**	**STANDARD DEVIATION**	**INTERPRETATION**
Users can quickly understand the system and efficiently complete their tasks.	4.83	0.4	EXCELLENT
Users are satisfied with the system’s interface and find it easy to use.	4.74	0.48	EXCELLENT
Average	4.79	0.44	EXCELLENT

The table 16 provides the summary of the system evaluation based on user-friendliness as assessed by non-technical users, this shows that the users effectively manage and customize tags ($\mu = 4.73$, $\sigma = 0.4439$) which denote “Excellent”. Moreover, the users feel the smooth experience when managing and searching for objects ($\mu = 4.72$, $\sigma = 0.4707$) and the user finds the interface easy to use for personalization ($\mu = 4.72$, $\sigma = 0.4915$) which both got the interpretation of “Excellent”. The findings conclude an “Excellent” rating for system’s user-friendliness assessed by non-technical users for having intuitive interface and easy management of tags. ($\mu = 4.72$, $\sigma = 0.4687$)

Table 16. Non-Technical Users' Assessment of User-Friendliness

INDICATOR	MEAN	STANDARD DEVIATION	INTERPRETATION
The system lets users manage and personalize tags for easier searching.	4.73	0.44	EXCELLENT
The app provides a smooth experience for managing and searching objects.	4.72	0.47	EXCELLENT
The interface provides a simple and intuitive way to modify personalization settings.	4.72	0.49	EXCELLENT
Average	4.72	0.47	EXCELLENT

The table 17 illustrates the evaluation of non-technical users with regards to the system's portability. The size of the locator is appropriately sized for daily use (μ = 4.55, σ = 0.6538) also the casing or the enclosure is sturdy and reliable enough when used (μ = 4.62, σ = 0.2956) which are both interpreted as "Excellent". The user finds it comfortable to operate physically like switching it on and off (μ = 4.80, σ = 0.4690) which is also interpreted as "Excellent". The system was assessed as "Excellent" as it ensured ease of use on a daily basis (μ = 4.66, σ = 0.4726).

Table 17. Non-Technical Users' Assessment of System Portability.

INDICATOR	MEAN	STANDARD DEVIATION	INTERPRETATION
The system is practical in size for daily use.	4.55	0.65	EXCELLENT
The system's case feels sturdy and reliable	4.62	0.3	EXCELLENT
The system is comfortable to operate physically, such as switching it on and off.	4.80	0.47	EXCELLENT
Average	4.66	0.47	EXCELLENT

Table 18 shows the overall summary of the non-technical evaluation with an average score of 4.77 and a standard deviation of 0.4695, which corresponds to an “excellent” rating. The results indicated that, from a non-technical perspective, the system performs well in terms of functionality, it offers reliable features, demonstrates high usability, and provides a user-friendly interface that enables users to operate the system efficiently and without difficulty.

Table 18. Overall Average Assessed by Non-Technical Esers.

SCORE	MEAN	STANDARD DEVIATION	INTERPRETATION
Functionality	4.79	0.47	EXCELLENT
Reliability	4.76	0.5	EXCELLENT
Usability	4.79	0.44	EXCELLENT
User-Friendliness	4.72	0.47	EXCELLENT
Portability	4.66	0.47	EXCELLENT
Average	4.74	0.47	EXCELLENT

SUMMARY, CONCLUSION, AND RECOMMENDATION

This chapter summarizes the study's findings, conclusions, and recommendations. The research output focused on providing ways to prevent the misplacement of personal belongings, speed up the process of finding items, and promote independence in location lost objects.

Summary

The capstone project aimed to develop a SEARCH IT: Smart ESP32-Powered Active Response Companion Hardware - Integrated Tracker. A system that provided an efficient and accessible solution for locating misplaced personal belongings indoors.

Data gathering was conducted through surveys and a review of related literature sourced from the internet. The data were collected from students and IT professionals from various departments under the CEIT at Cavite State University - Indang.

This study had four (4) modules: Tag Management Module for adding and renaming objects with custom labeling features, and creating a unique PIN for each tag. This allowed the user to update a specific object. Locator Actions Module consisted of triggering the passive buzzer to produce an audible sound on the tag and the LED to produce visible light. Signal Processing Module showed the available nearby tags, transmitted RSSI values for proximity, and provided out-of-range notifications. This allowed the user to determine which tag was emitting a signal. And the Search IT Tag Module consisted of the hardware components integrated together, which could be controlled via the mobile application. The system was developed using React-Native, Node.js, Typescript, Javascript, C++, Arduino IDE, and Expo Application Services (EAS).

The Agile Software Development Cycle was used as the development methodology, which included the following phases: requirement gathering, design, coding, testing, deployment, and feedback. This was a flexible and iterative approach that allowed continuous collaboration, rapid delivery, and adaptability to changing requirements. It provided a structured sequence of stages that a software product passed through from initial conception to final delivery, ensuring incremental progress, quality assurance, and responsiveness to user needs.

The study involved a total of one hundred ten (110) participants, including ten (10) IT and Electronic experts and one hundred (100) students from the CEIT at Cavite State University - Indang. Participants were selected using a random sampling technique. Software evaluations were conducted following the ISO 25010 standards, and the collected data were analyzed using statistical analysis software. The system is limited to single-user, short-range indoor use and is compatible only with Android devices that support Bluetooth 4.0 or higher. Evaluators tested the application along with the tag before completing the provided evaluation questionnaire. The results showed that most evaluators approved the SEARCH IT: Smart ESP32-Powered Active Response Companion Hardware-Integrated Tracker, rating it as “Excellent” in both technical and non-technical aspects.

Conclusion

To conclude, the researcher successfully developed the SEARCH IT: Smart ESP32-Powered Active Response Companion Hardware - Integrated Tracker, a tracker designed for misplaced personal belongings indoors. It allows users to use the application as a remote for the Search It tag, enabling them to manage and perform actions as needed. It is intended to reduce misplacement indoors and assist users who frequently misplace personal belongings, also to promote independence among students and faculty. The problems were identified through the use of a fishbone diagram to reveal the causes of the existing problem, which helped the researchers align the system to user needs.

From the findings of the study, the Search It tags have shifted the traditional method of searching from manual searching to a modern approach that integrates both software and hardware. The system provides a convenient method for tracking personal belongings as the application notifies the user through alerts, such as buzzing, lights, and screen indicators, like proximity detection. The researchers provide different feedback through sound cues and visual cues so the user would not rely on only what the screen indicator tells. Users have options depending on the situation they are in. For instance, users can use LED lights if the environment is dark or if the belongings are underneath; otherwise, use the buzzer, where users can move around following the sound.

Moreover, the study reveals that the signal detection depends on the environment, which can be inconsistent due to signal interference present indoors, such as wireless devices and concrete walls. The researchers tested the signal range in various interferences to determine how the environment affects the connectivity (See Appendix Table 4).

The system was evaluated based on the ISO 25010 with functionality, reliability, usability, efficiency, portability, and accuracy. The result of the evaluations was rated positively, although the feedback was from a different perspective. For the technical evaluators, those who have extensive knowledge about the software and hardware side. The system earned an average score of 4.63 and a standard deviation of 0.45, while the non-technical evaluators rated an average score of 4.77 and a standard deviation of 0.46. This proves that object locator is a practical and efficient tool that simplifies the process of finding personal belongings and is a dependable alternative to the traditional searching methods.

Recommendation

These recommendations highlight important improvements that can further improve the overall system performance and user experience:

1. Integrate a GPS module to enable precise, real-time tracking rather than relying solely on proximity-based methods. The system should remain dependable in outdoor environments while carefully maintaining the existing form factor, ensuring that the added component does not significantly increase the device's overall size or bulk
2. Enhance the battery capacity to ensure the device can operate for more than two hours on a single charge, while preserving the current form factor and without compromising overall battery lifespan. Please prioritize efficiency and longevity in the upgraded design.
3. Adopt a Land Grid Array (LGA) approach instead of relying on readily available open-source components, allowing the design to be optimized for a true micro-sized form factor. This ensures the device can be precisely tailored as a compact tag rather than assembled from larger, pre-made open-source modules that limit size and integration flexibility.
4. Explore alternative Bluetooth Low Energy (BLE) approaches that enable simultaneous pairing and communication with multiple tags, rather than relying on the current one-to-one connection model. This enhancement should improve scalability, efficiency, and overall user experience by allowing the system to manage several devices at once without compromising performance or stability.

REFERENCES

Afyouni, I., Musleh, M., Basalamah, A., & Tariq, Z. (2021). Passive BLE sensing for indoor pattern recognition and tracking. *Procedia Computer Science*. https://www.sciencedirect.com/science/article/pii/S187705092101423X

Ainul, R. D., Wibowo, S., Djuwari, & Siswanto, M. (2021). An improved indoor RSSI-based positioning system using Kalman filter and MultiQuad algorithm. In *2021 International Electronics Symposium (IES)* (pp. 1–6). IEEE. https://doi.org/10.1109/IES53407.2021.9594009

Al-Maktary, O., & Susanto, M. (2025). A comparative review of communication technologies for asset tracking in healthcare facilities. *Applied Engineering, Innovation, and Technology, 2*(1), 9–14. https://doi.org/10.62777/aeit.v2i1.59

Alsmadi, A. (2019, December 16). *Development of Indoor Positioning System Using RSSI and Beacon Weight Approach in iBeacon Networks* [Master's thesis, ProQuest Dissertations & Theses Global]. https://www.proquest.com/docview/3039734104

Alsmadi, I., & Kong, X. (2019). Improve indoor positioning accuracy using filtered RSSI and beacon weight approach in iBeacon network. *International Journal of Computer Applications, 178*(7), 1–7. https://doi.org/10.5120/ijca2019919563

Arduino Team. (2024). *Arduino software*. Arduino. https://www.arduino.cc/en/software

Arduino Team. (2024). *Arduino software libraries*. Arduino. https://docs.arduino.cc/learn/starting-guide/software-libraries/

Arduino Team. (2024). *What is Arduino?* Arduino. https://docs.arduino.cc/learn/starting-guide/whats-arduino/

Bai, L., Ciravegna, F., & Bond, R. (2020). A low-cost indoor positioning system using Bluetooth Low Energy. *IEEE Access, 8*, 1–1. https://doi.org/10.1109/ACCESS.2020.3012342
misplaced belongings: A review. *International Journal of Innovative Technology and Exploring Engineering, 8*(10), 4605–4608. https://doi.org/10.35940/ijitee.J8935.0881019

Bloch, V., & Pastell, M. (2020). Monitoring of cow location in a barn by an open-source, low-cost, low-energy Bluetooth tag system. *Sensors, 20*(14), 3841. https://doi.org/10.3390/s20143841

Brissenden, J. A., Tobyne, S. M., Osher, D. E., & Somers, D. C. (2025). Errors of attention adaptively warp spatial cognition. *Nature Human Behaviour*. https://doi.org/10.1038/s41562-025-02109-5

Cameron, N. (2023). *ESP32 formats and communication*. Springer. https://link.springer.com/book/10.1007/978-1-4842-9376-8

Castillo, D. (2023). What is soldering iron and solder? *Fine Power Tools*. https://www.finepowertools.com/diy/soldering-iron/

Chandrashekar, G., Vaishnavi, P., Neeharika, D., Suchitha, N., & Rohith, T. (2025). Smart building management system using ESP32. *International Research Journal on Advanced Engineering and Management, 3*(5), 1962–1966. https://doi.org/10.47392/IRJAEM.2025.0308

Clark, D. P. A., & Donnelly, N. (2024). An exploration of the influence of animal and object categories on recall of item location following an incidental learning task. *The Quarterly Journal of Experimental Psychology*. https://doi.org/10.1177/17470218241238737

Demrozi, F., Turetta, C., Chiarani, F., Kindt, P. H., & Pravadelli, G. (2021). Estimating indoor occupancy through low-cost BLE devices. *IEEE Sensors Journal, 21*(15), 17053–17063. https://doi.org/10.1109/JSEN.2021.3080632

Díaz, F., & Martín, J. (2021). Reducing search time for misplaced items: A user-centered approach. *Journal of Human-Computer Interaction, 37*(4), 362–378. https://doi.org/10.1080/07370024.2021.1886749

Espressif Systems. (2020). *Arduino-ESP32 libraries documentation*. https://docs.espressif.com/projects/arduino-esp32/en/latest/libraries.html

Flueratoru, L., Shubina, V., Niculescu, D., & Lohan, E.-S. (2022). On the high fluctuations of received signal strength measurements with BLE signals for contact tracing and proximity detection. *IEEE Sensors Journal, 22*(6), 5086–5100. https://doi.org/10.1109/JSEN.2021.3095710

GeeksforGeeks. (2024). Agile SDLC (Software Development Life Cycle). https://www.geeksforgeeks.org/agile-sdlc-software-development-life-cycle/

Giuliano, R., Cardarilli, G. C., Cesarini, C., Di Nunzio, L., Fallucchi, F., Fazzolari, R., Mazzenga, F., Re, M., & Vizzarri, A. (2020). Indoor localization system based on Bluetooth low energy for museum applications. *Electronics, 9*(6), 1055. https://doi.org/10.3390/electronics9061055

He, T., Tan, J., Zhuo, W., Printz, M., & Chan, S.-H. G. (2022). Tackling multipath and biased training data for IMU-assisted BLE proximity detection. In *IEEE INFOCOM 2022 Conference* (pp. 1259–1268). IEEE. https://doi.org/10.1109/INFOCOM48880.2022.9796716

Huang, X., Wang, J., & Ma, H. (2023). Psychological effects of lost personal belongings: A study on stress and anxiety in university students. *Frontiers in Psychology, 14*, 1012345. https://doi.org/10.3389/fpsyg.2023.1012345

IBM. (n.d.). What is the k-nearest neighbors (KNN) algorithm? https://www.ibm.com/think/topics/knn

Janczak, D., Walendziuk, W., Sadowski, M., Zankiewicz, A., Konopko, K., & Idzkowski, A. (2022). Accuracy analysis of the indoor location system based on Bluetooth Low-Energy RSSI measurements. *Energies, 15*(23), 8832. https://doi.org/10.3390/en15238832

Janczak, D., Walendziuk, W., Sadowski, M., Zankiewicz, A., Konopko, K., Słowik, M., & Gulewicz, M. (2024). Indoor positioning based on Bluetooth RSSI mean estimator for the evacuation supervision system application. *ResearchGate*. https://www.researchgate.net/publication/379880099

Mackey, A., Spachos, P., Song, L., & Plataniotis, K. N. (2020). Improving BLE beacon proximity estimation accuracy through Bayesian filtering. *IEEE Internet of Things Journal, 7*(4), 3160–3169. https://doi.org/10.1109/jiot.2020.2965583

Michael, A. (2024). How to avoid signal interference with wireless setups. *Handyman Telford*. https://handymantelfordshropshire.co.uk/how-to-avoid-signal-interference-with-wireless-setups/

Nguyen, V. T., Le, H. M., & Ha, D. T. (2024). Design and implementation of an IoT system for indoor measurement and monitoring fire and gas warning. *Buletin Ilmiah Sarjana Teknik Elektro, 5*(2), 123–130. https://journal2.uad.ac.id/index.php/biste/article/view/11254/4725

Peng, X., Chen, R., Yu, K., Ye, F., & Xue, W. (2020). An improved weighted K-nearest neighbor algorithm for indoor localization. *Electronics, 9*(12), 2117. https://doi.org/10.3390/electronics9122117

Philippopoulos, P. I., Koutrakis, K. N., Tsafaras, E. D., Papadopoulou, E. G., Sigalas, D., Tselikas, N. D., Ougiaroglou, S., & Vassilakis, C. (2025). Cost-efficient RSSI-based indoor proximity positioning for large/complex museum exhibition spaces. *Sensors, 25*(9), 2713. https://doi.org/10.3390/s25092713

Safwat, R., Shaaban, E., Al-Tabbakh, S. M., & Emara, K. (2023). Fingerprint-based indoor positioning system using BLE: Real deployment study. *Bulletin of Electrical Engineering and Informatics, 12*(1), 240–249. https://doi.org/10.11591/eei.v12i1.3798

Segen, V., Colombo, G., Avraamides, M. N., Slattery, T. J., & Wiener, J. M. (2022). The role of memory and perspective shifts in systematic biases during object location estimation. *Attention, Perception, & Psychophysics, 84*(4), 1208–1219. https://doi.org/10.3758/s13414-022-02445-y

Șipoș, E., Ciuciu, C., & Ivanciu, L. (2022). Sensor-based prototype of a smart assistant for visually impaired people—Preliminary results. *Sensors, 22*(11), 4271. https://doi.org/10.3390/s22114271

Santos, S., & Santos, S. (2025, April 12). *ESP32-CAM Video Streaming and Face Recognition with Arduino IDE | Random Nerd Tutorials*. Random Nerd Tutorials. https://randomnerdtutorials.com/esp32-cam-video-streaming-face-recognition-arduino-ide/

Skýpalová, E., Boroš, M., Loveček, T., & Veľas, A. (2025). Innovative indoor positioning: BLE beacons for healthcare tracking. *Electronics, 14*(10), 2018. https://doi.org/10.3390/electronics14102018

