Watering Intelligent System with Integrated Control (WISIC): An IoT-based Crop Watering System

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Abstract - This research aimed to develop and evaluate an Internet of Things (IoT)-based irrigation system titled "Watering Intelligent System with Integrated Control (WISIC): An IoT- based Crop Watering System," designed to optimize crop watering processes. Using a descriptive-developmental method, the study was conducted at Iloilo State University of Fisheries Science and Technology – San Enrique Campus from August to November 2024. The development adhered to the System Development Life Cycle (SDLC) - Rapid Application Development (RAD) model. A usability test was conducted using a standardized questionnaire checklist by John Brooke (1986), with respondents comprising four (4) purposively selected faculty members and twenty-five (25) students who were chosen randomly. Data collected were analyzed using the System Usability Scale (SUS), where WISIC achieved an SUS score of 95.60, denoting an "A+" grade within the 96-100 percentile range. The system was described as "Best Imaginable" and "Acceptable," with a Net Promoter Score categorizing it as "Promoter."

Keywords: Watering System, IoT, Blynk, Usability

I. INTRODUCTION

Background of the Study

With its vast area of 30 million hectares, 47% of which is agricultural land, the Philippines possesses abundant natural resources and a diligent farming community.

Despite this, agriculture, the backbone of the economy, has yet to be prioritized (Atilano, 2018). However, institutions like the Iloilo State University of Fisheries, Science, and Technology - San Enrique Campus (ISUFST- SEC) stand as fertile grounds for innovation, boasting diverse agricultural landscapes, committed faculty, and enthusiastic students.

Nestled amidst the verdant landscapes, ISUFST-SEC serves as a hub for agricultural innovation. With its lush fields and fertile soil, the College of Agriculture (CoAg) department embodies a dedication to sustainable farming practices and a commitment to excellence in

agricultural research and education. Despite this agricultural prowess, challenges persist in optimizing irrigation practices to meet modern agrarian demands.

Recognizing this need, the "Watering Intelligent System with Integrated Control (WISIC): An IoT-based Crop Watering System" project takes root within ISUFST-SEC. Drawing inspiration from the region's agricultural heritage and fueled by the university's vision of advancing agrarian technology, WISIC aims to revolutionize irrigation practices within and beyond the campus grounds

II. METHODOLOGY

Research Design

This study employed the descriptive-developmental research method. Descriptive research refers to a statement of conditions during the survey, with the researcher having no control over the variables. Descriptive studies aimed to determine, describe, or identify 'what is.' At the same time, analytical research sought to establish 'why' or 'how' it came to be. The primary purposes of descriptive studies were to describe, explain, and validate research findings. This type of research was famous for non-quantified topics.

Conceptual Framework

The Conceptual Framework of this study used the Input-Process-Output (IPO) Diagram. The Watering Intelligent System with Integrated Control (WISIC) conceptual framework encompassed input, process, and output components. Input included essential hardware components such as the NodeMCU ESP8266, Soil-Moisture Sensor, Wires, Relay Module, AC Contactor, Water Compressor, Hose, Pipes and Valves, Sprinklers, and software tools like the Arduino IDE and Blynk Platform.

These elements facilitated data collection, processing, and control within the system. The process component involved SDLC – Rapid Application Development for efficient project management and the Evaluation of WISIC to assess its performance and functionality. Output consisted of the developed WISIC system and the usability evaluation results, which provided valuable insights for system refinement and improvement, as presented in Figure 1.

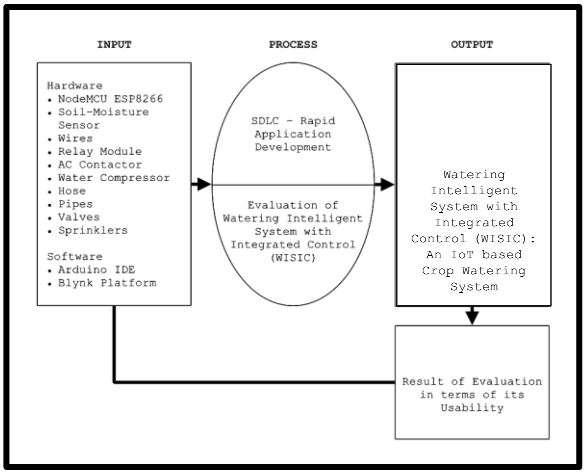

Figure 1: Input-Process-Output (IPO) Diagram.

Descriptive research illuminated current issues or problems through a data collection process, enabling a comprehensive description of the situation. It aimed to describe various aspects of the phenomenon. It was often utilized to outline the characteristics and behavior of the sample population. This method effectively gathered information to develop hypotheses and propose associations (Dudovskiy, J., 2007).

Developmental research, as opposed to simple instructional development, has been defined as the systematic study of designing, developing, and evaluating instructional programs, processes, and products that must meet criteria of internal consistency and effectiveness. Developmental research is particularly important in the field of instructional technology. The most common types of developmental research involve situations in which the product-development process is analyzed and described, and the final product is evaluated.

