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Mobile App for Incubator Monitoring to Optimize Quail Egg Production

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ABSTRACT Incubation is a crucial process in egg hatching, where eggs must be maintained under optimal temperature and humidity conditions. However, many existing IoT-based incubator monitoring systems remain at the prototype stage and provide limited evidence regarding their effectiveness in improving operational efficiency and supporting user-friendly monitoring for small-scale quail farmers. This gap highlights the need for a practical and validated monitoring solution that can be easily adopted in real farming environments. This study aims to develop a Mobile Application for Monitoring Temperature and Humidity in Quail Egg Incubators that is both valid and effective in supporting and optimizing quail egg production. The research adopted the Agile Method, consisting of the phases of Plan, Design, Develop, Test, Deploy, Review, and Launch. Product evaluation included validity testing by experts in computer and mobile application development and effectiveness testing involving end users. The validity test produced an Aiken's V score of 0.78, indicating that the application is valid. The effectiveness test yielded a G-Score of 0.35, which falls within the moderate effectiveness category. The implementation of the application at Nisya Farm demonstrated improvements in monitoring efficiency by enabling real-time access to incubator conditions through mobile devices. User evaluations showed that the application was easy to use due to its simple and intuitive interface. These findings suggest that integrating IoT and mobile technologies into quail egg incubation management can improve operational efficiency while increasing user confidence in monitoring and controlling the incubation process.

KEYWORDS: Mobile Application, Incubator Monitoring, Internet of Things, Agile Method, Quail Egg Production

I.INTRODUCTION

In the era of the Fourth Industrial Revolution (Industry 4.0), the Internet of Things (IoT) has extended its reach into various sectors, including agriculture and livestock farming. Significant innovations in livestock include the implementation of automation systems for incubating poultry eggs, which enhance production efficiency and reduce reliance on manual labor [1]. Among these, the quail (Coturnix coturnix japonica) stands out as a highly productive poultry commodity with strong economic potential and a rapid production cycle [2]. However, successful quail egg production hinges on achieving consistent and stable temperature and humidity during incubation [3].

In Indonesia, quail egg hatching still faces challenges, especially among small-scale farmers using conventional incubators without automatic control systems. According to Statistics Indonesia (2023), quail productivity has shown limited growth in recent years, indicating the need for improved hatchery management and incubation practices [4]. The main cause is an inability to maintain optimal incubator conditions throughout the typical 15–17 day incubation period [2].

Incubation is crucial for hatching, as eggs must be maintained under ideal temperature and humidity. Temperature plays a vital role in embryo development and hatch rate. Properly regulated warmth and moisture around 37.5 °C and 50–65% humidity during early incubation, rising to approximately 70% at hatch support both successful hatching and healthy post-hatch growth [5].

Maintaining these conditions requires a monitoring system that operates continuously, maintains adequate accuracy, and remains user-friendly. Conventional manual monitoring is limited by delays in response to environmental changes and dependence on the physical presence of operators [6]. IoT-based automation offers a practical solution: sensor and microcontroller integration enables real-time data collection and transmission to mobile apps via the internet, supporting efficient control and management [7]. With this system, users receive real-time incubator data and can take prompt action when parameters deviate from set thresholds [3].

To display temperature and humidity readings in a user-friendly way, an accessible and responsive platform is essential. A commonly used IoT interface is Blynk, a cloud service that allows developers to build mobile dashboards without the need to create apps from scratch. Using Blynk, users can view real-time temperature and humidity graphs, receive alerts, and monitor the incubator via smartphone anytime and anywhere [8].

Previous studies have evaluated microcontroller-based automation systems such as Arduino and ESP8266 paired with the Blynk app for remote monitoring and control [9]. These systems allow users to track environmental conditions in real time and automatically adjust heaters and fans. However, most of the current systems remain prototypes and have not been tested at scale or for long durations.

A notable gap in past research is the scarcity of quantitative evaluations regarding IoT-based automation's impact on quail hatch success. Few studies explicitly measure improvements in production efficiency or reductions in failure risk due to controlled temperature and humidity. Additionally, many systems do not adequately address affordability or user-friendliness for novice farmers [3].