Spachos, P., & Plataniotis, K. N. (2020). BLE beacons for indoor positioning at an interactive IoT-based smart museum. *IEEE Systems Journal, 14*(3), 3483–3493. https://doi.org/10.1109/JSYST.2020.2969088

SunFounder. (2025). *Passive Buzzer Module — SunFounder Ultimate Sensor Kit*. Retrieved November 25, 2025, from https://docs.sunfounder.com/projects/ultimate-sensor-kit/en/latest/components_basic/26-component_buzzer.html

Vaccari, L., Coruzzolo, A., Lolli, F., & Sellitto, M. (2024). Indoor positioning systems in logistics: A review. *ResearchGate*. https://www.researchgate.net/publication/386418538

Wilford, W., Pu, Q., Zhou, M., Khalid, W., & Tahir, M. J. (2022). RSSI fingerprint height-based empirical model prediction for smart indoor localization. *Sensors, 22*(23), 9054. https://doi.org/10.3390/s22239054

Wu, L., Guo, S. L., Han, L., & Baris, C. A. (2024). Indoor positioning method for pedestrian dead reckoning based on multi-source sensors. *Measurement, 229*, 114416. https://doi.org/10.1016/j.measurement.2024.114416

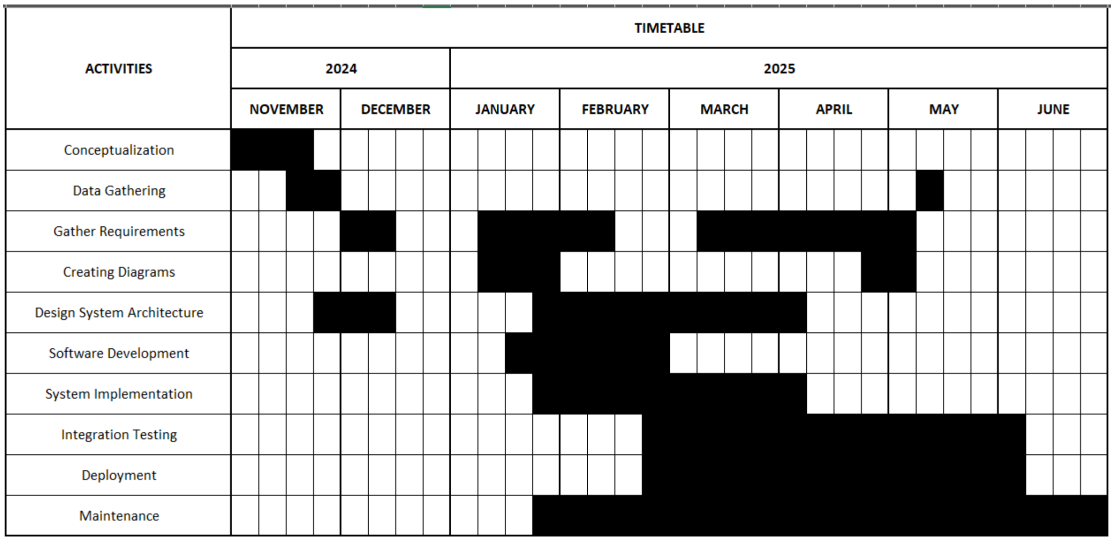
Xu, J., Miao, Y., & Zheng, X. (2021). Design and implementation of indoor positioning performance test system for IoT intelligent communication terminal. *Journal of Physics: Conference Series, 1732*(1), 012030. https://doi.org/10.1088/1742-6596/1732/1/012030

Yagi, T., Nishiyasu, T., Kawasaki, K., Matsuki, M., & Sato, Y. (2021). GO-Finder: A registration-free wearable system for assisting users in finding lost objects via hand-held object discovery. In *Proceedings of the 26th International Conference on Intelligent User Interfaces* (pp. 26–37). ACM. https://doi.org/10.1145/3397481.3450664

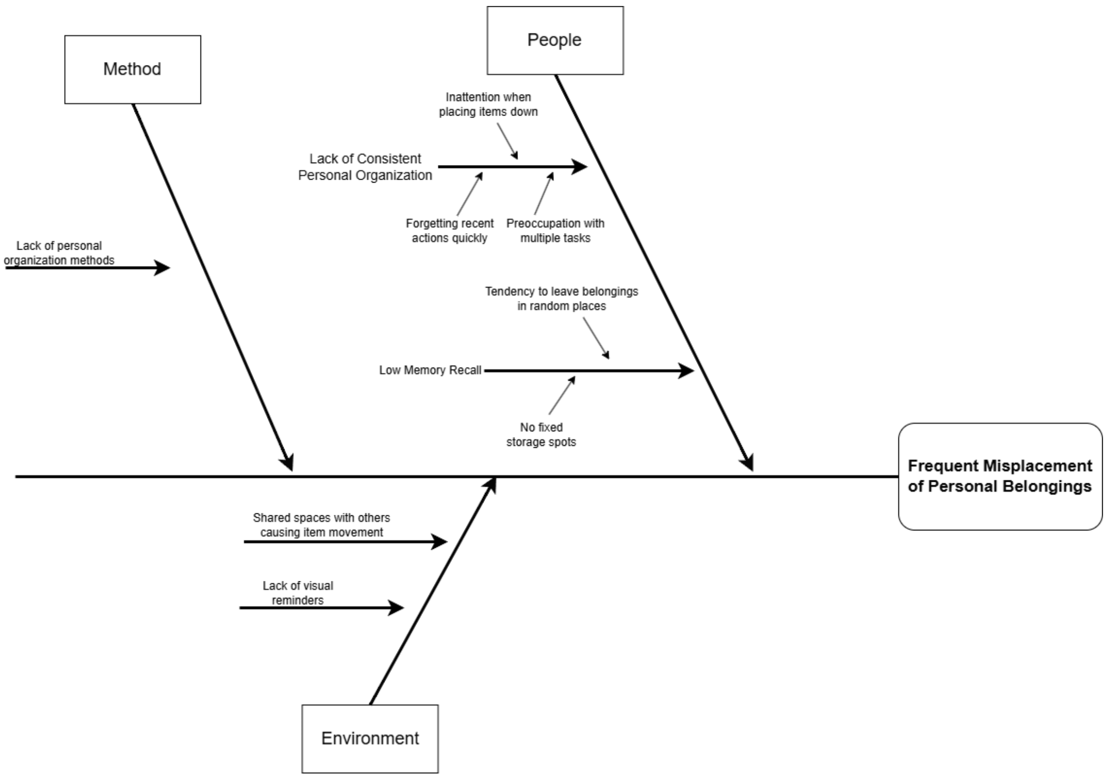
Yang, J., Poellabauer, C., Mitra, P., & Neubecker, C. (2020). Beyond beaconing: Emerging applications and challenges of BLE. *Journal of Systems Architecture, 102*, 101667. https://www.sciencedirect.com/science/article/abs/pii/S1570870518307170

Zadgaonkar, H., & Chandak, M. (2023). Locating objects in warehouses using BLE beacons & machine learning. *IEEE Xplore*. https://ieeexplore.ieee.org/document/9614122

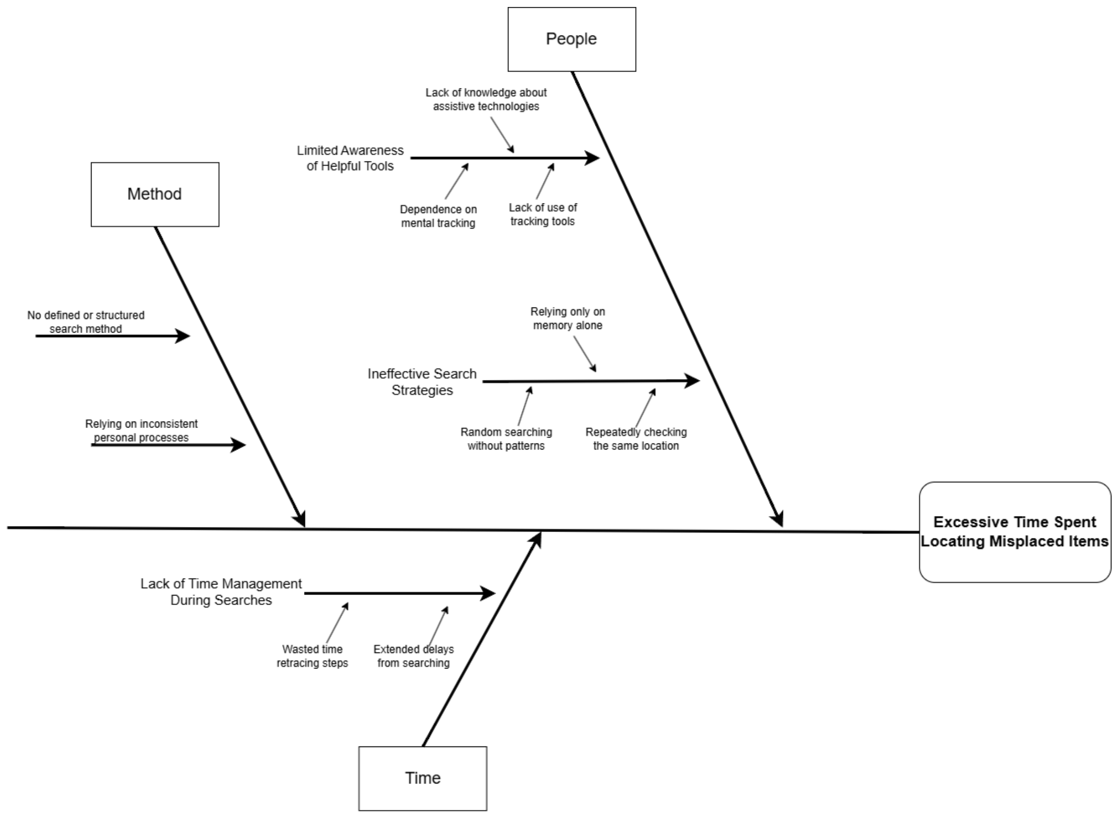
APPENDIX FIGURES



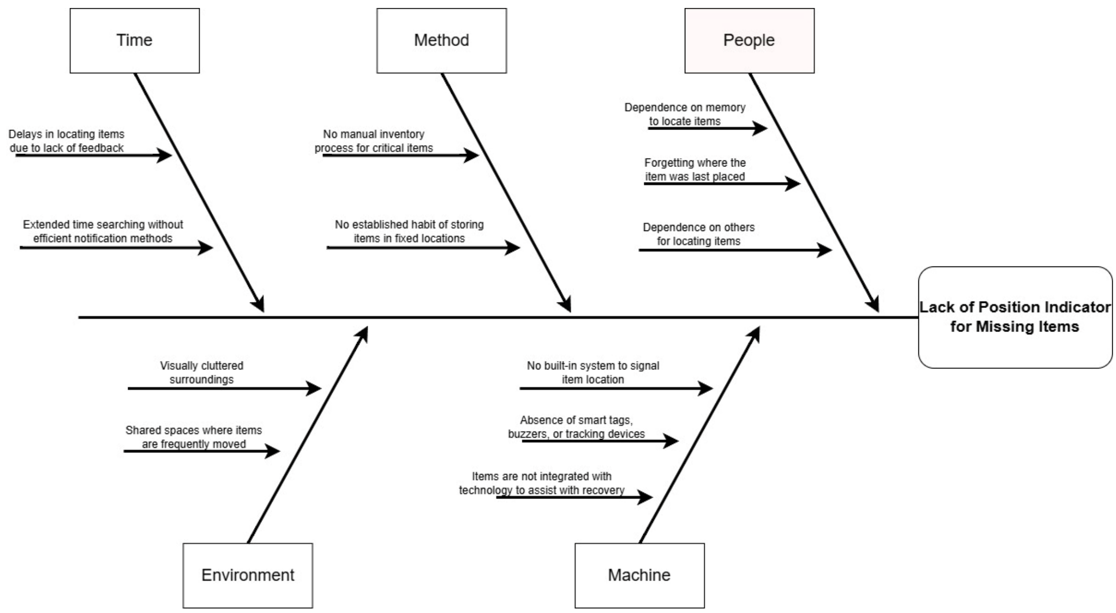
Appendix Figure 1. Gantt Chart of the Study.



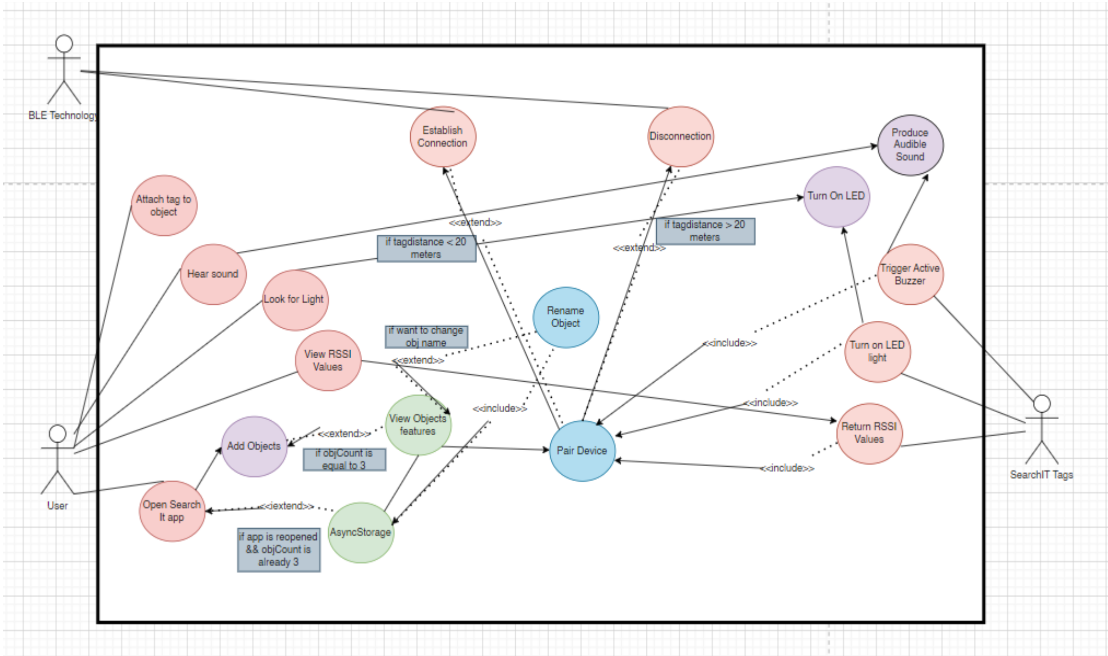
Appendix Figure 2. Frequent Misplacement of Personal Belongings.



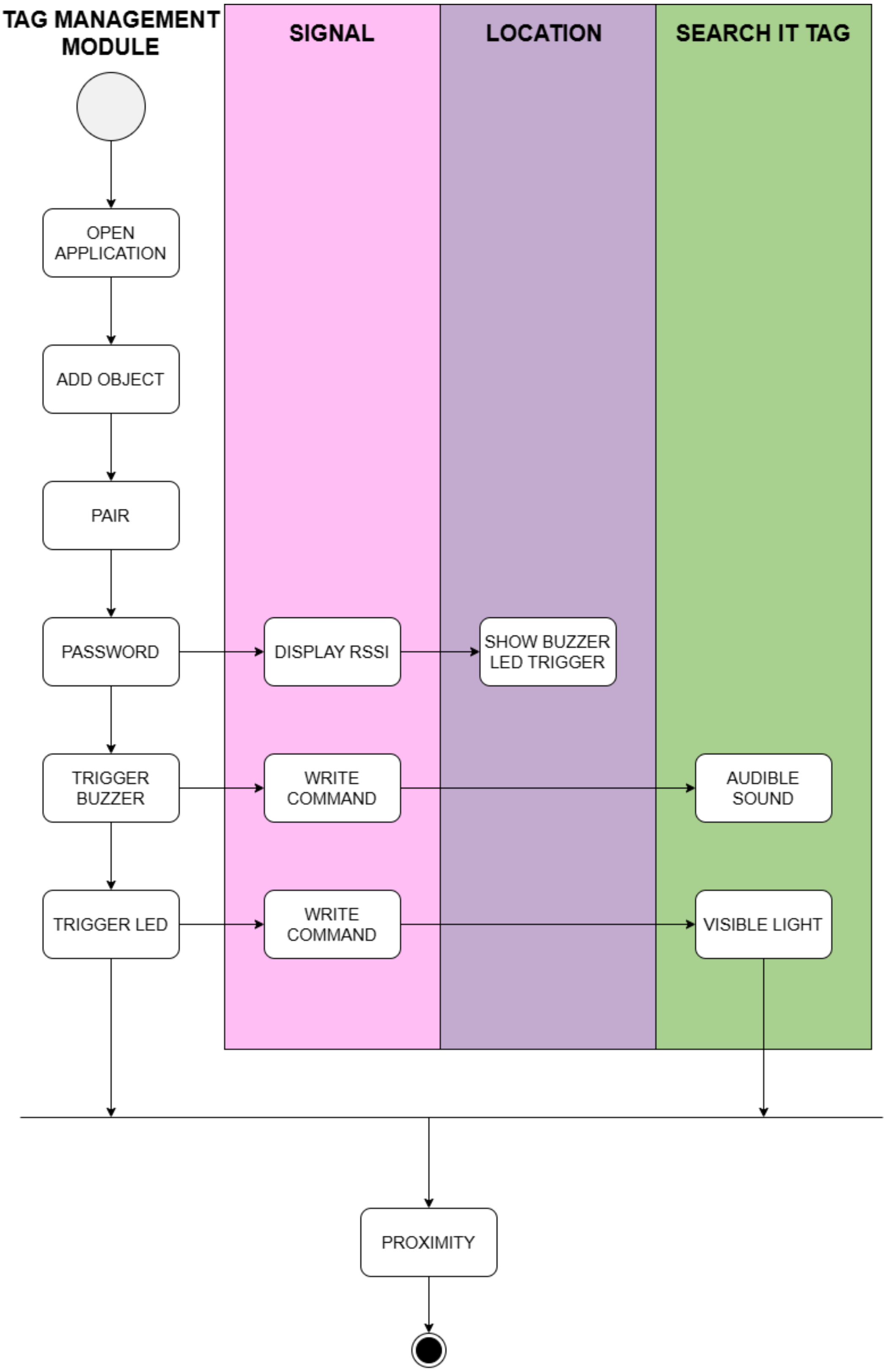
Appendix Figure 3. Excessive Time Spent Locating Misplaced Items.



