IoT-BASED SMART PLUGIN CHICKEN EGG INCUBATOR

JOHN KRISTOFER P. GINES
GRISSEL A. BELON
PAUL WILLIAM B. MARTIN
ALLAN A. VILLANUEVA

DON MARIANO MARCOS MEMORIAL STATE UNIVERSITY
MID LA UNION CAMPUS
COLLEGE OF INFORMATION TECHNOLOGY
CITY OF SAN FERNANDO, LA UNION

BACHELOR OF SCIENCE IN INFORMATION TECHNOLOGY

MAY 2023

APPROVAL SHEET

This thesis, **IoT-Based Smart Plugin Chicken Egg Incubator**, prepared and submitted by **John Kristofer P. Gines, Grissel A. Belon, Paul William B. Martin, and Allan A. Villanueva**, in partial fulfillment of the requirements for the degree Bachelor of Science in Information Technology was examined and passed on May 2023 by the Thesis Committee (OREC) composed of:

JOSEPH A. PATACSIL, Ph.D. Chair	**ZHELLA ANNE V. NISPEROS, MIT** Adviser
MANNY R. HORTIZUELA, MIT Member	**GLENN JOHN V. RARAS, CpA** External Evaluator

Accepted and approved in partial fulfillment of the requirements for the degree, Bachelor of Science in Information Technology.

SHEENA I. SAPUAY-GUILLEN, DIT
Chairperson, Bachelor of Science in Information Technology

____
Date Signed

ALVIN R. MALICDEM, DIT
Dean, Bachelor of Science in Information Technology

____
Date Signed

ACKNOWLEDGMENTS

Foremost, the researchers would like to express their sincerest gratitude to everyone who served as a helping hand in order to accomplish this study. They would never have been able to finish this without the supervision and help of the following people:

To Dr. Alvin R. Malicdem, Dean of the College of Information Technology, for motivating the researchers to finish this work in any way he can, and for his unfailing support to cultivate the researchers' skills and potentials;

To Dr. Sheena I. Sapuay- Guillen, Chairperson of the College of Information Technology, for motivating and supporting the researchers, and for helping the researchers complete their work, and worked to develop their skills and abilities;

To their adviser, Prof. Zhella Anne V. Nisperos, who willingly devoted her time, effort, knowledge, and patience to guide and help the researchers. Without her assistance, supervision, encouragements, and involvement in every step of the process, this paper would have been impossible to accomplish;

Sincerest gratitude also goes to Dr. Joseph A. Patacsil, the chair of the panel, for his valuable thoughts and constructive criticisms for the improvement of this research, and for always believing that this paper would be at its best;

Also, to the members of the panel and external evaluator, Prof. Manny R. Hortizuela and Mr. Glenn John V. Raras, who generously gave their precious time and knowledge which helped the researchers develop a broader perspective, and for lending their expertise in the enhancement of this study;

Sincerest gratitude also to Mr. Elvin E. Casem, for his valuable input to this study. His contribution has been instrumental in the success of the study. The researchers are grateful for the knowledge and expertise shared with the researchers;

To the respondents, who bravely and willing shared their experiences, and for enabling and entrusting their information to the researchers for the sake of this study;

To the researchers' family, friends and to their love ones, who have shown indebted support in all ways possible and for their unconditional financial, emotional, and moral support during the preparation of the study; and

Above all, to the God Almighty, the source of all knowledge and wisdom, for His most gracious help and divine intervention, for showering them with unending faith to push through their limits despite the challenges that they have encountered in pursuing this work.

JKG

GAB

PWM

AAV

This paper is humbly dedicated to our dearest families,

friends, loved ones, to those who put their faith and trust in us, and those

who generously offered their unflinching support.

This is all for you.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF PLATES

ABSTRACT

GINES, JOHN KRISTOFER P., BELON, GRISSEL A., MARTIN, PAUL WILLIAM B., VILLANUEVA, ALLAN A., (2023). **IoT-Based Smart Plugin Chicken Egg Incubator**. Bachelor of Science in Information Technology. Don Mariano Marcos Memorial State University Mid La Union Campus, College of Information Technology, City of San Fernando, La Union.

Adviser: **Nisperos, Zhella Anne V., MIT.**

Chicken and egg production are currently the most progressive animal businesses in the Philippines. This study aims to developed Arduino-based plugin calibrator with GSM capability; to evaluate quality of the prototype of the IoT-Based Smart Plug-in Chicken Egg Incubator using Technology Assessment Protocol Technical and Economic feasibility, environment soundness, political and social acceptability; To develop web-based monitoring system with data analytics using Agile Model and to determine the level of acceptability of the system using User Acceptance Testing. Developmental and purposive sampling was utilized to select 8 respondents was conducted to gather data. The data was analyzed using statistical tool such as weighted mean. In conclusion, this product as an innovation that can monitor the temperature, humidity, and through the graph data display created and applied through the smartphone display.

Keywords*: ArduinoUno, Smart Egg incubator, IoT*

Chapter 1

INTRODUCTION

Situation Analysis

Chicken and egg production are currently the most progressive animal businesses in the Philippines. As stated by Dela Cruz et al. (2020), native chickens are the most common domesticated fowl found in small-hold farms in the countryside (PCAARRD, 2018). Banabang Kalabaw is one of the recognized native chicken breeds in the Philippines, predominantly raised in the Quezon and Batangas provinces. Banaba chickens have an average egg weight of 40kg (Lambio, 2000; Guiam, 2018). The hatchability of native chicken eggs remains low even under artificial incubation, which becomes a significant challenge in products; smaller eggs have a higher surface area to absorb heat during incubation, and the optimum temperature for incubating native chicken eggs may be lower compared to commercial breeds.

There are different processes to be considered in the production of chicken and eggs. One of them is incubation. Warmth is maintained in fertilized eggs during incubation so that the embryo can grow into a chick. Maaño et al. (2018) stated that the natural incubation process involves a broody hen to fertile 14-16 eggs in optimum environmental conditions to stimulate embryonic development until hatching. The broody hen rotates the eggs during incubation about 96 times in 24 hours and maintains the proper humidity by sprinkling water on them from her break. Because the embryo is microscopic, the eggs initially require a tightly controlled heat input to maintain the ideal temperature of 38oC. The embryo creates more heat as it expands in size requires and may even need cooling.

Moisture levels of 60- 80% relative humidity stop additional moisture loss from the egg contents through the porous eggshell and membranes.

Yalcin (2022) further added that during incubation, the content of the egg is converted into a chick. This process is controlled by incubation conditions, which must meet the requirements of the chick embryo to obtain the best chick quality and maximum hatchability. Incubation temperature and light are the two main factors influencing embryo development and post-hatch performance. Because chicken embryos are poikilothermic, embryo metabolic development relies on the incubation temperature, which influences the use of egg nutrients and embryo development. Incubation temperature ranging between 37 and 38°C (typically 37.5–37.8°C) optimizes hatchability. Worldwide statistics show that about 8%-9% of all incubated eggs fail to hatch, which leads to a massive waste of time, space, labor force, and energy.

Furthermore, Mather (2021) added that the most common issue in incubation is uncontrolled temperature, which can harm embryo development and reduce poultry production. Manually monitoring the temperature and humidity of the poultry egg incubator is time-consuming and labor-intensive.

Purwanti et al., (2021) added that the development of technology had developed rapidly, including hatchery technology which has been able to create an artificial incubator known as the egg incubator (incubator).

An egg incubator is a system that provides the egg under incubation with constant temperature and humidity during hatching, invariably taking up the work of an animal for a particular period of days (Frederick et al., 2021).

Another impressive advancement in hatchery technology is supported by the article “Using predictive analytics to improve hatchery performance” (2021). Hatcheries have pivotal roles in poultry production systems. The data generated in this process can be better utilized with predictive analytic techniques to address common issues that affect hatchability and hatchling quality by supporting planning, preventive maintenance programs, and personnel interventions.

Internet of Things or IoT is a new paradigm that allows electronic communication between devices and sensors via the internet in order to improve our lives. IoT is gradually becoming an important aspect of our lives, and it can be felt all around us. Overall, IoT is an innovation that brings together a wide variety of smart systems, frameworks, intelligent devices, and sensors. Arduino is one of the many available solutions when you want to develop programmable hardware which can interact with the environment around us. The incubation system with the IoT is an add-on for the user to monitor and control anywhere in the world. This helps a lot for the user to continuously check the status of the system.

Gharti and Jirel (2020) added that in most developed countries, modern poultry houses rely upon electronic controllers such as Arduino, Raspberry Pi, and Node microcontroller units for monitoring the eggs. An electronic controller uses electrical signals and digital algorithms to perform its receptive, comparative, and corrective functions. Using controllers, it is possible to keep house temperatures within five different degrees of the desired temperature regardless of the outside temperature. This makes it possible to keep the birds comfortable, so they are not diverting energy from growth to stay warm or cool. To justify furthermore the same authors clearly stated that automation in poultry farms for monitoring and maintaining the inside temperature, feeding, monitoring water and poultry feed. The temperature sensor always monitors the inside temperature. If the temperature is not at the desired point, then the microcontroller controls the heater or cooling fan to set the temperature at desired condition. The humidity sensor monitors the amount of water vapor in air. When the temperature outside is cold, the relative humidity within the home is also cold, which causes dry dust to circulate in the air.

With the aforementioned scenario, this study intends to use automation in a poultry house the rapid development of Internet of Things (IoT) paradigm over the last decade enabled the production of smart egg incubators. These incubators are very easy and efficient to use in small hatcheries and provide controlling and monitoring incubation environment parameters easily. Besides this, they are provided with Internet connection, which is not the case with traditional incubators, so they enable chicken breeders to monitor these parameters anytime from anywhere.

Also, it is powered through the Arduino Uno and NodeMCU which binds all modules all together. The monitoring system allows the user to monitor the temperature and humidity over the network. The data values measure is transferred to an expert system that is running on a PC locally for analysis. The GSM module (SIM900A) is a system designed to transmit and receive user information anywhere and at any time through a messaging interface.

The IoT-based smart plug-in chicken egg incubator is a game-changer for chicken farmers and breeders. Its advanced technology allows for real-time monitoring and control of the incubation process via a smartphone or tablet. The smart plug-in chicken egg incubator eliminates the need for constant monitoring.

Statement of objectives

The general objective of the study was to design and develop an IoT-based monitoring for chicken egg hatchery with data analytics.

Specifically, it sought to address the following objectives:

1. to develop Arduino-based plugin calibrator with GSM capability;
2. to evaluate validity of the prototype of the IoT-Based Smart Plug-in Chicken Egg Incubator using Technology Assessment Protocol Technical and Economic feasibility, environment soundness, political and social acceptability (TAP-TEEPS);
3. to develop web-based monitoring system with data analytics using Agile Model; and
4. to determine the level of acceptability of the system using User Acceptance Testing (UAT).

Time and Place of the Study

This study was conducted at the College of Information Technology, City of San Fernando La Union from second semester, school year of 2021-2022 to first semester, school year of 2022-2023.

Definition of Terms

The following terms were defined for further understanding on the study:

Agile Model is a developmental software approach that breaks tasks into smaller parts and employs continuous planning, learning and improvement.

User Acceptance Testing (UAT) is a type of testing in which the end user or client verifies/accepts the software system before it is moved to the production environment.

Technology Assessment Protocol Technical and Economic feasibility, environment soundness, political and social acceptability (TAP - TEEPS) is a survey questionnaire that performed by the end user to validate the new technology's potential success based on its technical and economic feasibility, environmental sustainability, and political and social acceptability.

IoT-Based Smart Plugin Chicken Egg Incubator a smart plugin/calibrator tool to existing incubator to monitor the fertility rate and hatch rate and integrates the sensors to monitor the temperature, humidity and it can notify the poulter if he needs to candling, transfer, and reminder.

