

To cite this article: BERNARD D. DELGADO (2025). DEVELOPMENT OF A SOLAR-POWERED PUBLIC ADDRESS SYSTEM (PA) WITH AUTOMATIC SCHEDULING, International Journal of Applied Science and Engineering Review (IJASER) 6 (4): 56-102 Article No. 238 Sub Id 364

---

## DEVELOPMENT OF A SOLAR-POWERED PUBLIC ADDRESS SYSTEM (PA) WITH AUTOMATIC SCHEDULING

BERNARD D. DELGADO

Master in Industrial Education, Major in Electronics Technology  
Surigao del Norte State University

DOI: <https://doi.org/10.52267/IJASER.2025.6404>

### ABSTRACT

This study focuses on the development of a solar-powered public address (PA) system integrated with automatic scheduling, designed to enhance communication efficiency and energy sustainability in educational institutions. Traditional PA systems often depend on grid electricity and manual operation, making them vulnerable to power outages, human error, and operational inconsistencies. These limitations can disrupt school routines and reduce preparedness during emergencies, particularly in rural or disaster-prone areas.

The proposed system utilizes solar energy as its primary power source to ensure continuous operation, reduce electricity costs, and support environmental sustainability. An embedded microcontroller and real-time clock (RTC) module automate the scheduling of announcements, school bells, and emergency alerts, minimizing the need for human intervention. The design emphasizes affordability, reliability, and ease of maintenance, making it suitable for public schools with limited resources.

Through prototyping and testing, the system demonstrated its technical feasibility, economic viability, and operational reliability. The results suggest that integrating renewable energy and automation in school PA systems can significantly improve communication processes while contributing to broader sustainability goals. This project serves as a model for smart, energy-efficient educational infrastructure.

**KEYWORDS:** Solar-powered public address system with automatic scheduling

## **INTRODUCTION**

### **CHAPTER 1**

#### **PROBLEM AND REVIEW OF LITERATURE**

This chapter presents the introduction, review of related literature, conceptual framework, statement of the problem, significance of the study, scope and limitation, and definition of terms of the study.

#### **INTRODUCTION**

An effective communication system is essential in educational institutions, where daily routines, class transitions, and emergency alerts depend on timely and accurate announcements. According to Santos and Reyes (2021), a well-structured communication infrastructure significantly enhances productivity, preparedness, and institutional order. Villanueva and Soriano (2020) further emphasize that schools require reliable public address (PA) systems to support structured learning environments and ensure administrative efficiency. When communication systems are delayed or inconsistent, it can result in missed classes, confusion, and a lack of preparedness during emergencies (Mercado & De Guzman, 2018).

However, many schools—particularly in rural or under-resourced areas—still rely on conventional PA systems that are manually operated and dependent on grid electricity. These systems are often vulnerable to power interruptions and operational inconsistencies. Garcia, Ramos, and Villanueva (2020) found that traditional PA systems commonly suffer from human error, inaccurate scheduling, and limited functionality during outages. Similarly, Reyes and Aquino (2021) reported that schools located in disaster-prone areas often face serious risks due to the unreliability of grid-powered systems, which hinder the prompt dissemination of emergency information.

To address these challenges, researchers have explored the integration of renewable energy technologies, particularly solar power, into school infrastructure. Solar-powered systems offer a sustainable and cost-effective solution by reducing long-term dependence on electricity from the grid (Lopez & Martinez, 2019). Delos Reyes and Tan (2020) highlighted the successful implementation of solar-powered devices in public schools, noting significant cost savings and increased reliability. Cruz and Mendoza (2022) added that solar-powered PA systems not only provide energy independence but also reduce carbon footprints while maintaining full operational capability during power outages.

In addition to renewable energy integration, the application of automation through real-time clocks (RTCs) and microcontrollers is gaining momentum. Automated systems eliminate the need for continuous human supervision and reduce the chances of error in broadcasting scheduled announcements (Del Rosario, Bautista, & Hernandez, 2022). Fernandez and Domingo (2019) demonstrated that microcontroller-based school bell systems with RTCs improve punctuality and streamline daily

operations. Luna and Santos (2021) further argued that automated scheduling systems enhance institutional efficiency by ensuring announcements are played consistently and on time.