A second type of developmental research focuses more on the impact of the product on the learner or the organization. A third type of study is oriented toward a general analysis of design development or evaluation processes as a whole or as components. A fundamental distinction should be made between reports of actual developmental research (practice) and descriptions of design and development procedural models (theory). Although it has frequently been misunderstood, developmental research has contributed much to the growth of the field as a whole, often serving as a basis for model construction and theorizing (Richey, R., 1994).

System Development Life Cycle – Rapid Application Development

The researchers employed the principle of System Development Life Cycle (SDLC); specifically, the Rapid Application Development (RAD) method was used.

Phase One: Define Requirements.

During this phase, the researchers sought approval from the Campus Administrator to conduct the study entitled Watering Intelligent System with Integrated Control (WISIC): An IoT-based Crop Watering System (Appendix B). Once approved, the researchers conducted weekly meetings to plan for the development of the system.

Phase Two: User Design

During this phase, the researchers worked closely with the users and capstone adviser to design and develop a prototype for the WISIC system. This included the creation of key diagrams such as a block diagram, connection diagram, system and user data flow diagrams, and a use case diagram to ensure alignment with the system requirements. The design process involved several stages of prototyping, testing, and iteration based on continuous user feedback. The goal was to ensure that the WISIC system would function as intended and offer ease of use for the target users.

Phase Three: Rapid Construction.

During the Rapid Construction phase, the hardware components of the WISIC system were assembled and integrated according to the finalized design specifications. This phase is built directly upon the user design phase, translating the conceptual interface into a tangible, functioning system.

Phase Four: Implementation.

During this phase, the developed system was launched. This included data conversion, testing, transitioning to the new system, and conducting user training. All final adjustments were made while the researchers and users continued to identify and resolve any remaining bugs in the system.

Locale of the Study

The study was conducted in the College of Agriculture (CoAg) agricultural field at ISUFST San Enrique Campus. The campus is on Garrido Street, Poblacion Ilaya, San Enrique, Iloilo.

Respondents of the Study

The individuals who participated in the study to assess the project's usability comprised four (4) CoAg Department faculty/staff selected through purposive sampling and twenty-five (25) students who were chosen randomly.

Sampling Technique

The researchers utilized a purposive sampling technique to select four (4) CoAg Department faculty/staff and twenty-five (25) CoAg students chosen randomly as participants in the study. The purposive sampling technique, or judgment sampling, involved the deliberate choice of informants based on their specific qualities. This nonrandom technique did not require underlying theories or a predetermined number of informants. In essence, the researchers determined what information was needed and sought individuals who could and were willing to provide it based on their knowledge or experience. (Bernard 2002, Lewis & Sheppard 2006). On the other hand, to ensure a representative sample, the researchers applied simple random sampling, selecting participants from the college of agriculture student.

Research Instrument

The assessment of the application involved utilizing Brooke's (1986) standardized questionnaire checklist, which comprises ten statements. To assess the application's usability, the System Usability Scale will be used, featuring ratings that range from "strongly agree" and "agree" to "neutral," "disagree," and "strongly disagree." Items 1, 3, 5, 7, and 9 on the rating scale will be scored by deducting one from the scale position, while items 2, 4, 6, 8, and 10 will be scored by subtracting the scale position from 5. The rating scale to be utilized is shown in Table 2.

Table 2. *System's Usability Rating Scale*

Scale	Description	Numerica l Rating	
	Strongly Agree		
5		5	points
4	Agree	4	points
3	Neutral	3	points
2	Disagree	2	points
1	Strongly Agree	1	point

Data Gathering Procedure

The researchers sought permission by writing a letter to the College of Agriculture (CoAg) Department at Iloilo State University of Fisheries, Science, and Technology - San Enrique Campus (ISUFST-SEC) to conduct the study before developing the project. Once authorization was obtained, the intended users were interviewed to gather the information and data needed for the study. Questions were formulated during the interviews to aid the project's development, and the collected information served as the basis for the study's development.

Once the project was ready for testing, the researchers provided hard copies of the consent letter to the selected participants to assess the project's usability. A demonstration and explanation of how to use the newly created project, including accessing, exploring, and managing it, were presented to the users. Each participant was allowed to explore the project independently before providing the instrument. The data collected during the study were tabulated using the System Usability Score.

Data Analysis Procedure

Appropriate descriptive statistical tools have been employed to analyze the collected data.

The Application Usability Score has been utilized to tabulate and evaluate the gathered points regarding the application's usability. The formula for computing the SUS is: SUS=(X+Y) x 2.5

Where:

X= the points for odd-numbered questions minus 5

Y= 25 minus the points for even-numbered questions

The evaluation process provides data that can be used to determine the system's usability. The average score is calculated to aid interpretation. Table 3 provides the scale used to interpret the system's usability.

III. RESULTS AND DISCUSSION

The Developed Watering Intelligent System with Integrated Control (WISIC): An IoT-based Crop Watering System.

The Watering Intelligent System with Integrated Control (WISIC): IoT-based Crop Watering System was designed to automate crop irrigation, leveraging the Blynk platform for real-time monitoring and control. This system allows users to track soil moisture levels and initiate watering schedules, promoting efficient and precise water management for optimal crop growth.

