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Dexter Jhon G. Rayon *et al*, Cognizance Journal of Multidisciplinary Studies, Vol.3, Issue.5, May 2023, pg. 219-226
(An Open Accessible, Multidisciplinary, Fully Refereed and Peer Reviewed Journal)
ISSN: 0976-7797
Impact Factor: 4.843
Index Copernicus Value (ICV) = 76.35

Development of Portable Noise Detector Device with Vibration Mechanism and Light Warning Signal

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DOI: 10.47760/cognizance.2023.v03i05.020

Abstract: To assess the performance of a noise-detecting device, we conducted an experiment in the main library of the University of Science and Technology of Southern Philippines. The device was deployed on each table to detect different sound ranges: QUIET (below 50 decibels), WARNING (51-59 decibels), and NOISY (60 decibels and above). The results demonstrate that the portable noise detector effectively alerts library users about their excessive noise, relieving the need for repeated bell ringing and allowing staff to focus on more important matters. Furthermore, we conducted a survey among selected library users to evaluate the device's acceptability. The feedback from students was positive, indicating that they found the device acceptable and helpful. These findings suggest that the portable noise detector, equipped with a vibration mechanism and light warning signal, provides an effective solution for reducing excessive noise and notifying library users.
Keywords— Vibration mechanism, Light warning signal, Portable, Decibels, Noise.

I. INTRODUCTION

Libraries play a crucial role as public spaces that provide access to information and resources. They serve as quiet environments where individuals can study, read, and work. However, libraries often face the challenge of noise pollution, which can disrupt the concentration and productivity of library users. Noise pollution in libraries can arise from various sources, such as conversations, cellphone use, and the movement of books and furniture [1].

Excessive noise levels in libraries have a detrimental impact on users' ability to concentrate and study effectively. The presence of high noise levels leads to distraction, stress, and decreased productivity. To create a conducive environment for studying and research, libraries typically implement noise control policies. However, these policies may not always be successful in preventing noise disruptions. Consequently, the development of portable noise detection devices has gained attention in library research.

From the perspective of library users, excessive noise levels have negative consequences on their learning experience. Noise serves as a significant source of distraction, making it challenging for users to focus on their work. Noise level standards exist for libraries, with federal or local regulations specifying the maximum acceptable noise level. In accordance with federal rules, the recommended maximum noise level in libraries is typically between 40-45 decibels [2]. Therefore, a noise level of 71 decibels would be considered unacceptable within a library [3].

The adverse effects of noise pollution on human health and well-being are well-documented. Exposure to high noise levels can result in hearing loss, sleep disturbance, stress, and hypertension. The World Health Organization reports

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that noise pollution contributes to approximately 1.6% of the global burden of disease [8]. Prolonged exposure to high noise levels can lead to irreversible hearing loss, significantly impacting an individual's quality of life. Physiological effects, such as increased blood pressure, irregular heart rhythms, and ulcers, can also have severe health implications if not addressed [9]. Additionally, research has shown that noise pollution has a negative impact on students' concentration and academic performance, particularly in classroom environments.

Numerous studies have examined the effects of noise on student performance in various settings, including libraries. One study revealed that high levels of background noise significantly reduce reading comprehension and memory recall among college students. Furthermore, research on noise levels in libraries indicated that noise generated by other students is the most significant source of distraction, negatively affecting students' ability to concentrate and retain information [10]. Several studies have also measured noise levels in university libraries and found that they often exceed the recommended levels for quiet study. Moreover, elevated noise levels in academic libraries can lead to students leaving the premises, resulting in reduced study time and decreased academic performance. However, implementing specific measures has been shown to effectively reduce noise levels and improve student performance in libraries [11]. Strategies such as rearranging furniture and using sound-absorbing materials have proven to be effective in reducing noise levels and enhancing the learning environment. Recent research demonstrated that the use of acoustic panels and improved sound insulation in a university library significantly reduced noise levels and increased student satisfaction.

Noise exposure can have negative effects on worker health and safety, emphasizing the importance of accurate measurement and monitoring of noise levels in various environments. Personal noise dosimeters, portable devices that measure an individual's noise exposure, have been the subject of recent studies investigating their effectiveness in different settings [14]. One study found that personal noise dosimeters were effective in measuring noise exposure among construction workers, and the inclusion of vibration alerts and visual warnings helped raise workers' awareness of noise exposure [15]. Similarly, a study evaluated a portable noise meter equipped with vibration and light warnings and confirmed its accuracy and effectiveness in alerting users to high noise levels [16]. In a hospital setting, a portable noise dosimeter featuring vibration and light warnings was found to be effective in measuring noise levels and reducing noise-induced stress and light alerts can be valuable tools for noise monitoring and hearing conservation programs in various environments.

