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Development of Automated Egg Incubator With Backup Power Supply

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Abstract This study addresses the development of an automated egg incubator with backup power supply that could benefit farmer communities through the developmental research approach. A prototype is developed to respond to the needs for uninterrupted incubation which is affected by the frequent power outages that reduce its efficiency in egg handling. In this project, the automated egg incubator with a backup power supply is designed to hatch a capacity of 150 eggs (75 setters and 75 hatchers) every 21 days, ensuring continuous operation even in the absence of a consistent power supply. An inverter, connected to a battery, ensures a 12 hr uninterrupted power supply, maintaining a warm internal environment. The thermostat-controlled heater regulates the incubator's temperature within the range of 36 °C–38 °C. In case of a power outage, the incubator can seamlessly switch to grid power during brownouts, maintenance, or the rainy season. Based on rigorous testing, the incubation period is confirmed at 21 days, with an initial hatch rate of 70%, increasing to 80% in subsequent tests. The average chick weight, measured a few hours after hatching, stands at 40.8 g. To assess its practical impact, the researchers extended the device to a local game-fowl farmer, resulting in substantial income generation and improved breeding efficiency. Beyond direct economic benefits, the automated egg incubator represents a novel technological achievement, showcasing how science and technology can empower communities, foster economic growth, and contribute to the greater good within a practical context.

Keywords: egg incubator; egg hatching; automated system; prototype; power supply backup

1. Introduction

This paper aims to illustrate the development process of egg incubator with appropriate technological innovation and its testing before widely use by the community. Incubation, a critical phase preceding egg hatching, involves creating controlled environmental conditions. In natural settings, the parent, typically the female, establishes a conducive environment for egg development (Aru, 2017). Freshly laid eggs necessitate consistent incubation at approximately 37.3°C throughout the gestation period. A broody female chicken naturally fulfills this task, or alternatively, an artificially designed incubator can be employed (George, 2015).

An egg incubator serves to replicate the natural conditions provided by parent animals, enhancing the hatching success rate beyond natural capabilities (Aru, 2017). Precise control of factors such as temperature and humidity is crucial when using an egg incubator for the proper development of the egg into a healthy chick (Sanjaya et al., 2018). Some incubators incorporate fans to regulate air temperature and ensure oxygen supply. Turning eggs at regular intervals, a proven practice for improved hatching outcomes, can be automated or done manually at least three times a day. Strategic placement of the incubator in a location with a consistent temperature, avoiding direct sunlight exposure, is essential for maintaining temperature accuracy. Eggs can endure brief periods of low temperature but are highly susceptible to high temperatures. In a study by Sanjaya (2018), challenges faced by quail farmers in hatching large quantities of eggs led to reliance on quail parents for incubation. The proposed solution introduces a smart incubator tailored for quail eggs, leveraging the Arduino microcontroller to autonomously control temperature, humidity, and egg rotation for optimal hatching conditions.

Okpagu and Nwosu (2016) conducted a study concentrating on modeling, designing, and developing an egg incubator system capable of incubating various types of eggs within a temperature range of 35°C–40°C. The system integrated temperature and humidity sensors to monitor the conditions inside the incubator, automatically adjusting the environment to create suitable conditions for the eggs. Fluctuations in incubation temperature can adversely affect the developing embryo (Benjamin & Oye, 2012) and, consequently, post-hatch performance. To maintain the appropriate temperature, electric bulbs were utilized. Water and a controlled fan were used to ensure proper humidity and ventilation within the incubator. Although Okpagu and Nwosu's study presents a development in egg incubation, a more thorough exploration of the technical aspects of the system, empirical testing, and discussion of how this innovation benefits the local community could enhance their work.

Researchers developed and evaluated the performance of a solar powered poultry egg incubator, comparing it to an existing incubator proficient in hatching chicken eggs within a temperature range of 35°C–40°C. Key components of the newly developed incubator encompass the incubating unit, a temperature control device, and a photovoltaic system.

