Arduino-based Water and Plant Monitoring System for Efficient Water Resource Management

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Abstract: Agriculture has been a huge contributor to water stress globally. Even on small scale such as public high schools, their agricultural activities for students can play a huge part. Thus, this study developed a water and plant monitoring device using Arduino, which was evaluated by 43 respondents composed of teachers and students using the six Network Development Lifecycle (NDLC) criteria. The descriptive project successfully implemented the program of building the prototype, presenting and teaching it to the respondents, and assessing its effectiveness. The survey has a set of questions which are rated using a constructed response mode. Overall, the respondents found the device cost-effective, user-friendly, and beneficial in all aspects. The device also intended its purpose to manage water use and describe the soil conditions. However, the stability of the monitoring system needed improvement. Additionally, the study recommended adding an alarm feature and connecting to a mobile application for the optimization of the water and plant monitoring system.

Keywords: *Internet of Things; Arduino; Sensor; Water Monitoring System; Plant Monitoring System.*

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I. INTRODUCTION

A big composition of the planet is water and these water bodies allow the biotic factors to survive, adapt, and sustain life. However, water depletion has become one of the urgent concerns of the world because of the growing population, unbalanced ecosystem, pollution, and other environmental concerns.

According to the United Nations Educational, Scientific and Cultural Organization (UNESCO), approximately 50% of the global population is affected by water shortage and this percentage will increase in the coming decades without international cooperation and initiatives [1], [2]. Hence, the Internet of Things (IoT) devices aid in water conservation, monitoring, and management, which involve computing, wireless sensor networks, and cloud computing [3] The implementation of IoT encompasses the use of Arduino, which is demonstrated to create smart agricultural irrigation that monitors farm conditions to lessen the unused and wasted water during farming [4] Moreover, there is also Arduino-based irrigation that can measure temperature, humidity, and soil moisture and send these details to the farmers via text message in India [5].

In the Philippines, water consumption was reported to reach 214.79 billion cubic meters in 2020 and 33.8% of it came from the agricultural industry [6]. Thus, there are also existing monitoring devices using which are developed in the country such as the Arduino system for vegetables that can determine its water demand, soil moisture, humidity, and temperature [7]. A focus on water monitoring is important in this sector even in small-scale settings. The effect of water usage even in primary and secondary schools that have gardening as one of the activities for the students should not be disregarded and opened to the possibility of the application of IoT.

This study aimed to develop a prototype using Arduino that can help control the water supply to a public high school in the country. The prototype was intended to help people know about agriculture, specifically, to know the soil moisture and humidity of the plants.

Furthermore, this project focused on the application and performance of the prototype in San Ricardo National High School in Talavera, Nueva Ecija, Philippines. The respondents were limited to 43 people under the Technical-Vocational-Livelihood track of the school.

II. METHODOLOGY

The research design used in the project is IPO (Input-Process-Output) model. An Arduino-based water and plant monitoring system is an innovative solution for optimizing water consumption and increasing agricultural efficiency through technology. This system uses sensors and automation to monitor environmental parameters, resulting in accurate water resource management and sustainable practices. On the other hand, figure 1 illustrates the paradigm that guided the execution of the study from the materials needed to having the monitoring and control system device.

