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PAPER

ZeroTouchBin: Contactless IoT Smart Trash Can

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ABSTRACT

Waste management in public areas still faces issues of physical contact on bin lids, overflowing waste and lack of real-time monitoring. This situation can affect environmental cleanliness and increase the risk of surface contamination, especially in locations with high usage rates such as colleges, canteens, laboratories and offices. This article presents ZeroTouchBin, a prototype of a touchless smart bin that combines an ultrasonic sensor, ESP32 microcontroller, servo motor and Blynk IoT application. This system allows the bin lid to be opened automatically when an object or hand is detected at a set distance, while a second sensor is used to measure the fullness of the waste. The reading data is sent to the Blynk Cloud via WiFi connection and displayed on the user's smartphone. Product development is carried out using the ADDIE model which covers the analysis, design, development, implementation and evaluation phases. Testing is carried out in stages through sensor testing, servo testing, WiFi connection testing, Blynk datastream testing, notification testing and overall system testing. The findings show that the system can serve as a practical prototype for touchless waste disposal and full-level digital monitoring. This innovation has the potential to support modern hygiene practices, more efficient waste management and the concept of a sustainable smart environment.

KEYWORDS

ZeroTouchBin; Internet of Things; Smart Trash Can; Ultrasonic Sensor; Blynk IoT; ESP32

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1. INTRODUCTION

Solid waste management is an important aspect in ensuring cleanliness, comfort and public health safety. In educational environments such as community colleges, trash cans are frequently used by students, staff and visitors. Although conventional trash cans are easily available, their use still depends on manual actions such as opening the lid, checking the full level and waiting for cleaning action. In high-use situations, the lack of a monitoring system can cause the bins to be left full for too long, producing unpleasant odors, attracting insects and affecting the image of the environment.

The issue of surface hygiene has become more prominent after the increase in public awareness of disease prevention practices. The lid of the trash can that is repeatedly touched can become an unhygienic surface. Users also tend to avoid touching dirty lids, and waste may be thrown on the side of the bin. This problem shows that trash cans should not only function as waste storage containers, but also need to be designed as tools that are more responsive to user behavior and hygiene management needs. The development of the Internet of Things (IoT) opens up the space for smarter solutions. Through the combination of sensors, microcontrollers, wireless networks and mobile applications, everyday objects can be monitored and controlled in real time [1]-[4]. In the context of waste management, IoT technology can be used to detect the fullness of bins, send information to users or management, and reduce reliance on manual inspections. This approach is in line with the concept of smart cities and data-driven facility management.

Previous studies and projects related to smart bins have typically focused on full level detection using ultrasonic sensors, indicator displays or notification delivery via applications [5]-[9]. However, there is still room for improvement in terms of design simplicity, development costs, suitability for TVET student learning and integration of touchless automation with digital monitoring. At the educational level, good innovations need to not only be technically functional, but also easy to understand, easy to test and can be presented as evidence of learning real IoT applications.

Based on this gap, the ZeroTouchBin project was developed as a prototype of a smart bin that combines two main functions. The first function is the automatic opening of the lid using ultrasonic sensors and servo motors. The second function is monitoring the fullness of the bin through additional ultrasonic sensors and data transmission to the Blynk IoT application. The use of ESP32 was chosen because this microcontroller has built-in WiFi capabilities, is affordable and suitable for the development of prototype-scale IoT systems [10], [11].

The objectives of this innovation are to develop a touchless trash can, produce a full level detection system, provide smart notifications via the Blynk application and improve the level of cleanliness and efficiency of waste management.

This article is provided to describe the development of ZeroTouchBin as a student innovation product that has the potential to be applied in educational institutions, offices, public areas and spaces that require better hygiene control.

2. METHOD

2.1 Product Development Design

The development of ZeroTouchBin used the ADDIE model consisting of Analysis, Design, Development, Implementation and Evaluation. This model was chosen because it provided a clear work sequence for a project that combines hardware, software and IoT communication. In the analysis phase, the group identified three main problems, namely the need for physical contact with conventional bins, the lack of remote monitoring and the lack of integration of modern technology. The target users include students, staff, sanitation management and users in public areas such as canteens, workshops and libraries.

