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Original Article

Internet of Things for Monitoring Fish Cage Water Quality

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Abstract - *The purposes of this research consisted of two key areas: 1) to develop a prototype of a water quality monitoring system in real-time in fish cages using the Internet of Things and Blynk application, and 2) to study the satisfaction with the prototype of the water quality monitoring system. The population and sample were three instructors who acted as the expert to evaluate the questionnaire and 30 students who served as the respondents to assess their satisfaction with the system. All the samples are from the Faculty of Information Technology, Rajabhat Maha Sarakham University. The research tools comprised a water quality measurement application and an application satisfaction questionnaire. Statistics used in the satisfaction study were Mean, Standard Deviation (S.D.), and interpretation. From this research, the study's results can be summarized as follows: 1) The development of water quality measurement systems in fish cage farms can be used within the defined scope. 2) The results of the study of the satisfaction of the system development using the sample group, the overall study results were at the highest level of satisfaction, with means equal to 4.60 (S.D. = 0.54).*

Keywords - *Internet of Things, Monitor fish cage, Water quality, Quality monitoring system.*

1. Introduction

Adopting the Internet of Things and information technology has brought humanity far-reaching benefits and quality of life. The application of Internet of Things (IoTs) technology in agriculture is increasingly found, and it is used to solve problems for farmers concretely. Innovative farm systems and smart farming such as disease and pest control, humidity and temperature control, watering control, monitoring, and monitoring systems have become where the technology of all things has solved the problem. Therefore, promoting and improving the learning process to develop driven agricultural technologists, IoTs, and information technology deserves to be pushed forward in the future.

In rural Thailand, government support is complex. Farmers cultivating fish in cages are affected by environmental pollution from various industries, such as the impact of the agricultural sector, pollution from the chemical industry from factories, and household waste in the community. Environmental problems cause farmers who raise fish in cages to encounter enormous livelihood problems. They need a management system to control the agricultural system. For this reason, it convinced the researchers in this research, who were on-site and working in educational institutions with a mission to support and solve problems in Thai communities, were interested in the issues occurring in northeastern Thailand's rural areas.

IoTs refers to an integrated network of interconnected devices and technologies that facilitate communication between devices and the cloud and between the devices themselves, with the emergence of inexpensive computer chips and high-bandwidth telecommunications. As a result, we now have billions of devices connected to the internet. This means that devices in everyday life, such as toothbrushes, vacuum cleaners, cars, and machines, can use sensors to collect data and intelligently respond to users. Furthermore, IoTs are applied to the management of a smart farm system. For example, automatic notifications, device monitoring, automatic device activation and control, etc. [1].

The main factors in raising fish cages are feeding and controlling water quality suitable for it to grow best. Nowadays, human activities affect the water supply, causing contamination which degrades the water quality [2]. Water quality index measurements for fish farming include dissolved oxygen (DO), acidity and alkalinity (pH), water temperature (Temp), nitrates, etc., which are important parameters in aquaculture [4]. Low water quality can cause fish disease that affects fish growth and harvest production. Therefore, this research focuses on measuring water quality, which applies IoTs and Information technology to assist in the fish cage farming management system and maintain its health.