Key relevant studies include: (1) Ardianto et al. (2023), who developed an automatic incubator system using MQTT and a mobile app; their system maintained optimal temperature and humidity, achieved 99.8% MQTT connectivity stability, and achieved latency below 150 ms [10]. (2) Fery et al. (2019), who created an Android-based incubator monitoring system using a NodeMCU ESP8266 microcontroller, DHT11 sensors, and ThingSpeak server for real-time monitoring [11]. (3) Rizal et al. (2024), who designed an IoT-based quail coop environment monitoring system using fuzzy-Sugeno logic and sensors DHT11/LM35, maintaining average temperature of 34.8 °C and humidity of 63% [12].

Based on interviews, surveys, and field observations conducted at Nisya Farm in Balai Nan Tuo, several operational challenges were identified: *Time and labor constraints*: Farmers currently conduct incubation manually, periodically checking incubator conditions in person, consuming valuable time. *Monitoring and control issues*: Existing systems lack IoT-based automatic monitoring, making real-time adjustments difficult.

As a response to these challenges, this research aims to design a Mobile Application for Real-Time Temperature and Humidity Monitoring in Quail Egg Incubators, offering a valid and effective solution to optimize quail egg production.

II.METHOD

Research Procedure

In this study, the design procedure for developing a mobile application to monitor temperature and humidity in quail egg incubators follows the Agile methodology, as outlined in the proposed development model. The implementation of Agile methodology in designing this monitoring application aims to improve the efficiency and effectiveness of monitoring the incubation process, enabling farmers to access real-time environmental data remotely [13]. Therefore, the stages of this research are illustrated in Figure 1.

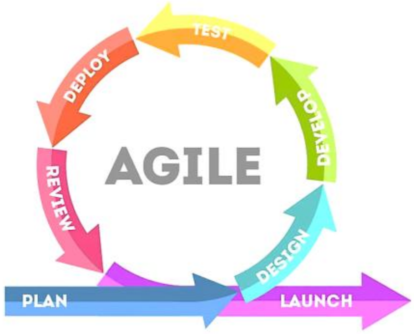
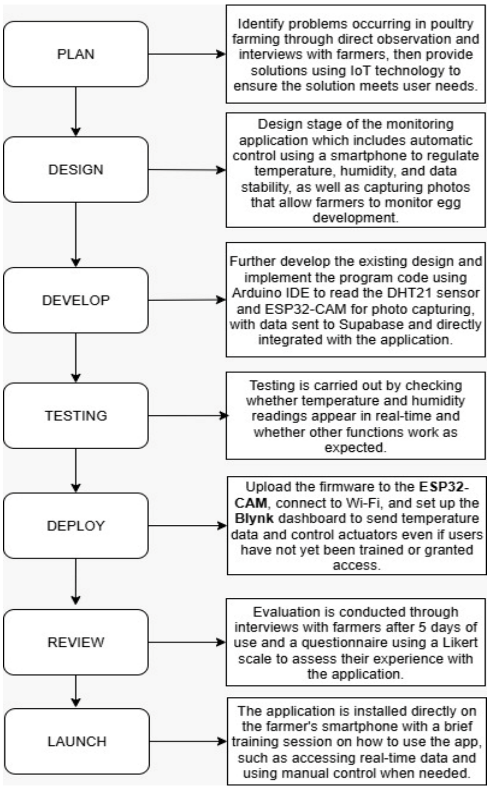


Figure 1. Agile Method Stages

The research process based on the Agile methodology consists of a series of sequential and interrelated stages. These stages include: Plan, Design, Develop, Test, Deploy, Review, and finally, Launch [14]. The process flow of these stages is presented in Figure 2.



Identify problems occurring in poultry farming through direct observation and interviews with farmers, then provide solutions using IoT technology to ensure the solution meets user needs.

Design stage of the monitoring application which includes automatic control using a smartphone to regulate temperature, humidity, and data stability, as well as capturing photos that allow farmers to monitor egg development.

Further develop the existing design and implement the program code using Arduino IDE to read the DHT21 sensor and ESP32-CAM for photo capturing, with data sent to Supabase and directly integrated with the application.

Testing is carried out by checking whether temperature and humidity readings appear in real-time and whether other functions work as expected.

Upload the firmware to the **ESP32-CAM**, connect to Wi-Fi, and set up the **Blynk** dashboard to send temperature data and control actuators even if users have not yet been trained or granted access.

Evaluation is conducted through interviews with farmers after 5 days of use and a questionnaire using a Likert scale to assess their experience with the application.