2.2 Materials, Hardware and Software

Table 1. ZeroTouchBin main components

Components/Software	Function	Role in ZeroTouchBin
ESP32	WiFi processing and communication unit	Sending sensor data to Blynk Cloud
Ultrasonic sensor HC-SR04 (2 units)	Distance detection	One sensor detects hands/objects, one sensor detects trash level
Servo motors	Mechanical actuator	Opening and closing the barrel lid
Trash can/case	Physical structure	Component installation location
Jumper wires and power source	Electrical connection	Provides power and connections between components
Arduino IDE	Code development	Writing and uploading code to ESP32
Blynk IoT	Dashboard and notifications	Displays real-time data and sends alerts

Table 1 shows the combination of components used. The selection of components was made based on cost, ease of installation and ability to support IoT functions. Ultrasonic sensors were used because they can read the distance of objects without contact, while servos were used to produce mechanical movement of the cover. The Blynk application was chosen because it provides an easy-to-configure dashboard, datastream and notifications for educational prototypes [12].

2.3 System Architecture and Operational Flow

The ZeroTouchBin architecture is divided into three layers, namely the hardware layer, the network layer and the application layer. The hardware layer includes the ultrasonic sensor, ESP32 and servo motor. The network layer involves the WiFi connection from the ESP32 to the Blynk Cloud. The application layer involves displaying status and notifications on the user's smartphone. The system flow is as follows: Sensor -> ESP32 -> WiFi -> Blynk Cloud -> Smartphone.

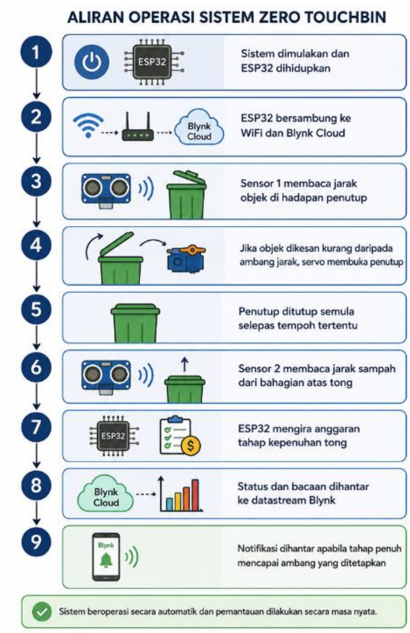

Figure 1. ZeroTouchBin system operation flow

2.4 Testing Method

Testing was conducted in stages to ensure that each component was functional before full integration was performed. The first test involved an ultrasonic sensor to ensure that the object distance could be read stably. The second test involved a servo motor to ensure that the lid could be opened and closed smoothly. The third test assessed the WiFi connection and the ESP32 connection to the Blynk Cloud. The fourth test checked the data display on the Blynk dashboard and the notification function. Finally, a test of the entire system was conducted to ensure that all components could operate simultaneously without conflict.

3. RESULT AND DISCUSSION

3.1 Product Design Results

The development results show that ZeroTouchBin has been successfully realized as a prototype of a smart trash can that has two main functions, namely touchless automation and digital monitoring of the level of fullness. From the physical aspect, the first sensor is installed on the outside of the lid to detect the presence of a hand or object. When the distance reading is below a threshold value, the ESP32 sends a command to the servo to open the lid. After a few seconds, the lid closes again automatically. This function allows users to throw away garbage without touching the surface of the bin.

The second sensor is installed inside the bin and faces downwards to measure the distance between the sensor and the surface of the garbage. This distance reading is used to estimate the level of fullness of the bin in percentage form. When the reading reaches the set threshold value, the system sends the status of 'Bin Full' to the Blynk application. This approach reduces the need for manual checks and allows users or management to know the status of the bin in advance.

