

Arduino-based multifunctional hygiene dispenser

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Abstract

Applying hand sanitizer can be an efficient method for decreasing germs on our hands when soap and water are not accessible. Using applied experimental and descriptive research design, this study aimed to develop an Arduino-based multifunctional automated hygiene dispenser and assess its effectiveness. The primary materials used were the Arduino Uno, a submersible pump, a power supply, an ultrasonic sensor, a plastic panel, an infrared sensor, and a SIM 800L EVB. Moreover, proximity sensors were calibrated to ensure accurate hand detection within a specified range, and dispensing mechanisms were set to dispense an appropriate amount of product to minimize wastage. During the experimental stage, the researchers observed and recorded the data after testing the product. This was to ensure the consistency of the data gathered. Additionally, the data needed for the regression analysis were collected directly by the researchers, demonstrating that the system performs effectively regarding the hand's distance from the sensor and the temperature of its surroundings. The finding shows that the system provides consistent and accurate dispensing, with high user satisfaction and improved hygiene compliance compared to manual dispensers. Findings reveal that the level of distance does not affect the performance of the automated hygiene dispenser in terms of speed and accuracy; on the other hand, the level of temperature affects the performance of the automated hygiene dispenser in terms of speed and accuracy. Thus, future researchers may use different types of sanitizers, sensor improvements, or better automation techniques to improve the system.

Keywords: multifunctional automated hygiene dispenser, Arduino Uno, sensor-based automation, proximity sensors, experimental study

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1. Introduction

Apart from preventing illness, sanitation and hygiene significantly impact education, society, and lifelong skills environments. Studies have shown that schoolchildren who practice and understand hand hygiene better have fewer absences and sick days and achieve better scores (Shilunga et al., 2018). Furthermore, it has been demonstrated that good hand-washing techniques are essential for controlling the spread of microbial diseases like diarrhea, the leading cause of death for students in sub-Saharan Africa (Tambe et al., 2015). A review of randomized controlled trials (Mbakaya et al., 2017) from developing countries found that improved hand hygiene accessibility and compliance could significantly reduce diarrheal and respiratory infections. Hand-washing systems that combine these strategies have shown promising results in reducing the transmission of diseases in schools. However, the habit of handwashing is frequently ignored. Multi-step systems like dispensers can significantly raise awareness and encourage good hand hygiene. Infections occurring in healthcare settings were being noticed by patients, governments, experts, and regulatory bodies due to the significant setbacks, hazards, and costs that they caused. Hence, these infections were preventable through proper sanitation practices, but medical communities forgot this simple but crucial safety protocol. The global spread of drug-resistant infections in healthcare settings and the pathophysiology of infectious diseases need to be significantly improved to improve school-age children's health and academic achievement. Thus, having water, sanitation, and hygiene (WASH) activities in schools aims to reduce diseases associated with water and sanitation (Molina et al., 2021). These advancements have reinforced the fundamental infection prevention procedures in contemporary healthcare, especially in light of the limited supply of novel antimicrobials. Evidence showing that rigorous adherence to hand cleanliness considerably lowers the risk of infection transmission is now indisputable. While hand hygiene is one of the most straightforward and economical infection prevention strategies, it is still underutilized despite being essential for lowering infection rates in healthcare settings, according to the World Health Organization's (WHO) "Clean Care is Safer Care" agenda, which highlights the pressing need for developing nations to adopt essential infection prevention policies.