II. METHODS

The objective of this research project is to design and develop a portable noise detector device specifically tailored for library environments, equipped with a vibration mechanism and light warning signal. The study will be conducted in three distinct phases: design and development, testing, and evaluation. During the design and development phase, the device will be created according to the specific requirements for a portable noise detector that incorporates both a vibration mechanism and a light warning signal. In the testing phase, the device's effectiveness will be evaluated by measuring noise levels in various areas of the library and comparing them with the device's readings. This assessment will determine how efficiently the device detects excessive noise levels and alerts users. In the evaluation phase, collected data, including experimental testing, surveys, interviews, and relevant literature, will be analyzed using statistical methods. This analysis will assess the device's efficiency, effectiveness, potential benefits, and limitations. The expected outcomes of this study are the successful development of an efficient and effective portable noise detector device for library settings and valuable insights into its impact on student focus and concentration. These findings will provide valuable information for improving library environments.

A. DESIGN AND DEVELOPMENT

The functionality of the noise detection device relies on multiple components carefully integrated into its design. At its core, the device is powered by the Arduino Nano Microcontroller (Item 5), which acts as the central control unit, overseeing all operations. The Sound Sensor Meter (Item 2) captures and measures the ambient noise levels, with the collected data processed by the microcontroller to initiate appropriate actions. Visual indications are provided by two LED lights, namely the Red LED Light (Item 1) and the Yellow LED Light (Item 3). These LEDs can be programmed to activate or deactivate based on specific noise thresholds or predetermined conditions. Additionally,

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an LED light indicator (Item 10) offers visual feedback regarding the device's status or alerts. For user convenience, a switch (Item 9) is incorporated to facilitate easy control and operation.

The Motor Driver (Item 6) serves as the intermediary between the microcontroller and the Motor 12V dynamo vibrator (Item 11), which generates vibrations as an alternative alert mechanism. Power is supplied to the device through a battery (Item 7), and if necessary, a DC power male plug jack adaptor (Item 8) enables connection to an external power source. Various connectors (Item 4) establish the essential connections between the components, ensuring seamless integration.

Collectively, these components work in harmony to create a noise detection device capable of monitoring the surrounding environment, processing noise data, and providing visual and tactile alerts to indicate different noise levels or specific conditions.

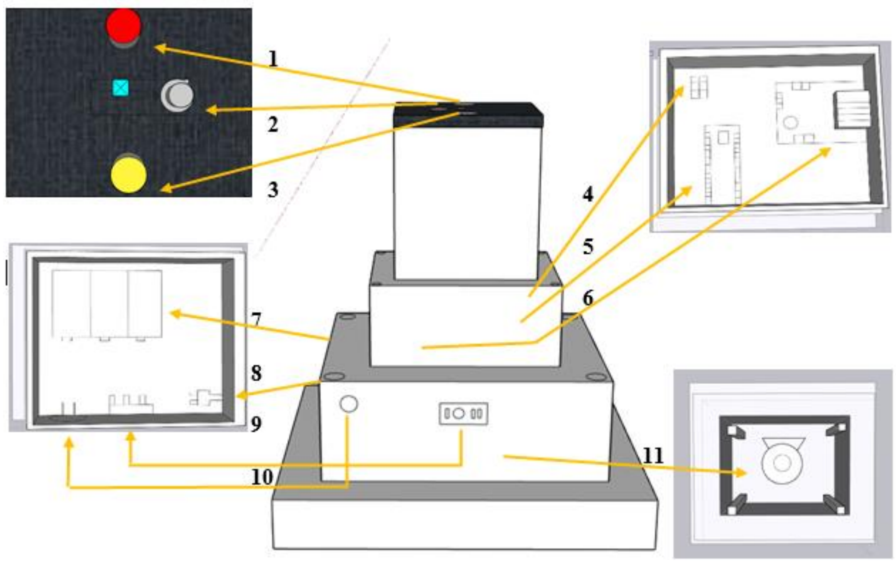

Figure 1 Components of noise detector device with vibration mechanism and light warning signal