Maintaining a consistent temperature is crucial throughout the incubation process to ensure the proper development of eggs. In domestic fowls, this process is known as brooding, where the parent sits on the eggs, providing essential warmth. The temperature supplied by the brooding parent remains constant, a critical factor for successful incubation. Additionally, humidity plays a pivotal role. In cases of excessively dry air, eggs may lose excessive moisture (Adame et al., 2023), leading to challenges during hatching (Dalangin & Ancheta, 2018). While offering fundamental insights into the importance of temperature and humidity in egg incubation, the study by Dalangin and Ancheta (2018) would benefit from discussing how this technology addresses challenges related to temperature and humidity control, highlighting its potential advantages over traditional brooding methods.

Nevertheless, the incubator may encounter frequent power outages, potentially compromising its efficiency. To address this issue, a continuous backup power source is recommended throughout the entire incubation period. Several studies, including Agbo et al. (2018), Gbabo et al. (2014), and Pallavi et al. (2018), propose alternative energy systems as backup sources during power outages. However, Gbabo et al. (2014) identify an issue without presenting an innovative solution or conducting a comprehensive integration analysis with the incubator.

Recognizing the necessity for uninterrupted incubation, the researcher conceived the development of an egg incubator equipped with a reliable backup power supply. The research introduces innovative features such as an automatic repositioning mechanism, temperature and humidity control systems, and seamless integration with a backup power supply. These features collectively represent a significant innovation in the field, addressing existing challenges and offering the potential for improved hatch rates and overall efficiency.

Going beyond design, the research rigorously evaluates the practical performance of the device, demonstrating its significance and confirming practical value for end users. The automated egg incubator not only enhances hatch rates and efficiency for farmers but also provides economic gains. Its reliability during power outages ensures continuous incubation, improving individual farmers' practices and fostering potential economic growth within the community.

2. Project Objectives

The research project is centered on the design and development of an automated hybrid egg incubator featuring a backup power supply. The novelty of the research project lies in its ability to integrate technological innovation, automation, and a community-focused approach to enhance the egg incubation process, increase hatch rates, and contribute to the economic well-being of the local community.

The project encompasses several specific objectives. Initially, it aims to design and construct a suitable casing and rack system capable of accommodating a significant number of eggs simultaneously. Additionally, there is a proposal for creating a mechanism that can automatically reposition the orientation of the rack to optimize incubation conditions. Furthermore, the research addresses the determination of the most suitable heating, air circulation, temperature control, and humidity control systems to be integrated into the device, ensuring an ideal incubation environment. To enhance the reliability and continuity of the incubation, the project involves integrating a backup power supply for the device, ensuring uninterrupted operation even during power outages or maintenance.

The assessment phase of the research involves evaluating the device using specific parameters, including the incubation period, hatch rate, and chick weight. These metrics provide insights into the effectiveness of the incubator in hatching eggs. Moreover, the research assesses the acceptability of the device by potential end users, covering various aspects, namely, functionality, reliability, maintainability, usability, portability, workability, and safety. This evaluation ensures that the incubator meets the practical needs of its users.

Finally, the project includes a comparative analysis where the specifications of the developed egg incubator are compared with conventional incubators. This comparison serves to highlight the innovation and advantages of the automated hybrid incubator over existing technology.

The research team driving this innovative project possesses a robust background in poultry farming and a profound understanding of the challenges confronted by local game-fowl farmers. With a deep-rooted commitment to making a substantial impact on the local agricultural community, they embarked on this project. Their extensive knowledge of incubation processes and technological innovations positioned them adeptly to design and develop the automated egg incubator. Furthermore, the researchers' commitment to community welfare is manifest in their choice to loan the device to a local farmer for real-world testing. This approach mirrors their dedication to empowering local communities by furnishing practical solutions and enhancing economic sustainability.