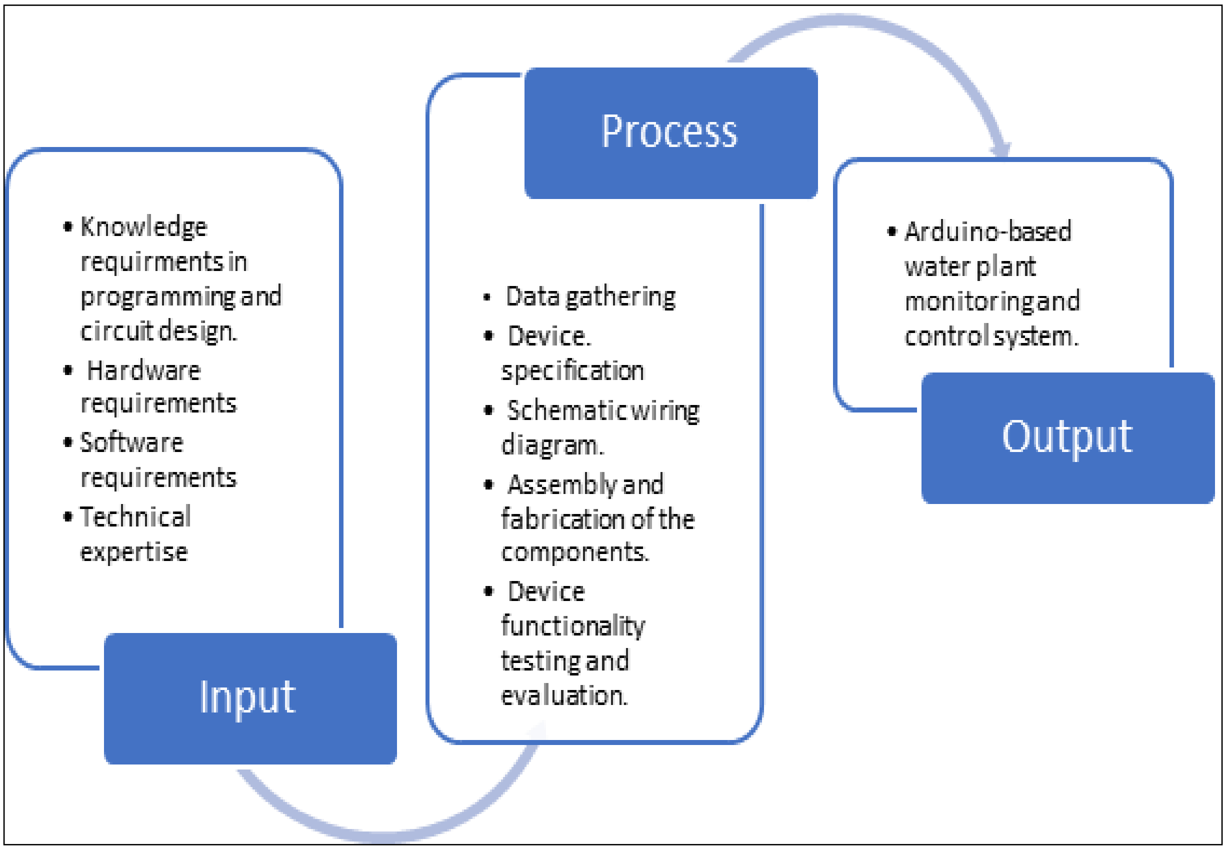

Fig. 1. Research Paradigm.

The research used an Arduino microcontroller to write and upload computer code to the physical board. The following devices were incorporated: water level sensor, soil moisture sensor, relay module, LCD, and buzzer. The system controls the duration of watering the plants via Arduino. It assigns to sense the moisture content of soil and water the plants. Furthermore, the microcontroller obtains a command from the soil moisture sensor. When there is no moisture in the soil, the microcontroller constantly compares the output from the soil moisture sensor. Through the driver, the microcontroller is connected to the water pump. It is designed to detect the moisture content of the plants at a certain point in time. If the moisture content is below a threshold that has been set in advance based on the specific plant's water requirement, the required amount of water will be delivered until that level is reached.