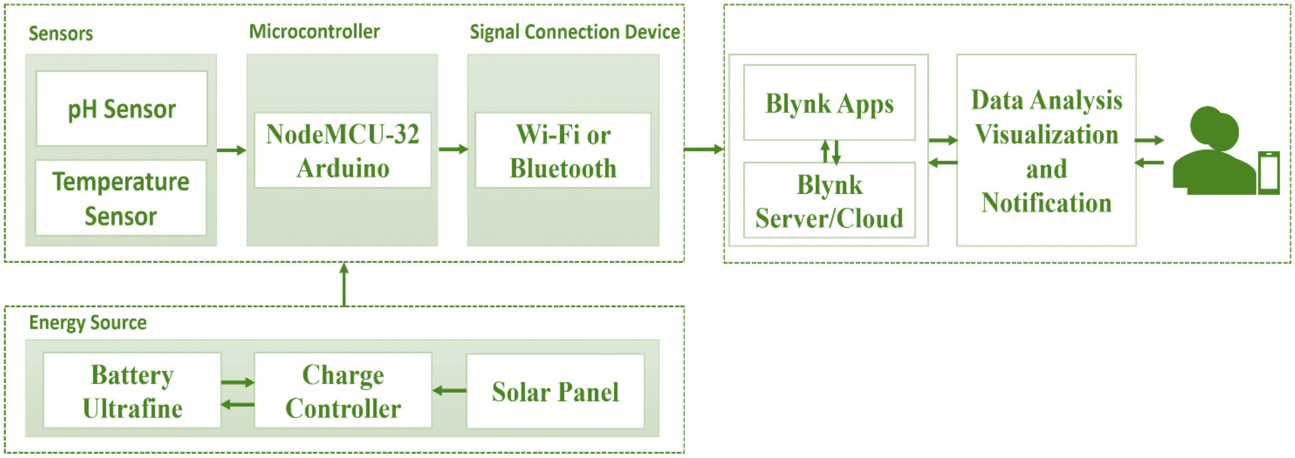

Fig. 1 Block diagram

The concept of IoTs has therefore been applied to prevent and solve the problems of fish farmers in cages affected by various environmental conditions in the community. The researchers designed the research concept as presented in the block diagram in Figure 1.

Figure 1 presents the operational system flow of the fish cage farm's water quality monitoring application research consisting of hardware and software. The hardware uses pH sensors, temperature sensors, solar panels, a charge controller, battery ultrafine, Node MCU 32, and a mobile device. The software includes a Wi-Fi or Bluetooth connection, Arduino IDE, and the Blynk application on the mobile phone. Details of each action are designed and presented in the research methodology section.

By random selection, this research target group and the testing group were 30 personnel and students of the Faculty of Information Technology, Rajabhat Maha Sarakham University. The selected samples were used to assess the efficiency and satisfaction with the prototype of a water quality monitoring system in fish cages using the IoTs and Blynk application on mobile technology using the system satisfaction questionnaire. The researchers are very hopeful that this research will benefit rural communities in northeastern Thailand in the future.

2. Literature Reviews

IoTs have seen fast development in the past decade and are widely used to solve agricultural problems. It can help the farmer monitor and manage agricultural equipment in a system. IoTs can also be applied to many systems of agricultural yields like irrigation, environmental monitoring, farming, and animal husbandry [1]. It is applied to farm agriculture to improve water quality [5] for fish farming. For example, it can be used to monitor animal husbandry's location and health and control agricultural equipment for fish farming [7].

Ismail et al. [8] presented a model of real-time fishpond water quality measurement (DO, pH, and Temp) and monitoring systems of aquaculture in Malaysia. This model saved cost, measured, monitored, reduced the process farmer's time, and helped ensure the growth and existence of fish in the pond. It increased production, reduced the loss, and the components were flexible. Their model recorded the data in a database server, but they were not taken advantage of to automatically analyze the system. Palconit et al. [10] did experimentation with a prototype to monitor the water quality, feed the fish, and record the fish tank on the cloud storage using IoTs. The water quality measurement of this system included the total dissolved solids (TDS), DO, pH, Temp, and turbidity. Their system was a success and accurate. Ya' acob et al. [11] designed a water quality monitoring system to manage the fishery.

This project focused on detecting the presence of fish and examining pH and Temp. Their system recorded the measurement of the water temperature data (morning, noon, and evening), pH values, and fish distance. It showed the measured information on a Blynk application. The notification information was sent to the user's email through a smartphone. The user monitored the fishpond, helped to warn them of the contamination of the water, and detected fish landing, which increased the survival rate of fish. Their system did not use wide areas because they used low-power devices. Susanti et al. [13] and Johar et al. [15] used IoTs and Blynk applications to observe and control the water quality on cloud storage. Their work was a goal to reduce the cost of them.

Tsai et al. [7] developed a smart aquaculture system to detect water quality parameters, which are DO, pH, temperature, and water hardness. This system can be added automatically to aerate when the DO value is poor using fuzzy inference, but it did not cover the water replenishment and temperature control. Their system helped to grow the living rate of aquatics. Rashid et al. [17] applied IoTs to check the water quality and manage the ecology of the fishpond, used an artificial neural network to predict the class, and developed an application to monitor and notify the irregularity of the water quality. This system measured the TDS, pH, and temperature, which checked real-time water quality. Their system reduced dependency on people and reduced the cost of raising fish. They should improve the accuracy of their model.