Additionally, WISIC incorporates a manual override feature, enabling users to maintain control of the irrigation system even in cases of sensor failure or automation downtime, ensuring reliability and uninterrupted operation.

Watering Intelligent System with Integrated Control (WISIC): An IoT-based Crop Watering System implemented at the Agricultural Field of College of Agriculture, ISUFST San Enrique Campus.

After connecting all the hardware parts, uploading all the codes and modules on the NodeMCU microcontroller, and creating a WISIC monitoring interface in the Rapid Construction phase of the SDLC, the result of the integration is shown in Figure 14. .

Figure 14. Watering Intelligent System with Integrated Control (WISIC): IoT-based Crop Watering System

Result of System Usability Evaluation

The WISIC: IoT-based Crop Watering System was evaluated by twenty five (25) College of Agriculture (CoAg) students and four (4) CoAg faculty and staff members to assess its usability and functionality in real world agricultural settings. The system achieved a System Usability Scale (SUS) score of 95.60, placing it within the "A+" grade category and the "Best Imaginable" descriptor for usability. This high score demonstrates that the system is exceptionally user-friendly, acceptable for practical use, and well-suited for precision irrigation management. Table 4 provides a detailed summary of the usability evaluation results, highlighting the system's strengths and its potential for effective implementation in agricultural practices.

Table 4. Result of Usability Evaluation

Respondent #	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	X	Y	**SUS Score**
1	5	1	5	1	5	1	5	1	5	1	20	20	100
2	5	2	4	1	4	2	5	1	4	2	17	17	85
3	5	1	5	1	5	1	5	1	5	1	20	20	100
4	5	1	5	1	5	1	5	1	5	1	20	20	100
5	5	1	5	1	5	1	5	1	5	1	20	20	100
6	5	2	5	2	5	2	4	2	4	4	18	13	77.5
7	5	1	5	1	5	1	5	1	5	1	20	20	100
8	5	1	5	1	5	1	5	1	5	1	20	20	100
9	5	1	5	1	5	2	5	2	5	4	20	15	87.5
10	5	1	4	3	4	2	5	1	5	3	18	15	82.5
11	5	1	5	1	5	1	5	1	5	1	20	20	100
12	5	1	5	1	5	1	5	1	5	1	20	20	100
13	5	1	5	1	5	1	5	1	5	1	20	20	100
14	5	2	5	2	5	2	5	2	4	2	19	15	85
15	5	1	5	1	5	1	5	1	5	1	20	20	100
16	5	1	5	1	5	1	5	1	5	1	20	20	100
17	5	1	5	1	5	1	5	1	5	1	20	20	100
18	5	1	5	1	5	1	5	1	5	1	20	20	100
19	5	1	5	1	5	2	4	1	4	4	18	16	85
20	5	1	5	1	5	1	5	1	5	1	20	20	100
21	5	1	5	1	5	1	5	1	5	1	20	20	100
22	5	1	5	1	5	1	5	1	5	1	20	20	100
23	4	1	4	2	4	2	4	2	3	4	14	14	70
24	5	1	5	1	5	1	5	1	5	1	20	20	100
25	5	1	5	1	5	1	5	1	5	1	20	20	100
26	5	1	5	1	5	1	5	1	5	1	20	20	100
27	5	1	5	1	5	1	5	1	5	1	20	20	100
28	5	1	5	1	5	1	5	1	5	1	20	20	100
29	5	1	5	1	5	1	5	1	5	1	20	20	100
System Usability Score													95.60

SUS Score:	95.60
Grade:	A+
Percentile Range:	90-95
Adjectivity:	Excellent
Acceptability:	Acceptable
NPS:	Promoter

CONCLUSIONS

Based on the results of the study, it is concluded that the Watering Intelligent System with Integrated Control: An IoT-based Crop Watering System was successfully developed using the Software Development Life Cycle (SDLC) - Rapid Application Development (RAD) Methodology. The iterative and user focused approach of RAD allowed for efficient design, development, and implementation of the system while addressing the specific needs of the target users. Furthermore, the evaluation conducted with the target users revealed that the system is not only functional but also highly acceptable in terms of its usability, efficiency, and ease of use. This positive feedback demonstrates the system's potential to enhance agricultural practices by automating crop watering, reducing manual effort, and promoting water conservation. Overall, the study highlights the effectiveness of IoT technology and user centered development approaches in addressing real-world challenges in agriculture.

RECOMMENDATIONS

Based on the result and findings of the study, the following are recommended: 1. Future research could explore the integration of additional sensors, such as humidity and temperature sensors, to provide more comprehensive data for precise crop management. Expanding the system's scope to include environmental monitoring can make the system even more adaptive. 2. It is recommended to include a more advanced control box with enhanced weatherproofing and modular designs, allowing for easier maintenance and potential hardware upgrades. 3. Future iterations of WISIC may consider integrating solar-powered components to make the system self-sustainable in rural or off-grid locations.

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