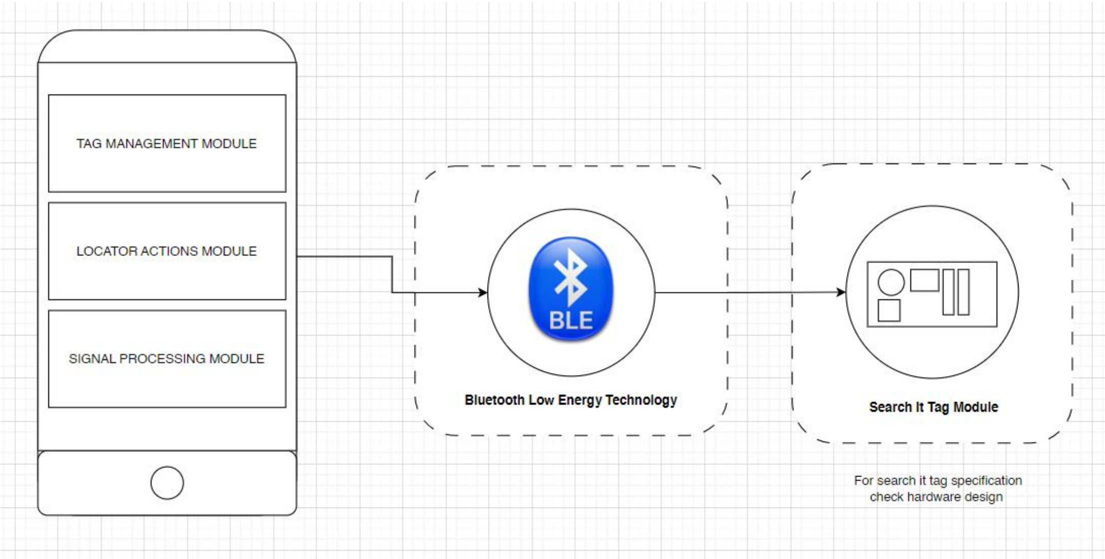
Appendix Figure 4. Lack of Position Indicator for Missing Items.



Appendix Figure 5. Use Case Diagram.



Appendix Figure 6. Activity Diagram.



Appendix Figure 7. Software Architecture.

APPENDIX TABLES

Appendix Table 1. Line-Item Budget.

PARTICULARS	AMOUNT
Data Cables	200.00
ESP32 (38 pins)	281.47
ESP32 (Super mini)	119.00
Buzzer Module for Arduino	65.74
Jumper Wires	136.34
Dupont Wires (Male – Female)	86.86
Dupont Wires (Male – Male)	49.00
Dupont Wires (Female – Female)	25.00
Breadboard (400 tie points half)	96.82
Soldering Lead	15.00
Desoldering Pump	87.00
LED Light	40.00
Board pin Connector	45.00
Resistor	20.00
9v Heavy Duty Battery	42.00
9v Battery Holder	11.00
Battery Holder	155.95
Step-down Converter	57.23
3.7 Flat LiPo Rechargeable Battery (200MAH)	104.00
TP4056 Module	62.00
Step-up Boost Converter	54.00
Lifepo4 Battery	56.82
2 Pin Rocker Switch	30.00
Passive Buzzer	70.00
Bond Paper (Ream)	1,000.00
Ink	299.00
Total Amount	**₱3,209.23**

Appendix Table 2. Project Cost Analysis

Item	Quantity	Unit price	Total price
ESP32 C3 Supermini	1	119.00	119.00
Passive Buzzer	1	70.00	70.00
LED	1	40.00	40.00
Resistor (200Ω)	1	5.00	5.00

Appendix Table 2. Continuation

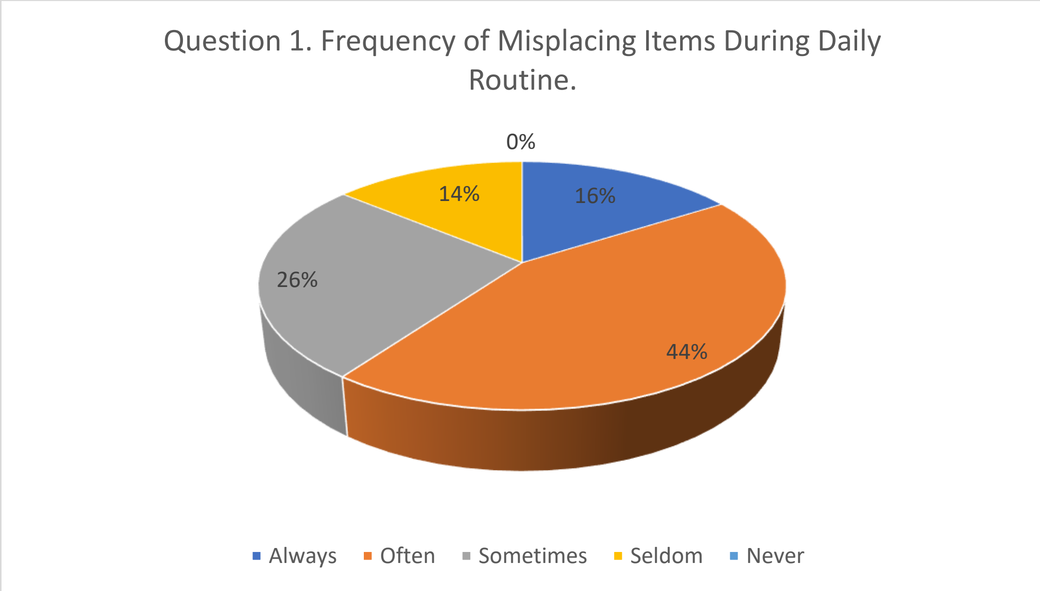
Rocker Switch	2	15.00	30.00
TP4055 Charging Module	1	62.00	62.00
3.7V 200mAh LiPo Battery	1	104.00	104.00
Labor / 3D Print (PETG)	1	2,000	2,000
Total			**₱2,430**

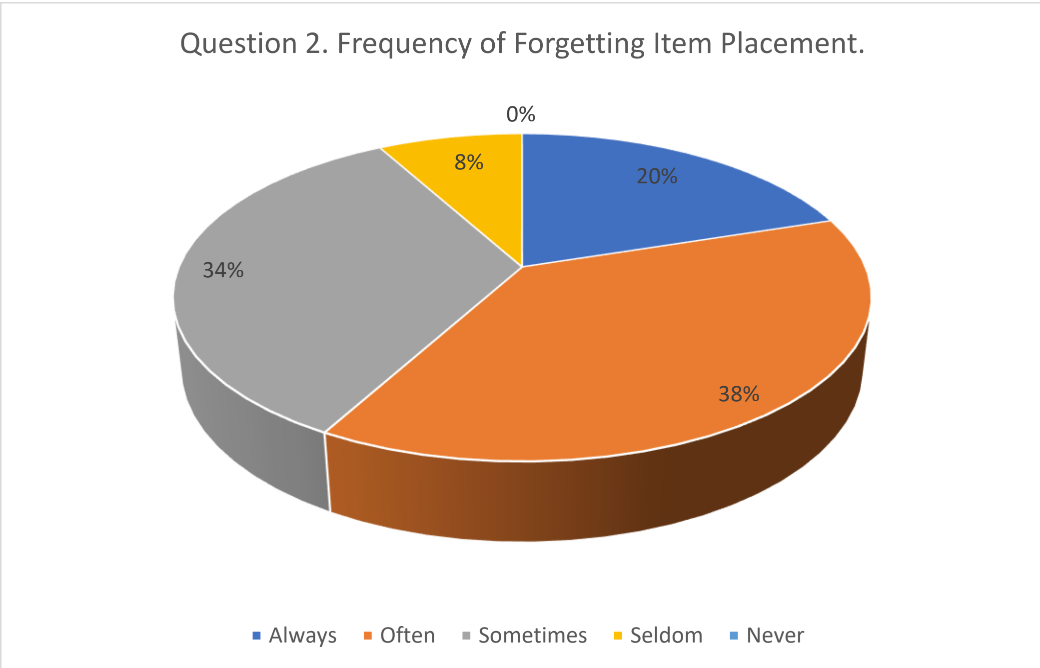
Appendix Table 3. Measured Maximum Signal Distance Under Various Environmental Conditions.

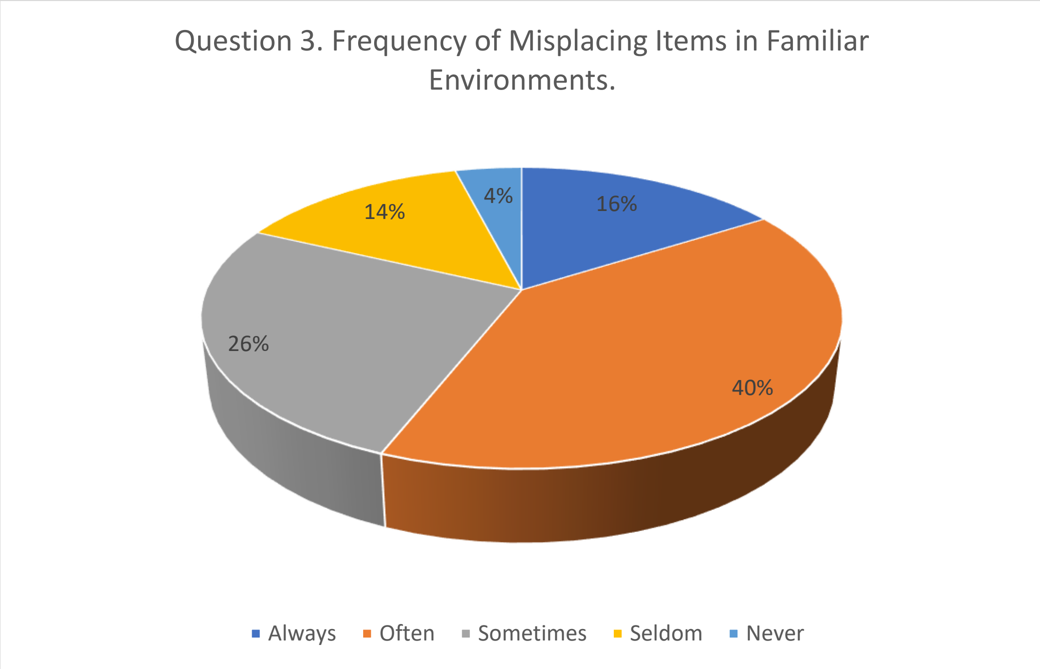
Condition	**Max Distance**
Concrete wall without signal interference (35 inches thick)	0.889 meters
Concrete wall with signal interference (23 inches thick)	0.5842 meters
Room with a wooden partition (DIT fifth floor)	35 meters
Hallway with signal interference (first floor)	19 meters
First floor to second floor	Not detected

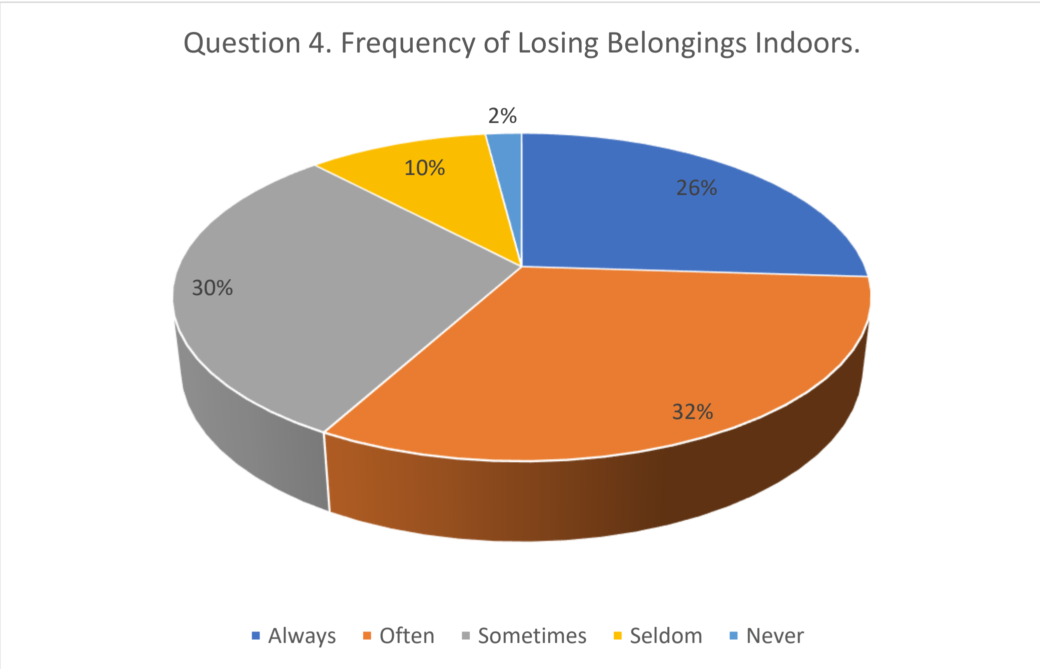
APPENDIX I

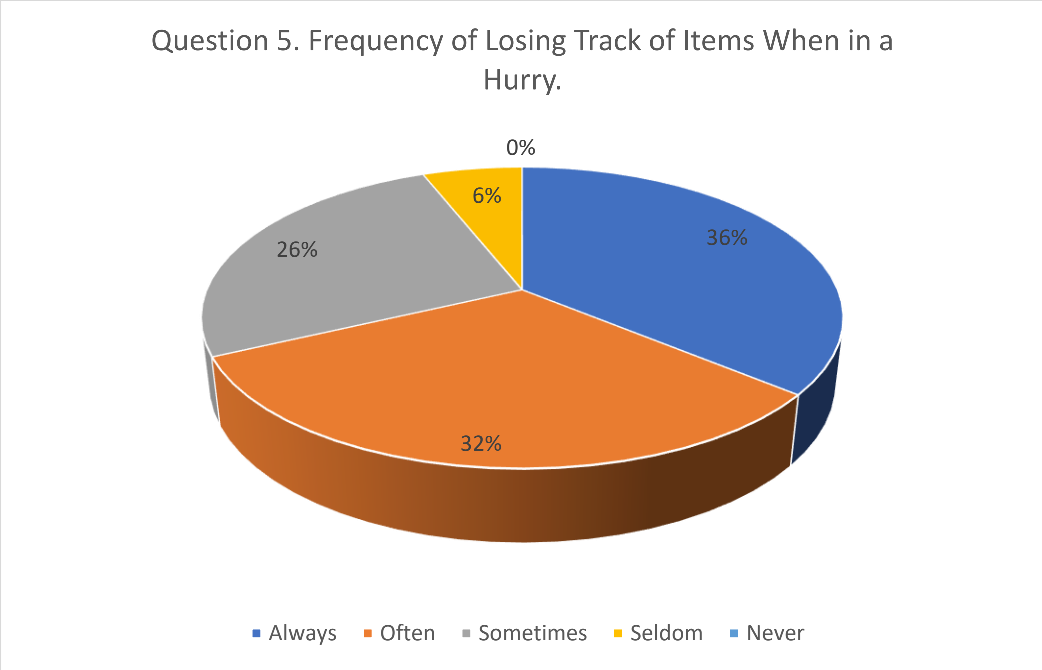
Survey Results

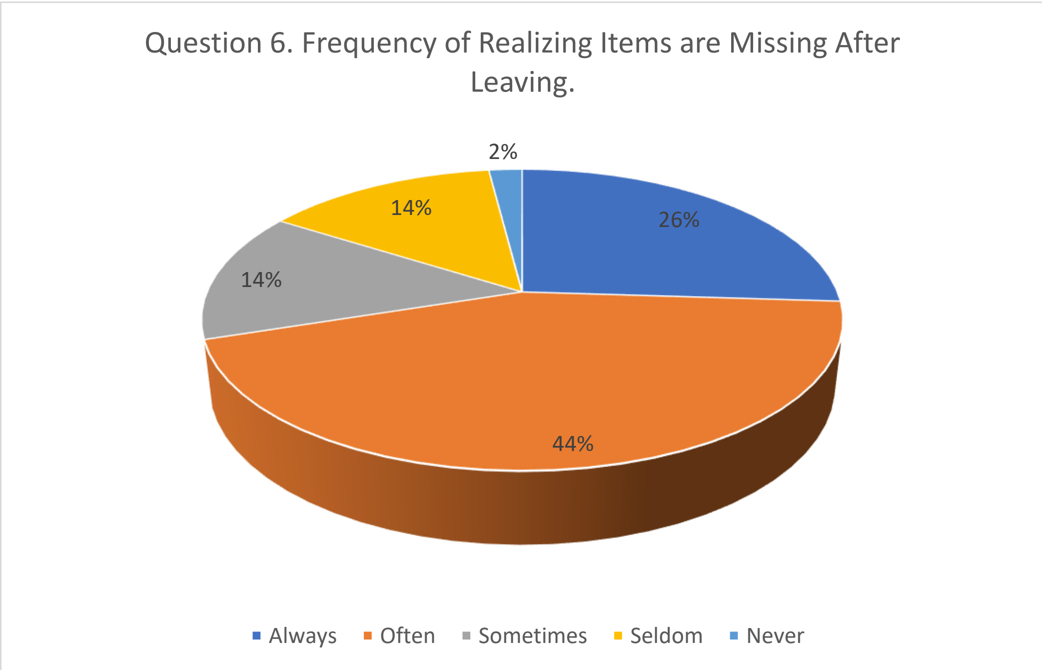

Question 1. Frequency of Misplacing Items During Daily Routine.
0%
16%
14%
26%
44%
Always
Often
Sometimes
Seldom
Never