B. IMPLEMENTATION

1. Establish system requirements: Clearly outline the objectives of the device, including the detection of noise levels above 60 dB and the activation of a warning mechanism. Specify the use of a sound sensor, vibration motor, and LED light for user alerts. Select the Nano microcontroller as the central control unit to facilitate seamless communication between input and output devices.
2. Select hardware components: Choose suitable hardware components that meet the system requirements. Opt for a reliable sound sensor, such as the "Sound detection" module based on an LM393. Utilize the Arduino Nano ATMEGA 328P microcontroller for its compact size and versatility. Include a 12V DC motor, 10mm Red & Yellow LEDs, a switch, a motor driver board module (L298N), and appropriate power supply options, such as an adapter and a 3.7V battery.
3. Assemble the hardware: Connect the sound sensor to the A0 analog input pin on the Nano microcontroller to capture noise levels. Establish connections between the motor and the motor driver. Set up the switch to provide power supply, connecting the 12V pin of the motor driver. Connect the 5V pin of the motor driver to the VIN pin of the Nano microcontroller. Ensure proper grounding connections. Attach the LED lights to digital output pins D7 and D6 for visual warnings.

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4. Develop the program: Use the Arduino IDE to program the Nano microcontroller. Utilize the analogRead () function to obtain input from the sound sensor. Implement conditional statements to compare noise levels with predetermined thresholds. For example, for noise levels below 60 dB, no action is taken. For noise levels between 51-59 dB, activate the yellow LED light for a warning. For noise levels exceeding 60 dB, trigger both the vibration motor and the red LED light as an alarm. Conduct thorough testing to ensure accurate and reliable performance.
5. Perform decibel calculations: Implement the necessary calculations to convert the analog voltage reading from the sound sensor to decibel values. Utilize appropriate formulas to calculate the power of the sound wave, reference power, and decibel value. Output the decibel value to the serial monitor for monitoring purposes.
6. Test the system: Generate various noise levels using a sound source to verify the correct triggering of the warning mechanism. Evaluate the sensitivity of the sound sensor and adjust the program code if necessary. Conduct comprehensive testing of all components and functionalities to ensure accuracy and reliability of the device.
7. Refine the prototype: Enhance the design of the device's housing to make it ergonomic and user-friendly. Consider factors such as ease of use, accessibility, and durability. Incorporate a battery pack to ensure portability and uninterrupted operation. Seek feedback from users and make necessary improvements to optimize the design and functionality.
8. Iterate: Conduct further testing and evaluation with the refined prototype. Address any issues or areas for improvement identified during testing. Iterate on the design, code, and hardware as needed to achieve the desired performance and user experience.
9. Produce the final product: Once the prototype meets all requirements and passes rigorous testing, proceed with manufacturing the final product. Adhere to quality control standards during production. Document the manufacturing process, including specifications, assembly instructions, and any modifications made during production.

C. PERFORMANCE EVALUATION

To ensure the device caters to the needs of library users with diverse learning styles, the researchers conducted a comprehensive evaluation process. This evaluation involved gathering library staff and groups of students, each representing a distinct learning style. Participants were asked to evaluate the device based on their personal experience while it was placed on their respective tables. The assessment focused on five key areas: functionality, mobility, safety, operability, and aesthetics. The goal was to determine how effectively the device met the needs of library users. Throughout the evaluation, the researchers observed the focus groups for an hour to assess their interaction with the device and identify any usability issues. Following the evaluation, participants were provided with feedback forms to assess the device's effectiveness. The researchers analyzed the feedback to pinpoint areas for design and functionality improvement. This evaluation process ensured that the device adequately addressed the needs of library users with diverse learning styles and enhanced its overall effectiveness as a noise monitoring system.

To measure the performance of the portable noise detector device equipped with a vibration mechanism and light warning signal, an adjectival rating system will be employed. This system will assess the device's functionality, operability, aesthetics, mobility, and safety. Evaluation sheets will be distributed to 16 library users at the Main Library of the University of Science and Technology of Southern Philippines. Respondents will rate each parameter using a scale that captures the intensity of their opinion. The adjectival rating formula used will be as follows: Average score = $(n1 \times v1 + n2 \times v2 + n3 \times v3 + n4 \times v4) / N$, where n represents the number of responses for each rating category (very poor, fair, good, excellent), and v represents the assigned value for each category. By utilizing this formula, the researchers will calculate an average score for each parameter. The adjectival rating system proves effective in gathering feedback on the device's performance and will aid in identifying areas that require improvement.