By combining solar energy and automatic scheduling technologies, schools can develop a smart PA system that is energy-efficient, sustainable, and operationally reliable. This fusion not only addresses the technical and economic limitations of traditional systems but also supports broader goals in environmental sustainability and disaster preparedness. As such, the development of a solar-powered public address system with automatic scheduling aligns well with the needs of modern educational institutions seeking smart and eco-friendly solutions.

### **REVIEW OF LITERATURE**

The development of a solar-powered public address (PA) system with automatic scheduling aligns with research in renewable energy and automation technology. This section reviews related literature to establish a theoretical foundation, focusing on the integration of solar power and automated systems for efficient and reliable communication.

According to Poobalan et al. (2018), a solar-powered automatic bell system integrated with smoke detection can enhance school safety and reduce operational costs, particularly in rural areas with limited access to electricity. In 2019, the Stanford University News reported that solar-powered school programs could offset up to 75% of electricity consumption and reduce carbon emissions by 28%, highlighting both environmental and economic advantages. That same year, Kim and Park (2019) emphasized the importance of integrated emergency alert systems in school PA setups, showing their effectiveness in improving crisis response times.

In 2020, Ahmad et al. demonstrated that photovoltaic (PV) systems with battery storage greatly enhance the reliability of school operations during power outages. Similarly, the National Fire Protection Association (2020) supported the integration of automated emergency systems to ensure immediate alerts during critical events. By 2021, Singh et al. validated these findings, confirming that solar-powered PA systems maintain communication functions even during blackouts. Complementary field evidence from the Philippines (BusinessMirror, 2021) showed improvements in power reliability and reduced utility costs after solar installations in public school laboratories. In the same year, Chen et al. (2021) and Lopez & Ramirez (2021) found that smart automation significantly reduces staff workload and electricity consumption, with Patel et al. (2021) further proving that automated bell systems minimize human error and improve scheduling accuracy.

In 2022, Johnson and Lee reinforced the value of automation by showing its ability to eliminate

inconsistencies in school schedules, improving overall time management. Avula et al. (2023) later demonstrated that RTC-based scheduling systems in school bells effectively reduce manual errors, while Martinez and Gonzales (2023) concluded that automated systems increase efficiency by ensuring timely announcements without manual input. Most recently, Jaman, Amirruddin, and Yusof (2024) conducted a comprehensive analysis on the technical and financial viability of standalone solar PV systems in rural schools, confirming their suitability for sustainable educational infrastructure.

Collectively, these studies illustrate a growing body of evidence that solar-powered PA systems with automated scheduling are a practical, cost-efficient, and sustainable solution for enhancing communication, safety, and reliability in educational institutions.

### **SYNTHESIS:**

The synthesis of related literature shows that integrating solar power and automation in public address (PA) systems enhances efficiency, reliability, and sustainability. Solar energy offers a dependable power source, especially in areas with unstable electricity, while automation reduces human error and improves scheduling accuracy. Research also highlights the role of automated alerts in ensuring timely communication during emergencies. Overall, a solar-powered PA system with automatic scheduling effectively addresses power interruptions, manual operation issues, and high electricity costs, making it a practical solution for improving institutional communication and safety.