3. Method of Study

To effectively execute this project, the researchers employed the developmental research approach. This approach entails systematic work that builds upon existing knowledge acquired from research or practical experience to generate new materials, products, and devices. It also involves the implementation of novel processes, systems, and services, along with substantial enhancements to existing embodiments (Catane, 1998). In simpler terms, this research type finds application in prototyping, inventing, innovating, and fabricating. Additionally, it encompasses research and development programs focused on creating instructional materials (Yaakub & Majundar, 2009).

The assessment of an automated egg incubator's performance relies significantly on the hatchability of eggs as a crucial test method. This method serves as a dependable indicator of the incubator's capacity to provide the optimal conditions necessary for successful embryo development and hatching. To initiate the hatchability test, a predetermined number of fertilized eggs are placed in the incubator and incubated for the entire incubation period. Periodic candling and inspection of the eggs are conducted to evaluate embryo growth and development. At the conclusion of the incubation period, the count of hatched chicks is determined. The hatchability rate is then calculated as the percentage of hatched chicks relative to the total number of eggs set (King'Ori, 2011).

3.1 Data-gathering tool

In this study, a standardized questionnaire served as the data-gathering instrument. The questionnaire was specifically crafted to evaluate the acceptance level of the automated hybrid egg incubator with a backup power supply among potential end users of the project. The instrument comprised seven criteria for evaluators to consider: functionality, safety, reliability, portability, usability, maintainability, and workability. To ascertain the descriptive rating of the project's acceptability, a Likert scale was employed as a reference. Likert scales offer a structured and efficient approach to collecting, analyzing, and comparing user feedback on device acceptability. Their quantitative nature, ease of analysis, and adaptability render them valuable tools for comprehending user perceptions and guiding device development and improvement.

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The subsequent text outlines the stages involved in evaluating the automated egg incubator by end users.

1. User recruitment: The assessment initiates with the recruitment of end users who will actively participate. This crucial step ensures the collection of feedback from a representative sample of potential users.
2. Survey development: A survey questionnaire is meticulously developed, incorporating Likert scale questions to gather structured feedback on various aspects of the automated egg incubator.
3. User feedback gathering: End users are presented with the survey, responding to Likert scale questions. This phase involves collecting feedback concerning the device's performance, usability, and other pertinent factors.
4. Data analysis: This stage encompasses the calculation of mean scores and standard deviations, potentially utilizing statistical tests to comprehend overall sentiments and variations in user responses.
5. Results presentation: Providing a clear understanding of how users perceive the automated egg incubator in terms of acceptability and other relevant criteria.
6. Feedback integration: Feedback acts as a valuable resource for pinpointing areas for improvement and enhancement in the device's design and functionality.
7. Device enhancement: Informed by insights gained from user feedback and assessment results, the device undergoes enhancements and improvements. These modifications aim to address identified issues, making the automated egg incubator more user-friendly and efficient.

Table 1. Rating scale of the acceptance

Descriptive Rating	Range
Very highly acceptable	4.51–5.0
Highly acceptable	3.51–4.5
Acceptable	2.51–3.5
Slightly acceptable	1.51–2.5
Unacceptable	0–1.5

Figure 1 presents the schematic illustrating the methods employed in the assessment of the project. By adhering to these stages, the assessment guarantees the incorporation of user perspectives in the device's development and refinement, ultimately culminating in a more user-accepted and effective automated egg incubator.

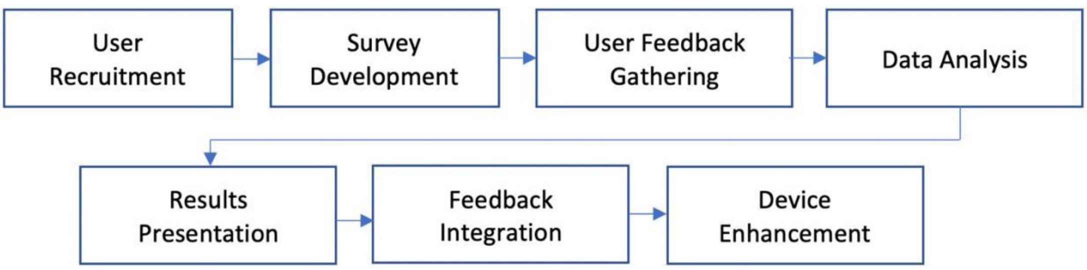

Figure 1. Schematic flow of the assessment

The performance of the egg incubator was tested in terms of hatchability, embryo mortality, and chick weight. These were computed using the following formula below:

$$\text{Hatchability rate (\%)} = \frac{\text{number of eggs hatched}}{\text{number of eggs incubated}} \times 100\%$$

$$\text{Average chick weight (\%)} = \frac{\text{total weight of chicks}}{\text{number of healthy chicks}} \times 100\%$$

3.2 Respondents of the study

Prior to the evaluation, a demonstration was held to showcase the key features and operation of the device. A total of 30 respondents took part in the evaluation, with 20 of them being members of the Bulacan Game-fowl Breeders Association and the remaining 10 being backyard cockfighting breeders situated in Calumpit, Bulacan. The respondents were selected using the purposive sampling method.

3.3 Assembly and package of the prototype

Figure 2 depicts the authentic appearance of the egg incubator. The device underwent testing to evaluate the following parameters: (1) incubation period; (2) hatch rate; and (3) chick weight. These parameters were measured and recorded throughout the entire egg incubation

Figure 3 presents a visual depiction and delineates the key components of the proposed incubator, including the dimensions of each element. The primary objective of this apparatus is to furnish the requisite heat and humidity essential for the effective incubation of eggs. This function is executed through the control circuit (B), equipped with digital displays for convenient monitoring. The upper section of the device (A) is bifurcated into two layers. The upper layer acts as the setter, initiating and sustaining incubation for 18 days. The lower layer serves as the hatcher section, where eggs are transferred for the remaining 3 days until hatching occurs.

Figure 2. Actual appearance of the assembled prototype of the project

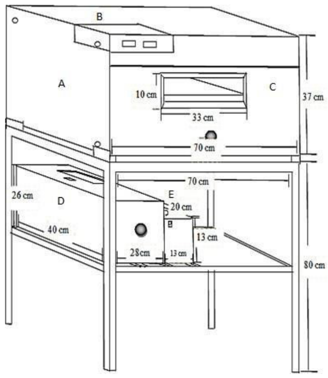

Figure 3. Pictorial layout, main parts, and measurements of the device

Prior to relocating the eggs from the setter to the hatcher section, a crucial step involves inspecting them to ascertain the presence of embryos. This inspection occurs in the egg inspection section (D), where the eggs are positioned against a light source to discern the presence of embryos. To mitigate the impact of potential electrical outages, the device incorporates a backup power supply (E) that activates automatically in the event of a power interruption. Figure 4 provides a visual representation of the key components of the circuit and their interconnections, elucidating the manner in which they are linked.