The application is installed directly on the farmer's smartphone with a brief training session on how to use the app, such as accessing real-time data and using manual control when needed.

Figure 2. Description of Research Stages

The detailed explanation of each stage based on the figure above is as follows: This study adopts an iterative and flexible Agile approach, starting with the **Planning** stage, during which system requirements are identified. During this phase, direct observation and interviews were conducted with quail farmers at Nisya Farm to understand the challenges they face in monitoring incubator conditions, particularly temperature and humidity, during the egg incubation process. The findings from this stage form the basis for defining the functional and non-functional requirements of the system to be developed [15].

Next, in the **Design** stage, an initial design of the monitoring application is created, tailored to the needs of field users. This includes designing the application workflow and the system for sensor integration. The following stage is **Development**, where the application is built using the Blynk platform, enabling Android app development without complex coding. At this stage, the application is developed with key features such as real-time temperature and humidity monitoring, graphical data visualization, and alert notifications when environmental values exceed defined thresholds. Sensor data collected by the ESP32-CAM microcontroller is transmitted to the Supabase cloud database and subsequently visualized through the Blynk application, enabling real-time monitoring and remote access.

After development, the process proceeds to the **Testing** phase, which involves thorough checking of application functionality, both internally and in actual hatchery conditions. The results of this testing serve as a reference for fixing bugs or addressing identified shortcomings [16].

The next phase is **Deployment**, in which the application is implemented at the quail farming facility, specifically within the egg incubation environment at Nisya Farm. This involves installing the sensor-based monitoring system within the incubator, deploying the application to farmers' mobile devices, and providing training on application usage and system operation [17]. Following deployment, the **Review** phase is conducted, where feedback is collected through interviews with quail farmers after five days of application use, and Likert scale questionnaires are distributed to users [18].

Finally, the **Launch** phase is carried out, marking the official release of the application for broader use. This phase involves distributing the application to target users, either as an installation file (.apk) or via an app distribution platform when necessary. The launch activities may include socialization, usage demonstrations, and documentation to facilitate user adoption. This stage signifies the beginning of real-world implementation of the system and provides an opportunity to gather feedback from early users for future improvements.

Research Instruments

The instruments used in this study were designed to support the design and evaluation process of the quail egg incubator temperature and humidity monitoring application developed using the Blynk platform. The instruments used include: 1). *User Requirement Questionnaire*, This questionnaire was used in the early stages to identify the needs and preferences of users, especially quail farmers, regarding application features, usability, and monitoring requirements. Questions are structured to ensure the application can answer user problems directly and in accordance with the field context [19]. 2. *Observation Guide*, This guide is used to observe the process of manually monitoring incubator environmental conditions commonly carried out by quail farmers. The observation results become the basis for designing the application workflow so that it can replace the manual process in a more efficient and practical way. 3. *Application Prototype*, The application prototype developed using Blynk was used as an instrument for initial testing. This prototype was utilized to obtain feedback from users regarding the appearance and flow of the application, so that improvements could be made before the final version was released. 4. *Structured Interview*, This instrument was used to dig deeper into users' opinions and experiences after using the app. Information from the interview was used as input for improving the overall design and features of the application.

Data Analysis Techniques

In this study, product evaluation was conducted using data analysis techniques focusing on validity and effectiveness. To measure these two aspects, a questionnaire was employed as the primary data collection instrument.

Validity Testing, Validity testing is a process used to verify the accuracy of the items within the research instrument and to assess the clarity of the research framework. The purpose of this test is to ensure that the instrument genuinely measures the intended aspects, emphasizing both accuracy and precision. This validity assessment involves expert evaluation from relevant fields as well as statistical analysis to ensure that the instrument aligns with its intended objectives and functions. To ensure the quality of the product being tested, validation by experts is essential. The experts evaluated ten assessment aspects covering interface design, usability, functionality, system integration, information presentation, and overall suitability of the application for quail egg incubation monitoring.