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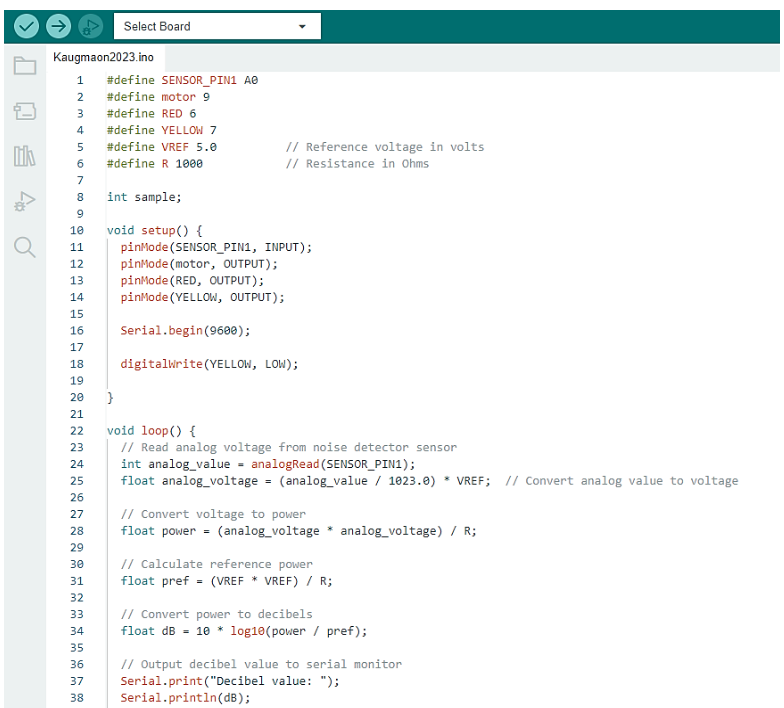
III. RESULTS AND DISCUSSION

The results and findings of the study are based on the stipulated methodology involved in the conduct of the study that highlighted the design, development, and evaluation.

The provided program codes as shown in Figure 2 below, outline the process of converting an analog value to decibels using a noise detector sensor. Initially, the program reads the analog voltage from the sensor, assuming it to be 2.5V in this example. This analog voltage is then divided by the reference voltage (VREF), which is set at 5.0V, to obtain a decimal value. The resulting decimal value is stored as "decimal value" for further calculations. Next, the program calculates the power of the sound wave based on the decimal value and the resistance of the circuit (R). This calculation is performed using the formula (analog voltage * analog voltage) / R, where the analog voltage represents the decimal value obtained earlier. The program also calculates the reference power (pref) using the reference voltage (VREF) and the resistance of the circuit (R) through the formula (VREF * VREF) / R. The decibel value of the sound wave is then determined using the obtained power and the reference power. The formula dB = 10 * log10(power / pref) is used to calculate the decibel value, which in this example is -7.97dB. The program displays this value as "Decibel value: -7.97" on the serial monitor.

Additionally, the program includes a check to evaluate whether the decibel value falls within a specific range, allowing for an assessment of whether the noise level exceeds a predefined threshold. If the noise level is deemed too high based on this evaluation, the program can trigger a warning or alarm accordingly. By implementing these program codes, it becomes possible to convert the analog voltage obtained from the noise detector sensor into a decibel value, enabling the monitoring and evaluation of noise levels based on predefined criteria.




```
#define SENSOR_PIN1 A0
#define motor 9
#define RED 6
#define YELLOW 7
#define VREF 5.0          // Reference voltage in volts
#define R 1000            // Resistance in Ohms

int sample;

void setup() {
  pinMode(SENSOR_PIN1, INPUT);
  pinMode(motor, OUTPUT);
  pinMode(RED, OUTPUT);
  pinMode(YELLOW, OUTPUT);

  Serial.begin(9600);

  digitalWrite(YELLOW, LOW);

}

void loop() {
  // Read analog voltage from noise detector sensor
  int analog_value = analogRead(SENSOR_PIN1);
  float analog_voltage = (analog_value / 1023.0) * VREF;  // Convert analog value to voltage

  // Convert voltage to power
  float power = (analog_voltage * analog_voltage) / R;

  // Calculate reference power
  float pref = (VREF * VREF) / R;

  // Convert power to decibels
  float dB = 10 * log10(power / pref);

  // Output decibel value to serial monitor
  Serial.print("Decibel value: ");
  Serial.println(dB);
```

Figure 2. Snippets of the Code for the Device

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The Noise detector device with vibration mechanism and light warning signal is evaluated using descriptive statistics utilizing the five-point rating scale that measures the acceptability of the Noise detector in accordance to acceptable criteria.