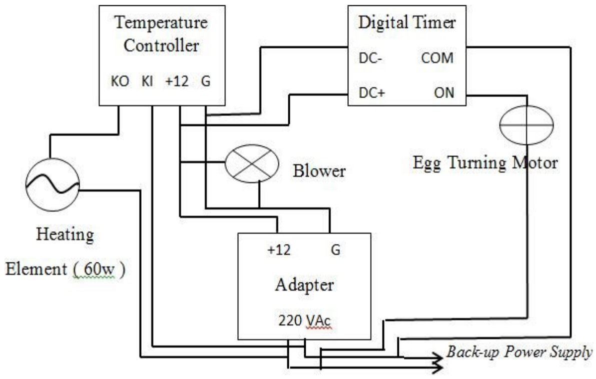

Figure 4. Block diagram of the automated egg incubator

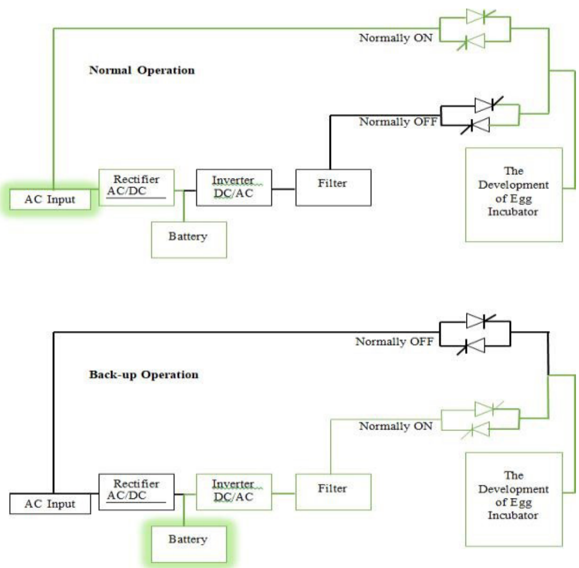

Figure 5. Block diagram of the backup power supply system

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Figure 5 illustrates the block diagram of the backup power supply system, tasked with furnishing auxiliary power during power outages. Figure 6 shows the various stages of the egg incubation process. In Figure 6a, the initial testing of the incubator on the first day of incubation is depicted, showcasing the arrangement of eggs on the rack. The unit effectively accommodated the eggs in the correct configuration. Moving to Figure 6b, the specimen eggs are portrayed on the 10th day of incubation. At this juncture, each egg undergoes meticulous inspection to ascertain the presence of a developing embryo.

a b c d

Figure 6. Procedures of the egg incubation

This inspection aids in identifying clear eggs or those with developed air pockets, signifying the existence of an embryo. Additionally, the presence of blood veins along the egg walls serves as a reliable indicator of the presence of an embryo. In Figure 6c, the transferring of fertilized eggs to the hatcher section is portrayed. This crucial step occurs on the eighteenth day of incubation, facilitating the identification of the bloodlines associated with each egg. Moving to Figure 6d, the hatched eggs are showcased, revealing that the chicks are grouped and separated by wooden panels. This separation guarantees that each group of chicks originates from a distinct brood.

4. Results and Discussions

The device is designed to concurrently incubate multiple eggs, aiming to establish and sustain optimal conditions for successful egg incubation until hatching. Additionally, it incorporates a backup power supply system to ensure continuous operation in the event of a power failure.

The incubator device boasts a maximum capacity of 150 eggs, with 75 eggs allocated to the setter section and 75 eggs to the hatcher section. To ensure successful hatching, a minimum humidity level of 60% is required, coupled with a temperature of 38 °C or 100 °F. The device is equipped with an automatic turning mechanism that rotates the eggs every 2 hr 50 min, ensuring proper incubation.

Hatching of the specimen eggs transpired between the 19th and the 21st day of incubation, aligning with the observations of Dalangin and Ancheta (2018), who noted hatching occurring between the 18th and 22nd day of incubation in their study. Notably, a significant majority of eggs hatched on the 20th day.

The hatch rate of the device was assessed through actual incubation tests using eggs from three distinct batches, each with varying specimen egg quantities. These eggs were confirmed to be fertilized, as attested by the cooperating owners who provided them for the study. The hatchability rate for fully hatched chicks using the incubator stood at 80%, with 2% of eggs partially hatched and 17% remaining unhatched. In comparison to literature, where average hatchability rates ranged from 27% to 75% in previous studies (Iqbal et al., 2014; Mansaray & Yansaneh, 2015; Okonkwo & Chukwuezie, 2012; Othman et al., 2014), the incubator's performance surpassed the average. The high hatch rate is attributed to consistent egg turning and the provision of optimal incubation conditions. Eggs used were sourced from hens with a known high hatchability rate, as confirmed by the contributing farmers.