Hand hygiene was critical to maintaining public health, as it helps prevent the spread of respiratory and diarrheal infections. The CDC emphasized the importance of washing hands during key times, such as before and after preparing food, using the toilet, or caring for a sick individual (About Handwashing, 2024). The five-step handwashing process—wetting, lathering, scrubbing, rinsing, and drying—remains one of the simplest and most effective measures for removing germs and preventing infection. In situations where soap and water are unavailable, hand sanitizers that contain at least 60% alcohol can serve as a good substitute. As such, this device is proposed because it consolidates three hand hygiene necessities—soap, tissue, and sanitizing alcohol—into a single, automatic dispenser. This device optimizes the cleaning process, conveniently lining up the components of hand hygiene. The automated hygiene dispenser addressed hygiene concerns and user convenience by enabling users to complete the entire hand-cleaning process without direct contact. It was designed to reduce cross-contamination and enhance the overall user experience in areas where sanitation is essential. This research addressed a critical need for a comprehensive hygiene system by developing an Arduino-based multifunctional automated hygiene dispenser that integrates soap, tissue drying, and alcohol disinfection in a single, contactless, and automatic device.

Statement of the Problem - This study sought to develop and assess the multifunctional automated hygiene dispenser, a contactless device that combines tissue drying, alcohol disinfection, and soap delivery. Specifically, the study sought to assess the effectiveness, convenience, and overall performance of the multifunctional automated hygiene dispenser compared to traditional and existing automated hygiene systems. The following questions addressed in the study: (1) What is the level of functionality of the automated hygiene dispenser in terms

of accuracy and precision, user convenience, distance of the hand from the sensor, and temperature of its environment? (2) What is the level of performance of the automated hygiene dispenser as assessed by its users in terms of user Satisfaction; and effectiveness of the device? (3) Is the level of performance of the Automated Hygiene Dispenser significantly affected by accuracy and precision, user convenience, distance of the hand from the sensor, and temperature of its environment?

Significance of the Study - By developing an Arduino-based multifunctional automated hygiene dispenser to improve hand sanitation, this study may be significant and beneficial to the following: To public and business establishments, this study benefited them by enhancing the handwashing process, especially hospitals, where sanitation is a crucial part of operation. This study benefited students because the hand-washing provided by the product helps students save time to spend on other activities in a busy schedule. This study benefited them in helping maintain a healthier classroom environment and reduced the frequency of student absences due to sickness. This study benefited parents by informing them that their children are being provided effective hygiene measures at school. This study benefited future researchers who further develop the system's features or apply the idea to other fields. This study benefited researchers by influencing community health initiatives and addressing significant health risks.

Scope and Delimitation of the Study - The study aimed to determine the effectiveness and performance of the automatic hygiene dispenser using Arduino Uno. This hands-free device helps reduce contact and lower the chances of contamination. This study focused on making it easier to maintain personal hygiene and stay safe from viruses simply and effectively. The study was conducted throughout S.Y. 2024-2025 at Divine Word College of San Jose (DWCSJ). The testing period was limited only to inside the school and not in public places. The limitation encountered by the researchers would be the availability of the materials; however, the researchers did their best to look and search for the needed materials. The study's scope was limited to the senior high school department and the janitors of DWCSJ. The hygiene dispenser system was compared to current dishwashing systems that employ manual handwashing facilities.

2. Methodology

Research Design - This study utilized both an applied experimental and descriptive research design. The applied experimental design was used to develop the 3-step automated hygiene dispenser, and a descriptive design was employed to describe its effectiveness and functionality.

Participants of the Study - The researchers actively took part in observing the 3-Step Automated Hygiene Dispenser. They assessed its effectiveness, convenience, and overall performance through direct observation. To evaluate the dispenser's functionality for both the janitor and user parts, the researchers included the five (5) janitors in the school and randomly selected five (5) students from the senior high school department to participate as users of this study. This method helped ensure that the study's findings were accurate and reliable, providing helpful knowledge into the dispenser's effectiveness, convenience, and overall performance.