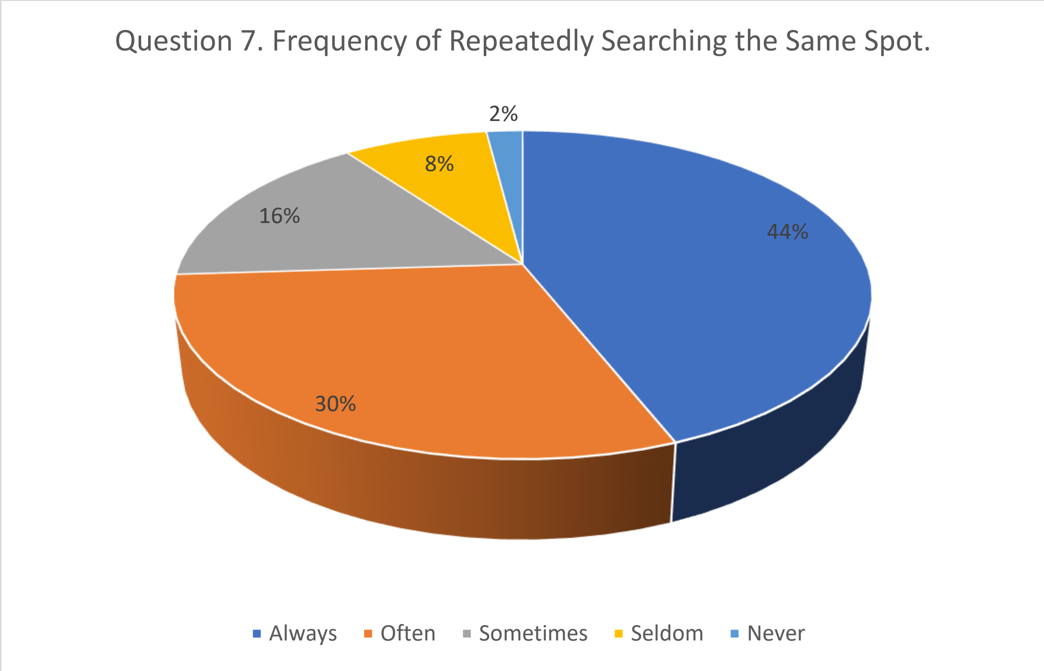

Question 2. Frequency of Forgetting Item Placement.
0%
8%
20%
34%
38%
Always
Often
Sometimes
Seldom
Never

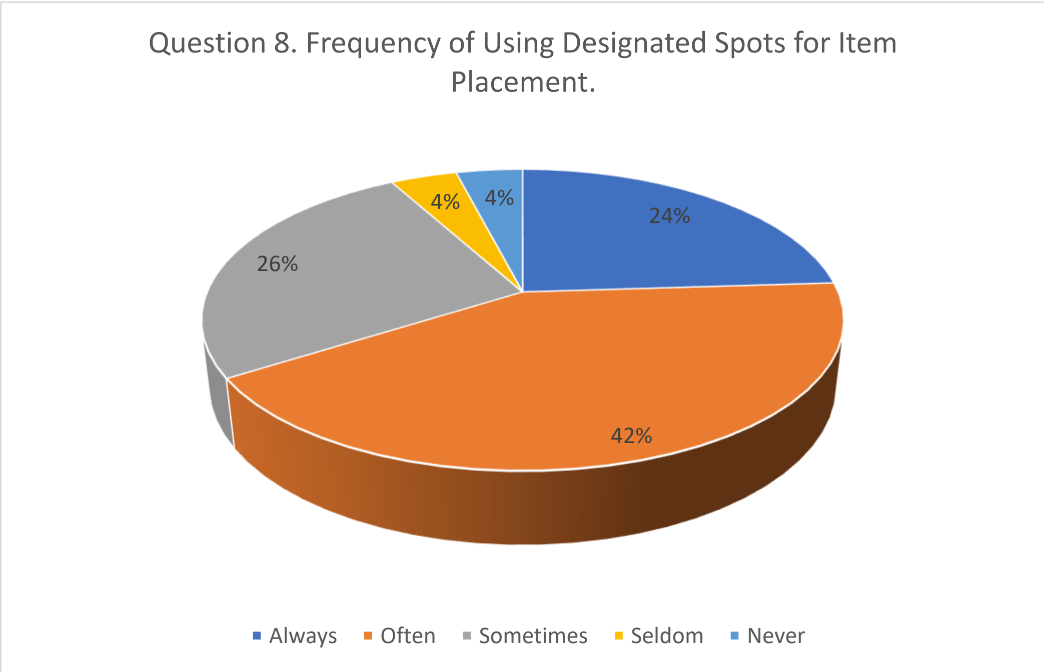

Question 3. Frequency of Misplacing Items in Familiar Environments.
16%
40%
26%
14%
4%
Always
Often
Sometimes
Seldom
Never

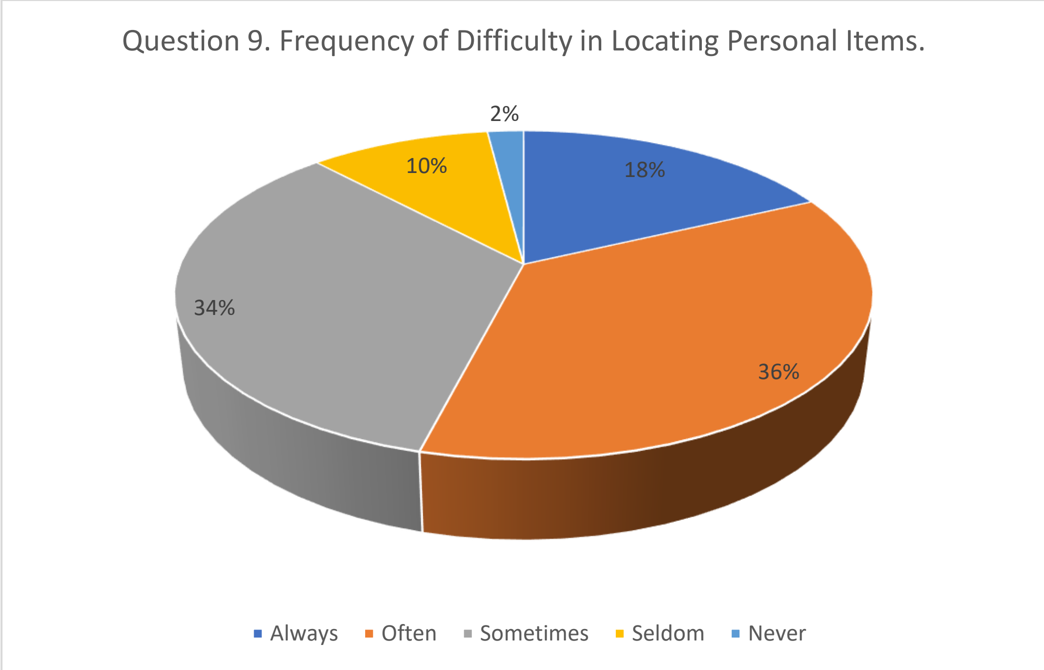

Question 4. Frequency of Losing Belongings Indoors.
26%
32%
30%
10%
2%
Always
Often
Sometimes
Seldom
Never

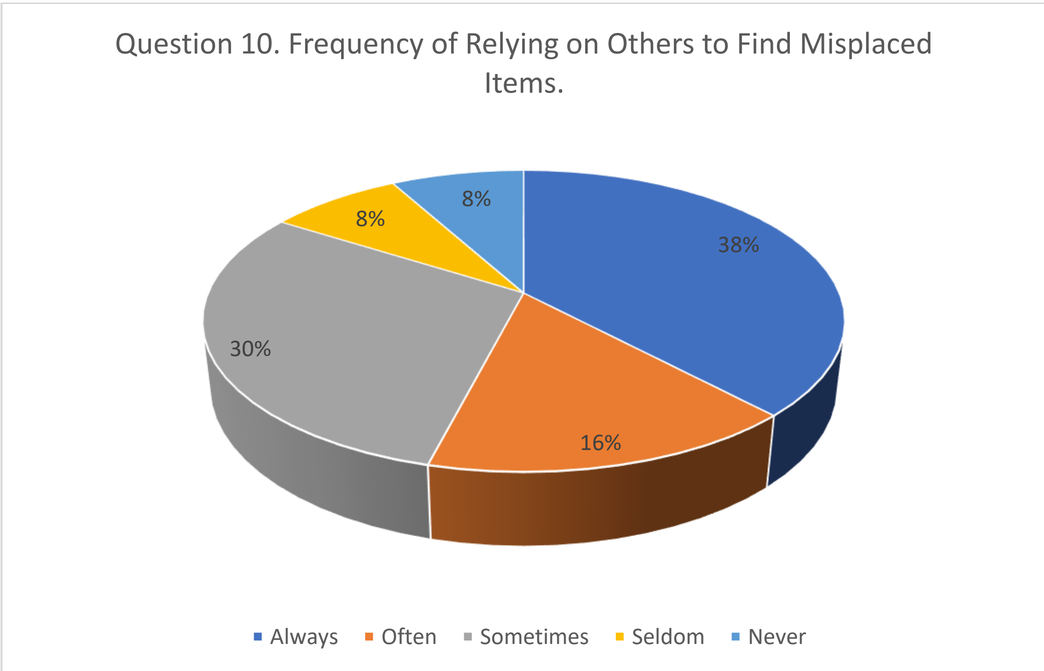

Question 5. Frequency of Losing Track of Items When in a Hurry.
0%
6%
36%
26%
32%
Always
Often
Sometimes
Seldom
Never

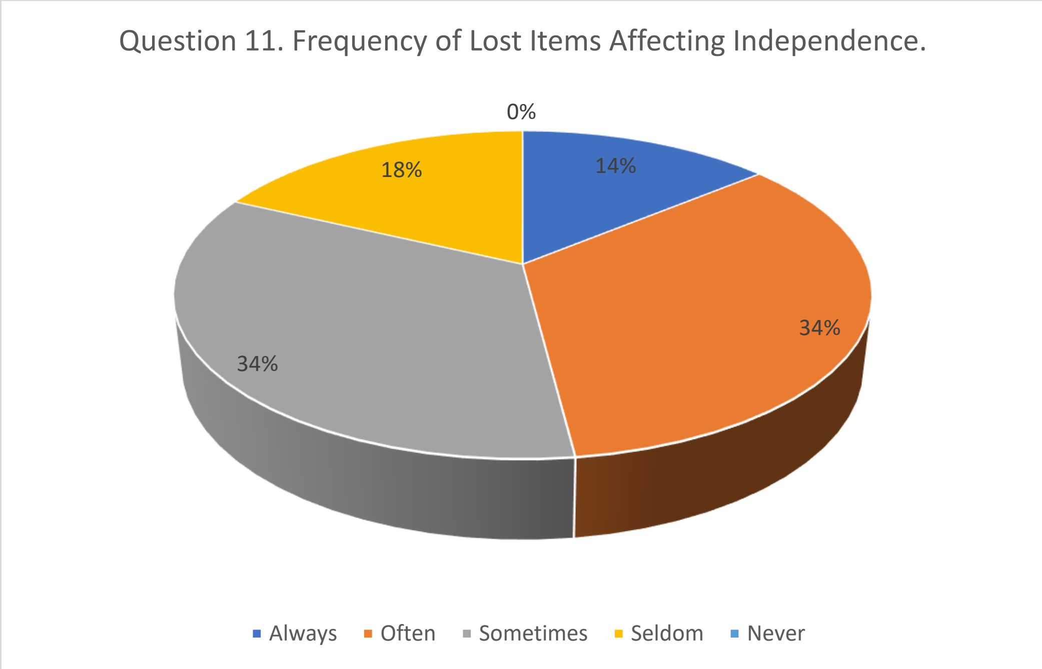

Question 6. Frequency of Realizing Items are Missing After Leaving.
2%
14%
26%
14%
44%
Always
Often
Sometimes
Seldom
Never

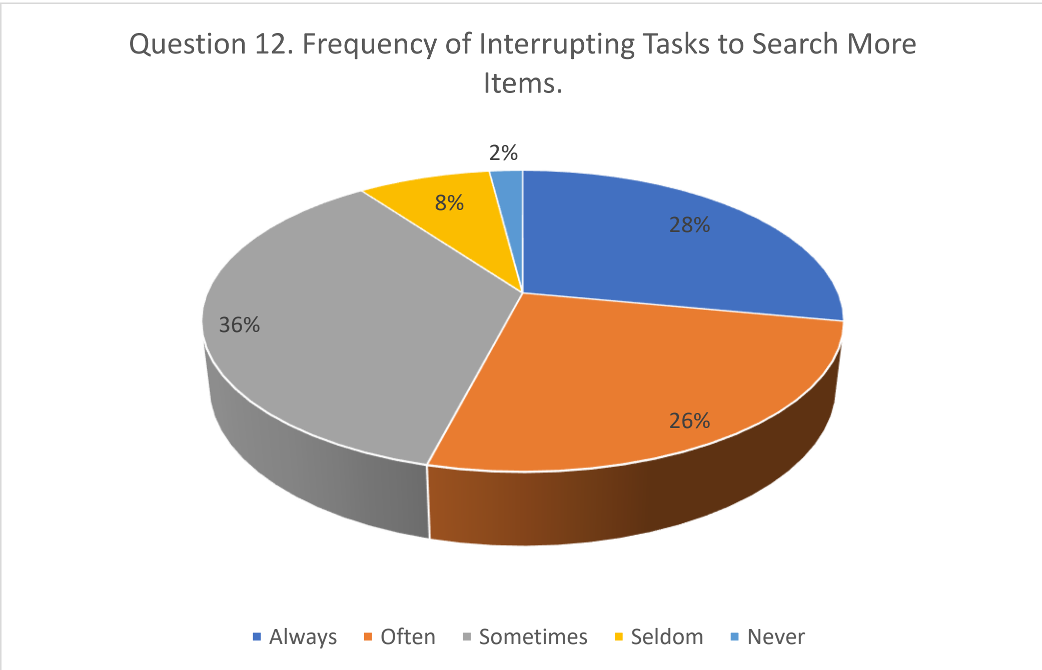

Question 7. Frequency of Repeatedly Searching the Same Spot.
2%
8%
16%
44%
30%
Always
Often
Sometimes
Seldom
Never