The average weight of chicks a few hours after hatching was determined to be 40.8 g, falling within the range reported by Deaton et al. (1979), who stated that chick weights at one day old varied between 32.2 g and 42.6 g. This recorded chick weight aligns with findings from previous research.

Table 2. Specifications of the existing and developed incubators

Specifications	Existing Commercial Incubator	Developed Incubator
The capacity of the egg tray	100	150
System size	25 cm × 42 cm × 49 cm	70 cm × 37 cm × 40 cm
Ventilation	30.8 W, 220 V, Cooling fan	1.8 W 12 V, DC fan
Egg turning process	Manual	Semi-automatic
Source of heat	50 W incandescent bulb (1 pc)	45 W LED bulb (5 pcs × 9 W)
Power dource	Grid (220 V AC)	Grid (220 V AC) with backup power supply
Control dystem	Thermostat	Thermostat
Power consumption	80.8 W	50 W
Price	PHP 50,000.00	PHP12,500.00

Table 2 compares the specifications of the existing commercial egg incubator with the developed incubator. The developed incubator presents several advantages over its counterpart. First, it achieves a power saving of 30.8 W, indicating enhanced energy efficiency. Second, its increased capacity allows for the accommodation of a significantly larger number of eggs, contributing to improved hatchability. The data suggest that the developed incubator excels in various aspects, including increased capacity, reduced size, enhanced energy efficiency, semi-automatic egg turning, cost-effectiveness, and heightened reliability with its backup power supply. These enhancements cater to the needs of end users by providing a more efficient, affordable, and user-friendly solution for egg incubation.

The results of the evaluation regarding the acceptability of the device by potential end users are outlined in Table 3. Evaluators assessed the device across various criteria, yielding mean scores as follows: Functionality received a mean score of 4.56, reliability scored 4.67, usability achieved a mean score of 4.65, maintainability was rated at 4.55, portability obtained a mean score of 4.67, workability scored 4.66, and safety received a mean score of 4.66. Combining these evaluations, the device earned an overall descriptive rating of “highly acceptable.” The mean numerical rating for the automated egg incubator with backup power supply stands at 4.63, corresponding to a verbal description of “highly acceptable.”

Table 3. Summary of mean scores for the acceptability evaluation of the project

Criteria	Mean	Interpretation
Functionality	4.56	Highly acceptable
Reliability	4.67	Highly acceptable
Usability	4.65	Highly acceptable
Maintainability	4.55	Highly acceptable
Portability	4.67	Highly acceptable
Workability	4.66	Highly acceptable
Safety	4.66	Highly acceptable
Overall mean rating	**4.63**	**Highly acceptable**

The device evidently excels in meeting the demands and expectations of potential end users. The high individual ratings collectively result in an overall mean numerical rating of 4.63, unequivocally denoting a “highly acceptable” verbal description. This resounding endorsement from evaluators underscore the device’s effectiveness and reliability, affirming its potential to make a significant impact on the community it intends to serve.

Figure 7. Proponents handing over the project for further testing to the owner of the game-fowl farm

Following the declaration of General Community Quarantine (GCQ) in the province of Bulacan, the device’s proponents conducted follow-up activities to assess its status. It was discovered that the majority of the game fowl raised on the farm were successfully hatched using the incubator. Additionally, nearby farms also utilized the machine to incubate their eggs, albeit in smaller quantities. The device has proven to be a valuable tool in supporting poultry breeding activities during the GCQ.

Table 4. Income derived from the use of the device

Capacity of the Incubator	Fee/Egg	Gross Income	Operation Cost/Batch	Net Income
150 eggs/batch	PHP 15	PHP 2250	PHP 200	PHP 2,050
Total projected annual income				**PHP 30,750**

Table 4 presents the income derived from the device's usage, projecting based on its peak capacity of 150 eggs per incubation period. The current fee charged per egg, as of this writing, is PHP 15. The operational cost per batch is set at PHP 200, primarily attributed to electrical utility expenses. With the device utilized for 15 periods within a year, the potential net income may amount to PHP 30,750 annually.