The display on the Blynk IoT functions as a monitoring interface. The datastream used includes object detection distance readings, lid status, garbage level in percentage and bin status. The use of a digital dashboard makes the system more user-friendly because information can be viewed via a smartphone. Compared to physical indicators such as LEDs or buzzers, app notifications are more suitable for remote monitoring and do not produce noise disturbances in public spaces.

Table 2. Blynk datastream structure proposal

Datastream	Data	Reading type	Function
V0	Object detection distance	cm	Shows front sensor readings
V1	Servo status	0/1	Shows closed or open status
V2	Garbage level	%	Shows the estimated capacity of the bin
V3	Barrel status	text	Empty, almost full or full

3.2 System Testing Results

Table 3. Summary of ZeroTouchBin testing

Test type	Test focus	Brief findings
Ultrasonic sensor 1	Hand/object detection	The sensor can detect nearby objects and activate the servo
Ultrasonic sensor 2	Full level reading	Distance readings can be used to estimate litter levels
Servo motors	Opening the lid	The lid moves according to the ESP32 commands.
WiFi and Blynk	IoT Connection	Data can be sent to Blynk Cloud when WiFi is stable
Blynk Datastream	Real-time display	Distance, percentage and status readings can be displayed
Blynk Notification	Full bin warning	Notifications can be sent when thresholds are reached
Overall system	Integration of all functions	The system works as a complete prototype without touch and digital monitoring

Table 4 summarizes the results of the tests carried out. The first sensor test showed that the system was able to detect objects in front of the lid and trigger the movement of the servo. This is important because the contactless function is a key value of the innovation. The second sensor test proved that the distance reading can be used as a basis for determining the fullness level of the bin. Although the sensor reading can be affected by the shape and position of the waste, the system can still provide a practical picture of the capacity status for prototyping purposes.

The WiFi and Blynk connection tests showed that data transmission depends on network stability. When the connection is good, the ESP32 can send data to the Blynk Cloud and the dashboard can display the system status in real time. The 'Bin Full' notification can also be received by the user. This finding shows that the IoT integration provides a clear advantage over conventional bins because the system status does not need to be physically checked.

The overall system test showed that all components can operate simultaneously. The sensor, servo, ESP32, WiFi and Blynk play their respective roles in an integrated workflow. From a learning perspective, this project demonstrates the application of the concepts of input, process, output and data communication in a physical product. This makes ZeroTouchBin suitable as a TVET innovation project because it combines elements of programming, electronics, physical design and real-world problem solving.

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3.3 Discussion on the Advantages of Innovation

The first advantage of ZeroTouchBin is the reduction of physical contact. This feature is relevant for spaces that require high cleanliness such as computer labs, lecture halls, offices, clinics, canteens and suraus. When users do not need to touch the lid of the bin, the risk of surface contamination can be reduced. This advantage also increases user comfort as the waste disposal process becomes easier and cleaner.

The second advantage is full digital level monitoring. Conventional bins require manual checks by cleaning workers. ZeroTouchBin allows bin status to be monitored via an app, thus supporting more information-based work management. If this system is expanded to several bins in different locations, management can create more efficient collection schedules based on actual status rather than just routine checks.

The third advantage is the cost and usability of the prototype. Components such as ESP32, HC-SR04 and servos are easily available and suitable for student projects. The system design can also be upgraded as needed, for example using a rechargeable power source, waterproof casing, more accurate sensors or database integration. This flexibility makes the project potentially expandable from educational prototypes to small-scale pre-commercial products.

From a sustainability perspective, ZeroTouchBin supports more organized waste management practices. Early notification can reduce the incidence of bin overflows, thus helping to maintain a clean environment. This innovation is also in line with sustainable development goals that emphasize cleaner, healthier and more efficient urban environments and communities [13], [14].

3.4 Technical Challenges and Improvements

Several challenges were identified during development. The main challenge is the stability of the WiFi connection. IoT systems rely on a good network; if coverage is poor, data may be delayed or notifications may not be received. Therefore, future versions may provide temporary data storage modes or use alternative communications such as LoRa or cellular networks for wider locations.