Data Gathering Procedure - The data-gathering procedure began with component testing and calibration. Before field deployment, each component of the dispenser system, including sensors and motors, underwent individual functionality tests to verify operational integrity. Proximity sensors were calibrated to ensure accurate hand detection within a specified range, and dispensing mechanisms were set to dispense an appropriate amount of product to minimize wastage. Once component testing was complete, usage testing took place with the dispenser as the sampling unit. The researchers explained to the respondents how the dispenser worked and how they could use it for enhanced handwashing. The respondents were then asked to wash their hands using the dispenser and compare their experience to manual dispensers. The data collection process was facilitated by observation and survey techniques. The researchers systematically gathered and compiled the requisite data through observational and experimental approaches. The utilized system and the researchers' data collection method collectively contributed to the credibility and objectivity of the gathered data. Additionally, operational data was logged by the

Arduino Uno system to facilitate detailed analysis of program integrity fluctuation patterns and system performance. Moreover, the researcher-made questionnaire was checked and validated by the experts in the field of science and research in the same department.

Following each interaction, a validated researcher-made questionnaire was administered to gather participant feedback on their experience with the dispenser. These surveys were designed to capture insights into the system's usability, convenience, and effectiveness from a user perspective. During the testing period, error logging was performed to document any operational issues, such as sensor failures or dispensing errors. This information was systematically recorded for later analysis, which helped identify areas for improvements in system design or calibration. Finally, data from surveys, system logs, and observational notes were reviewed in the analysis phase using descriptive and inferential statistics. User feedback was categorized to identify recurring issues or themes. At the same time, quantitative performance metrics, such as dispensing speed, accuracy, and error rates, were statistically analyzed to assess the system's effectiveness. This structured approach allowed researchers to comprehensively evaluate the dispenser's performance, providing data-driven insights for refining the system's design and functionality. The total number of days the researchers observed the hygiene dispenser was 4 days, and they gathered data for 2 days.

Research Process: Stage 1 Preparation and Gathering of Materials - The researchers purchased the materials from online and physical stores, assembled them, and calibrated them to fit the needs of the study. The materials used to develop the 3-step automated dispenser were the following: Arduino Uno, wires, submersible pump, DC motor, power supply, ultrasonic sensor, L298 Motor Driver, IR sensor, capacitor, SIM 800L EVB, LM2596, breadboard, plastic panel, door hinge, and gluing materials. The major components required to assemble the product were sourced online from various stores. Meanwhile, the materials used for the prototype housing were purchased from City Hardware, Oxy, and Handyman. The total cost for developing the product and housing materials amounted to ₱2,200.

Stage 2: Building and Development of the Project - After gathering all the materials to make the soap, tissue, and alcohol dispenser, the researchers tested the individual functionality of the materials to ensure a smooth process. The researchers made the necessary openings in the casing. Then, the researchers installed the soap and alcohol pumps in their proper compartments. The tissue compartment should have a slot for easy pulling. Next, the researchers connect the IR sensor, wiring, pumps, DC motors, and the materials, which are coded into the Arduino Uno, so they activate only when triggered by nearby motion. The researchers programmed the pumps and DC motors to dispense a specified amount of soap, alcohol, or tissue. Once the prototype was built, the researchers tested if the product and its program worked as intended (user-friendliness, the system's ability to sense and respond to a nearby object). The researchers placed their hand in the motion sensor of the dispenser, and they measured the time it took for the sensor to activate the dispensing mechanism. The researchers also measured the sensor's ability to detect a hand's proximity. The researchers placed their hands at different distances from the dispenser and recorded the time it took for the system to detect the presence of hands at various distances. Also, to test the effectiveness of the dispenser, the researchers ran tests for its durability and precision. The researchers tested and observed for 4 days to ensure the product works.



Figure 1: Actual Product of Arduino-Based Multifunctional Automated Hygiene Dispenser

Stage 3: Experimental Stage, Observation, and Data Recording - During the experimental stage, the researchers observed and recorded the data from testing the system. This was to ensure the consistency of the data gathered and that the product was efficient. When researchers handle the testing, they directly understand the product's design, intended use, and specific features being evaluated, reducing miscommunication and data-gathering errors (Patton, 2014). The researchers recorded the data to notice patterns more easily and to determine if the data shown was appropriate to the product's intended purpose. This involved observation and data recording, wherein the researchers used the product and recorded the time it took for the dispenser to dispense. Also, to test the effectiveness of the dispenser, the researchers ran tests for its durability and precision. The experimental stage lasted for 6 days. The researchers observed and collected data through surveys with a respondent of 5 students and a janitor. The researchers prepared all the materials and asked the respondents to consent to participate. The researcher observed the dispenser for 4 days and gathered data for 2 days. The procedure began with component testing and calibration. Before usage testing, each component was tested for individual functionality to verify operational integrity.