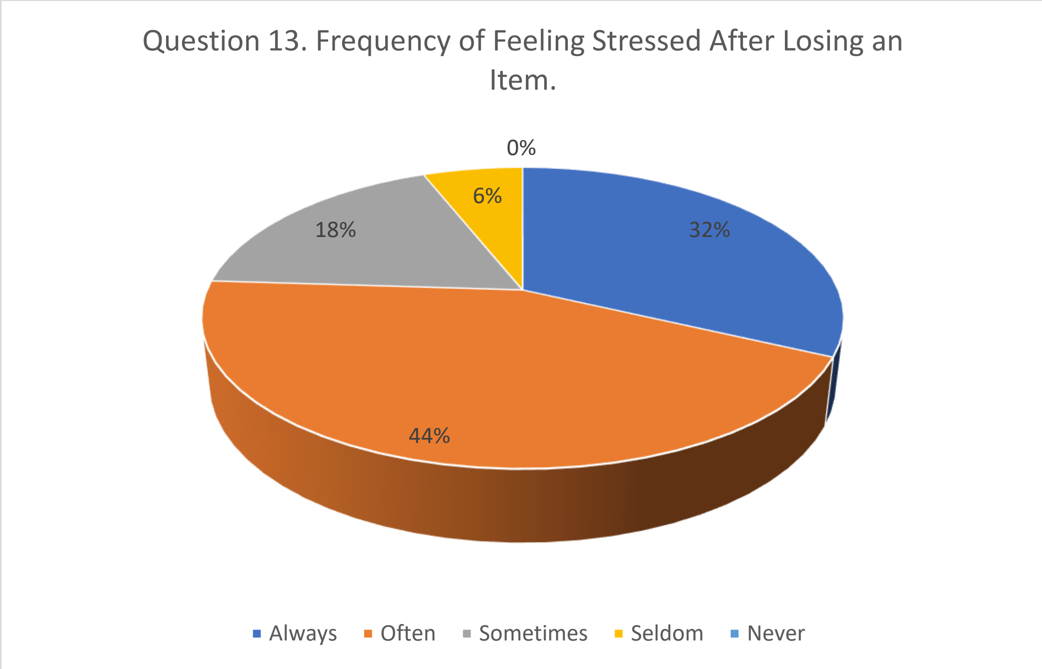

Question 8. Frequency of Using Designated Spots for Item Placement.
4%
4%
24%
26%
42%
Always
Often
Sometimes
Seldom
Never

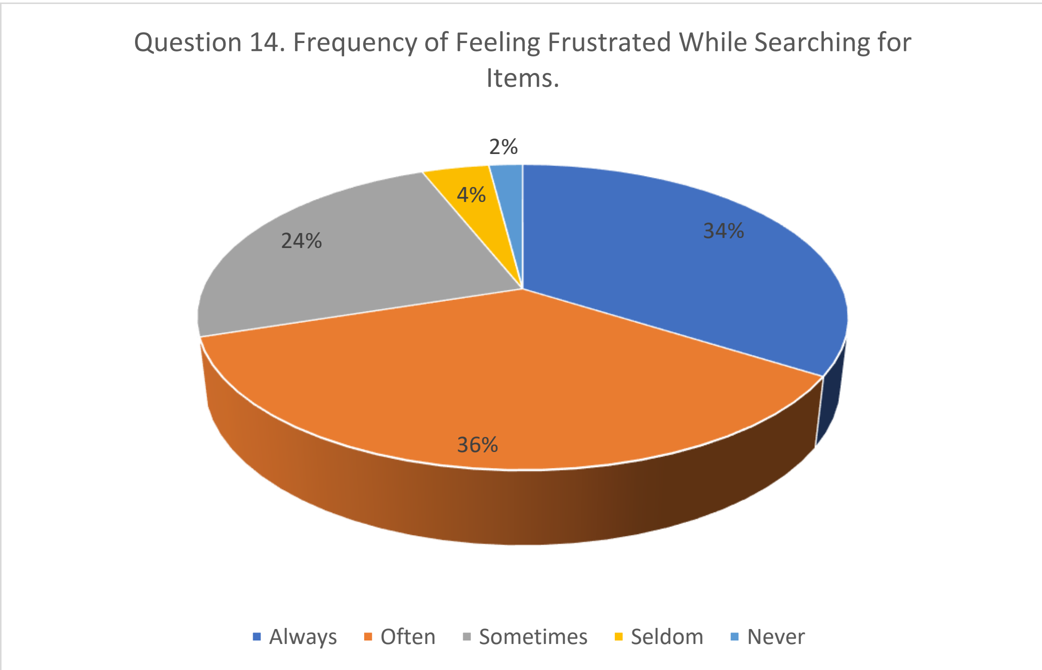

Question 9. Frequency of Difficulty in Locating Personal Items.
2%
10%
18%
34%
36%
Always
Often
Sometimes
Seldom
Never

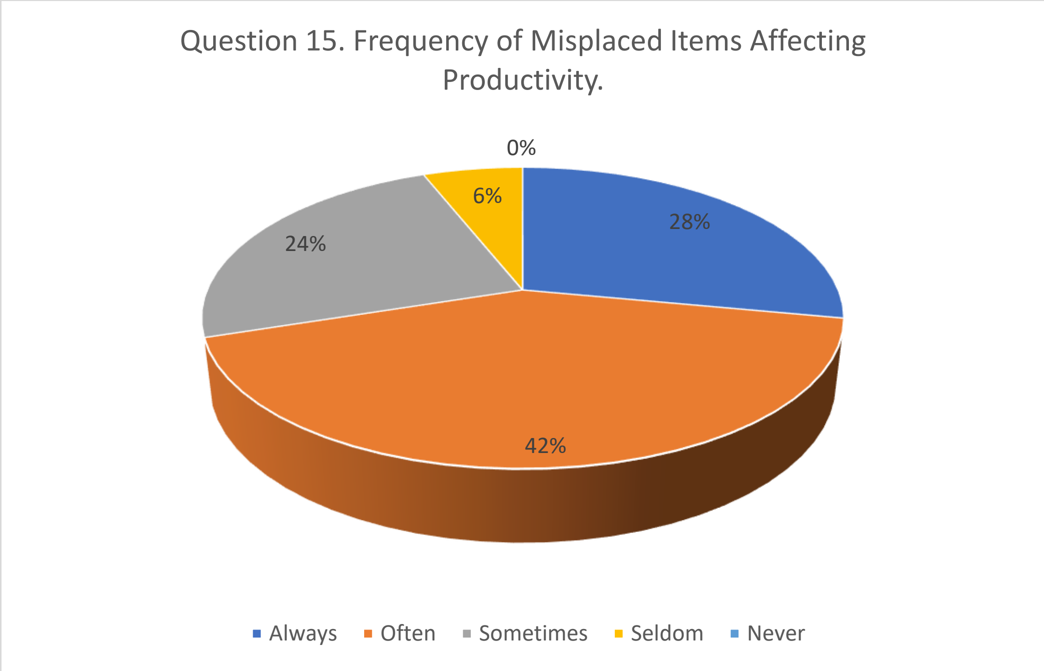

Question 10. Frequency of Relying on Others to Find Misplaced Items.
8%
8%
38%
30%
16%
Always
Often
Sometimes
Seldom
Never

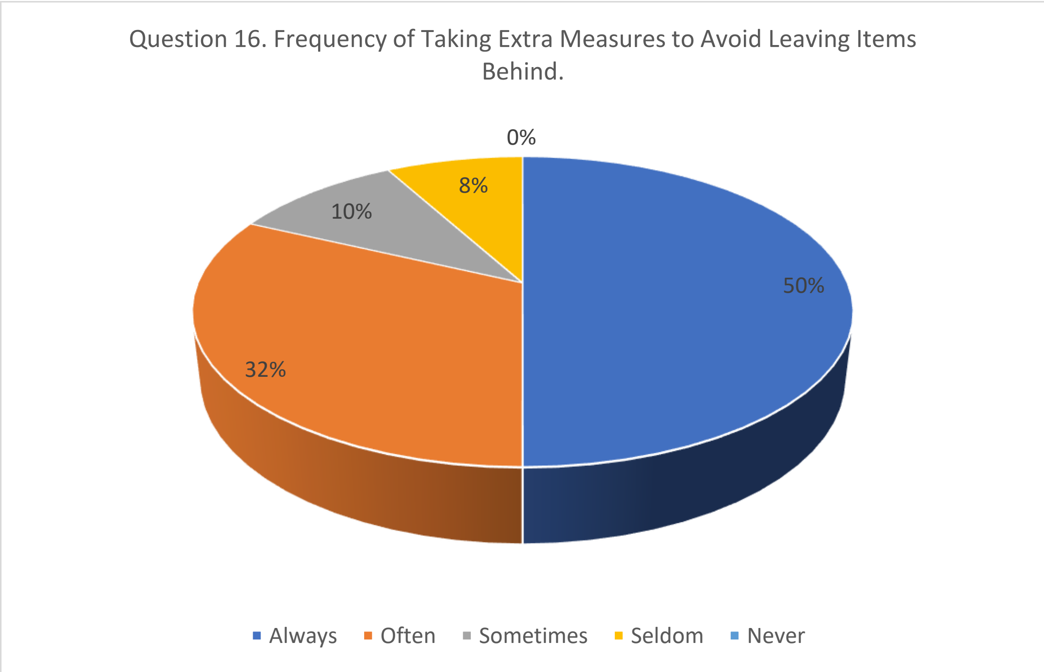

Question 11. Frequency of Lost Items Affecting Independence.
0%
14%
18%
34%
34%
Always
Often
Sometimes
Seldom
Never

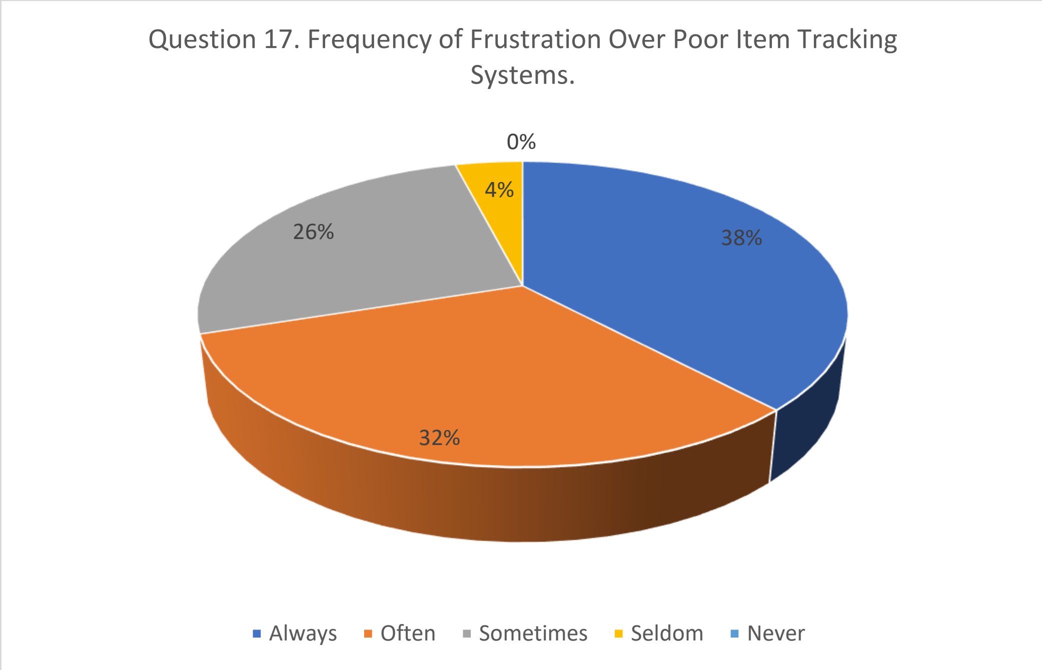

Question 12. Frequency of Interrupting Tasks to Search More Items.
2%
8%
28%
36%
26%
Always
Often
Sometimes
Seldom
Never

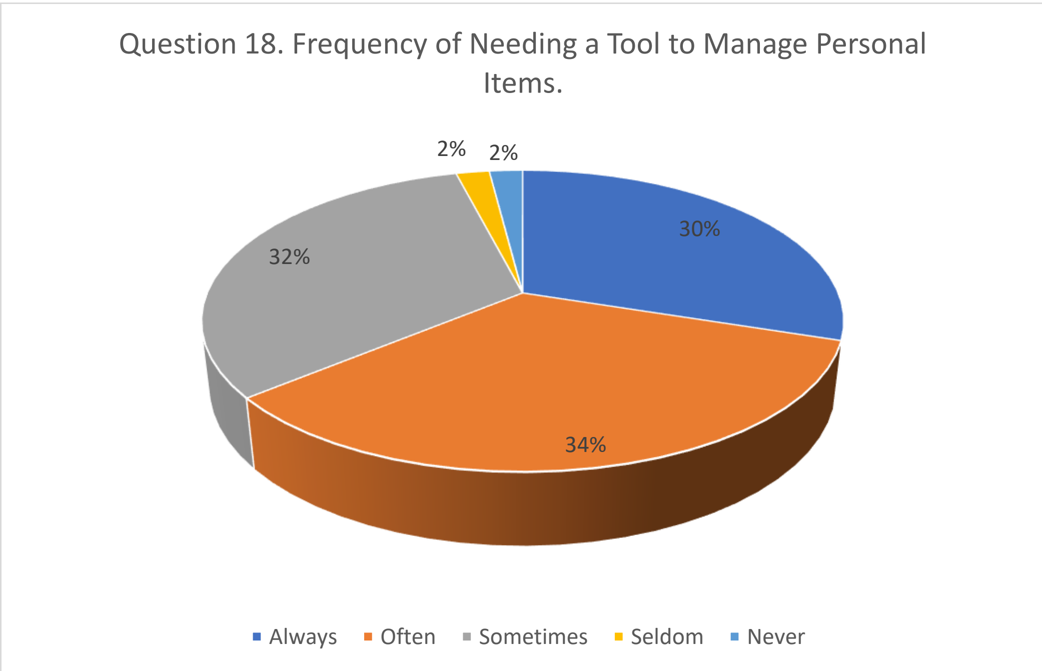

Question 13. Frequency of Feeling Stressed After Losing an Item.
0%
6%
18%
32%
44%
Always
Often
Sometimes
Seldom
Never

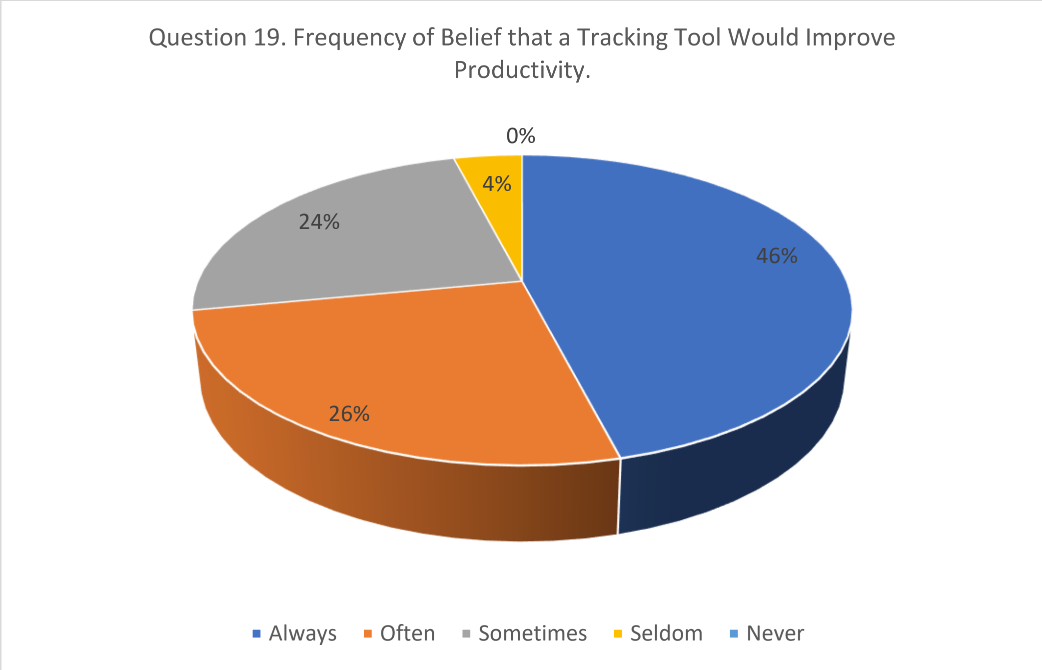

Question 14. Frequency of Feeling Frustrated While Searching for Items.
2%
4%
24%
34%
36%
Always
Often
Sometimes
Seldom
Never

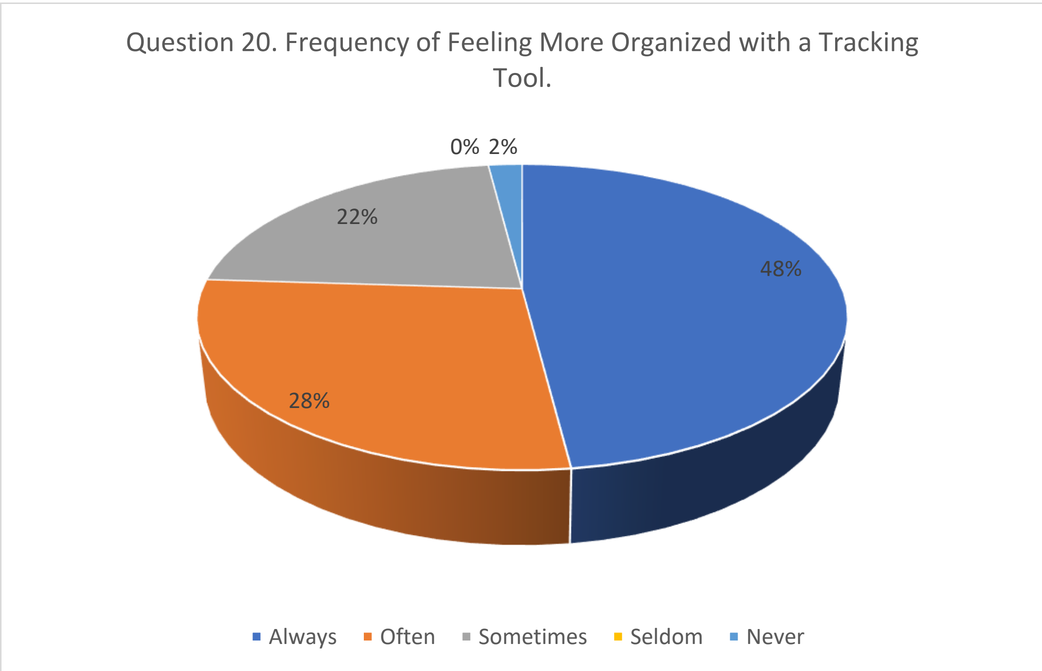

Question 15. Frequency of Misplaced Items Affecting Productivity.
0%
6%
28%
24%
42%
Always
Often
Sometimes
Seldom
Never