This research studies and IoTs the monitoring system in aquaculture for applying the monitoring of fish cage water quality. Thus, it decreases rising fish costs and reduces dependency on people on farms.

3. Materials and Methods

The materials and methods section contains four sufficient details, including population and sample, research tools, development of the system and performance, and interpretation of research findings.

3.1. Population and Sample

The research population was instructors and students of the Faculty of Information Technology, Rajabhat Maha Sarakham University. The sample consisted of a purposive sampling of 3 instructors and randomly 30 students of the Faculty of Information Technology, Rajabhat Maha Sarakham University. The three instructors were experts who assessed the IOC of the system satisfaction questionnaire. At the same time, 30 students are the system testers and determine their satisfaction with using the system.

3.2. Research Tools

The research tools consisted of two parts. The first tool is the water quality measurement application in the fish cage farm, and this development of the system process is presented in the next section. The second tool is the system user satisfaction questionnaire. There are eight functions for assessing the application, as shown in Table 1. Table 1 presents the questionnaire to study the satisfaction of the system by the satisfaction scoring criteria [18] divided into five levels: value one (1) means strongly dissatisfied or strongly disagree, value two (2) means dissatisfied or disagree, value three (3) means neither agree nor disagree, value four (4) means satisfied or agree, and value five (5) means strongly satisfied or strongly agree [19].

Data interpretation is divided into five tiers, summarized in the Analysis and Interpretation section.

3.3. Development and Performance

The development of a prototype water quality monitoring application in fish cages was done using a six-step software development life cycle (SDLC) as follows:

3.3.1. Project Planning

Project planning concerns problem analysis and contextual study of related issues. The researcher detected that the problems affecting fish farming in cages of farmers in northeastern Thailand have existed for a long time. It has a massive impact on the fishermen who raise fish cages. From the problems above, researchers have seen the problem and therefore developed this research with two parts of study and development: the development of IoT devices to measure water quality and applications for monitoring and alerting users. Offer details in the subsequent design stage.

3.3.2. Analysis

The part of the analysis the researchers designed and presented in Figure 1. The essential processes are as follows:

Hardware Analysis

The researchers analyzed the items and equipment required for the research, as shown in Table 2.

Table 1. Issues to evaluate the satisfaction of the system

Stages	Questions
Stage 1	Hardware and software connection capabilities
Stage 2	Login, member information editing, and password editing
Stage 3	Real-time water data management capabilities
Stage 4	Historical water data management capabilities
Stage 5	Water quality measurement accuracy capabilities
Stage 6	Water abnormality notification system via a social media application
Stage 7	Saving energy
Stage 8	The system is beneficial to water quality monitoring and fish cage farming.

Table 2. Hardware analysis

	Hardware	Characteristics	Implementation
1	E-201-C sensor	Measure the pH of the solution with the measured value in the range of 0-14 pH.	Measure the pH Value in the water.
2	Temperature sensor	Check the temperature	Check the temperature
3	NodeMCU-32 Arduino	It is a microcontroller that connects WIFI and Bluetooth.	Signal connection device
4	Solar panel 12V 20W	Convert solar energy into electrical energy	Energy source
5	Charge controller	Battery charge controller	Electricity control
6	Battery ultrafine 12V	Capacitor	Capacitor

Table 2 presents the hardware analysis to use the system. The hardware has six items: E-201-C sensor, Temperature sensor, NodeMCU-32 Arduino, Solar panel 12V, Charge controller, and Battery Ultrafine 12V, as shown in Figure 2 and Figure 3.

Software Analysis

The researchers measure certainty data for pH and temperature values from sensors using the Blynk application with Arduino microcontrollers. Blynk application is utilized to connect data in the microcontroller to the cloud using Wi-Fi. All hardware is synchronized with the Blynk application used on the internet.

Arduino IDE is used editing software to develop the source code for commanding and uploading programs or functions to Arduino microcontrollers of the system.

Flowchart

The researchers analyzed the hardware and software system map, as shown in Figure 4.