5. Conclusions

Based on the study conducted during the development process of a prototype of an automated egg incubator, it can be demonstrated that the backup power supply as additional element becomes a beneficial innovation for the farmer. It can be seen that the prototype received a good response from the potential users, as it successfully improves the incubation process, particularly needed for the hatching process. Following a thorough examination of the study's execution and the subsequent evaluation results, four following aspects conclusions can been drawn:

1. The most suitable casing rack system for the device is the square wood rolling system, capable of accommodating eighty egg units simultaneously. A 4 W AC motor serves as the primary driving force for repositioning the rack assembly. The device's optimal heating control system features a set of 5 W 12-unit heating elements, with an integrated microcontroller in the thermostat, while the humidity control is digitally actuated. The motor is under the regulation of a digital timer, and a backup power supply ensures the system's autonomy from mains power for 6 hr.
2. Typically, the incubation period spans 21 days. Although the initial hatch rate stood at 70%, subsequent tests achieved an impressive yield of 80%. The average chick weight was recorded at 40.8 g.
3. End-user evaluators highly approved of the project. The project's findings and design innovations hold promise for optimizing egg incubation processes, positively impacting communities engaged in poultry farming and hatchery operations.
4. Considering the aforementioned findings and conclusions, along with a commitment to further enhance the project, the researchers propose certain design changes. The following recommendations have been put forth: (1) for maximum hatching yield, egg specimens from healthy hens should be used; (2) to prevent chick deformities, the integration of a misting system is recommended, and in cases where the battery depletes rapidly, the introduction of a solar panel to augment power requirements is suggested.

Aside from the novel appropriate technological achievement, the project represents the potential economic benefits for the farmers. It shows how the appropriation of science and technological innovation can empower communities through its practical contribution. This community service initiative serves as an opportunity to educate farmers about the equipment's benefits and proper usage. Emphasizing the importance of knowledge sharing and capacity building initiatives is crucial for ensuring the long-term success and impact of interventions. It underscores the notion that equipping communities with the necessary knowledge and skills can foster greater self-reliance and contribute to sustainable development.

Author Contribution

Allen N. Maroma assumes the pivotal role of Project Administrator for the ongoing research initiative. As the principal proponent, he navigated the rigorous journey of securing essential funding from his university, demonstrating commendable dedication to advancing the project. Maroma not only spearheaded the financial aspects but also played a crucial role in conceiving the proposition for deploying the innovative device. His visionary idea involves assessing the real-world impact of the technology within a specific community adjacent to the university, providing a unique opportunity to evaluate its implications for industry practitioners in practical settings.

Dolly P. Maroma assumed the critical position of Project Supervisor, overseeing various facets of the research endeavor. Her responsibilities encompassed the periodic monitoring of the device's performance, ensuring its optimal functionality. She played a pivotal role in the meticulous selection and coordination with beneficiaries who directly engage with the device. She also took charge of preparing the comprehensive research monitoring reports, which were diligently submitted to the university. Her commitment extended to the refinement of the final manuscript of the research report, a crucial step in ensuring the accuracy and coherence of the findings before publication.

Bernardo A. Pangilinan assumed the pivotal role in spearheading the design and overseeing various technical aspects of the developed device. His primary responsibility encompassed the meticulous planning and execution of the device's design, demonstrating profound expertise in the technical domain. He also undertook the crucial task of conducting periodic monitoring sessions. This hands-on approach reflected his commitment to maintaining the device's functionality at an optimal level.

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Declaration of Conflicting Interest
The authors declare no conflict of interest in the conduct of the study.