### **Conceptual Framework**

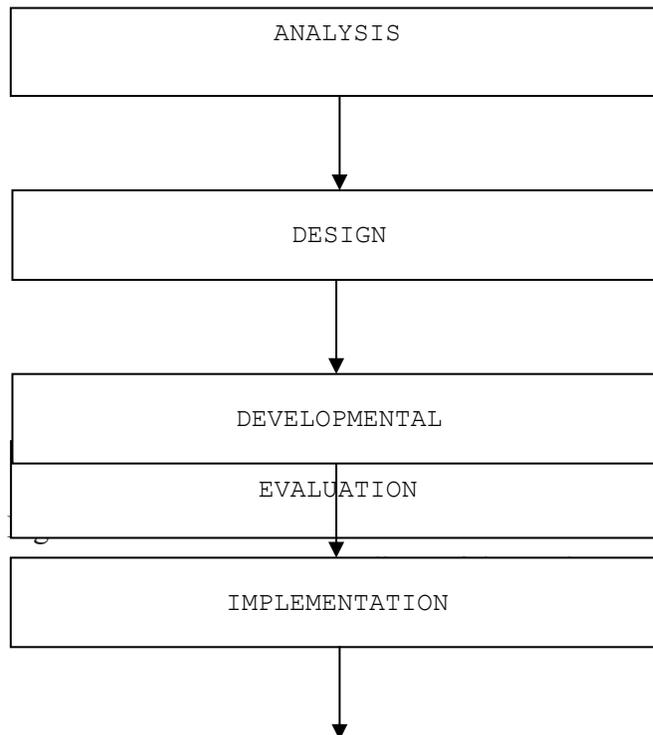
The development of a solar-powered public address (PA) system with automatic scheduling follows the ADDIE model, which consists of Analysis, Design, Development, Implementation, and Evaluation. This framework ensures a systematic approach to integrating solar energy and automation technology for efficient and reliable communication in schools and public spaces.

In the Analysis phase, the study identifies issues with traditional PA systems, such as power outages, manual inefficiencies, and high operational costs, while determining the technical requirements for solar energy integration and automation. The Design phase focuses on creating the system's blueprint, selecting components such as solar panels, microcontrollers, batteries, and audio transmission systems, and developing the automated scheduling mechanism. During the Development phase, the prototype is constructed, integrating solar power, embedded automation, and PA functionalities, followed by rigorous testing to verify system performance. The Implementation phase involves deploying the system in a real-world setting, such as a school or public facility, while monitoring its efficiency in power sustainability, automation accuracy, and sound clarity. Finally, in the Evaluation phase, the system undergoes performance assessments and user feedback collection to refine its functionality and address potential

improvements.

By applying the ADDIE model, the study ensures that the proposed system is technically feasible, efficient, and sustainable, providing a cost-effective and eco-friendly solution to modern communication challenges.

### The ADDIE Model Approach/Phases



### STATEMENT OF THE PROBLEM

This study aimed to develop a solar-powered public address system with automatic scheduling to ensure a reliable and efficient alarm system in Dapa National High School. Specifically, it seeks to answer the following questions:

1. What are the current limitations in reliability, efficiency, and power source of the existing public address system or alarm system at Dapa National High School, considering the school's specific needs?
2. How can a solar-powered public address system with automatic scheduling capabilities be designed to address the identified limitations and meet the requirements of Dapa National High School?
3. How can a functional and durable prototype of the solar-powered public address system with automatic scheduling be developed to ensure long-term reliability and efficiency?
4. How can the developed solar-powered public address system with automatic scheduling be

effectively implemented at Dapa National High School, including the installation and training of personnel for its operation and maintenance?

5. How efficient is the implemented solar-powered public address system with automatic scheduling in providing reliable alarms and facilitating scheduled announcements at Dapa National High School?

6. What are the perceptions of the respondents on the evaluation of the device based on DOST TAP-TEEPS parameters in terms of:

6.1 Reliability of the System;

6.2 Efficiency of the System;

6.3 Ease of Use;

6.4 Clarity and Audibility; and

6.5 Overall Satisfaction?

7. Develop user's manual of the device.

### **Significance of the Study**

This study may contribute to Dapa National High School, Emergency Response Teams, electronic technicians, and future researchers.

**Schools and Educational Institutions.** This study provides a more reliable and efficient communication system that ensures uninterrupted announcements, even during power outages. The automated scheduling feature eliminates human errors, improving time management, accuracy in class transitions, and emergency alerts, ultimately fostering a more organized and safer learning environment.