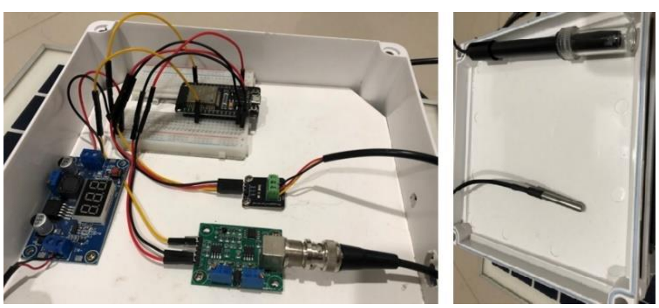

Fig. 2 NodeMCU-32 Arduino, pH and temperature sensor

Fig. 3 Solar panel, charge controller, and battery ultrafine

Figure 4 describes the operation flowchart of the system, starting from the connection between the microcontroller with the pH sensor and temperature sensor for receiving the pH and temperature values of the water and the relationship between the microcontroller and the mobile phone through Wi-Fi by users. Then read, upload, and forward the data to a mobile device. After that, considering the condition of the pH value, if greater than 6.5 and less than 9.0, it indicates that the water quality is standard, displays the result, and stops the operation. If the pH value is not specified, send a notification message to the Line application, and the condition of the temperature value, if greater than 25° C and less than 28° C, indicates that the water quality is standard, displays the result, and stops the operation. If the temperature value is not specified, send a notification message to the Line application—the water quality parameters for raising fish cages, as shown in Table 3.

Table 3. Water quality parameter range for raising fish cages

Parameter	Range value
pH	6.5 to 9.0
Temperature	25° C to 28° C

3.3.3. Design

As for the design, the researchers classified the design into two parts: hardware equipment assembly and mapping hardware and software for measuring the water quality, as shown in Figure 5 to Figure 6.

3.3.4. Implement

After successfully developing the device and the application, the researchers brought the device and application to work with a group of farmers in Yang Talat District, Kalasin Province, Thailand, which is the target area of this research.

3.3.5. Testing & Integration

During the testing and integration phase, researchers used the developed application to test with a sample of students who study in the Department of Information Technology, Rajabhat Maha Sarakham University, explore their satisfaction with the application, and make suggestions for improvement.