The second challenge is the accuracy of the ultrasonic sensor readings in the bin. Readings can be affected by the uneven shape of the trash, materials that absorb ultrasonic waves, or the position of the sensor. Improvements can be made by using averaging methods, data filters, additional sensors, or a more stable sensor mounting design. In addition, the determination of the full threshold needs to be calibrated according to the actual bin size.

The third challenge is power management. A prototype using a regular battery may be suitable for demonstration, but long-term operation requires a more stable power source such as a power bank, 5V adapter, or rechargeable battery system. For outdoor applications, a protective case should also be added to protect the ESP32 and the wire connections from dust, water, and shock.

Overall, the challenges identified do not affect the basic functionality of the prototype. On the contrary, they open up clear room for improvement. With improvements in networking, sensor accuracy, electrical safety and physical design, ZeroTouchBin has the potential to be enhanced as a more robust innovative product for use in public areas.

3.5 Potential Implementation in Educational Institutions

The implementation of ZeroTouchBin in educational institutions has practical value because areas such as computer labs, workshops, canteens, libraries and administrative offices receive different user flows throughout the day. In these locations, full or dirty trash cans can directly affect user comfort. With a digital monitoring system, responsible parties can identify bins that require action in advance. This can reduce time waste because inspections do not need to be done randomly or too frequently.

In the context of Community Colleges, this project can also be used as teaching demonstration material for the topics of Internet of Things, sensors, microcontrollers, system design, basic programming and troubleshooting. Students can see the relationship between sensor input, data processing by ESP32, actuator control and data display through an application. This combination makes ZeroTouchBin not just a final product, but also a learning tool that shows how theoretical concepts are translated into real systems.

In addition, this project has the potential to be the basis for the implementation of a mini waste management system at the college level. If several ZeroTouchBin units are used in different locations, each unit can be given a separate device name in Blynk or other dashboards. The cleaning management can monitor frequently full locations, peak usage times and bin replenishment needs. This data can help facility management make more objective decisions.

For the purpose of presenting innovation, the value of ZeroTouchBin can be explained through three main dimensions, namely cleanliness, efficiency and education. From a cleanliness perspective, the system reduces contact with the bin surface. From an efficiency perspective, the system provides bin status information to the user. From an educational perspective, the system demonstrates the students' mastery of skills in developing IoT solutions that have real-world applications.

Table 4. Potential applications of ZeroTouchBin in educational institutions

Suggested location	Usage requirements	ZeroTouchBin Benefits
Computer lab	Users often bring snacks or waste paper	Reduces contact and simplifies monitoring
Kafe	Jumlah sisa tinggi pada waktu rehat	Memberi amaran awal sebelum tong melimpah

Suggested location	Usage requirements	ZeroTouchBin Benefits
Office	Hygiene requirements and professional image	Providing modern and neat facilities
Workshop	Waste of various forms and periodic use	Help check the status of the barrel
College public space	Used by visitors, staff and students	Improve the comfort and cleanliness of the area

3.6 Innovation Impact Analysis

For the average user, the most obvious benefit is a cleaner and easier garbage disposal experience. Users do not need to press the pedal or open the lid by hand. This simple process can increase the user's tendency to throw garbage into the bin rather than outside the bin, especially when the lid of the bin looks dirty.

For the sanitation management, the main benefit is the bin status information that can be obtained digitally. In conventional systems, workers have to physically check the bins. This inspection sometimes results in suboptimal use of labor, as empty bins are also checked. With full-level notifications, focus can be given to bins that really need action. Although this prototype is still small-scale, its working principles can be extended to larger waste management systems.

For students, ZeroTouchBin has an impact on the development of technical and soft competencies. From the technical aspect, students learn circuit assembly, pin selection, code writing, WiFi integration, Blynk configuration and system testing. From the soft aspect, students need to solve problems, divide tasks, create documentation, present ideas and receive feedback. This is in line with the aspirations of TVET education which emphasizes hands-on skills and real problem solving.