Statistical Treatment of Data - The researchers used a descriptive analysis using the weighted mean to assess the effectiveness of an automated hand hygiene dispenser utilizing Arduino Uno in promoting basic personal hygiene among users. Additionally, Pearson's r correlation coefficient was used to assess whether the performance of the automated hand hygiene dispenser was significantly affected by accuracy and precision, user convenience, the distance of the hand from the sensor, and the temperature of its environment.

3. Results and Discussion

Table 1 displays the data collected from janitors and students through the questionnaire, including their corresponding weighted averages and descriptive ratings. Based on the findings, the Arduino-based multifunctional automated hygiene dispenser received an overall average rating of 3.1 from janitors, indicating its ability to dispense a consistent and appropriate amount of each component. Among the students, the highest recorded mean was 3.6, while the lowest was 3.2, resulting in an overall average of 3.4. Both groups' ratings fall within the "highly satisfactory" and "satisfactory" categories, reflecting a generally positive assessment of the dispenser's accuracy and reliability in dispensing soap, alcohol, and tissue.

Table 1

Level of effectiveness of the Arduino-based multifunctional Automated Hygiene Dispenser in terms of Accuracy and Precision, and User Convenience

Indicators (Accuracy and Precision)	Janitors Weighted Mean	Descriptive Equivalent	Students Weighted Mean	Descriptive Equivalent
The automated hygiene dispenser gives the desired amount of soap, alcohol, and tissue.	2.8	Satisfactory	3.4	Highly Satisfactory
The automated hygiene dispenser gives a consistent amount of soap, alcohol, and tissue.	3.4	Highly Satisfactory	3.2	Satisfactory
The automated hygiene dispenser gives a reliable amount of soap, alcohol, and tissue.	3.0	Satisfactory	3.6	Highly Satisfactory
Weighted Mean	3.1	Satisfactory	3.4	Highly Satisfactory
Indicators (User Convenience)				
The soap, alcohol, and tissue dispenser can be used simultaneously without any problem.	3.5	Highly Satisfactory	3.2	Satisfactory
The Arduino-based multifunctional automated hygiene dispenser responds immediately when I place my hand near the sensor.	3.1	Satisfactory	3.3	Satisfactory

The Arduino-based multifunctional Automated Hygiene Dispenser (soap, tissue, and alcohol) is less time-consuming than single-step dispensers.	3.5	Highly Satisfactory	3.8	Highly Satisfactory
Weighted Mean	3.4	Highly Satisfactory	3.4	Highly Satisfactory

Legend: 3.26–4.00: 4.00 Highly Satisfactory; 2.51–3.25: Satisfactory; 1.76 – Unsatisfactory; 1.00 – 1.75 Highly Satisfactory

Moreover, the device's sensor system and dispensing mechanism operate efficiently based on its capacity to distribute a steady and suitable amount of tissue, soap, and alcohol. These findings align with Boyce (2017), who emphasized the importance of systems that consistently dispense the correct amount of product, aiding in improved infection control measures. This demonstrated how important automated dispensing systems are for maintaining constant hand hygiene compliance and lowering the risk of cross-contamination, especially in high-traffic and healthcare settings.