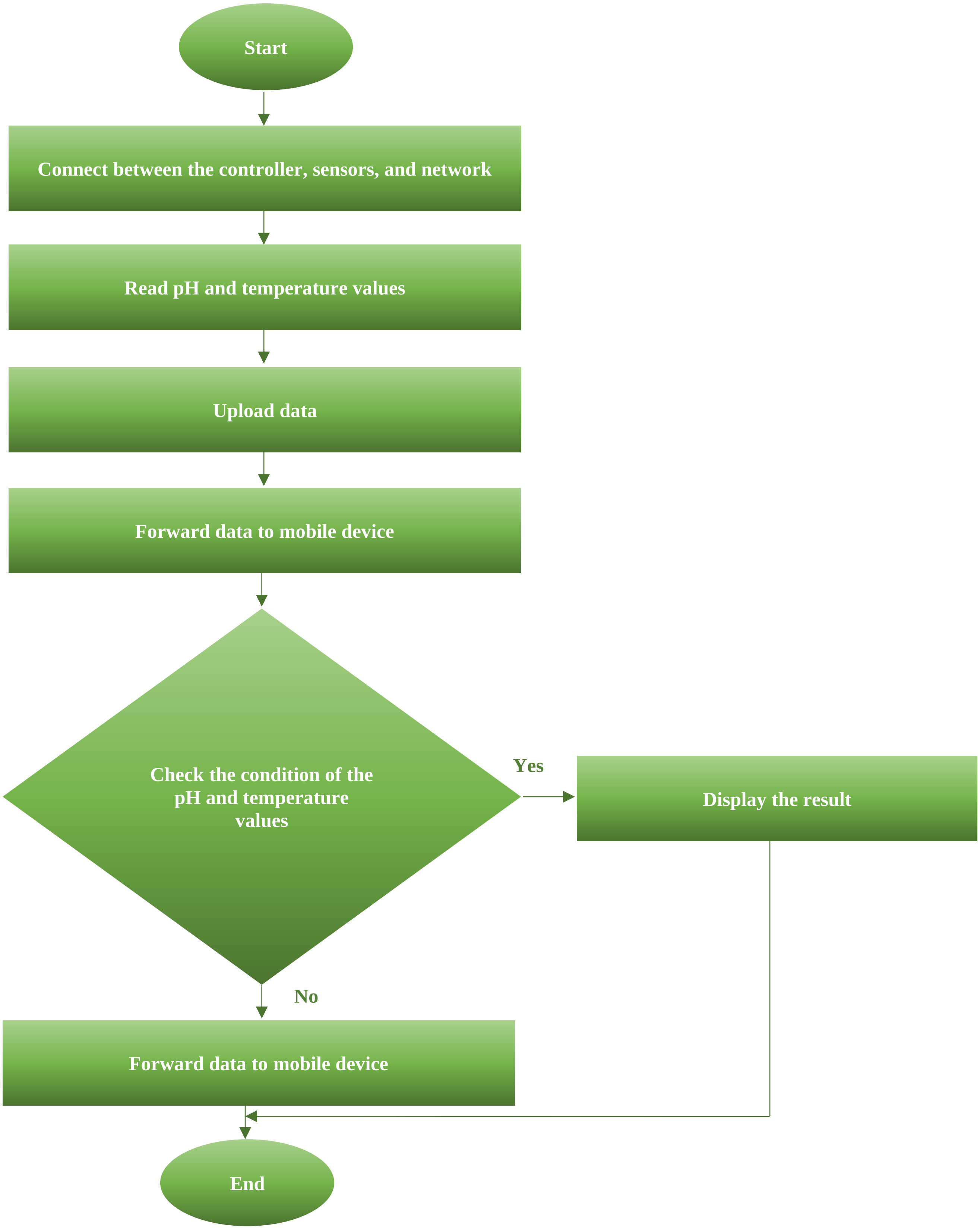

Fig. 4 Flowchart of the system

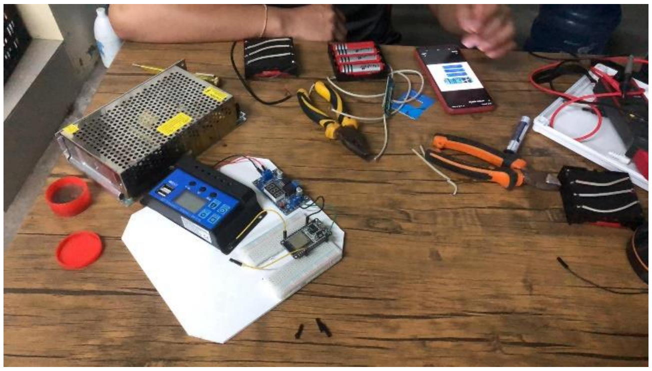
Fig. 5 Hardware equipment assembly

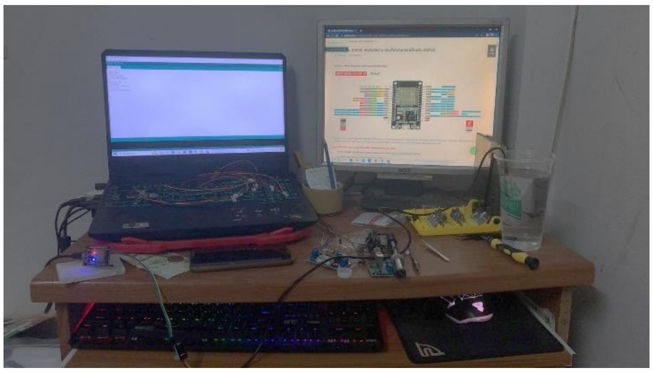
Fig. 6 Design and development of the water quality monitoring system

3.3.6. Maintenance

During the maintenance phase, the researchers get the equipment and applications to use in the community, develop a learning management plan, and disseminate it to community agriculture.

3.4. Interpretation of Research Findings

Interpretation and Interpretation of the Research Results The researchers used the application satisfaction assessment, which consisted of 8 issues, as shown in Table 1. The satisfaction criteria consisted of 5 levels interpreting the results classified into five sections: 1.00 – 1.79 means poorly acceptable or not satisfied, 1.80 – 2.59 means fairly acceptable or slightly satisfied, 2.60 – 3.39 means acceptable or satisfied, 3.40 – 4.19 means moderately acceptable or very satisfied, and 4.20 – 5.00 means highly acceptable or extremely satisfied. The application of the interpretation takes place in the reporting section.