Chapter 2

METHODOLOGY

Research Design

This study used descriptive and developmental types of research. Descriptive research is a research method. used to describe the existing phenomena as accurately as possible (Atmowardoyo, 2018), descriptive studies look at the characteristics of a population; identify the problems that exist within a unit, organization or population; or look at variations in characteristics or practices in organizations or even countries. This research utilized descriptive research by determining the level of validity of the device by evaluating its technical and financial viability, as well as its level of environmental soundness, political and social acceptability. And also determining the level of acceptability by evaluating user acceptance testing.

Developmental research methods, according to Beb (n.d.), is a body of research literature which pertains directly to the development of instructions, which means that an output will be developed after conducting this research.

This research utilized the developmental research by the continuous design and development of IoT-Based Smart Plugin Chicken Egg Incubator and the web- based monitoring system with the analytics to evaluate and imply the changes over time. Improving the prototype according to its main functions and satisfying the users' needs.

Materials and Procedures

For objective 1, in order to develop a micro controller-based incubator with GSM capability, the researchers utilized the Micro controller modules, C++ source codes, and adjust the necessary variables for the commercialized incubator for the usability of the device. The device components can be seen in Table 1.

Table 1. Materials used for the chicken -egg incubator plug-in

Item	Qty	Description	Price	Purchase date
1.Arduino Uno R3	1	an open-source firmware and development kit	₱261	November 10,2022
2.NodeMCU ESP8266	1	an open-source firmware and development kit	₱240	November 15,2022
3. DHT11	1	temperature and humidity sensor.	₱60	November 15,2022
4.SIM900AGSM	1	Module GPRS/GSM communication.	₱390	November 21,2022
5. JUMPER WIRES	40	used for wirings the module	₱70	November 15,2022
6. 12V Power Supply	1	used to power the modules	₱170	November 15,2022
7. Step down	1	step-down module	₱150	November 16,2022
8. 16x2 LCD	1	Used to display	₱150	November
9. Tactile Switch	1	Buttons	₱20	14, 2022
		Total	₱1,511	

For objective 2, in order to evaluate the prototype using Technology Assessment Protocol Technical and Economic feasibility, environment soundness, political and social acceptability of the IoT-Based Smart Plug-in Chicken Egg incubator, the researchers utilized the prototype using Technical and Economic feasibility, environment soundness, political and social acceptability (TAP-TEEPS). Pre-made questionnaire will utilized.

For Objective 3,, the researchers utilized an agile methodology that fits the continuous testing and improvement of the software and the device. Inclined with the article of APM, Agile project management is an iterative method for completing projects at all stages of their life cycles. Many incremental actions are taken to complete a project throughout the course of an iterative or agile life cycle. Since iteration has the advantage of allowing for on-the-fly adjustments rather than following a linear path, iterative approaches are widely employed in software development projects to promote velocity and adaptability. Release of benefits throughout the process rather than just at the conclusion is one of the objectives of an agile or iterative strategy. Agile initiatives should fundamentally display the essential beliefs and conduct of cooperation, trust, and adaptability.

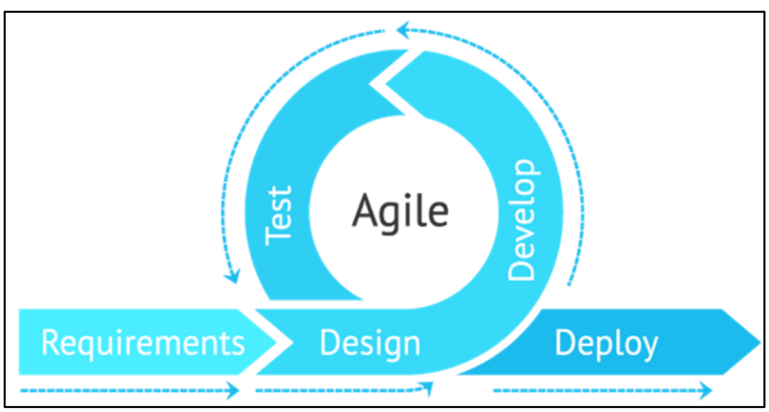

Fig 1. Agile Software Methodology

Figure 1 illustrates the methodology that the researchers will used to develop the project. The Agile methodology is composed of five (5) developmental phases; requirements phase, design phase, development phase, testing phase, deployment phase. One of the important values that are needed in Agile development are continuous communication with the customer and amongst the team. Frequent feedback through the system and acceptance testing and the changes during the development.

Requirements Phase

In the requirements phase of the study, the researchers needed to gather data from the respondents--Poultry farmers to determine the problem and come up with a solution. Moreover, the researchers prepared all the necessary requirements by discussing what would be the features of the project based on the data gathered moreover researcher create functional and non-functional requirements for user. Meanwhile, the researchers estimated the time needed to complete each phase of the project thus, doing this detailed analysis helped the researchers determine if the project would be feasible or not.

Design Phase

In the design phase of the project, the researchers designed circuits for the device and built the system architecture to illustrate the workflow of the project. Moreover, the researchers created the use case diagram and block diagram for the device and researchers made used of C++, HTML, CSS, JS and PHP for the architecture software and designed the UI/UX of the system based on the data gathered on the first phase. By doing this, the researchers determined the functionality of the features and to better understood what the outcome of the project would be.

Development Phase

In the development phase is the coding or developing the system, and it was the most challenging and crucial phase. At this phase, the design that was created was now being converted and coded into a programming language, refactoring the codes helped the programmer to have simple code. The researchers made use of Arduino IDE. After coding, the codes were tested for their functionality to test if the functions were working as intended. By this, the researchers progressed through trial and error and found the codes that supported this research's main functions. After the device was built, the researchers created the monitoring system for the device.

Testing Phase

In the testing phases, this included the testing of the device itself, where the researchers attached or put the device in the commercialized incubator to monitor the temperature and humidity, and if the device were able to calibrate the right temperature, humidity, days to candle, hatching rate and fertility rate without any bugs or glitches in the device and system. The codes were also checked by the built-in testing of the Arduino IDE and the monitoring system. This process detected and removed errors that can cause the device to malfunction to work as intended.

Deployment Phase

In the deployment phase of the project, the researchers introduced the device to its users. The researchers then explained the full functionality of the device and its features by providing a set of instructions or video demonstrations on how the device and IoT-Based Smart Plugin Chicken Egg Incubator worked.

For objective 4, in order to assess the level of acceptability of the IoT-Based Smart Plug-in Chicken Egg Incubator, the researchers utilized the User Acceptance Testing (UAT) Questionnaire.

Purposive sampling was utilized to select the respondents. Purposive sampling, also known as judgmental, selective, or subjective sampling, is a non-probability sampling method in which researchers choose people of the population to participate in their study based on their judgment (Rai et al., 2018).

Purposive Sampling was utilized in this study since the participants were carefully chosen to provide essential data for the study's objectives to be met. These respondents may have had experience in poultry farming.

There was a total of five (5) respondents in which that included five (5) farmers for the researchers to be able to get the more ideal results. The researchers decided to have the census where all of the respondents answered the questionnaires.

Data Analysis

The researchers applied statistical measures to evaluate the data gathered from the respondents of the survey questionnaire and evaluated the User Acceptance Testing of the developed system. Data analysis was interpreted through a 5-point Likert Scale.

TAP-TEEPS questionnaires followed a 5-point Likert scale in which every respondent can choose an option that best aligned with their view. It is often used to measure respondents' perspective by seeking the level of validity to the given statement. TAP-TEEPS score starts with 1(No Validity) and ended with 5 (Very High Validity). The higher the score, the better the performance and satisfaction. However, 3 is neutral but may not be the average and a score of above 3 did not indicate that the device would perform above average.

Points	Ranges	Descriptive Equivalent Ratings
5	4.20-5.00	Very High Validity
4	3.40-4.19	High Validity
3	2.70-3.39	Moderate Validity
2	1.80-2.69	Slight Validity
1	1.00-1.79	No Validity

The five-point Likert Scale was used for the categorization of all the above areas concerned.

UAT questionnaires follow a 5-point Likert scale in which every respondent can choose one option that best aligns with their view. It is often use to measure respondents' attitudes by asking the extent to which they agree or disagree with a particular question or statement. UAT score starts with 1(Strongly Disagree) and ends with 5 (Strongly Agree). The higher the score, the better the performance and satisfaction. However, 3 is neutral but may not be the average and a score of above 3 does not indicate that the device will be performed above average.

For the interpretation of the results of the mean rating in the Poultry farmers, the following scale was use:

Points	Ranges	Descriptive Equivalent Ratings
5	4.51-5.00	Strongly Agree
4	3.51-4.50	Agree
3	2.51-3.50	Undecided
2	1.51-2.50	Disagree
1	1.00-1.50	Strongly Disagree

The five-point Likert Scale was used for the categorization of all the above areas concerned.

The measurement scale of this study mostly referred to the classical scale which Venkatesh et al. (2020) put forward in the former research, and the questionnaire items of perceived cost relied on the scale.

Chapter 3

RESULTS AND DISCUSSION

Development of Arduino - based Plugin calibrator with GSM capability

In developing and building the components of Arduino – based plugin calibrator with GSM capability, figure 2 shows the device calibrator which has the following notable functions:

1. The device has SMS notification to alert the farmer when to candle.
2. The device can count the days when to candle the eggs.
3. Lastly, it can also display the current time and date.

Once the button is pressed, the device will start the incubation and the user will be notified everyfive (5) days to candle the egg.

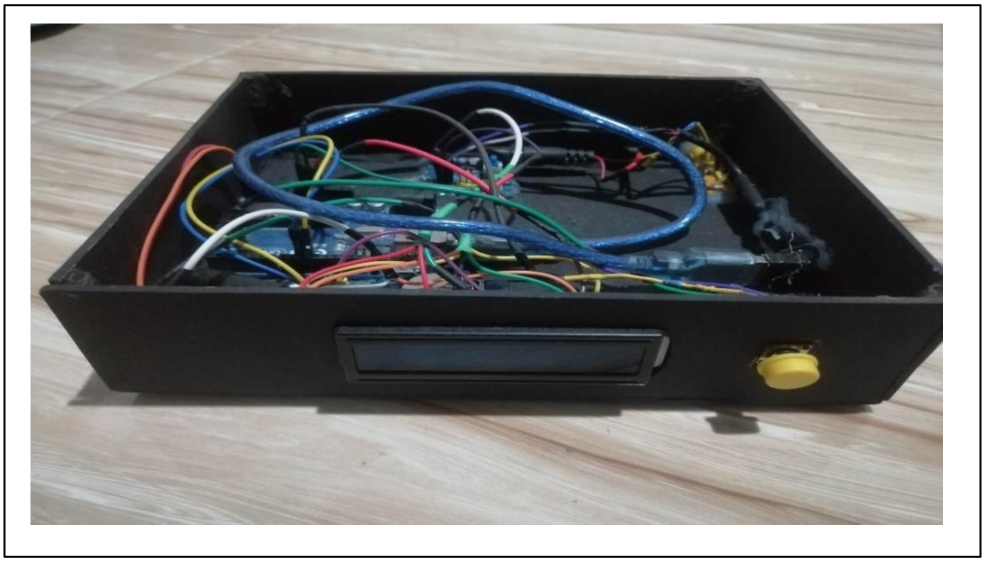

Plate 1. Device Calibrator

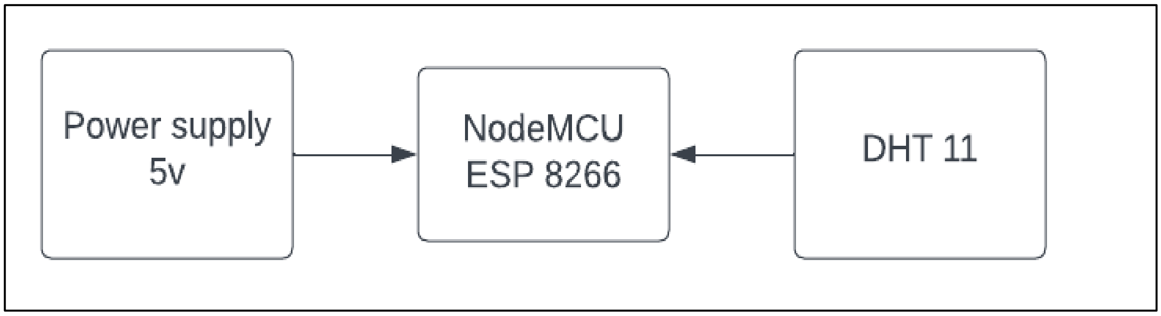

Fig. 2. Block Diagram (Nodemcu Microcontroller)

In figure 2, the pictorial block diagram shows how the components work together. The Arduino Uno will serve as main components where it will receive inputs from user sending the commands to the real time clock and GSM900A module and displaying data on the LCD. The buttons provide user input to the system for starting and stopping the process.