Table 1 also displays the survey results from both janitors and students, based on the user convenience of the automated hygiene dispenser. This includes the weighted averages and corresponding descriptive equivalents, offering a clear picture of overall user satisfaction. Janitors gave the dispenser an average score of 3.4, suggesting it was effective and satisfactory for their work environment. Similarly, students rated the dispenser with an average of 3.4, indicating they considered it reliable and user-friendly. Both groups classified it as "highly satisfactory," signaling a generally positive response from students and janitors. Two key features of the automated hygiene dispenser were particularly highlighted as beneficial: its ability to accommodate multiple users simultaneously without issues and its time-saving design. These results are consistent with research by Evans et al. (2022), which underscores the value of hands-free functionality and real-time monitoring systems in enhancing user convenience. Their study suggests that such technological improvements are especially useful in high-demand environments, where quick and easy access to hygiene products is essential. The positive feedback from both janitors and students reinforces that the dispenser offers a fast, efficient, and convenient solution for maintaining hygiene standards in various settings.

Table 2

Level of effectiveness of the Arduino-based multifunctional Automated Hygiene Dispenser in terms of Different Distances of the Hand from the Sensor

Indicators (Distance of the hand from the sensor)	No. of Trials					Total	Percentage
	1	2	3	4	5		
1 cm	1	1	1	1	1	5	100%
2 cm	1	1	1	1	1	5	100%
3 cm	1	1	1	1	1	5	100%
Indicators (Temperature)							
Indoor (Low Temperature)	1	1	1	1	1	5	100%
Outdoor (Moderate Temperature)	1	1	1	1	1	5	100%
Direct Sunlight (High Temperature)	0	0	0	0	0	0	0%

Legend: Able to Dispense: 1, Unable to Dispense: 0

Table 2 shows the results of the researchers' direct observations, including the total count and percentages. In all five trials at distances of 1cm, 2cm, and 3cm, the automated hygiene dispenser successfully worked, being marked as 1, which means it was "able to dispense" the liquid. The total success rate for all distances was 100%, proving that the dispenser works reliably. This means that the Arduino-based multifunctional automated hygiene

dispenser is highly effective in detecting hand movements within a short distance from the sensor. The trial period lasted one day to gather data for the hand's distance from the sensor. According to Syahputra et al. (2021), when a hand is placed within 5cm of the sensor, it automatically pumps and dispenses liquid. Since this experiment only tested up to 3cm, it suggests that the dispenser can still function at slightly greater distances. These results confirm that the automated hygiene dispenser can easily detect a hand within a short distance and function smoothly.

Moreover, in terms of temperature, in all five trials conducted by the researchers at different temperatures, the automated hygiene dispenser successfully worked indoors (low temperature) and outdoors (moderate temperature), being marked as 1, meaning it was "able to dispense" the liquid. The trial period lasted a day within a short time frame. However, under direct sunlight (high temperature), the dispenser was marked as 0, indicating it was "unable to dispense." The total percentage rate for indoor and outdoor conditions was 100%, while the percentage rate under direct sunlight was 0%. This means that the performance of the Arduino-based multifunctional automated hygiene dispenser is unaffected by indoor and outdoor conditions but is affected by direct sunlight and temperature conditions. This implies that although the dispenser operates dependably in regulated indoor and moderate outdoor settings, its usability in sun-exposed situations is limited due to its reduced operation in extremely hot temperatures. According to Ye et al. (2018), high temperatures and direct sunlight interfere with the sensor, preventing it from detecting hand movement. These findings confirm that extreme heat affects the dispenser's functioning ability. These findings highlight that extreme heat negatively affects the automated hygiene dispenser's performance, making it unsuitable for direct sunlight exposure. Thus, overheating might result in misaligned sensors or infrared interference, which makes it difficult for the device to detect movement accurately. This implies that failed attempts at dispensing may result from the automated hygiene dispenser's sensor becoming unresponsive or providing inaccurate readings under high temperatures.