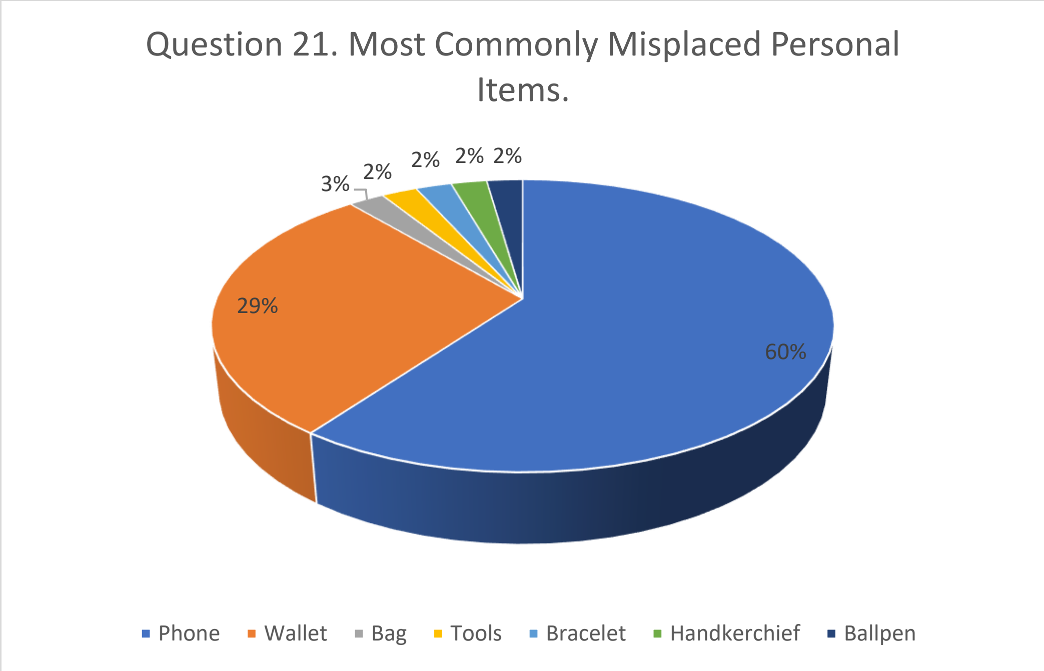

Question 16. Frequency of Taking Extra Measures to Avoid Leaving Items Behind.
0%
8%
10%
50%
32%
Always
Often
Sometimes
Seldom
Never

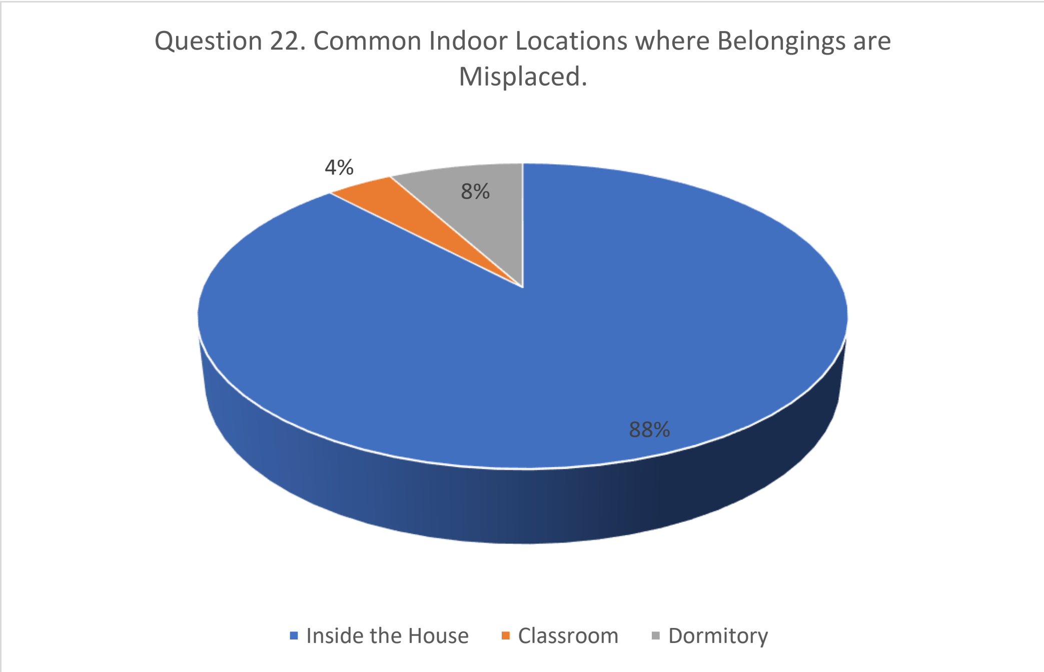

Question 17. Frequency of Frustration Over Poor Item Tracking Systems.
0%
4%
26%
38%
32%
Always
Often
Sometimes
Seldom
Never

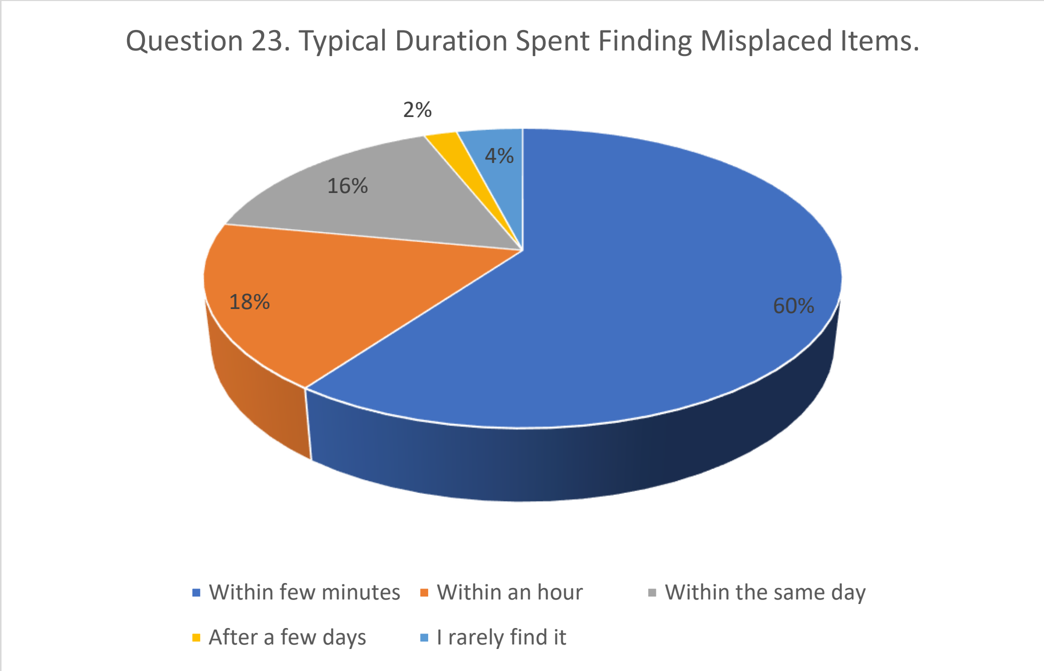

Question 18. Frequency of Needing a Tool to Manage Personal Items.
2%
2%
32%
30%
34%
Always
Often
Sometimes
Seldom
Never

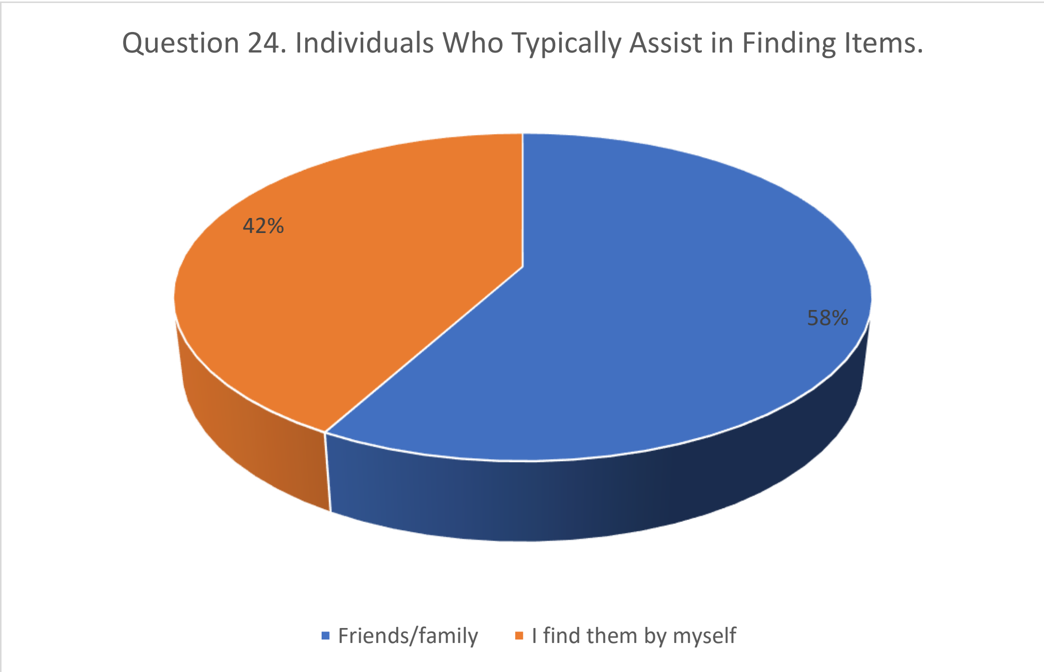

Question 19. Frequency of Belief that a Tracking Tool Would Improve Productivity.
0%
4%
24%
46%
26%
Always
Often
Sometimes
Seldom
Never

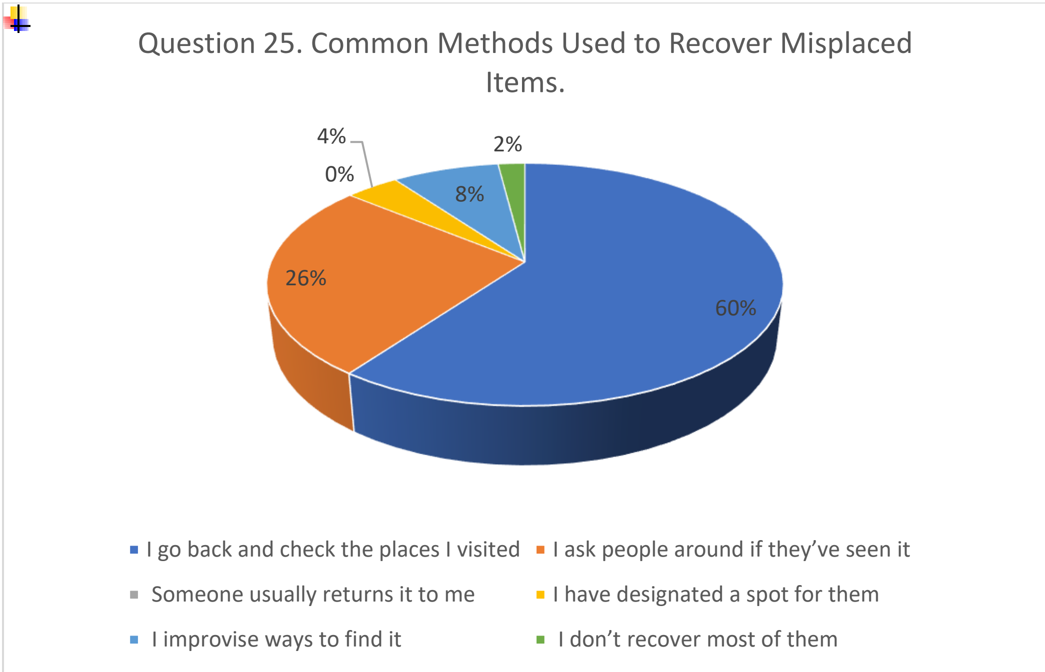

Question 20. Frequency of Feeling More Organized with a Tracking Tool.
0%
2%
22%
48%
28%
Always
Often
Sometimes
Seldom
Never


Question 21. Most Commonly Misplaced Personal Items.
3%
2%
2%
2%
2%
29%
60%
Phone
Wallet
Bag
Tools
Bracelet
Handkerchief
Ballpen


Question 22. Common Indoor Locations where Belongings are Misplaced.
4%
8%
88%
Inside the House
Classroom
Dormitory


Question 23. Typical Duration Spent Finding Misplaced Items.
2%
4%
16%
18%
60%
Within few minutes
Within an hour
Within the same day
After a few days
I rarely find it

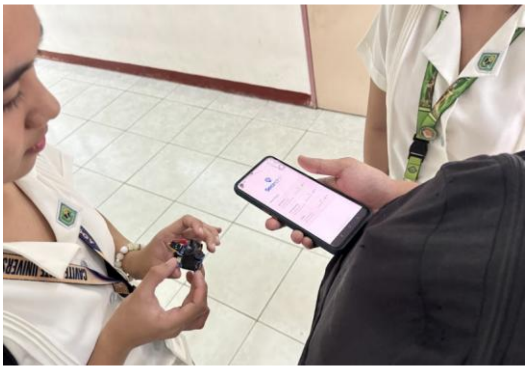

Question 24. Individuals Who Typically Assist in Finding Items.
42%
58%
Friends/family
I find them by myself


Question 25. Common Methods Used to Recover Misplaced Items.
4%
0%
2%
8%
26%
60%
I go back and check the places I visited
I ask people around if they've seen it
Someone usually returns it to me
I have designated a spot for them
I improvise ways to find it
I don't recover most of them

APPENDIX II

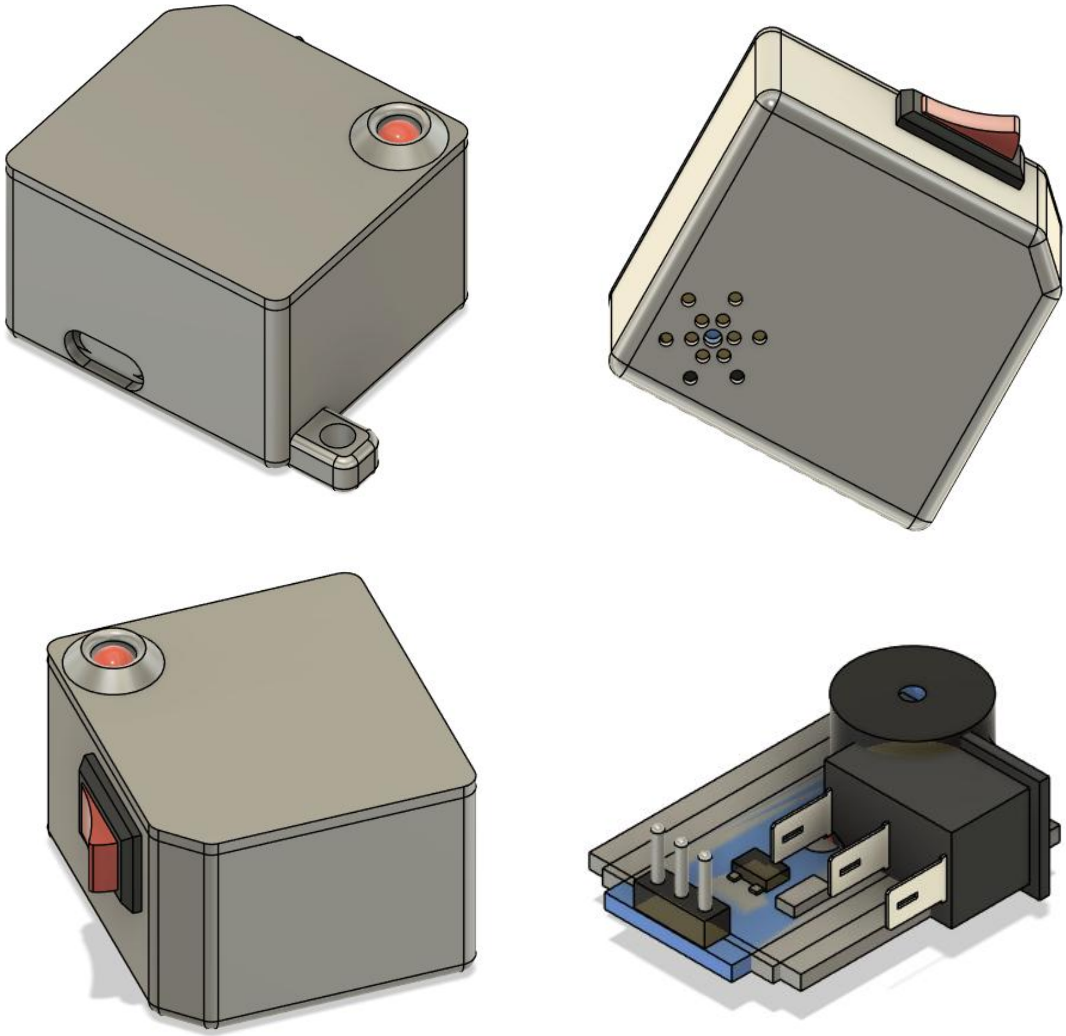
Prototype Documentation

Distance Testing



Search IT Tag Prototypes

Search IT Tag 3D Print Layout



APPENDIX III

Unit Testing

Republic of the Philippines
CAVITE STATE UNIVERSITY
Don Severino delas Alas Campus
Indang, Cavite

SEARCH IT: SMART ESP32-POWERED ACTIVE RESPONSE COMPANION HARDWARE - INTEGRATED TRACKER

Instruction: Please evaluate the system by its functionality and accuracy. Kindly put “PASSED” or “FAILED.”