The project also has environmental awareness value. While ZeroTouchBin does not solve all waste management issues, it helps build the mindset that technology can be used to improve hygiene practices and operational efficiency. In the long term, innovations like this could be combined with waste separation systems, odor sensors, weight sensors or analytics dashboards to support more sustainable waste management.

Table 5. The impact of ZeroTouchBin innovation

Stakeholders	Direct impact	Added value
User	No need to touch the barrel lid	A cleaner and more comfortable experience
Hygiene management	Receive bin status information	Waste collection is more organized
Student developer	Mastering real IoT applications	Increased technical and problem-solving skills
Institution	Have student innovation products	Improving the image of TVET innovation and learning
Environment	Reduces the risk of bin overflow	The space is tidier and cleaner

3.7 Comparison with Conventional Trash Cans

The main difference between ZeroTouchBin and conventional trash cans lies in the level of automation and data communication capabilities. Conventional bins only function as passive containers. Users need to open the lid manually or use a pedal, while management needs to physically check the full level. ZeroTouchBin, on the other hand, has the ability to detect user presence, open the lid automatically and send the full level status via an application.

In terms of cleanliness, conventional bins still depend on user discipline. If the lid is dirty, users may throw garbage outside the bin. ZeroTouchBin reduces this problem because the lid can be opened without touching. In terms of management, conventional bins do not provide early information when it is almost full. ZeroTouchBin provides notifications so that action can be taken earlier. In terms of innovation value, conventional bins do not show digital elements, while ZeroTouchBin combines sensors, actuators, microcontrollers and mobile applications.

However, conventional bins have the advantage of being low cost and not dependent on electrical power or internet networks. Therefore, ZeroTouchBin is more suitable for locations that require added value such as cleanliness, technology demonstration, status management and modern image. In real applications, the choice between conventional bins and smart bins needs to take into account location, budget, power source, internet network and user needs.

Table 6. Comparison of ZeroTouchBin with conventional bins

Aspect	Conventional barrel	ZeroTouchBin
Opening the lid	Manual or pedal	Automatic through sensors and servos
Full level monitoring	Manual inspection	Sensor readings and Blynk app
Notification	None	Digital warning when the bin is full
Power dependency	None or low	Requires a power source
The educational value of IoT	Limited	High because it involves sensors, code and cloud
Suitability	Low cost general use	Locations that require cleanliness and monitoring

3.8 Product Readiness for Innovation Presentation

For the purpose of presenting innovations in Medan, ZeroTouchBin can be presented as a product that has a clear problem, solution, development method, proof of function and improvement suggestions. The problem raised is easy to understand by the panel because everyone uses trash cans in their daily lives. The solution offered can also be shown through a live demonstration, namely the lid opens when the hand is brought close and a notification appears when the bin is considered full.

The strength of the presentation can be highlighted through the narrative that ZeroTouchBin is not just an automatic bin, but a prototype of a small-scale smart waste management system. Students can explain that the first sensor solves the touch issue, the second sensor solves the full level issue, the ESP32 acts as the brain of the system, WiFi becomes the communication channel and Blynk becomes the user interface. This narrative helps the panel see the relationship between the real problem and the technical solution.

To improve the quality of the presentation, students are advised to provide a stable demonstration. The WiFi connection needs to be tested in advance, the phone displaying Blynk needs to have sufficient battery and the sensor threshold needs to be calibrated according to the location conditions. Students can also provide a short video as support if the internet connection at the presentation location is unstable. With this preparation, the risk of demonstration failure can be reduced.

In terms of posters or slides, the information that needs to be emphasized is the objective, main components, system flow, Blynk functionality, test results and future suggestions. The code information does not need to be displayed at great length; it is enough to explain the logic of the system. Innovation panels usually evaluate the clarity of the problem, product functionality, impact and usability. Therefore, the presentation needs to be balanced between technical aspects and benefits to the user.