Table 3 displays the data gathered from the questionnaires, including the weighted means and descriptive indicators. The results show that the automatic dispenser is well-received, mainly by users, particularly due to its convenience compared to manual dispensers and the effectiveness of its motion sensors, which quickly respond to users. These features contributed to the automated hygiene dispenser being rated in the highest positive category: "highly satisfactory." Janitors' ratings ranged from 3.0 to 3.8, with an overall average of 3.5. Students rated between 3.5 and 3.7, leading to an average score of 3.6. These results suggest that both groups find the automated hygiene dispenser effective and easy to use, with students reporting slightly higher satisfaction than janitors. These findings demonstrate that the dispenser satisfies users' expectations regarding functionality, usability, and dependability; however, the janitors' slightly lower minimum score (3.0) raises the possibility of inconsistent usability or maintenance issues that should be investigated further to increase user satisfaction. Additionally, these findings are consistent with the research by Dawson et al. (2017), which emphasizes the importance of optimizing factors related to technology acceptance. Their study highlights that user satisfaction and ease of use are essential for adopting hand hygiene technology. The findings also support the importance of efficient decontamination processes in encouraging public adherence to handwashing practices.

Table 3

Level of performance of the Arduino-based multifunctional Automated Hygiene Dispenser as assessed by its users in terms of User Satisfaction and Effectiveness of the Device

Indicators (User Satisfaction)	Janitors Weighted Mean	Descriptive Equivalent	Students Weighted Mean	Descriptive Equivalent
The Arduino-based multifunctional automated hygiene dispenser is easy to use.	3.8	Highly Satisfactory	3.6	Highly Satisfactory
The Arduino-based multifunctional automated hygiene dispenser is more convenient than a manual dispenser (single-step dispensers).	3.6	Highly Satisfactory	3.7	Highly Satisfactory

The motion sensor responds quickly and efficiently.				Highly
		Satisfactory	3.5	Satisfactory
Composite Mean	3.5	Highly	3.6	Highly
		Satisfactory		Satisfactory
Indicators (Effectiveness)				
The sensor accurately detects hand movement at different distances.	3.6	Highly	2.8	Satisfactory
		Satisfactory		
The Arduino-based multifunctional automated hygiene dispenser effectively dispenses soap, tissue, and alcohol without delay.	2.8	Satisfactory	2.8	Satisfactory
The system performs consistently in different environments (e.g., temperature changes).	3.4	Highly	3.4	Highly
		Satisfactory		Satisfactory
Composite Mean	3.3	Highly	3.0	Satisfactory
		Satisfactory		

Legend: 3.26–4.00: Highly Satisfactory; 2.51–3.25: Satisfactory; 1.76–2.50: Unsatisfactory; 1.00–1.75: Highly Satisfactory

Furthermore, Table 3 also presents the data obtained from the questionnaires, their respective weighted means, and descriptive indicators. The results show that the system effectively detects hand movement, dispenses the components promptly, and maintains consistent performance across different environments (e.g., temperature changes). The average scores from janitors and students fall within the “highly satisfactory” and “satisfactory” ranges. For janitors, the ratings ranged from a minimum of 2.8 to a maximum of 3.6, with an overall average of 3.3. For students, the lowest rating was 2.8, while the highest was 3.4, resulting in an overall average of 3.0. Ratings in the “satisfactory” to “highly satisfactory” range indicate that both janitors and students thought the system was dependable and effective. The dispenser’s ability to recognize hand movement, quickly administer liquid, and operate reliably in various environmental settings earned it high ratings. Both groups thought the method was effective and efficient, even though janitors’ average ratings were somewhat higher (3.3) than students’ (3.0). The study by Al-Nassar et al. (2017) examined the design of low-power infrared (IR) transmitters and receivers, focusing on how circuit design and modulation schemes affect sensor performance and response time. Their research demonstrates that effective modulation strategies and well-calibrated circuit components can enhance the reliability and reduce delays in IR communication systems, which is crucial for real-time applications. However, challenges such as ambient light interference and electromagnetic noise can still cause detection delays. The findings suggest that with proper shielding, calibration, and advanced signal processing, these issues can be addressed, improving the responsiveness of IR sensors and making them more effective in practical scenarios.