Test case: 1.1
Module: Tag management module **May 21, 2025**

	CHECK IF WORKING PROPERLY	REMARKS,
USABILITY		
1. The user can successfully create a new tag and it appears in the tag list immediately.	✗	FAILED
2. The user can view all existing tags clearly in the tag list.	✗	FAILED
3. The user can rename a tag and the updated name is displayed correctly.	✗	FAILED
4. The user can delete a tag and it is removed from the tag list instantly.	✗	FAILED
5. The user is prompted for a PIN when accessing secured tags, and entering the correct PIN grants access.	✗	FAILED
PERFORMANCE		
1. A new tag is created and displayed in the tag list within 2 seconds of user action.	✗	PASSED
2. The tag list loads and displays all existing tags within 1 second.	✗	PASSED
3. Renaming a tag updates the display without delay and completes within 2 seconds.	✗	FAILED
4. Deleting a tag removes it from the list immediately, completing the action within 2 seconds.	✗	FAILED
5. Entering the correct PIN grants access to secured tags within 2 seconds.	✗	FAILED
RELIABILITY		
1. Tags remain accessible and functional after multiple creations without failure.	✗	FAILED

2. Tag information is displayed consistently even after repeated accesses.	✗	FAILED
3. Tags retain their updated names without errors after multiple renaming attempts.	✗	FAILED
4. Deleted tags are permanently removed and do not reappear after app restart.	✗	FAILED
5. Secured tags consistently require PIN entry and only allow correct PIN access every time.	✗	FAILED
COMPATIBILITY		
1. Android devices support the system.	✓	PASSED

AMANDA CATHERINE G. NOVENO
(TESTER)

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SEARCH IT: SMART ESP32-POWERED ACTIVE RESPONSE COMPANION HARDWARE - INTEGRATED TRACKER

Instruction: Please evaluate the system by its functionality and accuracy. Kindly put "PASSED" or "FAILED."

Test case: 1.2
Module: Tag management module **May 24, 2025**

	CHECK IF WORKING PROPERLY	REMARKS
USABILITY		
1. The user can successfully create a new tag and it appears in the tag list immediately.	✓	PASSED
2. The user can view all existing tags clearly in the tag list.	✓	PASSED
3. The user can rename a tag and the updated name is displayed correctly.	✓	PASSED
4. The user can delete a tag and it is removed from the tag list instantly.	✓	PASSED
5. The user is prompted for a PIN when accessing secured tags, and entering the correct PIN grants access.	✓	PASSED
PERFORMANCE		
1. A new tag is created and displayed in the tag list within 2 seconds of user action.	✓	PASSED
2. The tag list loads and displays all existing tags within 1 second.	✓	PASSED
3. Renaming a tag updates the display without delay and completes within 2 seconds.	✓	PASSED
4. Deleting a tag removes it from the list immediately, completing the action within 2 seconds.	✓	PASSED
5. Entering the correct PIN grants access to secured tags within 2 seconds.	✓	PASSED
RELIABILITY		
1. Tags remain accessible and functional after multiple creations without failure.	✓	PASSED

2. Tag information is displayed consistently even after repeated accesses.	✓	PASSED
3. Tags retain their updated names without errors after multiple renaming attempts.	✓	PASSED
4. Deleted tags are permanently removed and do not reappear after app restart.	✓	PASSED
5. Secured tags consistently require PIN entry and only allow correct PIN access every time.	✓	PASSED
COMPATIBILITY		
1. Android devices support the system.	✓	PASSED

Rdr

RAFAELLA P. DEL ROSARIO
(TESTER)

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Indang, Cavite

SEARCH IT: SMART ESP32-POWERED ACTIVE RESPONSE COMPANION HARDWARE - INTEGRATED TRACKER

Instruction: Please evaluate the system by its functionality and accuracy. Kindly put "PASSED" or "FAILED."

Test case: 2.1
Module: Locator action module **August 12, 2025**

	CHECK IF WORKING PROPERLY	REMARKS
USABILITY		
1. The Search It action button is clearly visible	✓	PASSED
2. The users can trigger tags easily in just a single tap.	✓	PASSED
PERFORMANCE		
1. The buzzer makes a sound after connecting the positive to the red wire and the negative to the black wire.	✗	FAILED
2. The LED light displays light when the anode (short leg) is connected to the black wire and the cathode (long leg) connected to the red wire.	✓	PASSED
RELIABILITY		
1. The buzzer should produce an audible sound immediately when its positive lead is connected to power and negative lead to ground.	✗	FAILED
2. The LED should light up immediately when its positive lead is connected to power and negative lead to ground through a resistor.	✓	PASSED
COMPATIBILITY		
1. The app communicates successfully with multiple tag hardware devices.	✓	PASSED

KEITH BRIAN L. CONER
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SEARCH IT: SMART ESP32-POWERED ACTIVE RESPONSE COMPANION HARDWARE - INTEGRATED TRACKER

Instruction: Please evaluate the system by its functionality and accuracy. Kindly put "PASSED" or "FAILED."

Test case: 2.2
Module: Locator action module **August 13, 2025**

	CHECK IF WORKING PROPERLY	REMARKS
USABILITY		
1. The Search It action button is clearly visible	✓	PASSED
2. The users can trigger tags easily in just a single tap.	✓	PASSED
PERFORMANCE		
1. The buzzer makes a sound after connecting the positive to the red wire and the negative to the black wire.	✓	PASSED
2. The LED light displays light when the anode (short leg) is connected to the black wire and the cathode (long leg) connected to the red wire.	✓	PASSED
RELIABILITY		
1. The buzzer should produce an audible sound immediately when its positive lead is connected to power and negative lead to ground.	✓	PASSED
2. The LED should light up immediately when its positive lead is connected to power and negative lead to ground through a resistor.	✓	PASSED
COMPATIBILITY		
1. The app communicates successfully with multiple tag hardware devices.	✓	PASSED

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SEARCH IT: SMART ESP32-POWERED ACTIVE RESPONSE COMPANION HARDWARE - INTEGRATED TRACKER

Instruction: Please evaluate the system by its functionality and accuracy. Kindly put "PASSED" or "FAILED."

Test case 3.1
Module: Signal processing module **May 21, 2025**

	CHECK IF WORKING PROPERLY	REMARKS
USABILITY		
1. The RSSI is displayed on the existing objects screen when the tag is turned off (not existing)	✗	FAILED
2. The RSSI is displayed on the existing objects screen when the tag is turned on	✗	FAILED
3. The pair device button is triggering to the enter PIN	✗	FAILED
4. The connection is successfully established after inputting an accurate PIN	✗	FAILED
5. The app can perform reconnection process	✗	FAILED
6. The out of range modal displays when the Bluetooth is turned off	✗	FAILED
7. The out of range modal displays when it exceeds more than 5 meters	✗	FAILED
PERFORMANCE		
1. The RSSI changes its values every 2 seconds on the existing objects screen	✗	FAILED
2. The RSSI changes its values every 2 seconds on the locator actions panel	✗	FAILED
3. Bluetooth signal strength is stable within a distance of up to *ten* (10) to *fifteen* (15) meters.	✗	FAILED

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SEARCH IT: SMART ESP32-POWERED ACTIVE RESPONSE COMPANION HARDWARE - INTEGRATED TRACKER

Instruction: Please evaluate the system by its functionality and accuracy. Kindly put “PASSED” or “FAILED.”

Test case 3.2
Module: Signal processing module **May 24, 2025**

	CHECK IF WORKING PROPERLY	**REMARKS**
USABILITY		
1. The RSSI is displayed on the existing objects screen when the tag is turned off (not existing)	✓	PASSED
2. The RSSI is displayed on the existing objects screen when the tag is turned on	✓	PASSED
3. The pair device button is triggering to the enter PIN	✓	PASSED
4. The connection is successfully established after inputting an accurate PIN	✓	PASSED
5. The app can perform reconnection process	✗	PASSED
6. The out of range modal displays when the Bluetooth is turned off	✗	PASSED
7. The out of range modal displays when it exceeds more than 5 meters	✗	PASSED
PERFORMANCE		
1. The RSSI changes its values every 2 seconds on the existing objects screen	✓	PASSED
2. The RSSI changes its values every 2 seconds on the locator actions panel	✓	PASSED

Kif

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SEARCH IT: SMART ESP32-POWERED ACTIVE RESPONSE COMPANION HARDWARE - INTEGRATED TRACKER

Instruction: Please evaluate the system by its functionality and accuracy. Kindly put "PASSED" or "FAILED."

Test case 3.3
Module: Signal processing module **May 29, 2025**

	CHECK IF WORKING PROPERLY	**REMARKS**
USABILITY		
1. The RSSI is displayed on the existing objects screen when the tag is turned off (not existing)	✓	PASSED
2. The RSSI is displayed on the existing objects screen when the tag is turned on	✓	PASSED
3. The pair device button is triggering to the enter PIN	✓	PASSED
4. The connection is successfully established after inputting an accurate PIN	✓	PASSED
5. The app can perform reconnection process	✓	PASSED
6. The out of range modal displays when the Bluetooth is turned off	✓	PASSED
7. The out of range modal displays when it exceeds more than 5 meters	✓	PASSED
PERFORMANCE		
1. The RSSI changes its values every 2 seconds on the existing objects screen	✓	PASSED
2. The RSSI changes its values every 2 seconds on the locator actions panel	✓	PASSED

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Instruction: Please evaluate the system by its functionality and accuracy. Kindly put "PASSED" or "FAILED."

Test case 4.1
Module: Search It tags **August 19, 2025**

	CHECK IF WORKING PROPERLY	**REMARKS**
USABILITY		
1. The device shows a red light while the battery is charging.	✗	FAILED
2. The device shows a blue light when the battery is fully charged	✗	FAILED
3. The switch button (for on and off) responds immediately when pressed.	✓	PASSED
RELIABILITY		
1. The device can be turned on and off repeatedly without malfunction.	✓	PASSED
2. The device completes shutdown safely without losing data or settings.	✓	PASSED
Compatibility		
1. The tag is small enough for proper attachment (First prototype).	✗	FAILED

Rdr

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SEARCH IT: SMART ESP32-POWERED ACTIVE RESPONSE COMPANION HARDWARE - INTEGRATED TRACKER

Instruction: Please evaluate the system by its functionality and accuracy. Kindly put "PASSED" or "FAILED."

Test case 4.2
Module: Search It tags **September 28, 2025**

	CHECK IF WORKING PROPERLY	**REMARKS**
USABILITY		
1. The device shows a red light while the battery is charging.	✓	PASSED
2. The device shows a blue light when the battery is fully charged	✓	PASSED
3. The switch button (for on and off) responds immediately when pressed.	✓	PASSED
RELIABILITY		
1. The device can be turned on and off repeatedly without malfunction.	✓	PASSED
2. The device completes shutdown safely without losing data or settings.	✓	PASSED
Compatibility		
1. The tag is small enough for proper attachment (Second prototype).	✗	FAILED

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SEARCH IT: SMART ESP32-POWERED ACTIVE RESPONSE COMPANION HARDWARE - INTEGRATED TRACKER

Instruction: Please evaluate the system by its functionality and accuracy. Kindly put "PASSED" or "FAILED."

Test case 4.3
Module: Search It tags **October 3, 2025**

	CHECK IF WORKING PROPERLY	**REMARKS**
USABILITY		
1. The device shows a red light while the battery is charging.	✓	PASSED
2. The device shows a blue light when the battery is fully charged	✓	PASSED
3. The switch button (for on and off) responds immediately when pressed.	✓	PASSED
RELIABILITY		
1. The device can be turned on and off repeatedly without malfunction.	✓	PASSED
2. The device completes shutdown safely without losing data or settings.	✓	PASSED
Compatibility		
1. The tag is compact enough to be attached securely (3D printed tag).	✓	PASSED

AMANDA CATHERINE G. NOVENO
(TESTER)

APPENDIX IV

Integration Testing

Republic of the Philippines
CAVITE STATE UNIVERSITY
Don Severino delas Alas Campus
Indang, Cavite

SEARCH IT: SMART ESP32-POWERED ACTIVE RESPONSE COMPANION HARDWARE – INTEGRATED TRACKER

INTEGRATION TESTING

Module:	Tag Management Module	
Developed by:	Keith Brian L. Coner	May 21, 2025
Tested by:	Rafaella P. del Rosario and Amanda Catherine G. Noveno	May 25, 2025

The following are the preconditions of the system:

- The application enables the user to add a maximum of three (3) objects
- The system allows the user to rename the object name
- The system allows the user to remove an existing object
- The user is required to set a PIN for authentication
- It allows the user to change the PIN when needed

Test case 1.1

Test Action	**Expected Result**	**Actual Result**	**Pass or Fail**	**Remark**
Add objects	Add a maximum of three (3) objects	The three (3) objects are successfully added	Passed	Working
Rename the object name	Object name is updated on the list	It displays a new object name	Passed	Working
Remove an existing object	Object is removed on the list	Selected object was removed and no longer displayed on the list	Passed	Working
Prevent last object deletion	System blocks deletion and keeps the last object on the list	Last object was not removed and remains displayed on the list	Passed	Working
Set PIN	The PIN is saved and is required to open an object	The PIN is stored and prompted during access	Passed	Working
Change PIN	The old PIN is replaced with a new one	The new PIN is now recognized	Passed	Working

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Indang, Cavite

SEARCH IT: SMART ESP32-POWERED ACTIVE RESPONSE COMPANION HARDWARE – INTEGRATED TRACKER

INTEGRATION TESTING

Module:	Locator Action Module	
Developed by:	Keith Brian L. Coner	
Tested by:	Keith Brian L. Coner	July 18, 2025

The following are the preconditions of the system:

- At least one (1) tag is registered in the app
- The user is authenticated with a valid PIN before performing an action.
- The app is configured to control the LED light
- The app is set up to control the buzzer

Test case 2.1				
Test Action	**Expected Result**	**Actual Result**	**Pass or Fail**	**Remark**
Verify tag	The tag is registered in the app	The tag is connected and is shown on the user interface	Passed	Working
Authenticate	The user enters the PIN and gains access to perform the action	Access is granted after logging in with a PIN	Passed	Working
Trigger LED	The LED light is turned on when clicked.	The LED light successfully turned on/off after clicking	Passed	Working
Trigger Buzzer	The buzzer sounds when the buzzer button is clicked.	The buzzer failed to emit sound on click; it produced sound right after connecting	Failed	Buzzer responds correctly (on/off), yet it sounds automatically when paired without being triggered (boot sequence)

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Indang, Cavite

SEARCH IT: SMART ESP32-POWERED ACTIVE RESPONSE COMPANION HARDWARE – INTEGRATED TRACKER

INTEGRATION TESTING

Module:	Locator Action Module	
Developed by:	Keith Brian L. Coner	
Tested by:	Keith Brian L. Coner	August 8, 2025

The following are the preconditions of the system:

- At least one (1) tag is registered in the app
- The user is authenticated with a valid PIN before performing an action.
- The app is configured to control the LED light
- The app is set up to control the buzzer

Test case 2.2

Test Action	**Expected Result**	**Actual Result**	**Pass or Fail**	**Remark**
Verify tag	The tag is registered in the app	The tag is connected and is shown on the user interface	Passed	Working
Authenticate	The user enters the PIN and gains access to perform the action	Access is granted after logging in with a PIN	Passed	Working
Trigger LED	The LED light is turned on/off when clicked	The LED light successfully turned on/off after clicking	Passed	Working
Trigger Buzzer	The buzzer sounds when the buzzer button is clicked	The buzzer failed to emit sound on click; it produced sound right after connecting	Failed	Fixing the boot sequence error by testing alternative digital pins for the buzzer

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Indang, Cavite

SEARCH IT: SMART ESP32-POWERED ACTIVE RESPONSE COMPANION HARDWARE – INTEGRATED TRACKER

INTEGRATION TESTING

Module:	Locator Action Module	
Developed by:	Keith Brian L. Coner	
Tested by:	Keith Brian L. Coner	August 14, 2025