The validity assessment in this study employed Aiken's V coefficient because it is widely recognized as an appropriate method for evaluating the content validity of research instruments based on expert judgment. Aiken's V is particularly suitable for assessing the relevance, clarity, and representativeness of questionnaire items using ordinal rating scales, such as the five-point scale applied in this study. The validation process involved four experts consisting of lecturers with expertise in software engineering, mobile application development, and Internet of Things (IoT) systems. Compared with the Content Validity Ratio (CVR), which is primarily designed to determine the essentiality of items using a dichotomous assessment, Aiken's V provides a more detailed evaluation by accommodating multiple rating categories and measuring the degree of agreement among experts. Furthermore, although the Content Validity Index (CVI) is commonly used for content validation, Aiken's V is considered more suitable for studies involving a relatively small number of expert raters because it produces a direct coefficient that reflects the validity level of each item. Therefore, Aiken's V was selected as the most appropriate method for evaluating the validity of the developed application and its assessment instrument [20].

The validity test refers to Aiken's V statistical formula, as follows:

$$V = \sum \frac{s}{[n(c-1)]} \tag{1}$$

Formula Explanation: S is obtained from: r – lo; lo is the lowest score on the validity scale; c is the highest score on the validity scale; r is the rating given by an expert; n is the number of experts involved. The Aiken's V validity score ranges from 0.00 to 1.00. A product is considered valid if the V-value falls between 0.60 and 1.00, and not valid if it is below 0.60 [15].

Effectiveness Testing, Effectiveness testing is a process used to assess the extent to which a product, program, method, or instrument can optimally achieve its intended objectives. This test aims to determine whether the obtained outcomes meet the expectations or predefined targets. Effectiveness testing focuses on how well the product achieves the desired goals, with an emphasis on the impact and benefit for users.

The effectiveness test refers to Richard R. Hake's statistical formula (G-Score), as follows:

$$< g >= \frac{(\%<Sf>-\%<Si>)}{(100\%-\%<Si>)} \tag{3}$$

Formula Explanation: <g> is the G-Score value; Sf is the final score; Si is the initial (pre-test) score. The G-Score effectiveness criteria are categorized as follows: High-g (high effectiveness): if G-Score > 0.7; Medium-g (moderate effectiveness): if 0.7 > G-Score > 0.3; Low-g (low effectiveness): if G-Score < 0.3 [21].

III.RESULT AND DISCUSSION

Research Result

Plan, This research began with field observations and interviews at the Nisya Farm quail farm to identify the need for an automatic monitoring system. The main issue faced was the inefficiency of manually monitoring temperature, humidity, and egg conditions, which was time-consuming and labor-intensive. To address this problem, an automatic monitoring application was developed, allowing remote access without the need for constant supervision.

To ensure optimal access and functionality of the monitoring application, several key components are required: 1) Hardware: A smartphone is used to run the Android-based application, while a laptop is utilized for application development and server management. 2) Software: Blynk is used to design and build the Android/web application, and Supabase Console is employed for managing real-time databases, log history, and user authentication. 3) Cloud services: Supabase serves as the data transmission medium, sending sensor data from the microcontroller to the cloud.

Design, At this stage, the design of the IoT-based system architecture was carried out, as illustrated in the Figure 3.

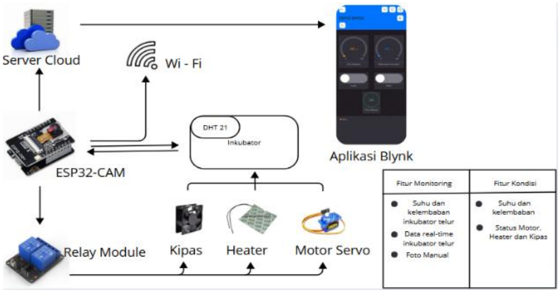


Figure 3. the design of the IoT-based system architecture

The IoT-based egg incubator system starts with a DHT21 sensor that monitors temperature and humidity in real time. The data is sent to an ESP32-CAM microcontroller, processed, and transmitted via Wi-Fi to a cloud server, allowing remote access through the Blynk app on a smartphone.

The ESP32-CAM also controls a fan, heater, and servo motor via a relay module. The fan reduces excess heat, the heater maintains optimal temperature, and the servo motor rotates the eggs periodically. Users can also trigger the ESP32-CAM camera to capture live images of the incubator via the app. This system enables automatic, real-time monitoring and control from anywhere, enhancing efficiency and hatch success. The user interface, built with Blynk widgets, includes real-time gauges, historical SuperCharts, manual control buttons, and an image gallery. The full design is illustrated in Figure 4.