Table 4

Regression Analysis of the Relationship of Accuracy and Precision and Effectiveness of the Arduino-Based Multifunctional Automated Hygiene Dispenser as Assessed by Users

Regression Statistics	
Multiple R	0.635135135
R Square	0.40339664
Adjusted R Square	-0.19320672
Standard Error	0.233345238
Observations	3

<i>ANOVA</i>	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	0.036816667	0.036816667	0.676155494	0.561888801
Residual	1	0.05445	0.05445		
Total	2	0.091266667			

* *Significant at p-value < 0.05*

Table 4 presents the relationship between accuracy and precision and the effectiveness of the Arduino-based multifunctional automated hygiene dispenser as assessed by users, showing the regression analysis of the relationship between user convenience and efficacy as assessed by users. This reveals that the critical value (F) is greater than the significance F, thus leading to the acceptance of the null hypothesis. This indicates that the product's performance is not just determined by its measured accuracy or precision but also by individual user variances and external factors like the environment in which it is used. Similarly, Evans et al. (2022) pointed out that while ease of use is important, it does not always change how effective a system is. The results suggest that other factors, like the environment or differences between users, have a greater effect on the product's performance. They also found that users may believe a system works well based on perceived convenience rather than real performance data. While people might find a dispenser easy to use, that does not necessarily mean it functions accurately. The results suggest that user-assessed accuracy, precision, and effectiveness do not have a strong relationship.

Table 5

Regression Analysis of the Relationship of User Convenience and Effectiveness as Assessed by Users

<i>Regression Statistics</i>	
Multiple R	0.188982
R Square	0.035714
Adjusted R Square	-0.92857
Standard Error	0.424264
Observations	3

<i>ANOVA</i>	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	0.006667	0.006666667	0.037037037	0.878962282
Residual	1	0.18	0.18		
Total	2	0.186667			

* *Significant at p-value < 0.05*

Table 5 presents the regression analysis of the relationship of user convenience and effectiveness as assessed by users. The presented data indicates that user convenience is significantly influenced by the system's effectiveness, as demonstrated by regression analysis. The significance F is considerably higher than the critical value (F), confirming that the relationship between effectiveness, openness, and user convenience is statistically significant. Chan et al. (2021) state that improving consumer convenience and satisfaction requires good service design. E-government platforms can significantly enhance the user experience by ensuring that core, facilitating, and supporting services are carefully integrated and satisfy user expectations. It is generally accepted that a system's perceived efficacy directly impacts user comfort and satisfaction. This finding aligns with previous research by Chan et al. (2021), which highlighted that perceived effectiveness significantly impacts user satisfaction in digital services. Their study suggests that when users view a system as effective, they are more likely to find it convenient, easy to use, and reliable. These results emphasize the crucial role of effectiveness in

shaping user convenience. If a system functions efficiently and meets user expectations, it enhances overall satisfaction and usability. This insight highlights the importance of prioritizing effectiveness in service design.

Table 6

Level of performance of the Arduino-based multifunctional Automated Hygiene Dispenser as assessed by its users in terms of the Distance of the Hand from the Sensor

Indicators (Distance of the Hand from the Sensor)	Janitors Weighted Mean	Descriptive Equivalent	Students Weighted Mean	Descriptive Equivalent
There are no delays or failures in dispensing sanitizer when placing my hand at different distances.	3.1	Satisfactory	3.2	Satisfactory
The distance I place my hand relative to the sensor feels natural.	3.5	Highly Satisfactory	3.3	Highly Satisfactory
The Arduino-based multifunctional automated hygiene dispenser can detect my hand at various distances.	2.8	Satisfactory	3.2	Satisfactory
Composite Mean	3.1	Satisfactory	3.2	Satisfactory