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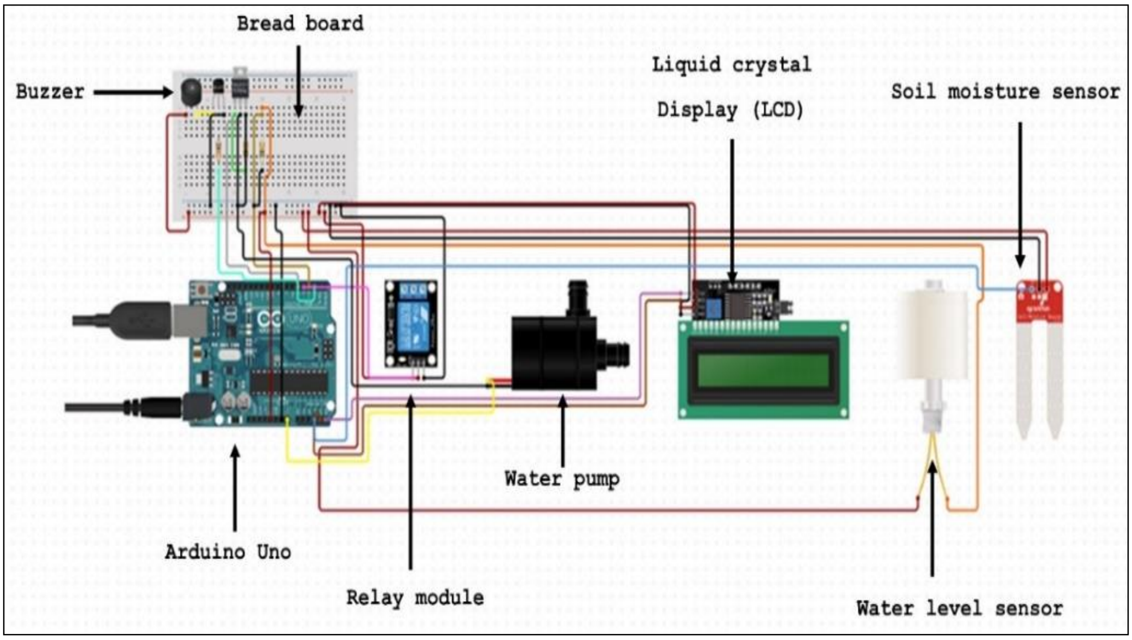

Fig. 2. Schematic Wiring Diagram.

Figure 2 demonstrates how the wires are connected in the device with the safety and protection considerations of the sensors. Moreover, figure 3 shows the prototype design and device connectivity.

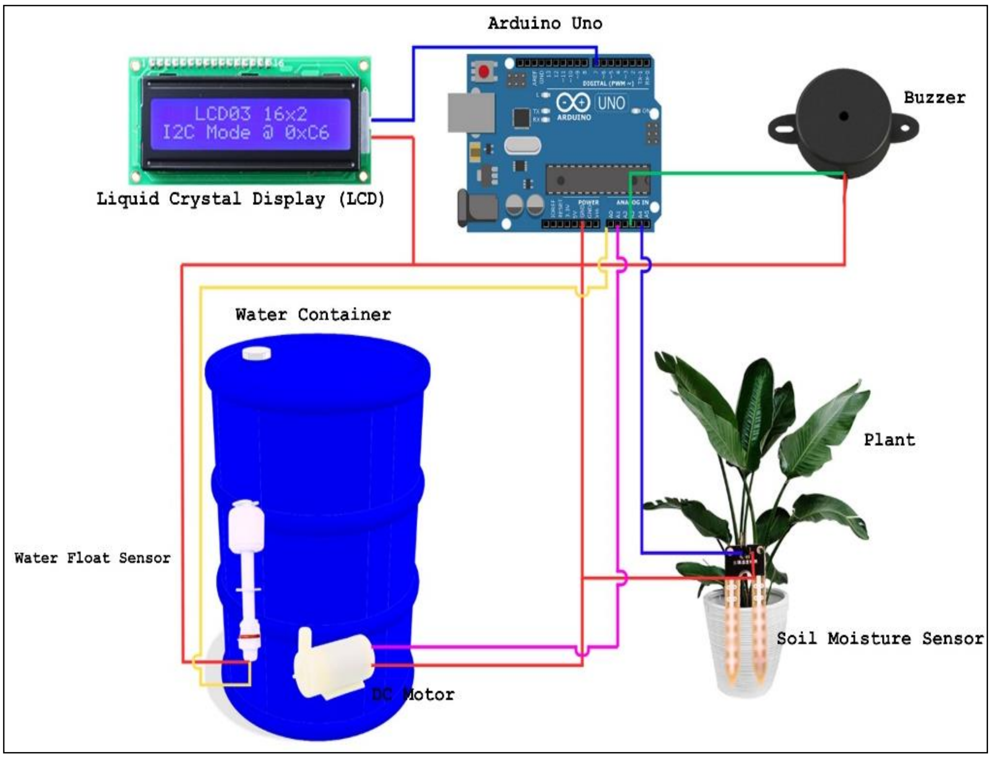

Fig. 3. Prototype Design

A. Data Gathering

After the development of the monitoring system, the device is deployed for the respondents to use. The respondents were composed of 5 teachers and 38 students from the Technical-Vocational-Livelihood track of San Ricardo National High School in Talavera, Nueva Ecija, Philippines.