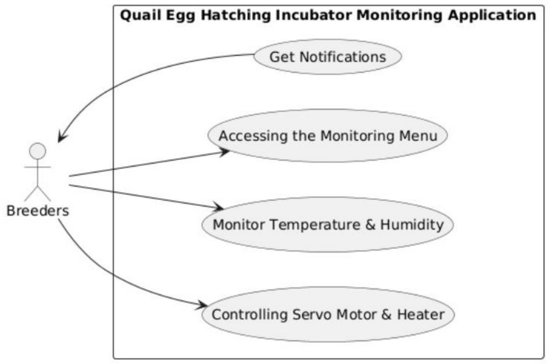


Figure 4. the design of Usecase diagram

To illustrate the user's activity flow when using the temperature and humidity monitoring application for the incubator, an activity diagram is also presented. This diagram represents the sequence of system responses to user inputs, leading to the real-time display of monitoring results, as shown in Figure 5.

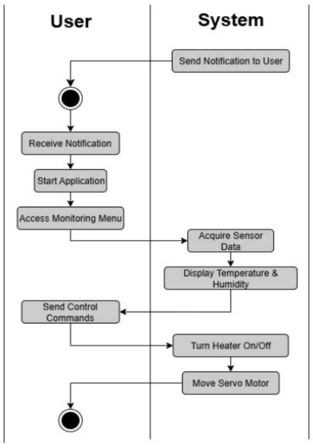


Figure 5. the design of Activity diagram

The following sequence diagram illustrates the interaction between the farmer, Blynk application, ESP32-CAM microcontroller, and Supabase cloud service in the monitoring and control of the incubator. The process begins with the ESP32-CAM reading temperature and humidity data, then sending it in real time to the Blynk app for the farmer to monitor.

This diagram highlights the integration of IoT devices, mobile applications, and cloud services to enable efficient monitoring and remote control during the egg incubation process, as shown in Figure 6.

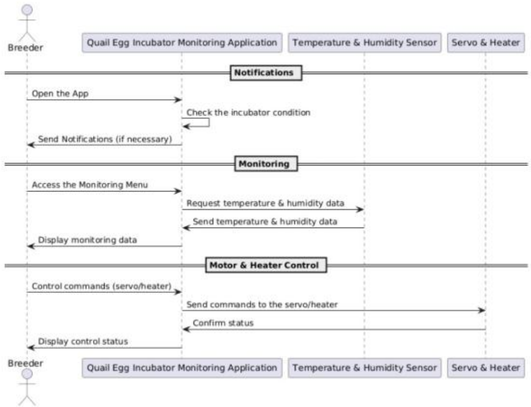


Figure 6. the design of Sequence diagram

Finally, to illustrate the overall system structure in terms of objects and the relationships between classes that form the monitoring system, a class diagram is used. This diagram includes entities such as Sensor, ESP32CAM, User, BlynkApp, and Database, which interact within this IoT-based system, as shown in Figure 7.