Arduino IDE is used to fully integrate the codes for the microcontroller. It is an open-source system that it makes developing code and uploading it to the board easier. Every Arduino board is compatible with this software. but in this research, IoT-Based Smart Plug-in Chicken Egg Incubator used the NodeMCU ESP8266 and Arduino Uno.

There are similar studies on where the IoT-Based Smart Plug-in Chicken Egg Incubator was based from the “Development of a small scaled microcontroller-based poultry egg incubation system” and the “Development of hen eggs smart incubator for hatching system based on internet of things”.

With the centralizing point of Gutiérrez (2019), it should be noted that the little or no presence of egg incubators with Internet connection denotes the lack of development of the IoT in agriculture. The motivation of this work was to promote the development of such applications. The cost of the equipment compared to other options in the market is low. However, in comparison with the industrial versions, incubators with Internet connection stand out for their prices and the advantages provided by remote monitoring using a smart phone.

Another study “Development of hen eggs smart incubator for hatching system based on internet of things” wherein according to Kutsira et al. (2019), the designed prototype system performed as expected based on the study specification. After a period of 21 days of incubation, the first chick was hatched from the incubation process. The other two eggs were hatched on day 23 and the last egg was hatched on day 25 before the incubation process was terminated. This work could be improved on by incorporating the Internet of Things and alternative power supply functionalities. This would result in the usability and reliability of the system.

Out of these similar studies, the researchers came up with an idea on how to execute an IoT-Based Smart Plugin Chicken Egg Incubator for an incubator. Just like the development of a small scaled microcontroller-based poultry egg incubation system on which they integrated the IoT on the incubator, the researchers integrated the plugin calibrator for incubators and monitoring system with data analytics to improve the hatchability and fertility rate.

The micro-controller comprises with a 5v output suitable for powering the NodeMCU and DHT11 is connected to the micro controller to output the temperature and humidity.

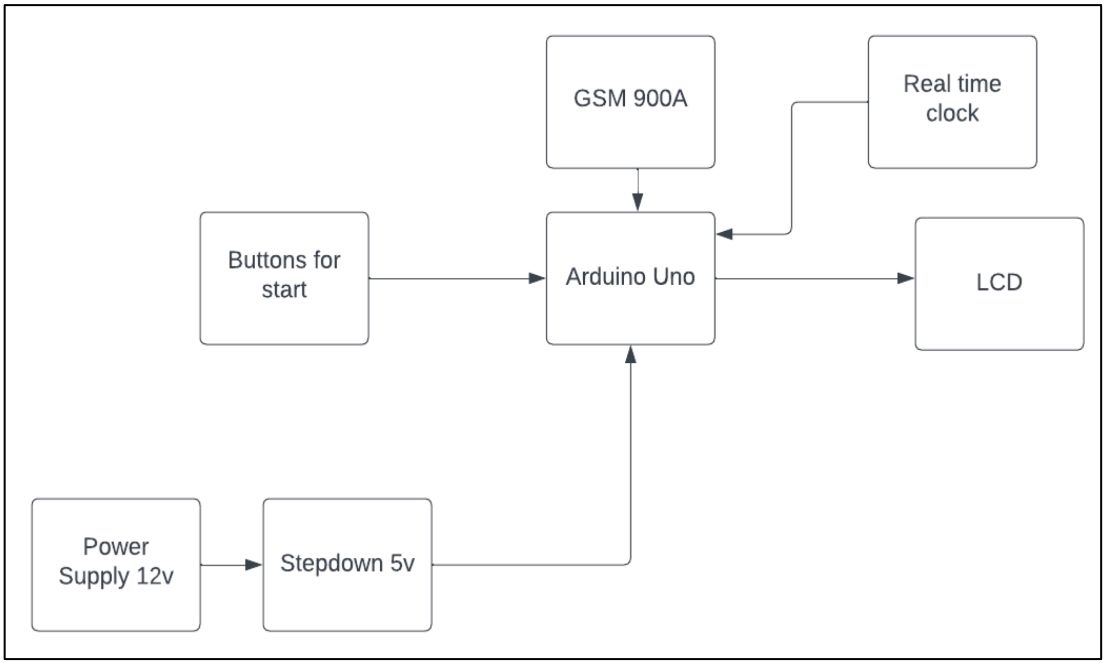

Fig. 3. Block Diagram (Arduino Uno)

The micro-controller comprises a 12V power supply that powers the 5V step-down regulator, which converts the 12V input to a 5V output suitable for powering the Arduino Uno and other components. The GSM900A module provides cellular connectivity for sending and receiving SMS messages for the farmer, the real-time clock module ensures that the system is synchronized with accurate time, enabling it to schedule events, log data, and trigger alarms.

Evaluation of Technology Assessment Protocol Technical and Economic Feasibility, Environment Soundness, Political and Social Acceptability (TAP-TEEPS)

Technology Assessment Protocol is a systematic evaluation framework that assesses the technical and economic feasibility, environmental sustainability, and political and social acceptability of new or emerging technologies. The aim of this protocol is to provide a comprehensive and balanced assessment of the potential impacts and benefits of these technologies, allowing decision-makers to make informed choices about their development and deployment. By considering technical and economic factors, such as the availability of resources and expertise, as well as the potential environmental impacts and social and political implications of the technology, the Technology Assessment Protocol provides a comprehensive and multi-disciplinary approach to technology evaluation.

On Table 4, the indicator “All parts and components can withstand continuous operation.” got a mean of 4.75 being the highest, which implies that the device is **very highly valid**, and with the indicator “Electrical components are properly installed with 4.5 mean rating, being the lowest, it implies that improper installation of electrical components can cause malfunctions, leading to unexpected downtime or system failures.

With the overall performance of the device which garnered a 4.62 rating or **highly valid,** the respondents suggested that it must wrap in a better enclosure to make it more

Table 4. Technical Feasibility in terms of durability

Indicators	Mean	Descriptive Equivalent Rating
a. Electrical components are properly installed.	4.5	Very highly Valid
b. All parts and components can withstand continuous operation.	4.75	Very highly Valid
Total Mean Rating	4.62	Very highly Valid

presentable. However, Hilder (2020) said that it is a real challenge to create an eye-catching packaging design that can reproduce for years, especially with the new trends of industrial designs.

Table 5 shows the data on the technical feasibility of the device in terms of its safety of operations. Being the highest mean of 4.62, the indicator “The machine is equipped with over current protection device,” it implies a need to improve its safety. Furthermore, relying solely on the overcurrent protection device may lead to a false sense of security and neglect of other safety measures, such as proper grounding and insulation. It is crucial to regularly test and maintain the overcurrent protection device to ensure that it is functioning correctly and to implement additional safety measures to prevent potential hazards and 4.37 being the lowest implies that this can result in potential safety hazards, such as electrical shocks, fires, or equipment damage.

Table 5. Technical Feasibility in Terms of Safety of Operations

Indicators	Mean	Descriptive Equivalent Rating
a. The machine is equipped with over current protection device.	4.37	Very Highly Valid
b. Electrical wirings and connections are properly insulated.	4.62	Very Highly Valid
c. The machine is labeled with safety precaution stickers.	3.75	Highly Valid
Total Mean Rating	4.25	Very Highly Valid

The overall performance is 4.25 or **very highly valid.** Saba et al. (2019) agree with this findings. The findings that emerged among others are: electricity users are aware of the risks associated with faulty electrical installations, damaged electrical appliances, and equipment; and they are not aware of the risks associated with ungrounded equipment, coiled extension leads, and other issues.

The table 6 shows the data on the technical feasibility of the device in terms of its speed and accuracy. Being the highest at 4.62, the indicator "The device parts and components are accurate," shows that the device is likely to function effectively and efficiently. At being 4.5 being the lowest, it implies that if the sensor malfunctions or is not properly calibrated, it may provide inaccurate readings. This can result in potential hazards, such as overheating or underheating of the incubator, which can affect the development of eggs or other materials being incubated. Furthermore, relying solely on the sensor's accuracy without regular calibration and maintenance can lead to false

Table 6. Technical Feasibility in terms of Speed and Accuracy

Indicators	Mean	Descriptive Equivalent Rating
a. The temperature and humidity senor can measure incubator temperature and humidity quickly and accurately.	4.5	Very highly valid
b. The device parts and components are accurate.	4.62	Very highly valid
Total Mean Rating	4.56	Very highly valid

readings, resulting in incorrect decisions or actions taken based on the sensor's output. implies the device parts and components being accurate is that it ensures the device's performance meets the required specifications.

The overall performance is 4.56 or **very highly valid**. Garaizar et al. (2019) said that the acceleration sensor gives useful information to distinguish between distinct activities by measuring the acceleration of the devices along several axes. The authors were interested in learning how varied sensors, devices, and workloads can affect potential heterogeneities in activity identification.

As gleaned from the table 7, having the indicator "The operation of the Prototype IoT-Based Smart Plug-in Chicken Egg Incubator is simple and easy to understand." being the highest with a mean rating of 4.87, this implies that the prototype IoT-Based Smart Plug-in Chicken Egg Incubator having a simple and easy-to-understand operation is that it reduces the learning curve and increases user adoption. Users of the incubator can quickly understand how to use the device, reducing the likelihood of user errors and

Table 7. Technical Feasibility in terms of Simplicity and Mechanism

Indicators	Mean	Descriptive Equivalent Rating
a. The operation of the Prototype IoT-Based Smart Plug-in Chicken Egg Incubator is simple and easy to understand.	4.87	Very highly valid
b. The machine can operate without human intervention once switched on.	4.25	Very highly valid
Total Mean Rating	4.56	Very highly valid

increasing the likelihood of proper usage. And having the indicator "The machine can operate without human intervention once switched on," at 4.25 rating, and being the lowest, it implies that without human intervention, the machine may be unable to make critical decisions or take appropriate actions in response to changing circumstances, potentially resulting in dangerous or costly outcomes.

The overall performance is 4.56 or **very highly valid**. Mohanty (2022) said that IoT architectures and protocols must be simple. While IoT devices need to be user-centered and valuable to the user, it is equally important that for end-users are easy to understand, which is why simplicity is an important construct for safeguarding the privacy of IoT device users.

Table 8 shows the data on the technical feasibility of the device in terms of its precision design. 4.75, being the highest mean, implies that this leads to a more streamlined design, lower manufacturing costs, and reduced maintenance needs. Additionally, a machine with well-defined and optimized parts can increase reliability and improve overall performance, as each component is working together towards a

Table 8. Technical Feasibility in terms of Precision Design

Indicators	Mean	Descriptive Equivalent Rating
a. Every part of the machine has a function and purpose.	4.75	Very highly valid
b. The concept of the design was not copied and is the original idea of the researcher.	4.50	Very highly valid
Total Mean Rating	4.62	Very highly valid

specific goal. With the indicator “The concept of the design was not copied and is the original idea of the researcher.” 4.50 being the lowest implies that the design is not a copy or imitation of someone else's work and demonstrates creativity and innovation.

The overall performance is 4.62 or **very highly valid.** Although the device rating falls on a very highly validity rating, there are more things to consider improving its preciseness. Chen (2020) says the role of designers is to meet the expressed needs of users about product design, by providing production and expectations, and cost to realize these product innovation features.