Legends: 3.26–4.00 Highly Satisfactory, 2.51–3.25 Satisfactory, 1.76–2.50 Unsatisfactory, 1.00–1.75 Highly Satisfactory

Table 6 presents the level of performance of the Arduino-based multifunctional automated hygiene dispenser as assessed by its users in terms of the distance of the hand from the sensor. According to the janitors, the sensor for detecting the hand's distance within the sensor was rated as performing well, with an average score of 3.1. For students, there are two aspects: there are no delays or failures in dispensing sanitizer when placing a hand at different distances and being able to detect a hand at various distances; both received an average rating of 3.2. Both janitors' and students' overall responses indicate "satisfactory". The results suggest that users find the sensor's ability to detect hand proximity valuable and efficient. Students may have performed significantly better than janitors or had different expectations, as indicated by the relatively small rating difference between students (3.2) and janitors (3.1). Both groups rated the sensor satisfactory, implying that despite the system working, there can be inconsistent inefficiencies, such as minor delays, inconsistent detection at various distances, or different user experiences.

Table 7

Correlation Analysis of the Effect of Distance on the Arduino-based Multifunctional Automated Hygiene Dispenser

Dependent Variable	Independent Variable	R value	p value*	Interpretation
Distance of the Hand from the Sensor	Sensor detection time	0.9737	0.005092	Significant

*Significant at $p < 0.05$

Table 7 shows the correlation analysis of the effect of distance on the Arduino-based multifunctional automated hygiene dispenser, showing that the sensor detection time has a significant relationship with distance. The R value, equal to 0.9737, and the p-value, equal to 0.005092, show a significant correlation between distance and the detection time of the sensor. Infrared (IR) sensors measure distance by optical triangulation. This means that the sensors use reflected waves to pinpoint position and displacement. The distance can be determined by analyzing the variation in the intensity of the received light. In the case of an infrared (IR) sensor, the color of the obstacle's material may also influence the sensor's readings (Adarsh et al., 2016). They concluded that although both infrared and ultrasonic sensors can identify barriers, how well they work depends

on the particular application and environmental conditions. This indicates that as the distance increases, the detection time of the sensor also increases in a highly predictable manner. The strength of the correlation suggests that the sensor provides consistent and reliable readings under controlled conditions.

4. Conclusions

Based on the summary of findings, the following were concluded regarding the research problems stated: The level of effectiveness of the Arduino-based multifunctional automated hygiene dispenser as assessed by its users shows high satisfaction upon being consistent, accurate, and responsive and upon being easy to use without any prior instructions, much better compared to single-step dispensers and user-friendly. Moreover, the level of distance does not affect the performance of the automated hygiene dispenser in terms of speed and accuracy; on the other hand, the temperature level affects the performance of the automated hygiene dispenser in terms of speed and accuracy.

4.1 Recommendation

After examining the current investigation and findings, the researchers suggest the following topics for further exploration: Further, to improve the performance of the automated hygiene dispenser, the researchers recommend that the future developers of this device may add a rechargeable battery system to the dispenser, allowing it to function for extended periods without requiring a direct power source. This will improve the automated hygiene dispenser's portability and ensure continuous operation, especially in common power outages. The researchers also recommend that users use a higher-quality infrared (IR) sensor not affected by sunlight to ensure accurate hand detection in all lighting conditions. The IR sensor currently used in the dispenser can be affected by bright environments, which may cause detection issues. A better sensor will improve reliability and ensure the unit functions perfectly indoors and outdoors. The researchers recommend using a more advanced liquid detection module instead of the current ultrasonic sensor for custodians. While ultrasonic sensors are readily available and easy to use, other liquid detection technologies, such as capacitive or optical sensors, may provide higher accuracy and better performance detecting liquid levels inside the automated hygiene dispenser. The researchers recommend that future researchers improve the Arduino-based multifunctional automated hygiene dispenser by adding new ways to improve hand sanitation. Future researchers can experiment with different types of sanitizers, sensor improvements, or better automation techniques.

5. References

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