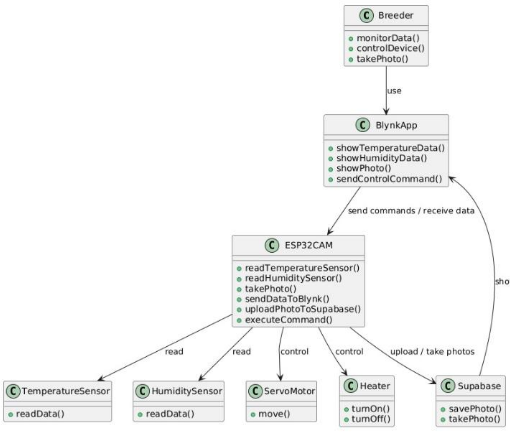


Figure 7. the design of Class diagram

Develop, This stage focuses on implementing the program code in the Arduino IDE to read data from the DHT21 sensor, control the motor, and configure the ESP32-CAM to capture photos and upload them to Supabase. The Blynk app was customized by adding relevant widgets, and real-time data is transmitted via Wi-Fi to Supabase, which is automatically displayed in the Blynk application, as shown in Figures 8.

```
// === LIBRARY ===
#include <WiFi.h>
#define BLYNK_TEMPLATE_ID "[illegible]"
#define BLYNK_TEMPLATE_NAME "Inkubator"
#define BLYNK_AUTH_TOKEN "[illegible]"

#include <HTTPClient.h>
#include "esp_camera.h"
#include "time.h"
#include <DHT.h>
#include <BlynkSimpleEsp32.h>
#include <ArduinoJson.h>

// === WIFI & BLYNK ===
const char* ssid = "[illegible]";
const char* password = "[illegible]";

// === SUPABASE CONFIG ===
const char* SUPABASE_URL = "https://[illegible].supabase.co";
const char* SUPABASE_API_KEY = "[illegible]
const char* SUPABASE_BUCKET = "[illegible]";
const char* SUPABASE_LOG_TABLE_URL = "https://[illegible].supabase.co/rest/v1/log_foto";

// === WAKTU NTP ===
const char* ntpServer = "pool.ntp.org";
const long gmtOffset_sec = 25200;
const int daylightOffset_sec = 0;
```

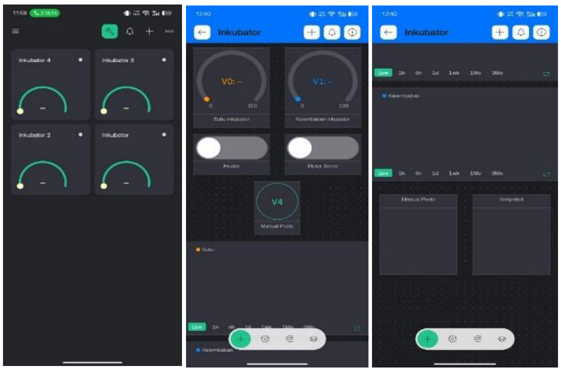


Figure 8. Sensor configuration with Blynk and Supabase apps on Arduino IDE

The development of the quail egg incubator monitoring application began using the Blynk platform, which allows visual user interface (UI) design through a drag-and-drop system without manual coding. The initial interface was designed with several widgets, including gauges, on/off buttons, a superchart for temperature and humidity graphs, and an image gallery to display photos captured by the ESP32-CAM inside the incubator. Captured photos are sent to Supabase Storage and logged in the Supabase real-time database using a logic block stored in a table with fields such as tag (UUID), timestamp (timestamptz), message, and file_url (text). Once uploaded, users can view the images in the image gallery widget.

Two gauge widgets display real-time temperature and humidity readings from the DHT21 sensor, with ranges of 1–100°C for temperature and 1–100% for humidity. Additionally, on/off buttons allow users to manually control the heater, camera, and servo motor from the app if desired. To support data tracking, a superchart widget is included to visualize historical temperature and humidity data over time, as shown in Figure 9.

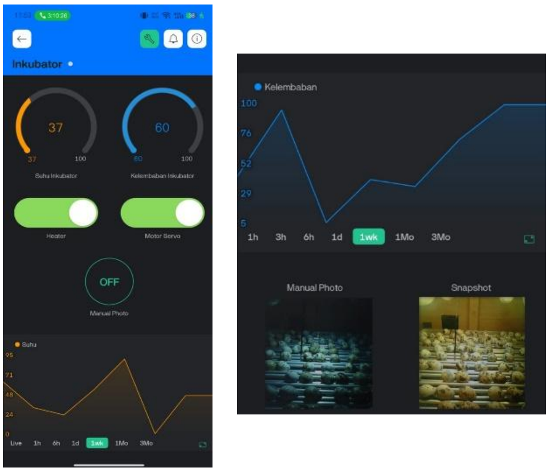


Figure 9. Finished result App view when running

To enable the application to read and write data to the Supabase real-time database, initial configuration is done via the Supabase Console. The researcher creates a new project, activates the real-time database feature, and copies the database URL into the Supabase component in Blynk. For testing purposes, database rules can be set to open, allowing both read and write access.

Supabase integration allows the application to receive temperature and humidity data sent from microcontrollers such as NodeMCU or ESP32-CAM. This data is displayed in real time within the monitoring app through widgets like gauge, superchart, and image gallery. By combining Blynk with Supabase's real-time database, the monitoring system can be implemented quickly and efficiently without building a custom backend. This application aims to improve the efficiency of quail egg incubation monitoring, especially for farmers who need real-time, remote access to egg conditions.