Table 9 shows the evaluation of respondents with the indicator “The expenses in the production of the Prototype IoT-Based Smart Plug-in Chicken Egg Incubator System are affordable to end users.” Being the highest with mean rating of 4.50. This implies that the device is viable in terms of cost. And with the indicator “Parts are readily available locally and online with affordable price.” at 4.37 rating, and being the lowest,

Table 9. Economic/Financial viability in terms of Cost

Indicators	Mean	Descriptive Equivalent Rating
a. Parts are readily available locally and online with affordable price.	4.37	Very highly valid
b. The expenses in the production of the Prototype IoT-Based Smart Plug-in Chicken Egg Incubator System are affordable to end users.	4.50	Very highly valid
Total Mean Rating	4.43	Very highly valid

implies that the availability of parts locally and online at an affordable price is that it may encourage users to opt for cheaper, lower-quality parts that may not meet the required standards or specifications of the machine.

The overall mean rating is 4.43 or **very highly valid**. Respondents finds the device is financially viable. The result could also mean that the IoT-Based Smart Plug-in Chicken Egg Incubator is affordable to them and could be possible to others. Albert (2020), economic viability as "the ability of a project, activity, or enterprise to achieve economic returns that are sufficient to cover its costs and generate net revenues over the long term." It implies further that the device has potential for market as it is not expensive for its usefulness and it could benefit mankind.

Table 10 shows, the evaluation of respondents with the indicator “The Prototype IoT-Based Smart Plug-in Chicken Egg Incubator System does not pose hazards to human welfare.” 4.50 being the highest implies the Prototype IoT-Based Smart Plug-in Chicken

Table 10. Environmental Soundness

Indicators	Mean	Descriptive Equivalent Rating
a. The Prototype IoT-Based Smart Plug-in Chicken Egg Incubator System is not harmful to the environment.	4.37	Very highly valid
b. The Prototype IoT-Based Smart Plug-in Chicken Egg Incubator System does not pose hazards to human welfare.	4.50	Very highly valid
Total Mean Rating	4.68	Very highly valid

Egg Incubator System not posing hazards to human welfare is that it promotes safety in the workplace or in the user's home. The system has been designed and tested to ensure that it does not produce harmful emissions, expose users to dangerous voltages, or create other safety hazards that could potentially harm human health. And having the indicator “The Prototype IoT-Based Smart Plug-in Chicken Egg Incubator System is not harmful to the environment.” at 4.37 rating, and being the lowest, it implies that the Prototype IoT-Based Smart Plug-in Chicken Egg Incubator System not being harmful to the environment is that it may not be designed with sustainable or eco-friendly materials, components, or processed.

The device got a rating with an overall mean of 4.68 or **very highly valid**. It implies that its use does not pose any harm to the environment. Buena (2021) mentioned that people are trained to use IoT technologies, they tend to believe that these products are useful and easy to use, increasing the intention to use them.

Table 11. Political Acceptability

Indicators	Mean	Descriptive Equivalent Rating
a. The Prototype IoT-Based Smart Plug-in Chicken Egg Incubator System matches the interests and needs of the target end-users	4.37	Very highly valid
b. The technology meets the standards for its utilization.	4.50	Very highly valid
Total Mean Rating	4.87	Very highly valid

Table 11 shows the evaluation of respondents. Having the indicators “The technology meets the standards for its utilization” 4.50 being the highest implies that it ensures the safety and reliability of the product. Standards are set to ensure that products meet certain criteria for quality, safety, and performance, and adherence to these standards can help to build trust and confidence in the product among users and regulators. And having the indicators “The Prototype IoT-Based Smart Plug-in Chicken Egg Incubator System matches the interests and needs of the target end-users” 4.37 being the lowest implies that the interests and needs of the target end-users is that it may limit the potential market for the product.

The device got a rating with an overall mean of 4.87 or **very highly valid.** Devine-Wright et al. as cited in the study of Antawi and Ley (2021) stated that because of how knowledge and policies are retained at the national level and scarcely distributed to

Table 12. Social Acceptability

Indicators	Mean	Descriptive Equivalent Rating
a. Gender acceptability: The device can be operated and used by both men and women with ease and precision.	5	Very highly valid
b. The device fits the local socio-cultural environment (social practices, local traditions and more, and cultures)	4.62	Very highly valid
c. The device serves the needs of the majority of those whom it seeks to benefit.	4.43	Very highly valid
Total Mean Rating	4.76	Very highly valid

the local levels, the difficulty of local people to gain the required knowledge on regulations, alternatives, and rights related a project may further impede project success at the community level.

Table 12 shows the respondents' perception of the device in terms of iys social acceptaqbility. With the indicator "Gender acceptability: the device can be operated and used by both men and women with ease and precision.", it was rated the highest as 5.00 which implies that the device promotes gender equality by being accessible and user-friendly for all genders, allowing both men and women to engage in poultry farming and egg incubation with ease and precision, regardless of their previous experience or knowledge. And having the indicator "The device serves the needs of the majority of those whom it seeks to benefit" being the lowest with a rating of 4.43, it implies that the device is designed to be accessible and user-friendly for both genders, there is a risk that it may overlook the needs of specific minority groups, such as people with disabilities, non-binary individuals, or individuals from different cultural backgrounds.

The overall mean on social acceptability is 4.76 or **very highly valid**. Koelle (2020) agreed that social acceptability of human-machine interactions has gained relevance and growing interest from the HCI community. Yet, there are no best practices or established methods for evaluating social acceptability.

Table 13 presents the summary table for TAP- TEEPS assessment of the IoT-Based Smart Plug-in Chicken Egg Incubator System to evaluates it level of validity. With this table having the indicator "Political Acceptability" at 4.43 being the highest implies that the device describes as very highly valid. The use of the device did not violate any regulatory requirements and standards of lawmakers and authorities. "Economic viability" at 4.43 being the lowest implies that is very highly valid. It also means that the device is affordable for the target end-users and does not require high maintenance costs.

The result indicates that the IoT-Based Smart Plug-in Chicken Egg Incubator System is very highly valid with an overall mean rating of 4.65. it simply means that the developed device is very effective, Dibb and Simkim (2021), defining and selecting the target audience in business, facilitates the communication between the company and customers, based on a reliable and direct communication. Companies can understand their customer better, as the messages and feedbacks, are more relevant when reaching the right audience.

Table 13. Summary for level of validity of the IoT-Based Smart Plug-in Chicken Egg Incubator System

Indicators	Mean	Descriptive Equivalent Rating
Technical Feasibility	4.52	Very highly valid
Economic Viability	4.43	Very highly valid
Environmental Soundness	4.68	Very highly valid
Political Acceptability	4.87	Very highly valid
Social Acceptability	4.76	Very highly valid
Mean	4.65	Very highly valid

The Developed Web application and device using Agile Model

Overview of the System

IoT-Based Smart Plug-in Chicken Egg Incubator is a device that regulates temperature and humidity of the incubator with monitoring and data analytics that displays the current data from the sensors and notification system for candling schedule and transfer to the hatcher.

Requirements Phase. Based on gathered information, the researchers built a device that can calibrate the incubator. Poulter experienced uncontrolled temperature and humidity due to an uncalibrated incubator. Thus, many eggs and workforce are being wasted. The functional and non-functional requirement were the primary deliverables used in developing the Web Application

- Non-Functional Requirements

As the researchers were now aware of the problems that needed to be solved, they were able to develop with the non- functional requirements.

1. Operability: Device can be operated up to 24hrs working operation.
2. Accuracy: The device sensor can detect the temperature and humidity of the environment.
3. Portability: The device can plug and use in the existing incubator.

- Functional Requirements

As the researchers were now aware of the problems that needed to be solved, they were able to develop with the non- functional requirements.

1. Once the incubation begins, the device can start the reminder system

2. Website monitoring can display the temperature, humidity and compute the fertility and hatching rate of the eggs.

D*esign Phase.* Figure 3 below shows the block diagram of IoT-Based Smart Plugin Chicken Egg Incubator. The project is controlled by two microcontrollers, Arduino Uno and NodeMCU. Arduino Uno controls input and outputs of the device while NodeMCU controls the input of the user in web application.

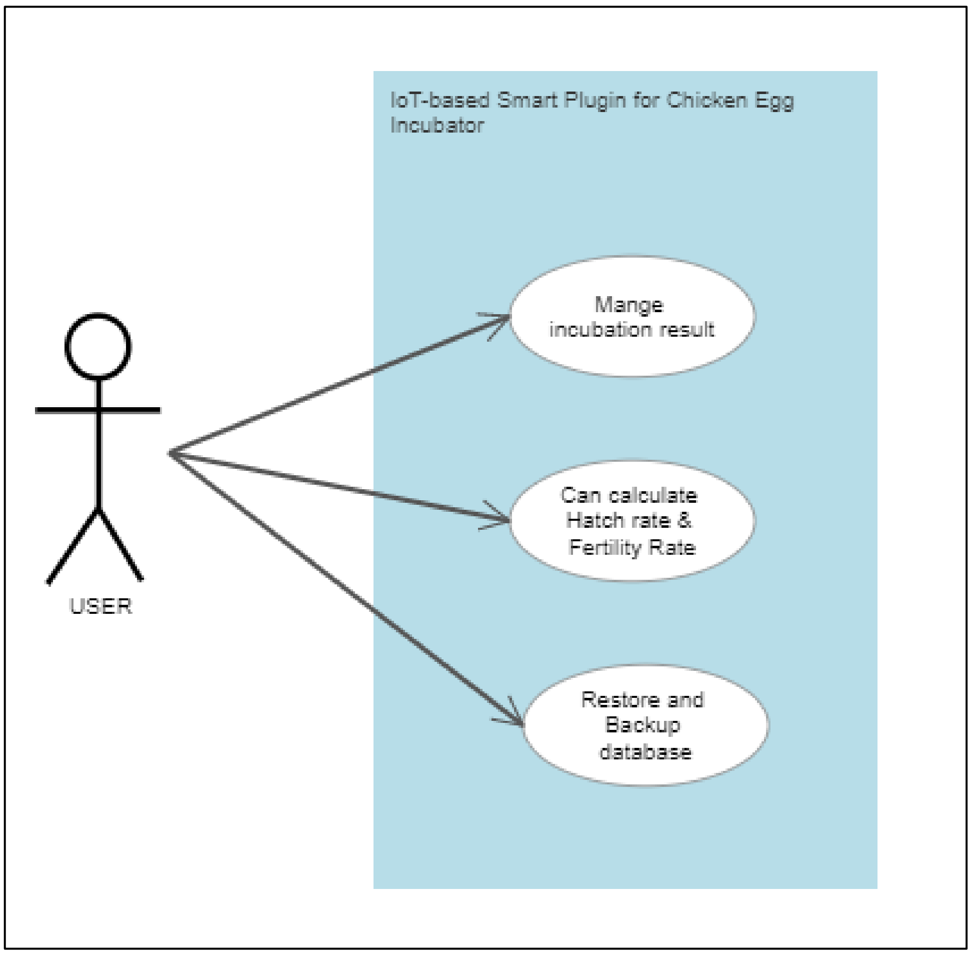

Fig 4. Use Case Diagram

User can manage the incubation result, calculate the hatch rate and fertility rate of the incubation and also user can back the database.

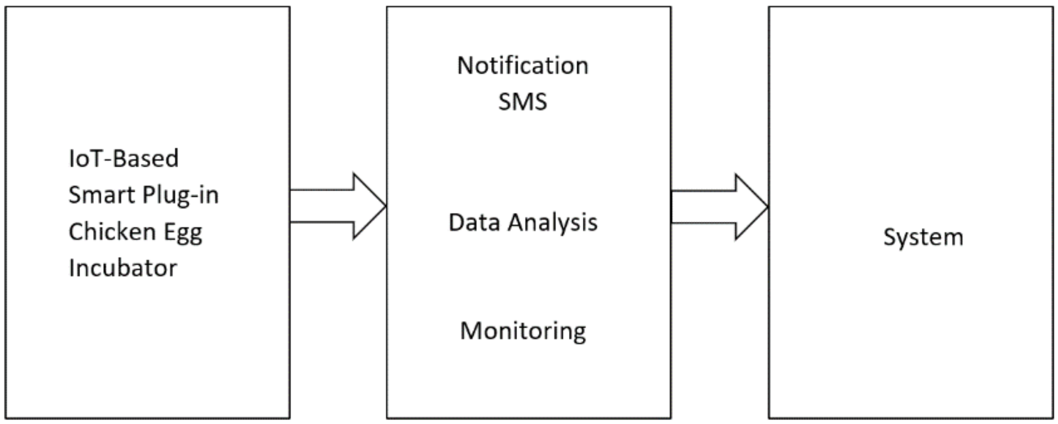

Fig.5 Process Flow of the System

The device can message the user for candling the eggs, data analysis for the past and present incubation for further analysis of the incubation and lastly user can monitor the temperature and humidity of the incubator.