The following are the preconditions of the system:

- At least one (1) tag is registered in the app
- The user is authenticated with a valid PIN before performing an action.
- The app is configured to control the LED light
- The app is set up to control the buzzer

Test case 2.3

Test Action	Expected Result	Actual Result	Pass or Fail	Remark
Verify tag	The tag is registered in the app	The tag is connected and is shown on the user interface	Passed	Working
Authenticate	The user enters the PIN and gains access to perform the action	Access is granted after logging in with a PIN	Passed	Working
Trigger LED	The LED light is turned on/off when clicked	The LED light successfully turned on/off after clicking	Passed	Working
Trigger Buzzer	The buzzer sounds when the buzzer button is clicked	The buzzer failed to emit sound on click; it produced sound right after connecting	Failed	Fix the boot error by adding a 1k ohm resistor to prevent the board from booting

Republic of the Philippines
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Don Severino delas Alas Campus
Indang, Cavite

SEARCH IT: SMART ESP32-POWERED ACTIVE RESPONSE COMPANION HARDWARE – INTEGRATED TRACKER

INTEGRATION TESTING

Module:	Locator Action Module	
Developed by:	Keith Brian L. Coner	
Tested by:	Keith Brian L. Coner	August 16, 2025

The following are the preconditions of the system:

- At least one (1) tag is registered in the app
- The user is authenticated with a valid PIN before performing an action.
- The app is configured to control the LED light
- The app is set up to control the buzzer

Test case 2.4				
Test Action	**Expected Result**	**Actual Result**	**Pass or Fail**	**Remark**
Verify tag	The tag is registered in the app	The tag is connected and is shown on the user interface	Passed	Working
Authenticate	The user enters the PIN and gains access to perform the action	Access is granted after logging in with a PIN	Passed	Working
Trigger LED	The LED light is turned on/off when clicked	The LED light successfully turned on/off after clicking	Passed	Working
Trigger Buzzer	The buzzer sounds when the buzzer button is clicked	The buzzer functions properly when clicked.	Passed	The tag operates with a passive buzzer instead of an active buzzer

Republic of the Philippines
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Don Severino delas Alas Campus
Indang, Cavite

SEARCH IT: SMART ESP32-POWERED ACTIVE RESPONSE COMPANION HARDWARE – INTEGRATED TRACKER

INTEGRATION TESTING

Module:	Signal Processing Module	
Developed by:	Keith Brian L. Coner	
Tested by:	Keith Brian L. Coner	May 24, 2025

The following are the preconditions of the system:
- At least one (1) Search It tag is powered on and within Bluetooth range.
- The mobile application is connected to the tag.
- The tag has a unique name assigned through Tag Management Module.
- The user is authenticated with a valid PIN .
- The application has permission to access device Bluetooth.

Test case 3.1				
Test Action	**Expected Result**	**Actual Result**	**Pass or Fail**	**Remark**
Scan for tags	The system detects nearby tags and displays it on the app	Tags are successfully detected and listed	Passed	Working
Display detected tags	Each detected tag appears with its unique name	The tag names do not show correctly on the list	Failed	Fix tag name display
Display RSSI values	RSSI values are shown for each detected tag	RSSI always displays on the first object only	Failed	Incorrect RSSI display
Update RSSI real-time	RSSI values update dynamically without noticeable delay	RSSI updates freeze at times	Failed	Signal updates inconsistent
Out-of-range notification	App displays warning when a tag moves beyond eight (8) meters	Notification delayed or inconsistent	Failed	Out-of-range detection not stable
Return tag within range	Warning disappears when tag returns to range and RSSI updates normally	Warning remains even after tag returns	Failed	Clearing logic not functioning

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INTEGRATION TESTING

Module:	Signal Processing Module	
Developed by:	Keith Brian L. Coner	
Tested by:	Keith Brian L. Coner	May 24, 2025

The following are the preconditions of the system:

- At least one (1) Search It tag is powered on and within Bluetooth range.
- The mobile application is connected to the tag.
- The tag has a unique name assigned through Tag Management Module.
- The user is authenticated with a valid PIN.
- The application has permission to access device Bluetooth.

Test case 3.2

Test Action	**Expected Result**	**Actual Result**	**Pass or Fail**	**Remark**
Scan for tags	The system detects nearby tags and displays it on the app	Tags are successfully detected and listed	Passed	Working
Display detected tags	Each detected tag appears with its unique name	The tag names display correctly	Passed	Fixed display
Display RSSI values	RSSI values are shown for each detected tag	RSSI still only appears on the first object	Failed	Incorrect RSSI display
Update RSSI real-time	RSSI values update dynamically without noticeable delay	RSSI updates freeze at times	Failed	Signal updates inconsistent
Out-of-range notification	App displays warning when a tag moves beyond eight (8) meters	Notification still delayed and inconsistent	Failed	Out-of-range detection not stable
Return tag within range	Warning disappears when tag returns to range and RSSI updates normally	Warning remains on screen	Failed	Clearing logic not functioning

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INTEGRATION TESTING

Module:	Signal Processing Module	
Developed by:	Keith Brian L. Coner	
Tested by:	Keith Brian L. Coner	May 25, 2025

The following are the preconditions of the system:

- At least one (1) Search It tag is powered on and within Bluetooth range.
- The mobile application is connected to the tag.
- The tag has a unique name assigned through Tag Management Module.
- The user is authenticated with a valid PIN.
- The application has permission to access device Bluetooth.

Test case 3.3

Test Action	**Expected Result**	**Actual Result**	**Pass or Fail**	**Remark**
Scan for tags	The system detects nearby tags and displays it on the app	Tags are successfully detected and listed	Passed	Working
Display detected tags	Each detected tag appears with its unique name	The tag names display correctly	Passed	Fixed display
Display RSSI values	RSSI values are shown for each detected tag	Correct RSSI displays per tag	Passed	Working
Update RSSI real-time	RSSI values update dynamically without noticeable delay	Real-time updates smoothly	Passed	Working
Out-of-range notification	App displays warning when a tag moves beyond eight (8) meters	Notification still inconsistent at times	Failed	Inconsistent
Return tag within range	Warning disappears when tag returns to range and RSSI updates normally	Warning remains on screen	Failed	Clearing logic not functioning

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INTEGRATION TESTING

Module:	Signal Processing Module	
Developed by:	Keith Brian L. Coner	
Tested by:	Keith Brian L. Coner	May 29, 2025

The following are the preconditions of the system:

- At least one (1) Search It tag is powered on and within Bluetooth range.
- The mobile application is connected to the tag.
- The tag has a unique name assigned through Tag Management Module.
- The user is authenticated with a valid PIN.
- The application has permission to access device Bluetooth.

Test case 3.4

Test Action	**Expected Result**	**Actual Result**	**Pass or Fail**	**Remark**
Scan for tags	The system detects nearby tags and displays it on the app	Tags are successfully detected and listed	Passed	Working
Display detected tags	Each detected tag appears with its unique name	The tag names display correctly	Passed	Fixed display
Display RSSI values	RSSI values are shown for each detected tag	Correct RSSI displays per tag	Passed	Working
Update RSSI real-time	RSSI values update dynamically without noticeable delay	Real-time updates smoothly	Passed	Working
Out-of-range notification	App displays warning when a tag moves beyond eight (8) meters	Warning appears immediately when tag is out of range	Passed	Working
Return tag within range	Warning disappears when tag returns to range and RSSI updates normally	Warning clears correctly and RSSI updates resume	Passed	Working

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INTEGRATION TESTING

Module:	Search IT Tag	
Developed by:	Keith Brian L. Coner	
Tested by:	Keith Brian L. Coner	

The following are the preconditions of the system:

- At least one (1) Search It tag is registered in the application.
- The tag is powered on.
- The mobile application is connected to the tag.
- The user is authenticated with a valid PIN.
- The mobile device has Bluetooth permissions enabled

Test case 4.1

Test Action	**Expected Result**	**Actual Result**	**Pass or Fail**	**Remark**
Register tag	Tag is successfully registered in the application	Tag is registered and displayed in the list	Passed	Working
Display tag status	Application displays correct status of the tag	Status not updating correctly	Failed	
Remove tag	Tag is successfully removed from the application	Tag removed and no longer displayed	Passed	Working
Detect-power off	When tag is powered off, it is shown as disconnected	Tag remains displayed	Failed	Status not updating correctly
Handle drained battery	When the battery is drained, the tag disappears and shows disconnected automatically	Tag remains visible and appears connected even when battery is drained	Failed	Not detecting battery drain

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INTEGRATION TESTING

Module:	Search IT Tag	
Developed by:	Keith Brian L. Coner	
Tested by:	Keith Brian L. Coner	

The following are the preconditions of the system:

- At least one (1) Search It tag is registered in the application.
- The tag is powered on.
- The mobile application is connected to the tag.
- The user is authenticated with a valid PIN.
- The mobile device has Bluetooth permissions enabled

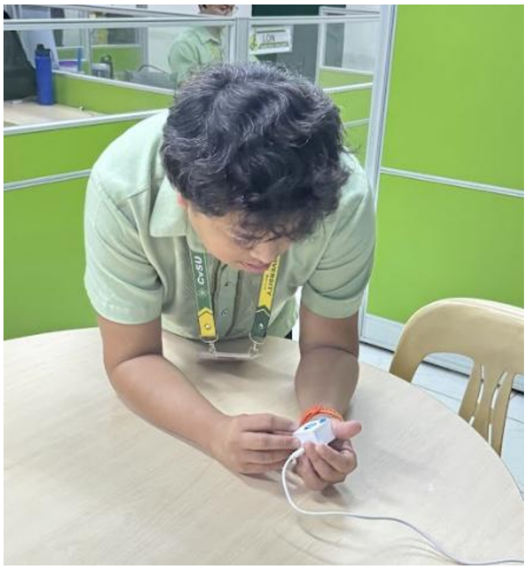
Test case 4.2

Test Action	**Expected Result**	**Actual Result**	**Pass or Fail**	**Remark**
Register tag	Tag is successfully registered in the application	Tag is registered and displayed in the list	Passed	Working
Display tag status	Application displays correct status of the tag	Tag status updates correctly	Passed	Working
Remove tag	Tag is successfully removed from the application	Tag removed and no longer displayed	Passed	Working
Detect-power off	When tag is powered off, it is shown as disconnected	Tag disappears and shows disconnected	Passed	Working
Handle drained battery	When the battery is drained, the tag disappears and shows disconnected automatically	Tag remains visible and appears connected even when battery is drained	Failed	Not detecting battery drain

APPENDIX V

Evaluation Documentation

Evaluation of Technical Participants



Evaluation of Non-Technical Users

APPENDIX VI

Evaluation Questionnaire

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SEARCH IT: SMART ESP32-POWERED ACTIVE RESPONSE COMPANION HARDWARE – INTEGRATED TRACKER

Proponents: Keith Brian L Coner, Rafaella P. del Rosario, Amanda Catherine G. Noveno

Evaluators Name (Optional): ______________________________

Types of Evaluator: ☐ **Instructor** ☐ **Student** ☐ **Others:** ________

Instruction: Please kindly evaluate the software material by using the given scale and placing a checkmark (✓) under the corrupting numerical rating.

NUMERICAL RATING	EQUIVALENT	DEFINITION
5	Excellent	The system fully meets and far exceeds the most expectations
4	Very Good	The system fully meets all and exceeds several expectations.
3	Good	The system fully meets all expectations.
2	Fair	The system does not fully meet all expectations.
1	Poor	The system fails to meet expectation to a significant degree in several areas.

INDICATORS	5	4	3	2	1
A. FUNCTIONALITY					
1. The system allows users to register and manage tags with unique names and passwords effectively.					
2. The LED light on the tag can be successfully activated through the application.					
3. The buzzer on the tag can be successfully activated through the application.					
4. The app displays nearby tags and its proximity status correctly.					
B. RELIABILITY					

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1. The Search It app saves registered tags correctly without losing data.					
2. The app allows users to perform the Search It action without any errors or interruptions.					
3. Do password-protected actions consistently block unauthorized access? **C. USABILITY**					
1. The mobile application interface is easy to understand and navigate.					
2. Users can easily switch between different features like adding, editing, and searching tags.					
3. The application's design provides clear visuals.					
D. EFFICIENCY					
1. The system responds quickly when triggering the buzzer and LED features.					
2. Search actions are completed with minimal waiting time.					
3. The system performs smoothly without causing delays.					
E. PORTABILITY					
1. The tag is lightweight and convenient to carry around.					
2. The tag design allows it to be attached to different types of personal belongings.					
3. The battery can last up to two (2) hours and thirty-three (33) minutes of continuous use.					
F. ACCURACY					
1. The system provides accurate proximity detection within a five (5) meter range.					
2. The buzzer activates at the correct distance indicated in the system and is clearly audible up to five (5) meters.					
3. The LED light activates at the correct distance indicated in the system and remains visible indoors.					

- *Based on ISO 25010*

Suggestions:

____

____

____

Signature

APPENDIX VII

Sample Evaluation Questionnaire

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SEARCH IT: SMART ESP32-POWERED ACTIVE RESPONSE COMPANION

HARDWARE – INTEGRATED TRACKER

Proponents: Keith Brian L Coner, Rafaella P. del Rosario, Amanda Catherine G. Noveno

Evaluators Name (Optional): ____________________

Types of Evaluator: [✓] **Instructor** [ ] **Student** [ ] **Others:** ________

Instruction: Please kindly evaluate the software material by using the given scale and placing a checkmark (✓) under the corrupting numerical rating.

NUMERICAL RATING	EQUIVALENT	DEFINITION
5	Excellent	The system fully meets and far exceeds the most expectations
4	Very Good	The system fully meets all and exceeds several expectations.
3	Good	The system fully meets all expectations.
2	Fair	The system does not fully meet all expectations.
1	Poor	The system fails to meet expectation to a significant degree in several areas.

INDICATORS	5	4	3	2	1
A. FUNCTIONALITY					
1. The system allows users to register and manage tags with unique names and passwords effectively.		✓			
2. The LED light on the tag can be successfully activated through the application.		✓			
3. The buzzer on the tag can be successfully activated through the application.	✓				
4. The app displays nearby tags and its proximity status correctly.		✓			
B. RELIABILITY					
1. The Search It app saves registered tags correctly without losing data.	✓				
2. The app allows users to perform the Search It action without any errors or interruptions.	✓				
3. Do password-protected actions consistently block unauthorized access?		✓			

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C. USABILITY					
1. The mobile application interface is easy to understand and navigate.	✓				
2. Users can easily switch between different features like adding, editing, and searching tags.	✓				
3. The application's design provides clear visuals.		✓			
D. EFFICIENCY					
1. The system responds quickly when triggering the buzzer and LED features.	✓				
2. Search actions are completed with minimal waiting time.		✓			
3. The system performs smoothly without causing delays.		✓			
E. PORTABILITY					
1. The tag is lightweight and convenient to carry around.	✓				
2. The tag design allows it to be attached to different types of personal belongings.		✓			
3. The battery can last up to two (2) hours and thirty-three (33) minutes of continuous use.	✓				
F. ACCURACY					
1. The system provides accurate proximity detection within a five (5) meter range.		✓			
2. The buzzer activates at the correct distance indicated in the system and is clearly audible up to five (5) meters.		✓			
3. The LED light activates at the correct distance indicated in the system and remains visible indoors.	✓				

- *Based on ISO 25010*

Suggestions:

Multiple connection / devices
Consider using GPS Module
Higher battery capacity w/o compromising the size
Lower power usage of device

Signature

APPENDIX VIII

Letters, Certifications, and Other Documents

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October 1, 2025

DR. WILLIE C. BUCLATIN
Dean

Dear Dr. Buclatin:

Greetings!

We, the undersigned, fourth year Bachelor of Science in Information Technology students of this University, are tasked to conduct research for our ongoing capstone project entitled *"SEARCH IT: Smart ESP32-Powered Active Response Companion Hardware- Integrated Tracker"*. The purpose of our research is to develop an object locator as an innovative solution to help people to easily track their personal belongings when misplaced.

In line with this, we respectfully request your permission to conduct a face-to-face software evaluation with one hundred (100) randomly selected students from this college and ten (10) professionals with relevant technical background. The evaluation will be carried out in accordance with the institution's guidelines, ethical standards, and the Data Privacy Act of 2012 (Republic Act 10173). It will also be administered at a schedule convenient to the respondents.

We sincerely hope for your kind consideration of this request and look forward to your favorable response.

Sincerely,

KEITH BRIAN L. CONER
Researcher
main.keithbrian.coner@cvsu.edu.ph

RAFAELLA P. DEL ROSARIO
Researcher
main.rafaella.delrosario@cvsu.edu.ph

AMANDA CATHERINE G. NOVENO
Researcher
main.amandacatherine.noveno@cvsu.edu.ph

Recommending Approval:

MARK PHILIP M. SY
Adviser

MA. FATIMA B. ZUÑIGA
Technical Critic

GLADYS G. PEREY
Unit Research Coordinator

CHARLOTTE B. CARANDANG
Department Chairperson

Approved:

WILLIE C. BUCLATIN, PhD, *ASEAN Eng*
College Dean