Testing, Testing was conducted on-site to verify the following: whether temperature and humidity data appeared in real time, whether manual control buttons for the heater, motor, and camera functioned properly, whether camera images were displayed in the image gallery, and whether data transmission latency from the sensor to the app was acceptable. All tests were performed using the black-box method, as shown in Table 1.

TABLE 1. Test results with the Blackbox method

ID	Function Tested	Input	Expected Output	Status
001	Temperature Gauge	Sensor sends temperature data in °C	Application displays temperature data ranging from 1–100°C	Passed
002	Humidity Gauge	Sensor sends humidity data	Application displays humidity data in the 1–100% range	Passed
003	Heater Switch Button	Button responds to user input	Heater turns on/off according to the switch button	Passed
004	Servo Motor Switch Button	Button responds to user input	Servo motor turns on/off according to the switch button	Passed
005	Manual Camera Button	Button responds to user input	ESP32-CAM activates camera and captures a photo inside incubator	Passed
006	Temperature Superchart	—	Superchart displays temperature trends in graph form	Passed
007	Humidity Superchart	—	Superchart displays humidity trends in graph form	Passed
008	Image Gallery	Image captured by ESP32-CAM and sent to	Image appears in the image gallery widget; farmer can also view past images	Passed

ID	Function Tested	Input	Expected Output	Status
009	High Temperature Alert	Supabase, then to app Temperature > 39°C	Blynk app sends an email: “Temperature too high”	Failed

Deploy, The firmware was uploaded to the ESP32-CAM, connected to Wi-Fi, and the Blynk dashboard was configured to send temperature and humidity data and control actuators, even without prior user access. The monitoring application was evaluated through validity and effectiveness testing to ensure proper system implementation. Validity testing involved several lecturers from the Computer Engineering Technology program to confirm that all features functioned correctly. Detailed results of the validity tests are presented in Tables 2.

TABLE 2. Validity test results with Aiken's V formula

Aspect ID	Validator 1		Validator 2		Validator 3		Validator 4		∑s	n (c - l)	V score
	R	S	R	S	R	S	R	S			
001	4	3	4	3	4	3	4	3	16	20	0,8
002	4	3	4	3	4	3	4	3	15	20	0,75
003	4	3	3	2	4	3	4	3	15	20	0,75
004	5	4	5	4	4	3	4	3	12	20	0,6
005	4	3	5	4	4	3	5	4	16	20	0,8
006	5	4	4	3	4	3	4	3	18	20	0,9
007	5	4	4	3	4	3	5	4	20	20	1
008	4	3	3	2	3	2	4	3	15	20	0,75
009	4	3	4	3	4	3	3	2	16	20	0,8
010	4	3	4	3	3	2	4	3	14	20	0,7
Average Value V											**0,78**
Category											**Valid**

Effectiveness testing assessed user experience by allowing real users to interact with the app. Effectiveness testing involved 20 respondents consisting of the farm owner, farm workers, and community members who interacted directly with the application during the trial period. The results showed that the application is effective and functional through all trial phases. Detailed results of the effectiveness tests are presented in Tables 3.

TABLE 3. Effectiveness test results

Respon-dent	Product Usage before sum	average	after sum	average	G-Score
R1	220	22	420	42	0,31
R2	230	23	450	45	0,32
R3	210	21	430	43	0,34
R4	200	20	410	41	0,34
R5	190	19	400	40	0,36
R6	195	19,5	405	40,5	0,35
R7	180	18	390	39	0,37
R8	185	18,5	395	39,5	0,36
R9	210	21	420	42	0,34
R10	220	22	440	44	0,33
R11	200	20	430	43	0,36
R12	190	19	410	41	0,36
R13	185	18,5	400	40	0,37
R14	210	21	420	42	0,34
R15	205	20,5	415	41,5	0,34
R16	195	19,5	405	40,5	0,35
R17	200	20	420	42	0,35
R18	190	19	410	41	0,36
R19	195	19,5	415	41,5	0,36
R20	200	20	430	43	0,36
Average G-Score					**0,35**
Category					**Moderate Effectiveness**

Review, At this stage, an evaluation was conducted on the features that had been designed and developed. The goal of this evaluation was to ensure that all features functioned properly, met the needs of the farmers, and to identify any bugs or shortcomings that needed to be fixed or improved. Feedback gathered during this process served as valuable input for refining and enhancing the application in the next development sprint.