Development Phase.

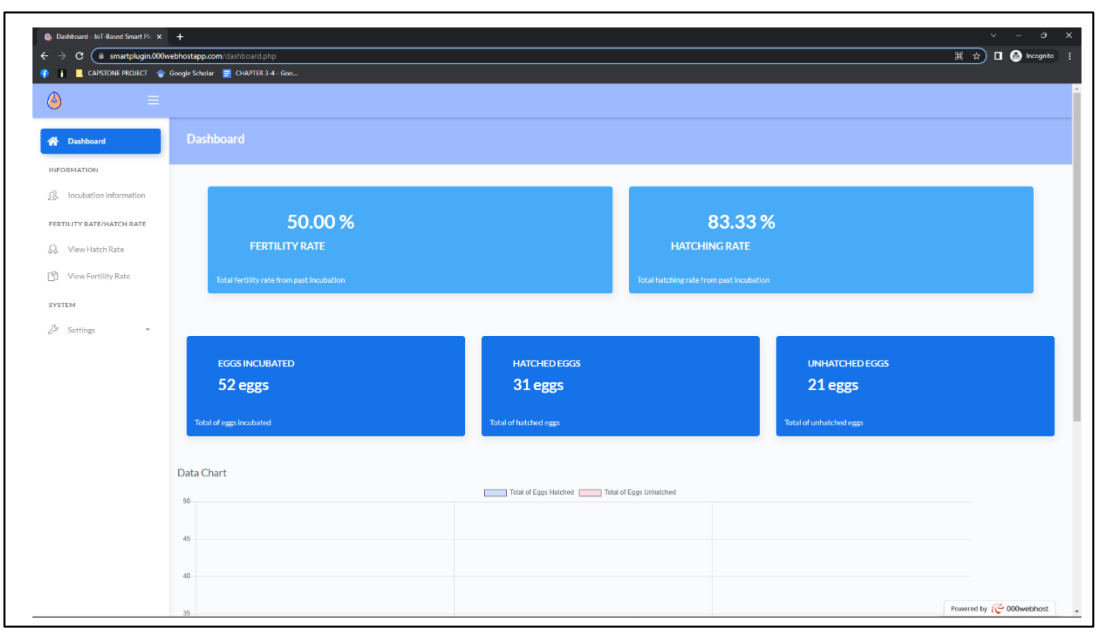

Plate 2. Home Page

The feature that allows users to view their incubation rate is an innovative and powerful tool that can help user track and improve their productivity and efficiency. By measuring the time, it takes for a user to turn an idea into reality, the incubation rate feature provides users with valuable insight into their creative process and enables them to identify areas where they may need to focus more attention or make improvement.

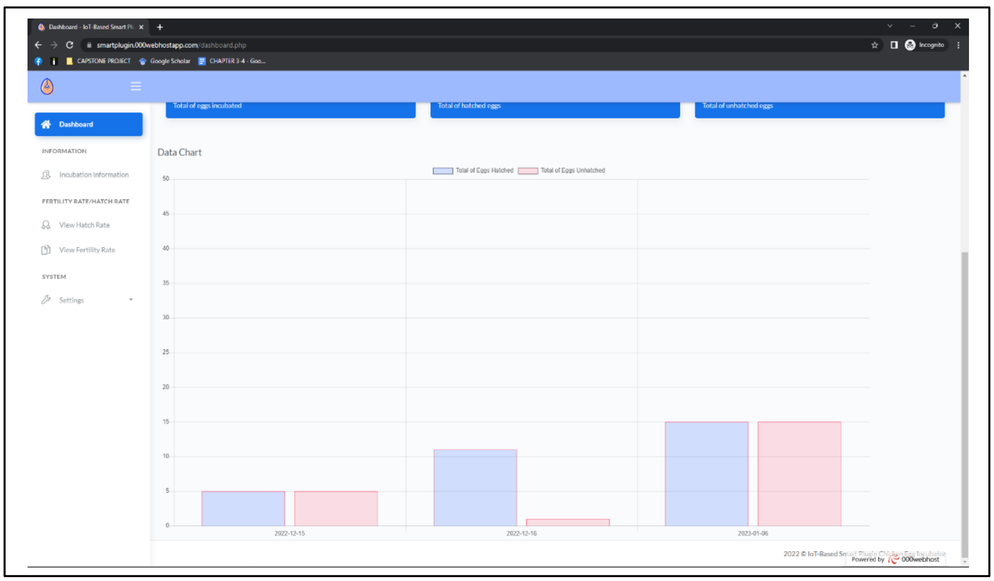

Plate 3. Data Chart

A chart that displays the historical trends of variables can be a useful tool for users who need to track changes over time. By visually representing data in a clear and concise way, the chart allows users to easily compare past and present values and make informed decisions based on the data.

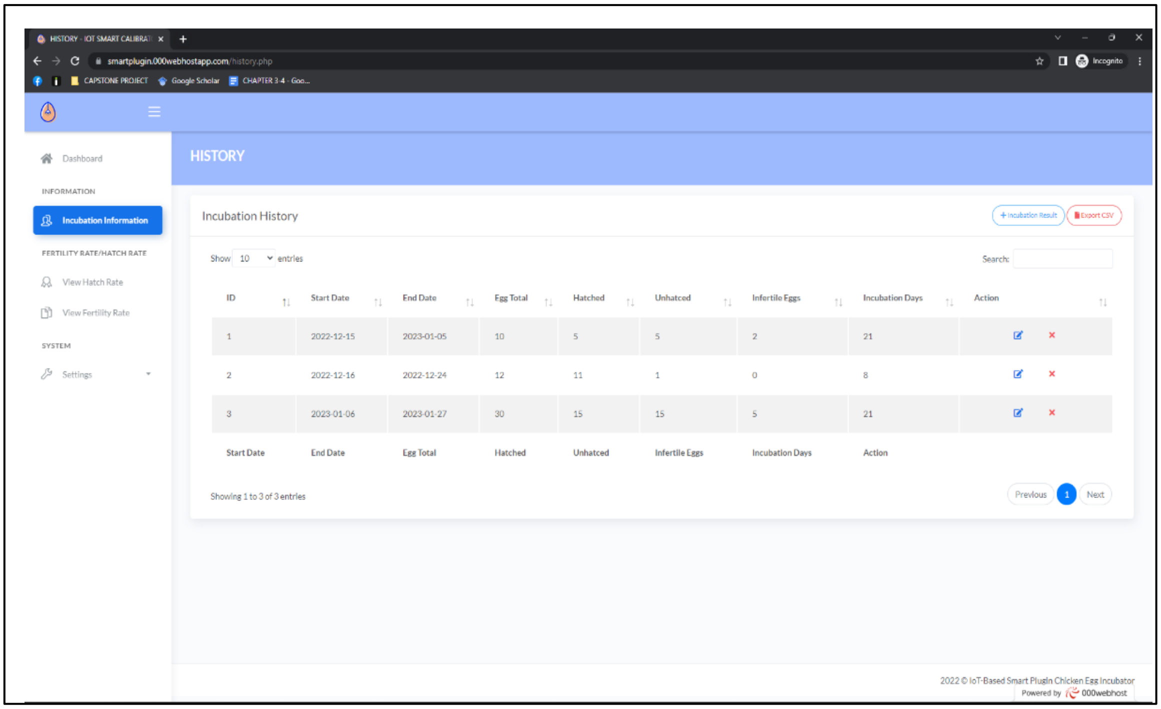

Plate 3. Incubation Information Page

This feature allows users to input data on an incubation cycle and displays it on the home page, providing an overview of the process. It is helpful for animal breeders to track success rates and make informed decisions to optimize their efforts.

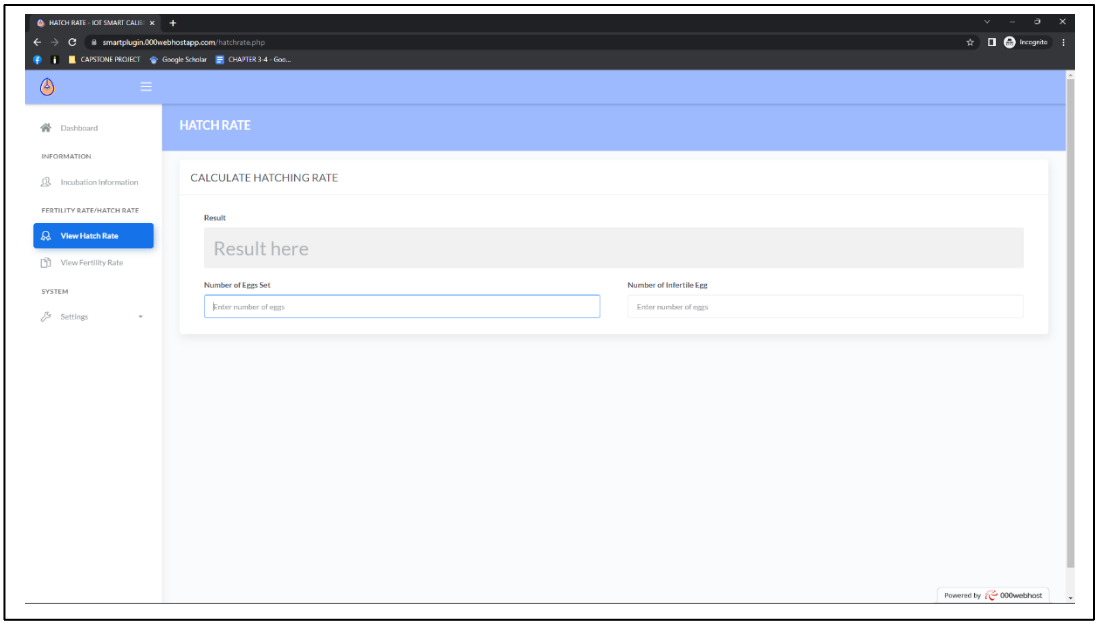

Plate 4. Hatch Rate Calculator Page

This feature calculates hatching rates based on the number of eggs incubated and hatched, allowing users to monitor and adjust their incubation practices. It is helpful for animal breeders to optimize productivity and efficiency, and provides essential data to improve success rates over time.