3.9 Limitations of the Study and Scope of the Prototype

Although ZeroTouchBin has successfully demonstrated its main functionality, the scope of this project is still at the prototype stage. This means that the product is being developed to prove the concept and basic functionality, not as a commercial product that has undergone safety, durability and long-term use certification. Therefore, the test results should be interpreted as initial evidence that the idea can work, while the actual implementation requires additional testing in real locations with various usage conditions.

The first limitation is the environmental conditions. Ultrasonic sensors can give different readings if the surface of the trash is uneven, too soft or at a certain angle. In addition, dust, humidity and physical interference can affect the sensor's durability if the system is used outdoors. Therefore, the sensor placement and type of casing need to be adjusted according to the location of use.

The second limitation is the dependence on internet connection. Blynk's notification function can only work properly when the ESP32 has stable WiFi access. If the system is used in an area with poor coverage, the readings may not be sent in real time. To overcome this issue, future systems can be equipped with offline logging functions, temporary storage of readings and retransmission when the network recovers.

The third limitation is the scale of the test. Prototype testing is done to ensure that each component is functional, but does not include long-term daily usage data such as the number of times the lid is opened and closed, battery life, false notification frequency or servo mechanical durability after repeated use. This long-term data is essential if the product is to be brought to the real application level.

Table 7. Limitations of prototypes and control suggestions

Limitations	Impact on the system	Control recommendations
Sensor accuracy	Reading is influenced by the shape of the garbage	Threshold calibration, average readings and additional sensors
Internet	Depends on WiFi	Offline logging or alternative communication
Power	Regular batteries are not suitable for long-term operation.	Powerbank, 5V adapter or rechargeable battery
Casing	Electronic components need protection	Dust/splash-proof casing
Test scale	Not tested for long periods of time	Field tests and operational data records

3.10 Future Development Proposals

Future developments can focus on improving stability, scalability and user experience. In terms of stability, the system can use a more suitable power supply and neater wiring connections. In terms of scalability, each bin can be given a unique ID and monitored through a central dashboard. This dashboard can display the bin location, full level, notification time and collection history.

The system can also be supplemented with a weight sensor to confirm the full level reading. The combination of ultrasonic sensors and weight sensors can provide a more accurate picture of waste capacity. For example, light but high waste may fill the bin space, while heavy but low waste may require a different reading approach. The combination of the two types of sensors can reduce interpretation errors.

In addition, analytical functions can be introduced. The real-time data collected can be used to identify bin usage patterns by day and time. If data shows that bins in the cafeteria are often full after breaks, collection schedules can be adjusted. If bins in the lab are rarely full, inspections can be reduced. This shows how small innovations can grow into data-driven facility management systems.

In terms of product design, the casing can be improved to look more professional and secure. Wires need to be hidden, electronic components need to be protected, and mechanical parts need to be tested to prevent damage. The enclosure also needs to be designed to prevent excessive loads on the servos. If the product is to be used by the general public, user safety factors need to be prioritized.

Finally, ZeroTouchBin can be expanded into an educational version and an application version. The educational version keeps the components open so that students can see the connections and learn IoT concepts. The application version uses a closed casing that is more robust and suitable for real-world use. This split version can help the project grow without losing the original learning value.

Table 8. ZeroTouchBin development direction recommendations

Phase	Development focus	Main features
Version 1	Basic prototype	Sensor, servo, ESP32 dan Blynk
Version 2	Stable prototype	Better power supply, neat casing and sensor calibration
Version 3	Multi-barrel monitoring	Device ID, central dashboard and historical data
Version 4	Analytics and reports	Usage graphs, full-time patterns and suggested collection schedules
Version 5	Pre-commercial	Product design is sturdy, safe and suitable for public locations

3.11 Commercialization and Marketability Value

From a commercialization perspective, ZeroTouchBin has potential because the problem it solves is close to daily life. This product can be marketed to educational institutions, small offices, clinics, meeting rooms, laboratories and premises that want to improve the image of cleanliness. However, before being marketed, several aspects need to be strengthened including electrical safety, mechanical durability, sensor accuracy and product packaging.