4. Results and Discussion

The results and discussion are presented separately in two subsections.

4.1. Application

The researcher has developed an application by presenting the following components:

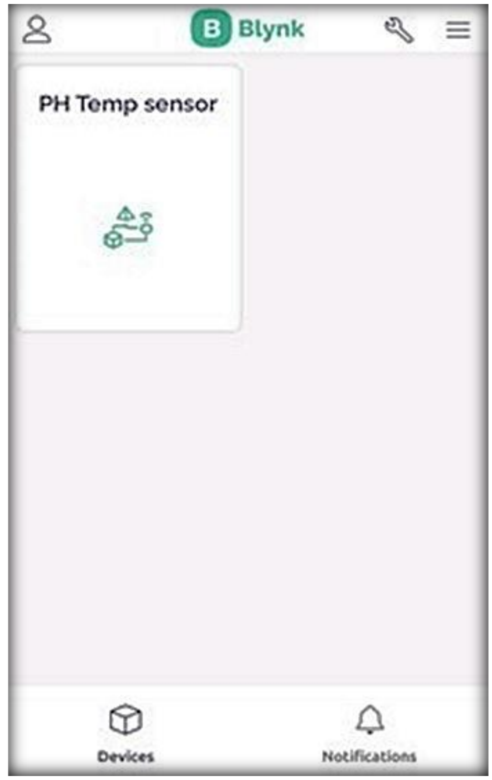

Fig. 7 Main page

Fig. 8 Determine pH and Temperature mode

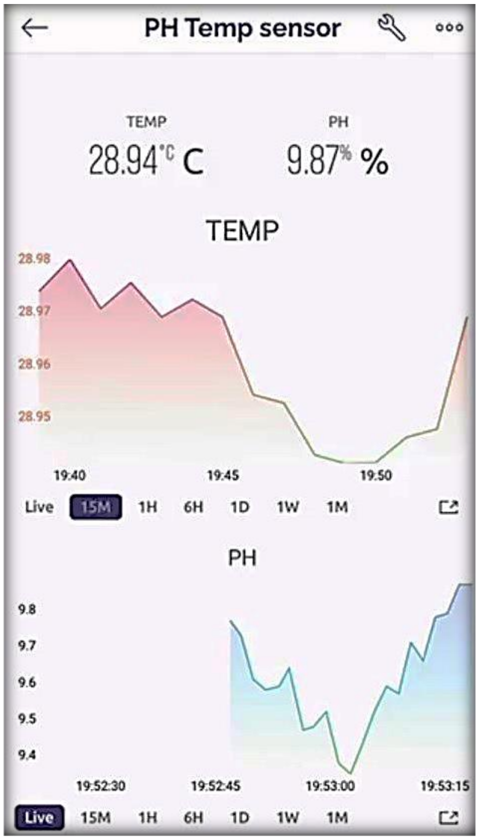

Fig. 9 Time mode to Determine pH and Temperature

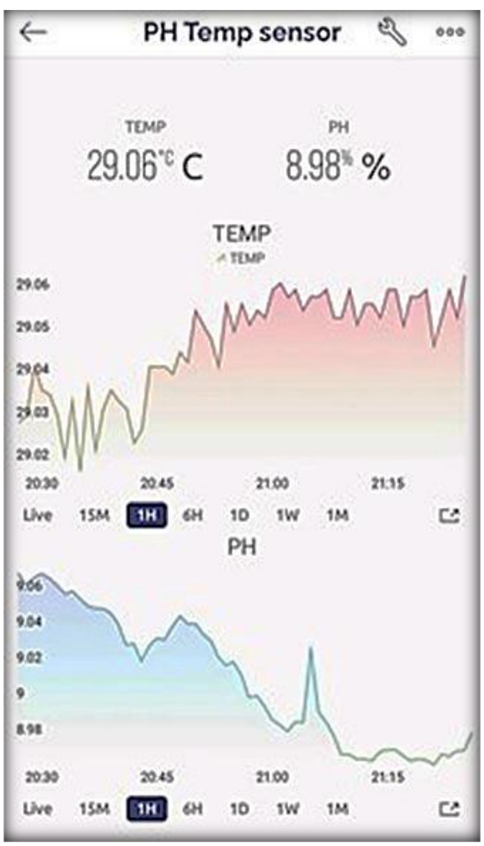

Fig. 10 pH and Temperature data displayed on the mobile phone

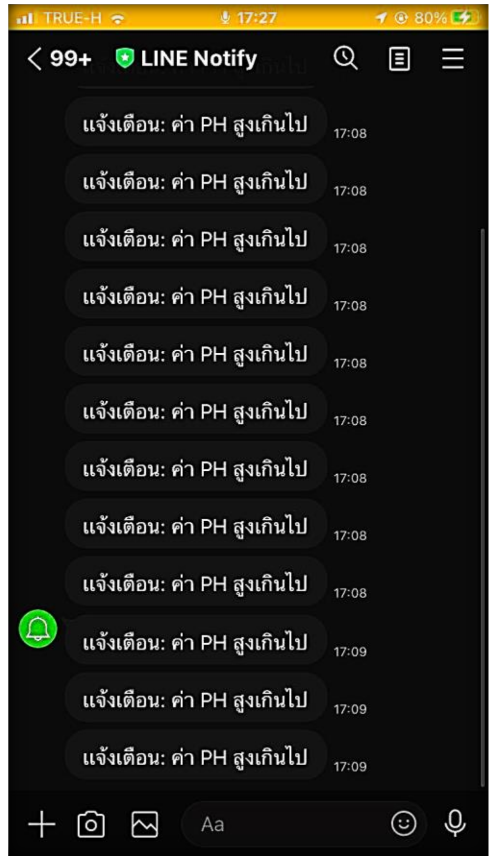

Fig. 11 Notification message on line application (message displays in Thai: "Reminder: PH value too high")

4.2. Application Satisfaction

Satisfaction with the application after being tested with a sample group is as follows.

Table 4. Application satisfaction

Stages	Level of Satisfaction		
	Means	S.D.	Interpretation
Stage 1	4.53	0.57	Extremely Satisfied
Stage 2	4.53	0.63	Extremely Satisfied
Stage 3	4.67	0.48	Extremely Satisfied
Stage 4	4.70	0.47	Extremely Satisfied
Stage 5	4.60	0.50	Extremely Satisfied
Stage 6	4.63	0.56	Extremely Satisfied
Stage 7	4.61	0.58	Extremely Satisfied
Stage 8	4.53	0.51	Extremely Satisfied
Overall	4.60	0.54	Extremely Satisfied

Table 4 shows that the sample has the highest level of application satisfaction, with means equal to 4.60 (S.D. = 0.54). The stage that received the highest satisfaction was stage 4: Water abnormality notification system via the web application, with means equal to 4.70 (S.D.0.47). The results of this satisfaction study were further discussed in the Discussion section of the research findings.

4.3. Discussion

From this research, the study's results can be summarized as follows:

- The results of the development of water quality measurement applications in fish cage farms can be used within the defined scope.
- The results of the study of the satisfaction of the application development using the sample group, the overall study results were at the highest level of satisfaction, with means equal to 4.60 (S.D. = 0.54).

The research's recommendations consisted of two points:

- Users of devices and applications should consult the manual additionally before each use.
- Researchers are students and educators and therefore do not have the potential to acquire devices. Therefore, relevant agencies should support the budget and invest in more efficient equipment.

5. Conclusion

The purposes of this research consisted of two key areas:

- To develop a prototype of a water quality monitoring system in fish cages using the Internet of Things and Blynk application.
- To study the satisfaction with the prototype of the water quality monitoring system. The population and sample were three instructors who acted as the expert to evaluate the questionnaire and 30 students who served as the respondents to assess their satisfaction with the system. All the samples are from the Faculty of Information Technology, Rajabhat Maha Sarakham University. The research tools comprised a water quality measurement system and a system satisfaction questionnaire. Statistics used in the satisfaction study were Mean, Standard Deviation (S.D.), and interpretation.

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The results of this research have benefited farmers in rural communities in the Northeast of Thailand. The researcher is confident that this research will further promote and drive the development of Thailand. In future work, the researchers will plan to develop a system that can be controlled by devices to on-off it for improving water quality is unsuitable for fish farming.

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