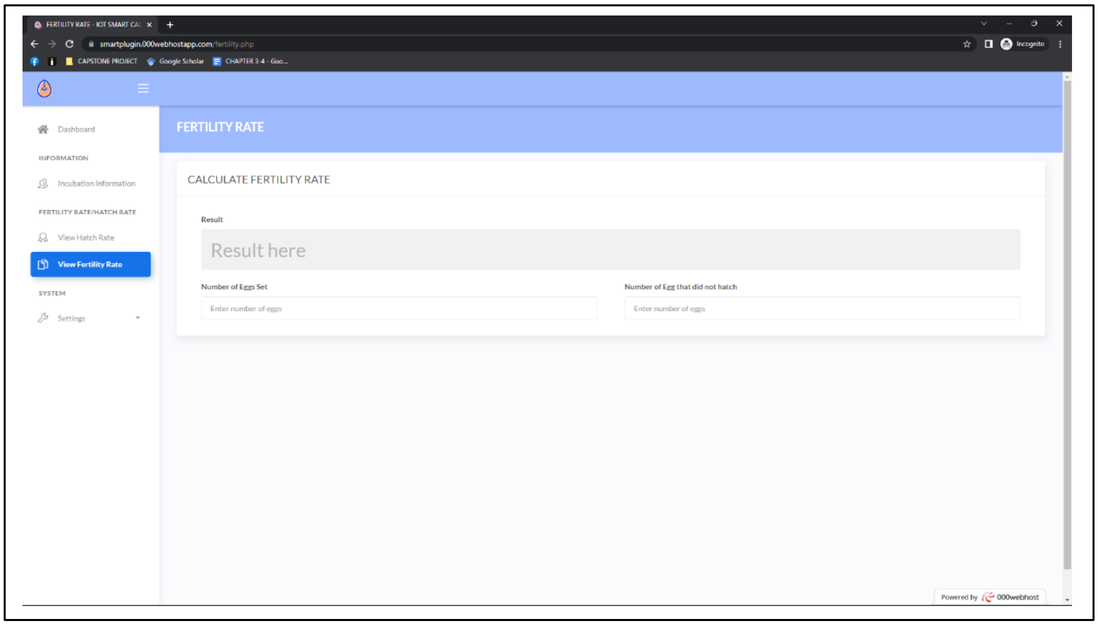

Plate 5. Fertility Rate Calculator Page

The function determines the fertility rate based on the quantity of fertile eggs and the quantity of infertile eggs, which is frequently used in animal breeding to follow development. It allows users to adjust their breeding practices to achieve optimal results, providing valuable data for businesses and individuals involved in animal breeding. The fertility rate calculation feature offers a valuable tool for anyone in animal breeding to monitor and improve their breeding success rates.

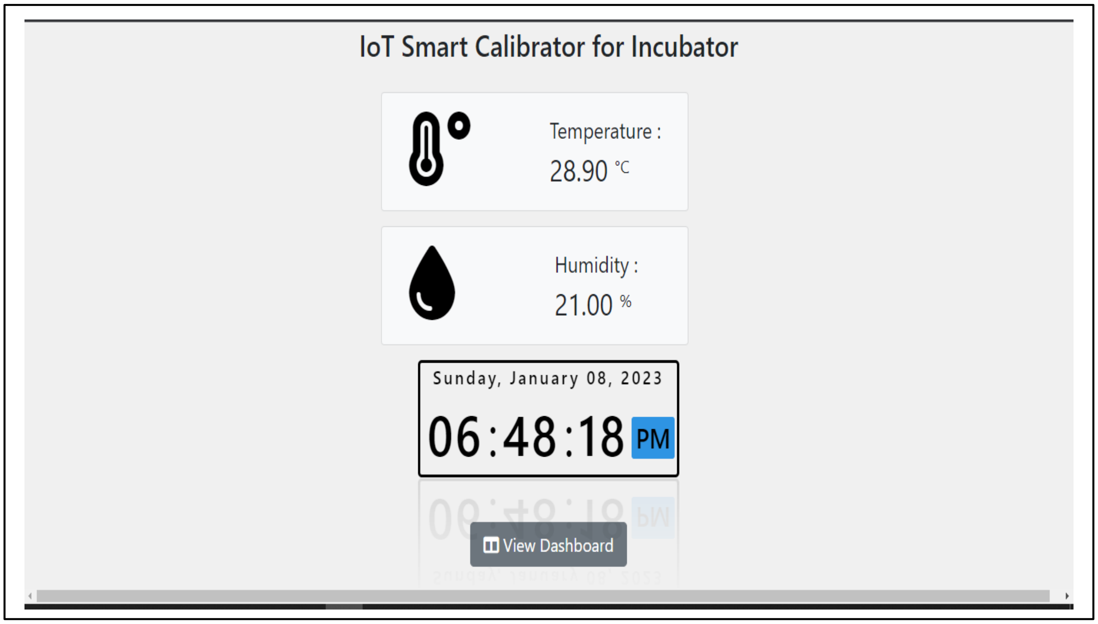

Plate 6. Monitoring Page

The feature displays real-time information on temperature and humidity levels inside the incubator, allowing users to monitor and adjust settings as needed to optimize the incubation process. It is particularly useful for animal breeding and incubation, where precise environmental conditions are crucial for successful hatching rates.

In the first phase of the continuous development of both web application and the device, the researchers first built the device casing to serve as protection to the device components. The researchers then arranged the placement of GSM Module and DHT 11 which were then connected to the NodeMCU and powered up by centralized power supply.

In the second and final phase, it involved developing the web application itself. In this final phase, the researchers developed the system based on the needs of the user as stated from the gathered data.

Plate 7. Second Development Phase

The device used to display the number of days to candle and the current time and date.

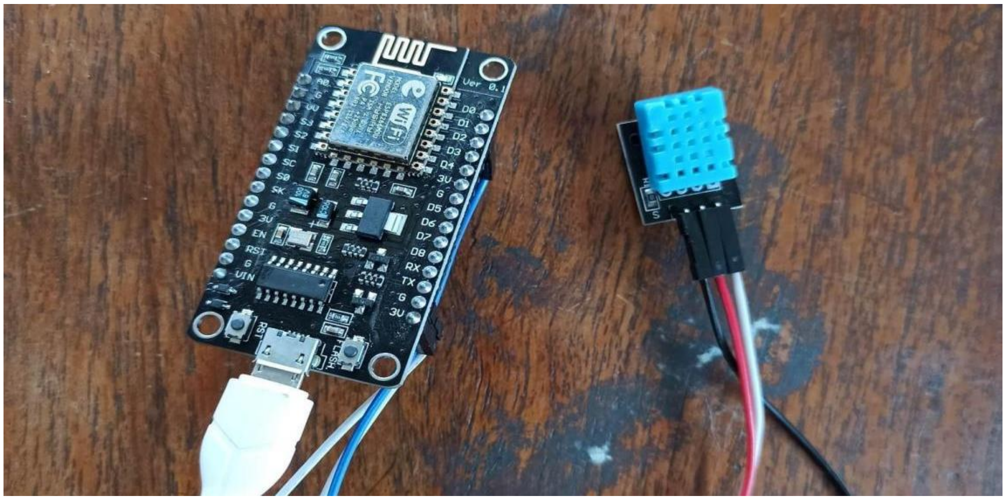

Plate 8. Second Development Phase: The Plug in Device

The plugin device shown in Plate 8 goes through the incubator and calibrate the desired temperature and humidity.

Testing Phase. In the first phase of the testing phase, the researchers inputted the codes for the device on which they encountered complications on the wiring such as misplacements. When the wiring was placed according to the code's instructions, the researcher connect ed the wires in place and tested the device sensors with the web application.

In the second phase of the testing, the researchers inputted the codes for the web monitoring system in which the sensor will be displayed on the web application and for the hatching rate and fertility rate the user will input the data to compute the percentage of hatching rate and fertility rate. Moreover, the researcher encountered loose pins on the board in displaying the temperature and humidity which then worked with the tightening of the pins.

In the final phase of the testing phase, the researchers encountered problems on the devices power capability. They tried using 5V power supply however it wasn't enough to power the device. Next, they tried using 12V centralized power supply which maximized the devices full power and can run 24/7 working operation.

Deployment Phase. After the final phase of the testing phase when every components of the device were working as intended, the researchers deployed the device in poultry and present and discuss the main functionalities such as user setting up the plugin calibrator and user input for the hatching and fertility rate through the web application. the researchers used purposive sampling and allowed respondents that are often using chicken egg incubator and expert evaluator to evaluate the web application together with the device and let them answer the Technology Assessment Protocol Technical and Economic feasibility, environment soundness, political and social acceptability (TAP-TEEPS) and User Acceptance Testing (UAT) and survey questionnaires will be given. The TAP-TEEPS questionnaires evaluates the validity of the prototype and the UAT questionnaire evaluates the device User Acceptance Testing.

Level of Acceptability of the System

User Acceptance Testing (UAT) is to validate that the software and hardware system functions as intended, is user-friendly, and meets the needs of the business. This testing is performed in a controlled environment and simulates real-world scenarios to provide the researcher with feedback on the product's functionality and usability.

Table 14. Overall rating of User Acceptance Testing

Indicators	Mean	Descriptive Equivalent Rating
1. The smart plugin chicken egg incubator is usable.	4.75	Strongly Agree
2. The smart plugin chicken egg incubator is capable of regulating the humidity.	4.62	Strongly Agree
3. the smart plugin chicken egg incubator controls the temperature and humidity inside the enclosure?	4.5	Agree
4. The requirements for smart plugin chicken egg incubator met?	4.5	Agree
5. The functionalities of the smart plugin chicken egg incubator perfectly working.	4.75	Strongly Agree
6. The temperature of smart plugin chicken egg incubator is reliable.	4.62	Strongly Agree
7. Were the results what you expected.	4.37	Agree
8. The system is functioning very well.	4.75	Strongly Agree
9. Did encounter system error.	2.37	Disagree
10. Did the device malfunction.	2.37	Disagree
11. The system responds quickly.	4.625	Strongly Agree
12. Would you consider using the smart plugin chicken egg incubator?	4.25	Agree
13. Would you recommend the smart plugin chicken egg incubator?	4.25	Agree
14. Software continue functioning if changes are made.	4.25	Agree
15. Software tested easily.	4.62	Strongly Agree
16. Smart plugin chicken egg incubator can be moved to other environments.	4.5	Agree
17. Smart plugin chicken egg incubator can be installed easily.	4.5	Agree
18. SMS notifications are received?	4.37	Agree
19. The system is user friendly and not confusing.	4.37	Agree
20. The software performs the tasks required.	4.75	Strongly Agree
21. The result appears as expected.	4.5	Agree
22. Do the user interface looks good?	4.5	Agree
23. The user uses the system without much effort.	4.62	Strongly Agree
Total Mean Rating	4.34	Agree

Table 14 shows the overall result of the measurement of the functionality, usability, and acceptability of the device which gathered a mean rating 4.34 which is considered as **agree**. This means that overall, the users find the developed device functional and usable. With this table having the indicators “The system is functioning very well.”, “The smart plugin chicken egg incubator is usable” at 4.75 being the highest implies that the device is functional and usable to use. With the indicators “Did you encounter system error?”, “Did you encounter system error?” at 2.37 being the lowest implies that the device did not encounter error over testing. As cited in the study of Chen, Karen, et al. (2023), the degree to which a product may be utilized by particular users to accomplish particular goals in a particular context of use with effectiveness, efficiency, and satisfaction.

Chapter 4

SUMMARY, CONCLUSION AND RECOMMENDATION

Summary

This study aimed to develop a device: IoT-Based Smart Plug-in Chicken Egg Incubator. Specifically, it sought to achieve the following: design and build the device: IoT- Based Smart Plug-in Chicken Egg Incubator; and determine the quality of the prototype of the device and system by using TAP-TEEPS (Technology Assessment Protocol Technology Assessment Protocol Technical and Economic feasibility, environment soundness, political and social acceptability) Questionnaires in terms of overall quality of the prototype.

The researchers developed the IoT-Based Smart Plug-in Chicken Egg Incubator that helps the local farmer or owner of poultry to improve the production of chicken. This also lessens the risking method of the owner or farmer to monitor the incubator using manual system. It also helps the owner of poultry to adopt new innovation of technology to increase the industrial chicken production. The problems encountered by the user were mostly the signal of their mobile phones, which causes delay in receiving data or notification with the device.

In developing the device and web-application, the researchers used the Agile Model which consist of five phases: planning phase, design phase coding phase, testing phase and deployment phase. Additionally, in determining the level of acceptability of the device, the researchers used User Acceptance Testing (UAT). A total of five (5) respondents including five (5) farmers to assess the level of acceptability of the device. The gathered information was quantified and analyzed using the mean and Likert scale and the develop system was found out to be usable.