Table 1. Mean Responses in terms of Functionality

Parameters	Mean
The input device work in accordance with the intended design	3.36
The output device responds to triggering of the input device	3.14
The controller recognizes all interfaced input and output devices	3.37
The input, output and the microcontroller were recognized by the system	3.67

Table 1 showed the mean responses of the device based on its functionality. Overall, the evaluation results indicate that the device generally performs well in terms of its intended design, recognition of input and output devices, and system compatibility. However, there may be room for improvement in terms of the responsiveness of the output device to the triggering of the input device.

Table 2. Mean Responses in terms of Operability

Parameters	Mean
The prototype functions based on the expected output	3.38
The prototype operates consistently in accordance with the input/output’s microcontroller and operating systems.	3.49
The control system operates consistently with the desired parameters	3.58
Operational flaws are tolerable and acceptable	3.50

As shown on Table 2, the evaluation results indicate that the prototype generally functions based on the expected output, operates consistently with the input/output's microcontroller and operating systems, and aligns well with the desired parameters of the control system. The evaluators also find the operational flaws to be tolerable and acceptable. These results suggest that the prototype shows promise, but there may be areas for improvement to enhance its performance and address any identified flaws.

Table 3. Mean Responses in terms of Safety

Parameters	Mean
The prototype is electrically safe to use	3.60
The prototype is compliance with the safety standards	3.70
prototype is compliant with structural integrity, durability, and protection against physical hazards	3.46
The prototype is environmentally safe to use	3.48

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Table 3 showed the evaluation results indicating that the prototype generally demonstrates satisfactory safety performance in terms of electrical safety and compliance with safety standards. However, there may be areas for improvement in terms of structural integrity, durability, protection against physical hazards, and environmental safety. These results highlight the need to address potential risks and ensure greater compliance with safety considerations to enhance the overall safety of the prototype.

IV. CONCLUSIONS AND RECOMMENDATIONS

The researchers' findings indicate that a portable noise detector equipped with a vibration mechanism and light warning signal is an effective tool for detecting excessive noise levels in library settings. The study established three distinct noise levels: QUIET (50 dB or lower), WARNING (51-59 dB), and NOISY (60 dB or higher). The sensor's omnidirectional sensitivity allows it to detect noise equally well from all directions. However, it is important to consider that the sensor's sensitivity can be affected by the distance between the sensor and the noise source. As the noise source moves further away, the sensor's ability to detect the noise may decrease. This distance factor should be considered to ensure the accuracy and reliability of the sensor's readings when the distance between the sensor and the noise source varies.

The device has been designed to prioritize the 3-second sound as a critical variable for validating noise, ensuring accurate readings without being overly sensitive to unwanted sounds. By maintaining noise levels within acceptable limits, the portable noise detector device contributes to a peaceful and productive environment for library users, supporting their studying and learning experience.

The study concludes that the portable noise detector is a valuable tool for monitoring noise levels in libraries, promoting better study habits, and enhancing academic performance. The researchers have gathered extensive recommendations from the panel and evaluators to improve the device's performance and effectiveness in maintaining a quiet environment in the library.

One important recommendation is to incorporate LED digital messages into the device's design to provide a stronger and more noticeable warning for library users regarding noise levels. This implementation will increase awareness among library users and contribute to a peaceful environment. Using 3D printing technology to manufacture the device casing is also suggested to improve aesthetics, mobility, and durability.

Furthermore, incorporating a rechargeable battery module with a 12-voltage capacity is recommended to extend the device's lifespan and reduce maintenance costs. Another suggestion is the development of a noise level transmitter that can be registered on the librarian's computer, enabling real-time monitoring of noise levels and identification of high-decibel sources. This feature empowers librarians to take prompt actions to control noise levels and maintain a peaceful environment for library users.

Implementing these recommendations will significantly enhance the device's performance and effectiveness in maintaining a quiet and conducive environment in the library. The LED digital messages, 3D printed casing, and noise level transmitter will provide a comprehensive solution for noise management, contributing to a more comfortable and productive atmosphere for library users.

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