The market value of ZeroTouchBin does not necessarily depend on the sale of bins alone. This product can also be developed as an IoT education kit. The kit can contain ESP32, ultrasonic sensor, servo, assembly guide, basic code and learning modules. The education kit approach is suitable for schools, community colleges and training programs that want to teach IoT through easy-to-understand projects. In this way, the commercial value of the project involves both product and educational aspects.

If taken to the community level, ZeroTouchBin can be part of a cleanliness campaign. A smart product that looks attractive can attract the attention of consumers, especially students. When consumers see technology being used to manage waste, they may be more aware of the importance of disposing of garbage properly. Therefore, the impact of the product is not only technical but also in the form of community education.

Realistically, marketability requires a more detailed cost analysis. Component costs, installation time, casing costs, maintenance costs and application platform costs need to be calculated. The product also needs to be compared to existing automated bins on the market. The advantage of ZeroTouchBin lies in the integration of IoT monitoring, while the main challenge is to ensure that the price is still affordable for educational institutions and small organizations.

3.12 Presentation Strategy and Panel Evaluation

In the innovation presentation, students should emphasize the relationship between the problem, the solution, and the impact. The presentation can begin with an easy-to-understand everyday situation, where a user needs to touch the lid of a dirty bin and a cleaning worker needs to manually check the bin. Once the problem is understood, students can introduce ZeroTouchBin as a solution that combines automation and smart monitoring.

The product demonstration should be brief but clear. The first step is to show the lid opening when the hand is brought close to the sensor. The second step is to show the garbage level reading on the Blynk app. The third step is to show a notification when the bin reaches a full level. If these three functions can be demonstrated smoothly, the panel will understand the value of the innovation more easily than a long theoretical explanation.

Students should also be prepared to answer questions regarding product limitations. For example, if the panel asks about WiFi, students can explain that the current version uses WiFi as a proof of concept, while future versions can be added with temporary data storage or alternative communication functions. If the panel asks about sensor accuracy, students can explain the need for calibration according to the bin size and shape of the garbage. Answers like this show that the group has a mature understanding of the product's strengths and weaknesses.

In terms of impact, students can emphasize that ZeroTouchBin has three main values. First, the hygiene value because it reduces physical contact. Second, the management value because it allows the status of the bin to be monitored. Third, the educational value because it proves that students are capable of developing IoT products that solve real problems. The combination of these three values makes ZeroTouchBin suitable to be presented as a practical and relevant TVET student innovation.

Table 9. ZeroTouchBin presentation short strategy

Presentation section	Important content	Presentation suggestions
Problem	Explain the issue of manual bins and full bins	Use examples of locations such as canteens or laboratories.
Solution	Introduce sensors, servos, ESP32 and Blynk	Briefly show the system flow

Presentation section	Important content	Presentation suggestions
Demonstration	Open the cover and Blynk notifications	Make sure WiFi and phone have been tested
Impact	State cleanliness, efficiency and education	Connect with real users
Improvement	State boundaries and directions	Answer honestly and technically

4. CONCLUSION

ZeroTouchBin is a touchless smart trash can innovation developed to address the problems of surface cleanliness, waste overflow and lack of full level monitoring in conventional bins. This project successfully combines ultrasonic sensors, ESP32, servo motors and Blynk IoT application in a system that is easy to understand and suitable for student learning and innovation contexts. Based on the tests conducted, the system can automatically open the lid when an object is detected, estimate the bin fullness level and send the status to a mobile application. These results show that IoT technology can be practically applied to improve waste management efficiency and support modern hygiene practices. However, this innovation still has limitations in terms of WiFi stability, sensor reading accuracy for irregular waste shapes and the need for a more suitable power source for long-term use. Future improvements could involve the use of a stronger casing, a rechargeable power system, more accurate sensor calibration, database integration and the development of a management dashboard to monitor multiple bins simultaneously. With these improvements, ZeroTouchBin has the potential to be a beneficial small-scale solution for educational institutions, offices and public areas.

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