The following were the salient findings:

1. The prototype device has demonstrated its ability to perform its main function effectively, specifically the plugin calibrator with GSM capability. Despite its current status as a prototype, it has shown successful performance.
2. The TAP-TEEPS (Technology Assessment Protocol Technical and Economic Feasibility, Environmental Soundness, Political and Social Acceptability) questionnaires were utilized to evaluate the quality of the prototype device. The results of the evaluation revealed the effectiveness of the prototype in terms of technical and economic feasibility, environmental sustainability, political and social acceptability.
3. The web-based monitoring system and the device demonstrated effective performance in presenting temperature and humidity readings and processing user input data. The system was able to accurately display and analyze the readings, providing reliable information for monitoring purposes.
4. The web-based monitoring system and the device were evaluated by the respondents and were perceived as acceptable.

Conclusions

The following conclusions were drawn based on the findings:

1. The Arduino-based plugin calibrator with GSM capability is built and developed according to the user's need and function correctly like how it has been coded

however this is still a prototype because there are still many functions that can possibly be integrated to the device.

2. The evaluation of the technology assessment protocol technical and economic feasibility, environment soundness, political and social acceptability of an IoT-Based Smart Plug-in Chicken Egg incubator prototype shows that it is a viable and promising technology for the agriculture industry.
3. The Agile Methodology Agile software development method is an appropriate software methodology to develop the web-based monitoring system with data analytics.
4. The evaluation of the user acceptance testing of the IoT-based Smart Plug-in Chicken Egg Incubator was a successful and insightful process. Through the completion of questionnaires and the analysis of the responses received, it has been determined that the product meets the needs and expectations of the target users.

Recommendations

From the fconclusions, the following were recommended:

1. It is recommended to use SMS notifications to keep the user informed of the incubation progress. These notifications should provide essential details, such as the current temperature, humidity levels, and the number of days left until hatching. Furthermore, the SMS notifications should promptly alert the user if any

parameters deviate from the optimal range, enabling them to take timely action to guarantee the health and well-being of the chicken eggs.

2. The implementation of this technology could significantly benefit the agriculture industry, leading to a positive impact on the industry as a whole. To maximize its potential and ensure its long-term viability and success, it is advisable to continue testing and fine-tuning the technology.
3. The Agile Methodology is the right model to be used for creating the web-application because of its flexibility and adaptability to adjust according to what is also changed in the device.
4. It is recommended that the product be brought to market. The evaluation process, which included the use of questionnaires and analysis of responses, showed that the product meets the needs and expectations of its target users. This is a strong indication of the product's potential for success in the market. It is advised to continue monitoring the product's performance and gather feedback from users to ensure that it continues to meet their needs and expectations. Additionally, any necessary improvements or updates to the product can be made based on this ongoing feedback.
5. Integration of solar panels in IoT-Based Smart Plug-in Chicken Egg Incubator could be the optimization of energy usage. This could include studying the most efficient ways to harness and store solar energy, as well as determining the optimal power levels for incubating eggs.

LITERATURE CITED

Acals, B., & Jo, E. (n.d.). *Development and construction of poultry egg incubator temperature and humidity controller (peitch) with sms notification*. https://ssrn.com/abstract=3779301

Aldair, A. A., Rashid, A. T., & Mokayef, M. (n.d.). *Design and Implementation of Intelligent Control System for Egg Incubator Based on IoT Technology*.

APM. (n.d.). Practical Adoption of Agile Methodologies. Retrieved from https://www.apm.org.uk/resources/find-a-resource/practical-adoption-of-agile-methodologies/

Asher, R. (2017). WHAT IS THE NATURAL INCUBATION PROCESS OF CHICKEN? Retrieved from https://animals.mom.com/what-is-the-natural-incubation-process-of-chicken-12168647.html

Azahar, K. B., Sekudan, E. E., & Azhar, A. M. (2020). Intelligent Egg Incubator. *International Journal of Recent Technology and Applied Science*, *2*(2), 91–102. https://doi.org/10.36079/lamintang.ijortas-0202.129

Cavite, B. G. (2014). Poultry Farming. Retrieved from https://www.academia.edu/7554895/Poultry_Farming

Chen, Karen, et al. "Just-in-Time Workplace Training via Mixed Reality." ISE ; Industrial and Systems Engineering at Work, vol. 55, no. 3, Institute of Industrial and Systems Engineers (IISE), Mar. 2023, p. 34.

Choosumrong, S., Raghavan, V., & Pothong, T. (2562). Smart Poultry Farm Based on the Real-Time Environment Monitoring System Using Internet of Things. In *Naresuan Agriculture Journal* (Vol. 16, Issue 2).

Choukidar, G. (2017). *2017 International Conference on Computing, Communication, Control and Automation (ICCUBEA)*. IEEE.

dela Cruz, M. R., Faylon, W. S., Joy Lagliva, A. A., Magarro, A. B., Ryenel Parungao, A. M., & Magpantay, V. A. (2020). Effects of lowering incubation temperature on hatch of fertile and post-hatch performance and correlation between egg and chick weights of banabang kalabaw philippine native chicken. In *Philipp J Vet Anim Sci* (Vol. 46, Issue 1)

Department of Science and Technology. (2015). Retrieved from https://intranet.pcieerd.dost.gov.ph/files/PQMS-Corner/PCIEERD-WI-005, 20Work20Instruction%20for%20Technology%20Assessment,%20Rev1_1541730332.pdf?fbclid=IwAR0BOpFBGCaivpzS_xxT-c7tCQmTKCSKwKmbfTe2E-SJBU1vQkrJI3dofSc.

DHAN PRASAD GHARTI, M. J. (2020). SMART POULTRY FARM. Retrieved from https://electronicsworkshops.com/2020/10/16/smart-poultry-farm/#2OBJECTIVES

Gillis, A. S. (2022). What is user acceptance testing (UAT)? Retrieved from https://www.techtarget.com/searchsoftwarequality/definition/user-acceptance-testing-UAT

Goud, K. S., & Sudharson, A. (2015). Internet based smart poultry farm. *Indian Journal of Science and Technology*, *8*(19). https://doi.org/10.17485/ijst/2015/v8i19/76227

Guillermo, A. &. (2020). Design and Development of an Op-Amp Solar Charge Controller. Retrieved from http://solidstatetechnology.us/index.php/JS

Guillermo, A. Q., & Racoma, R. A. (2021). Development and Evaluation of a Motorcycle Ignition System Testing Instrument. In *Journal of Science, Engineering and Technology* (Vol. 9).

Institute of Electrical and Electronics Engineers. (n.d.). *2019 IEEE 39th Central America and Panama Convention (CONCAPAN XXXIX).*

Islam Mahfujul, Tonmoy Shaharya Sourov, Quayum Sazzad, Sarker Al Russel, Hani Sumaiya Umme, & Mannan Mohammad Abdul. (2019). *2019 International Conference on Robotics, Electrical and Signal Processing Techniques (ICREST)*. IEEE.

Koelle, M., Ananthanarayan, S., & Boll, S. (2020). Social Acceptability in HCI: A Survey of Methods, Measures, and Design Strategies. Human Factors in Computing Systems. https://doi.org/10.1145/3313831.3376162

Kuhlmann, T., Garaizar, P., & Reips, U. (2021). Smartphone sensor accuracy varies from device to device in mobile research: The case of spatial orientation. Behavior Research Methods, 53(1), 22–33. https://doi.org/10.3758/s13428-020-01404-5

Kutsira, G. v, Nwulu, N. I., & Dogo, E. M. (n.d.). *Development of a Small Scaled Microcontroller-Based Poultry Egg Incubation System*.

Maricar R. Dela Cruz, W. S. (2020). Effects of lowering incubation temperature on hatch of fertile and post-hatch performance and correlation between egg and chick weights of Banabang Kalabaw Philippine native chicken. Retrieved from https://www.academia.edu/69347061/Effects_of_lowering_incubation_temperature_on_hatch_of_fertile_and_post_hatch_performance_and_correlation_between_egg_and_chick_weights_of_Banabang_Kalabaw_Philippine_native_chicken

Mazwan Bin Azamir, I., Subramaniam, T. S., & Fairuz, W. M. (2021). *Development of Egg Incubator Monitoring System using Thingspeak as Database*. *1*(1), 194–201. https://doi.org/10.30880/ritvet

Mohd, C. K. N. C. K., & Shahbodin, F. (2015). Personalized Learning Environment: Alpha Testing, Beta Testing & User Acceptance Test. *Procedia - Social and Behavioral Sciences*, *195*, 837–843. https://doi.org/10.1016/j.sbspro.2015.06.319

Peprah, F., Gyamfi, S., Amo-Boateng, M., Buadi, E., & Obeng, M. (2022). Design and construction of smart solar powered egg incubator based on GSM/IoT. *Scientific African*, *17*. https://doi.org/10.1016/j.sciaf.2022.e01326

Philippine-Council-for-Agriculture. (n.d.).

Saba, T. M., Tsado, J., Raymond, E., & Adamu, M. J. (2019). The level of awareness on electrical hazards and safety measures among residential electricity user's in Minna metropolis of Niger State, Nigeria.

Siedlecki, S. L. (2020). Understanding Descriptive Research Designs and Methods. *Clinical Nurse Specialist*, *34*(1), 8–12. https://doi.org/10.1097/NUR.0000000000000493

Silva, R. B. T. R. da, Nääs, I. de A., Oliveira Júnior, A. J. de, Reis, J. G. M. dos, Lima, N. D. da S., & Souza, S. R. L. de. (2020). Improving the management of poultry production: Mobile application development and validation. *Research, Society and Development*, *9*(10), e4019108806. https://doi.org/10.33448/rsd-v9i10.8806

APPENDECIES

APPENDIX A

Informed Consent Form

Dear Respondent:

Greetings!

We are presently conducting a study entitled **"IoT-Based Smart Plugin Chicken Egg Incubator"**, as a requirement of the course BS Information Technology in the subject and ITPC 117 (Capstone Project II).

The undersigned would like to request for your participation by answering the instrument sincerely and truthfully Rest assured that all the information that we would gather will be treated with utmost confidentiality and it will be used for academic purposes only.

Your favorable response regarding this matter is highly appreciated. Thank you very much.

Respectfully Yours,

JOHN KRISTOFER P. GINES
Researcher

GRISSEL A. BELON
Researcher

PAUL WILLIAM B. MARTIN
Researcher

ALLAN A. VILLANUEVA
Researcher

Noted by:

ZHELLA ANNE V. NISPEROS
Capstone Adviser

Approved by:

SHEENA I. SAPUAY-GUILLEN
Program Chair, BS Info Tech

APPENDIX B

User Acceptance Testing Questionnaire

Participant:(Optional) ___________________ Contact No.:________________________

System**: IoT-Based Smart Plugin Chicken Egg Incubator**
This questionnaire gives you an opportunity to tell your reactions to the system used. Your responses will help understand what aspects of the system you are particularly concerned about and the aspects that satisfy you.

Please evaluate IoT-Based Smart Plugin Incubator by checking the corresponding box using the scale:

5 – Strongly Agree
4 – Agree
3 – Undecided
2 –Disagree
1 – Strongly Disagree

Thank you.

Items	**Rating**				
User Acceptance Testing	**5**	**4**	**3**	**2**	**1**
1. The smart plugin chicken egg incubator is usable.					
2. The smart plugin chicken egg incubator is capable of regulating the humidity.					
3. the smart plugin chicken egg incubator controls the temperature and humidity inside the enclosure?					
4. Are the requirements for smart plugin chicken egg incubator met?					
5. The functionalities of the smart plugin chicken egg incubator is perfectly working.					
6. The temperature of smart plugin chicken egg incubator is reliable.					
7. Were the results what you expected.					
8. The system is functioning very well.					
9. Did encounter system error.					
10. Did the device malfunction.					
11. The system responds quickly.					
12. Would you consider using the smart plugin chicken egg incubator?					

13. Would you recommend the smart plugin chicken egg incubator?					
14. Software continue functioning if changes are made.					
15. Software tested easily.					
16. Smart plugin chicken egg incubator can be moved to other environments.					
17. Smart plugin chicken egg incubator can be installed easily.					
18. SMS notifications are received?					
19. The system is user friendly and not confusing.					
20. The software performs the tasks required.					
21. The result appears as expected.					
22. Do the user interface looks good?					
23. The user uses the system without much effort.					