References

Adame, M. M., Yusuf, Y., & Kuda, N. T. (2023). Influences of types of incubators on hatchability of eggs. *Advances in Applied Sciences*, *8*(3), 80–85. https://doi.org/10.11648/j.aas.20230803.13

Agbo, D. O., Otengye, O. J., & Dodo, S. H. (2018). Proposed development of a solar-powered automated incubator for chickens. *International Journal of Engineering and Techniques*, *4*(1), 517–524. https://doi.org/10.29126/23951303/IJET-V4I1P69

Aru, O. E. (2017). Development of a computerized engineering technique to improve incubation system in poultry farms. *Journal of Scientific and Engineering Research, 4*(6), 109–119.

Benjamin, N., & Oye, N. D. (2012). Modification of the design of poultry incubator. *International Journal of Application or Innovation in Engineering & Management*, *1*(4), 90–102.

Catane, J. A. (1998). Types of research and research methodology. *Philippine Journal of Industrial Education and Technology*, *8*(1), 12–41.

Dalangin, F. T., & Ancheta, A. C. (2018). Performance evaluation of the developed solar powered poultry egg incubator for chicken. *Journal of Science, Engineering, and Technology*, *6*, 67–81.

Deaton, J. W., McNaughton, J. L., & Reece, F. N. (1979). Relationship of initial chick weight to body weight of egg-type pullets. *Poultry Sciences*, *58,* 960–962. https://doi.org/10.3382/PS.0580960

Gbabo, A., Liberty, J. T., Gunre, O. N., & Owa, G. J. (2014). Design, construction, and performance evaluation of an electric-powered egg incubator. *International Journal of Research in Engineering and Technology*, *3*, 521–526. http://dx.doi.org/10.15623/ijret.2014.0303097

George, E. B. (2015). Life way's mini solar poultry egg incubator market research. *Kerala Renewable Energy Entrepreneurship Promoter Association Indian Stream Research Journal*.

Iqbal, J., Khan, S. H., Mukhtar, N., Ahmed, T., & Pasha, R. A. (2014). Effects of egg size (weight) and age on hatching performance and chick quality of broiler breeder. *Journal of Applied Animal Research*, *44*(1), 54–64. https://doi.org/10.1080/09712119.2014.987294

King'Ori, A. M. (2011). Review of the factors that influence egg fertility and hatchability in poultry. *International Journal of Poultry Science*, *10*(6), 483–492. https://doi.org/10.3923/ijps.2011.483.492

Mansaray, K. G., & Yansaneh, O. (2015). Fabrication and performance evaluation of a solar powered chicken egg incubator. *International Journal of Emerging Technology and Advanced Engineering*, *5*(6), 31–36.

Okonkwo, W. I., & Chukwuezie, O. C. (2012). Characterization of a photovoltaic powered poultry egg incubator. *International Proceedings of Chemical, Biological and Environmental Engineering (IPCBEE)*, *47*, 1–6.

Okpagu, P. E., & Nwosu, A. W. (2016) Development and temperature control of smart egg incubator system for various types of egg. *European Journal of Engineering and Technology*, *4*(2), 13–21.

Othman, R. A., Amin, M. R., & Rahman, S. (2014). Effect of egg size, age of hen and storage period on fertility, hatchability, embryo mortality and chick malformations in eggs of Japanese quail (*Coturnix coturnix japonica*). *IOSR Journal of Agriculture and Veterinary Science*, *7*(1), 101–106.

Pallavi, B., Tripathi, J., Hermant, G., Barapatre, V., Ramteke, P., & Burange, R. (2018). Development of a smart egg incubator system using Arduino. *International Journal of Engineering Science and Computing, 8*(3).

Sanjaya, W. S. M., Maryanti, S., Wardoyo, C., Anggraeni, D., Aziz, M. A., Marlina, L., Roziqin, A., & Kusumorini, A. (2018). The development of quail eggs smart incubator for hatching system based on microcontroller and Internet of Things (IoT). *2018 International Conference on Information and Communications Technology (ICOIACT)*, 407–411. https://doi.org/10.1109/ICOIACT.2018.8350682

Yaakub, M. N., & Majundar, S. (2009). *Research in TVET made easy*. Colombo Plan Staff College.

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