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Six specific criteria in line with the NDLC conceptual model were used: Accuracy, stability, usability, accessibility, effectiveness, and reliability. A survey was constructed based on the criteria which served as an instrument to assess the significance of the system.

B. Data Analysis

The study used a constructed response mode which is used to determine the overall rating of each item in the questionnaire. The arithmetic mean of the evaluation ratings is verbally interpreted using the response mode shown in Table 1.

Table 1. Response Mode

Response	Scale	Qualitative Description
5	4.20 – 5.00	Strongly agree
4	3.40 – 4.19	Slightly agree
3	2.60 – 3.39	Agree
2	1.80 – 2.59	Neither
1	1.0 – 1.79	Disagree

III. RESULTS AND DISCUSSION

One part of the study is the assessment of the usability of the monitoring system. Table 2 enumerates the weighted mean and the interpretation of each item in the questionnaire.

Table 2 Assessment of the Usability of the Monitoring System

Items	Weighted Mean	Verbal Interpretation
The use of Arduino microcontrollers in water plant monitoring and control systems is a cost-effective solution.	4.63	Strongly Agree
The proposed water plant monitoring and control system is easy to operate and maintain.	4.52	Strongly Agree
The implementation of the proposed system improves water quality in the plant.	4.50	Strongly Agree
The proposed system provides accurate and reliable monitoring of water quality parameters.	4.47	Strongly Agree
The proposed system allows for flexible and adaptable water management.	4.44	Strongly Agree
The use of Arduino microcontrollers in the proposed system is a suitable technology choice.	4.36	Strongly Agree
The proposed system enables small-scale water plants to implement effective water management.	4.52	Strongly Agree
The proposed system reduces the need for skilled personnel to operate water plant monitoring systems.	4.47	Strongly Agree
Overall, the proposed water plant monitoring and control system using Arduino is a promising solution for efficient water management.	4.39	Strongly Agree
Average Weighted Mean	4.47	Strongly Agree

The results achieved a weighted mean of 4.47 which was interpreted as “strongly agree.” The prototype implied that it is cost-effective, user-friendly, and beneficial to the plants. Additionally, the findings suggested that the proposed system would contribute to the optimization of resource allocation by reducing the dependency on skilled personnel. Thus, the respondents affirmed that the proposed water plant monitoring and control system, leveraging Arduino technology, stands as a promising and efficient solution for advancing water management practices.

Table 3 Assessment of the Usability of the Monitoring System

Criteria	Weighted Mean	Verbal Interpretation
Accuracy	4.63	Strongly Agree
Stability	4.21	Strongly Agree
Usability	4.52	Strongly Agree
Effectiveness	4.47	Strongly Agree
Accessibility	4.50	Strongly Agree
Reliability	4.44	Strongly Agree
Average Weighted Mean	4.46	Strongly Agree

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The NDLC criteria obtained an overall average of 4.46 which also suggested a "strongly agree" interpretation from the respondents. Stability has the least weighted mean among the criteria while accuracy has the highest weighted mean. These results described that the Arduino-based system provided accurate outputs according to the end-users. This implied that the monitoring device provided the correct amount of water needed by the plants and the correct reading of soil condition. However, the stability in terms of performance and operation over time without malfunctioning still needs improvement.

IV. CONCLUSION

The proposed monitoring system using Arduino for efficient water resource management was implemented, and its performance using the NDLC criteria by the respondents and at the same time beneficiaries.

The system was effective in its function to regulate water usage and to determine the soil quality in San Ricardo National High School. The device could be beneficial also to the people who would have access to the device. Since the device is a prototype, the monitoring system needs enhancement on stability without compromising its accuracy.

Thus, recommendations were made to contribute to this promising technological application that can help agricultural water regulation. The device can be more effective, especially to the respondents, if an alarm is added as its feature and if it is connected to a mobile application to notify the students, teachers, and other persons involved regarding the status of the soil and the progress of watering.

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