Comments and Suggestions:
____
____
____

APPENDIX C

Evaluation Instrument to Assess the Design and Development of a Prototype IoT-Based Smart Plug-in Chicken Egg Incubator System

For Expert & End User Evaluators

Participant:(Optional) ___________________ Contact No.:_______________________

Instruction: After inspection/Demonstration of the Prototype IoT-Based Smart Plug-in Chicken Egg Incubator System, please assess its level of technical feasibility, economic viability, environmental soundness, political acceptability, and social acceptability. Please check the number that corresponds to the descriptive rating of your assessment using the rating scale below:

5 = Very High Validity 4 = High Validity 3 = Moderate Validity

2 – Slight Validity 1 – No Validity

Indicators:	5	4	3	2	1
1.Level of Technical Feasibility					
1.1 Durability of parts					
a. Electrical components are properly installed					
b. All parts and components can withstand continuous operation.					
1.2 Safety of operations					
a. The machine is equipped with over current protection device					
b. Electrical wirings and connections are properly insulated					
c. The machine is labeled with safety precaution stickers					
1.3 Speed and Accuracy					
a. The temperature and humidity senor can measure incubator temperature and humidity quickly and accurately					
b. The device parts and components are accurate					
1.4 Simplicity of the Mechanism					
a. The operation of the Prototype IoT-Based Smart Plug-in Chicken Egg Incubator is simple and easy to understand					
b. The machine can operate without human intervention once switched on					
1.5 Precision of Design					
a. Efficiency of parts - Every part of the machine has a function and purpose					
b. Originality of the design - The concept of the design was not copied and is the original idea of the researcher					
Indicators	**5**	**4**	**3**	**2**	**1**
2. Economic/Financial Viability					
2.1 Cost in terms of a. Maintenance - Parts are readily available locally and online with affordable price					
b. Affordability					

-The expenses in the production of the Prototype IoT-Based Smart Plug-in Chicken Egg Incubator System are affordable to end users					
3. Environmental Soundness					
a. The Prototype IoT-Based Smart Plug-in Chicken Egg Incubator System is not harmful to the environment					
b. The Prototype IoT-Based Smart Plug-in Chicken Egg Incubator System does not pose hazards to human welfare.					
4. Political Acceptability					
a. The Prototype IoT-Based Smart Plug-in Chicken Egg Incubator System matches the interests and needs of the target end-users.					
b. The technology meets the standards for its utilization.					
5. Social Acceptability					
a. Gender acceptability: The device can be operated and used by both men and women with ease and precision.					
b. The device fits the local socio-cultural environment (social practices, local traditions and more, and cultures)					
c. The device serves the needs of the majority of those whom it seeks to benefit.					

Comments and Suggestions:
____
____
____

APPENDIX D

Ethical Clearance

Decision Letter

January 31, 2023

DMMMSU
RELEASED
BY:
DATE: 1/31/2023
RESEARCH ETHICS

MR. JOHN KRISTOFER P. GINES
Information Management Students, CIT
DMMMSU – MLUC, City of San Fernando, La Union

RE: IoT-Based Smart Plugin Chicken Egg Incubator

RETC Code: 2022-253-Egg Incubator-Gines

Subject: Ethical Clearance

Dear ***Mr. Gines***:

This is to acknowledge receipt of your request and the following supporting documents dated January 31, 2023

- F015-Application for Ethics Review of Amendments
- Full proposal / Study protocol

After a review of your amendment's documents, the RETC decides to APPROVE your protocol. Attached with this letter is your Ethical Clearance.

Please note the responsibilities of the researchers/Investigators after protocol approval. Note that failure to comply with the conditions and responsibilities may result in the withdrawal of approval of your protocol.

Yours sincerely,

JOEL C. ESTACIO
Chair, Research Ethics

DMMMSU-RETC-F010

Ethical Clearance

January 31, 2023

MR. JOHN KRISTOFER P. GINES
Information Management Students, CIT
DMMMSU - MLUC, City of San Fernando, La Union

RE: IoT-Based Smart Plugin Chicken Egg Incubator

RETC Code: 2022-253-Egg Incubator-Gines

Subject: ETHICAL CLEARANCE

Dear ***Mr. Gines***:

This is to acknowledge receipt of your request and the following supporting documents dated January 30, 2023.

- F015-Application for Ethics Review of Amendments
- Full proposal / Study protocol

Your protocol has been **APPROVED** by DMMMSU Research Ethics Committee. Your ethical clearance is valid until January 2024.

The following are the responsibilities of the investigators/researchers after protocol approval:

1. Seek approval from DMMMSU Research Ethics for any protocol amendment after this date.
2. Submit SAE and SUSAR Reports to RETC when deemed necessary.
3. Submit progress report.
4. Notify DMMMSU RETC of any Protocol deviation/violation.
5. Abide by the principles of good clinical practice and ethical research
6. Comply with relevant international and national guidelines and regulations
7. Submit the final report after completion of the study.

Very truly yours,

JOEL C. ESTACIO
Chair, Research Ethics

APPENDIX E

Certificate of Plagiarism Check

Don Mariano Marcos Memorial State University
MID - LA UNION CAMPUS

COLLEGE OF INFORMATION TECHNOLOGY

"Center of Development in Information Technology"

City of San Fernando, La Union
Website: http://www.dmmmsu-mluc.edu.ph
Telephone: (072) 6194817

CERTIFICATION

This is to certify that the manuscript of **John Kristofer P. Gines, Grissel A. Belon, Paul William B. Martin and Allan A. Villanueva** with the title **"IoT-based Smart Plugin Chicken Egg Incubator"**, with a rate of 4.46% has successfully **PASSED** the standards of the Plagiarism Checker set forth by the college.

Issued this 3rd day of April 2023 at College of Information Technology, DMMMSU-MLUC, City of San Fernando, La Union.

ZHELLA ANNE V. NISPEROS
Research Facilitator

ALVIN R. MALICDEM
Dean, CIT

PROGRAMS: *Bachelor of Science in Information Technology*
Master in Information Technology

APPENDIX E

Certificate of English Critique

Don Mariano Marcos Memorial State University
MID - LA UNION CAMPUS
COLLEGE OF INFORMATION TECHNOLOGY
"Center of Development in Information Technology"
City of San Fernando, La Union
Website: http://www.dmmmsu-mluc.edu.ph
Telephone: (072) 6194817

CERTIFICATION

This is to certify that the undersigned has read, reviewed and edited the manuscript of **John Kristofer P. Gines, Grissel A. Belon, Paul William B. Martin and Allan A. Villanueva** entitled **"IoT-based Smart Plugin Chicken Egg Incubator"**.

This further certifies that the scope of editing is within the technical preparation of the manuscript only. This certification is issued to **Mr. Gines et al.** for the English Critic requirement.

Issued this 4th day of April, 2023 at the Don Mariano Marcos Memorial State University - Mid La Union Campus, College of Information Technology, Catbangen, City of San Fernando, La Union.

DANNILYN U. MACATO, MAEd
English Critic

PROGRAMS: *Bachelor of Science in Information Technology*
Master in Information Technology

CURRICULUM VITAE

PERSONAL INFORMATION

Name	: John Kristofer P. Gines
Place of Birth	: Quirino Memorial Hospital QC
Date of Birth	: January 22, 2000
Age	: 23
Sex	: Male
Citizenship	: Filipino
Religion	: Roman Catholic
Father's Name	: George B. Gines
Mother's Name	: Delia P. Gines
Civil Status	: Single
Contact Number	: 09207988286
Email Address	: gineskris22@gmail.com
Address	: Poblacion East, Asingan, Pangasinan

EDUCATIONAL BACKGROUND

Tertiary	: Bachelor of Science in Information Technology Don Mariano Marcos Memorial State University Mid-La Union Campus (DMMMSU)
	2019 - Present
Senior High	: Saint Louis College
	Lingsat, City of San Fernando, La union
	2017-2019
Secondary	Luciano Millan National High School (LMNHS)
	Poblacion West, Asingan, Pangasinan

	2013-2017
Elementary	Little Learners Guided Education Center (LLGEC) Poblacion West, Asingan, Pangasinan (2007-2013)

SPECIAL SKILL/TALENTS

Video editing
Junior Level Programming (HTML, CSS, JavaScript, PHP)
Proficient on Microsoft (Word, Excel, PowerPoint)
Sports (Basketball and Bike)

CURRICULUM VITAE

PERSONAL INFORMATION

GRISSEL A. BELON

Name	:	Grissel A. Belon
Place of Birth	:	Baguio City
Date of Birth	:	November 11, 1999
Age	:	23
Sex	:	Female
Citizenship	:	Filipino
Religion	:	Roman Catholic
Father's Name	:	Pablo H. Belon
Mother's Name	:	Gemma A. Belon
Civil Status	:	Single
Contact Number	:	0995824179
Email Address	:	grhisselbelon@gmail.com
Address	:	Acao, Bauang La Union

EDUCATIONAL BACKGROUND

Tertiary	: Bachelor of Science in Information Technology Don Mariano Marcos Memorial State University Mid-La Union Campus (DMMMSU) 2019 – Present
Senior High	: Saint Louis College City of San Fernando, La Union 2016-2018
Secondary	: Saint Louis College City of San Fernando, La Union 2012-2016
Elementary	: Bauang North Central School Central East, Bauang La Union 2006-2012

SPECIAL SKILL/TALENTS

Proficient on Microsoft (Word and PowerPoint)
Photo Editing
Video Editing
Singing

CURRICULUM VITAE

PERSONAL INFORMATION

Name	:	Paul William B. Martin
Place of Birth	:	San Fernando La Union
Date of Birth	:	October 27, 1999
Age	:	23
Sex	:	Male
Citizenship	:	Filipino
Religion	:	Roman Catholic
Father's Name	:	Dean Paul B. Martin
Mother's Name	:	Vilma G. Boadilla
Civil Status	:	Single
Contact Number	:	09158775589
Email Address	:	paulboadilla27@gmail.com
Address	:	Sitio Cantingan, Quinavite Bauang La Union

EDUCATIONAL BACKGROUND

Tertiary	: Bachelor of Science in Information Technology Don Mariano Marcos Memorial State University Mid-La Union Campus (DMMMSU) 2019 – Present
Senior High	: Saint Louis College City of San Fernando, La Union 2016-2018
Secondary	: Sacred Heart School Central East, Bauang La Union 2012-2016
Elementary	: Sts. Peter and Paul Learning Center Central East, Bauang La Union 2006-2012

SPECIAL SKILL/TALENTS

Proficient on Microsoft (Word, PowerPoint and excel)
Photo Editing
Social Media Management
Hardware Deployment

CURRICULUM VITAE

PERSONAL INFORMATION

Name	: Allan Villanueva
Place of Birth	: Naguilian, La Union
Date of Birth	: April 27, 2000
Age	: 22
Sex	: Male
Citizenship	: Filipino
Religion	: Roman Catholic
Father's Name	: Hipolito A. Villanueva
Mother's Name	: Marites A. Villanueva
Civil Status	: Single
Contact Number	: 09260374672
Email Address	: villanuevaallan000@gmail.com
Address	: Dal-lipaoen Naguilian, La Union

EDUCATIONAL BACKGROUND

Tertiary	: Bachelor of Science in Information Technology Don Mariano Marcos Memorial State University Mid-La Union Campus (DMMMSU) 2019 - Present
Senior High	: STI College La Union Aguila Road, San Fernando City, La Union 2016-2018
Secondary	: Naguilian National High School Imelda Naguilian, La Union

	2012-2018
Elementary	: Daramuangan Elementary School
	Daramuangan Naguilian, La Union
	2006-2012

SPECIAL SKILL/TALENTS

Hardware troubleshooting
Network troubleshooting
Junior Level Programming (Javascript, Php, Html, Css, VB)
Microsoft Office (MS Word, Excel, Powerpoint)
Adobe Creative Suite (Photoshop, Illustrator, Premier)
Playing musical instruments (Guitar, Bass Guitar, Piano, Drums)