Launch, The application was installed directly on the farmer’s smartphone, accompanied by a brief training session on how to operate it. The training included guidance on accessing real-time temperature and humidity data, as well as using manual controls for the heater, servo motor, and camera when needed. This step was intended to ensure that the farmer could independently and efficiently monitor the incubator conditions.

Discussion

This study successfully developed and evaluated a mobile application for incubator monitoring to optimize quail egg production. The system enables real-time monitoring of the incubator’s environmental conditions. The DHT21 sensor, embedded within the incubator, effectively detects temperature and humidity with a rapid response rate. The data is immediately transmitted to the ESP32-CAM microcontroller, which then forwards it to the Supabase cloud platform. The information is displayed through the Blynk application, accessible via mobile devices, allowing farmers to monitor incubator conditions in real time.

The Mobile App for Incubator Monitoring to Optimize Quail Egg Production has undergone a product testing phase, including validity testing by experts in computer/mobile applications, yielding a score of 0.78, which falls into the valid category. Meanwhile, the effectiveness test resulted in a score of 0.35, indicating a moderate level of effectiveness. Through this system, users can obtain real-time information on incubator conditions and take anticipatory actions in the event of deviations from predefined parameters [3].

The findings of this study are consistent with the work of Rohman et al. [10], who developed an automatic egg incubator system integrated with a mobile application using the MQTT protocol. Both studies demonstrate that mobile-based monitoring enables users to access incubator information remotely and supports more efficient supervision of the hatching process. However, the present study extends previous work by integrating the Blynk platform with Supabase cloud services and incorporating image monitoring through the ESP32-CAM, allowing users not only to monitor environmental parameters but also to visually observe incubator conditions in real time.

The results are also in line with those reported by Ardiansyah et al. [11], who developed an Android-based egg incubator monitoring system to improve accessibility and convenience in monitoring incubation conditions. Similar to their findings, users in this study perceived the application as easy to use and beneficial for reducing the need for direct physical inspection. Nevertheless, this research provides additional evidence through validity and effectiveness evaluations, demonstrating that the developed application achieved a validity score of 0.78 and a moderate effectiveness score of 0.35, thereby supporting its practical applicability in real farming environments.

Furthermore, this study complements the findings of Imam and Abdillah [12], who implemented an IoT-based monitoring system for temperature and humidity control in poultry environments. While their study focused on maintaining environmental conditions in broiler chick housing, the present research specifically addresses quail egg incubation management. The integration of real-time monitoring, remote access, actuator control, and image acquisition features provides a more comprehensive monitoring solution that supports operational efficiency during the incubation process. These findings indicate that the adoption of IoT and mobile technologies can be successfully applied across different livestock management contexts while offering practical benefits for farmers.

The implementation of this monitoring application has significantly improved operational efficiency in quail farming, particularly at Nisya Farm. Prior to the adoption of the system, farmers had to manually and periodically check incubator conditions a time-consuming process prone to inconsistent supervision. After implementation, users can remotely monitor the incubator simply using a smartphone. Moreover, the manual override feature enabling remote activation of the heater, motor, and camera provides additional flexibility not possible with conventional manual systems. This demonstrates that an IoT- and mobile app based approach substantially reduces dependency on physical presence and offers clear advantages in terms of time, labor, and maintenance efficiency of the incubation process.

The respondents generally reported that the application was easy to use due to its simple and intuitive user interface. Widgets such as gauges, supercharts, and image galleries provide a comprehensive view of the incubator's condition even for users unfamiliar with digital technology. User feedback reinforces the notion that technology integration impacts not only technical aspects but also fosters greater confidence among farmers in managing the hatching process. This is essential, as the successful adoption of technology largely depends on how comfortable and accessible it is for its intended users.

IV.CONCLUSION

This study successfully developed a mobile application for monitoring temperature and humidity in quail egg incubators using IoT technology and the Agile development method. The application enables real-time monitoring through mobile devices and supports more efficient incubation management. Product evaluation showed a validity score of 0.78 (valid category) and an effectiveness score of 0.35 (moderate effectiveness category), indicating that the application is suitable for practical use. The implementation at Nisya Farm demonstrated improvements in monitoring efficiency and provided farmers with easier access to incubator information. Future work may focus on enhancing automatic control features and evaluating the system's impact on hatchability rates over longer operational periods.

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