**Emergency Response Teams.** The integration of an automated emergency alert feature enhances institutional safety by ensuring immediate and accurate warnings during critical situations such as fires, earthquakes, or security threats. This improves response times, minimizes risks, and ensures the safety of students, staff, and the general public.

**Electronic Technicians and Engineers.** This study contributes to the field of electronics and automation by providing insights into the integration of solar power and automation in communication systems. It offers new opportunities for electronic technicians to develop, install, and maintain energy-efficient PA systems, advancing expertise in renewable energy technologies.

**Energy Conservation and Cost Reduction.** The use of solar power as the primary energy source for the PA system promotes sustainability by reducing reliance on grid electricity. This not only lowers

operational costs for institutions but also supports global efforts toward renewable energy adoption, contributing to environmental conservation.

**Future Researchers and Technologists.** This study serves as a reference for future innovations in renewable energy-powered automation systems. It provides valuable insights into integrating solar technology and automated scheduling into communication infrastructure, encouraging further research and development in sustainable and intelligent communication systems.

Overall, this study contributes to the advancement of energy-efficient, cost-effective, and intelligent communication solutions, addressing key challenges in institutional operations while promoting sustainable and eco-friendly technology.

### Scope and Limitation of Study

To facilitate delimitation in understanding the purpose and content of this study, the following parameters are specified

**Focus.** The main focus of this study is to analyze, design, develop, implement and evaluate a solar-powered public address system with Automatic Scheduling that can be used as a class transition management and emergency alerts of the School at Dapa National High School, Brgy 6, Poblacion, Dapa, Surigao del Norte.

**Respondents.** The respondents of the study are the school administrator, Faculty and Staff, and students, Emergency Response Teams, electronic technicians, and future researchers.

**Place and time.** This study will be conducted at Dapa National High School this School Year 2024-2025.

### Definition of Terms

To facilitate clear understanding of the content and purpose of this study, the following terms are operationally described as follow:

**Public Address (PA) System** – A sound amplification and broadcasting system used to deliver announcements to a large audience in public spaces such as schools, offices, and institutions.

**Solar-Powered System** – A system that operates using energy harnessed from solar panels, converting sunlight into electricity to power various devices, reducing reliance on conventional electricity sources.

**Automatic Scheduling** – A programmed feature that allows announcements or alerts to be broadcast at predetermined times without manual intervention, ensuring timely communication.

**Manual Operation** – The traditional method of operating PA systems where staff or administrators manually control announcements and schedules. The study aims to minimize reliance on manual operation.

**Microcontroller** – A compact integrated circuit that serves as the brain of an embedded system,

responsible for controlling automated operations such as scheduling and broadcasting announcements.

**Photovoltaic (PV) Panels** – Devices that convert sunlight into electrical energy, commonly used in solar power systems to generate renewable energy for continuous operation.

**Battery Storage System** – A component that stores electrical energy generated by solar panels, ensuring the system remains functional during low sunlight conditions or nighttime.

**Real-Time Clock (RTC) Module** – A component used in embedded systems to maintain accurate timekeeping, allowing scheduled operations to occur precisely as programmed.

**Amplifier** – An electronic device that increases the power of audio signals to drive speakers and ensure clear sound transmission over long distances.

**Emergency Alert System** – A feature of the PA system that broadcasts urgent messages during critical situations, such as natural disasters, fire drills, or security threats.

**Energy Efficiency** – The ability of a system to use minimal energy while maintaining optimal performance, crucial in solar-powered applications to maximize battery life and sustainability.

**Grid Independence** – The capability of a system to operate without reliance on the main electrical grid, ensuring uninterrupted functionality even during power outages.

**Time Management** – The process of organizing and scheduling activities efficiently, enhanced by the PA system's automatic scheduling to improve class transitions and institutional operations.

**Sound Clarity** – The quality of audio output from the PA system, ensuring that announcements are clear and audible to all intended listeners without distortion.

**Embedded System** – A computer-controlled system designed to perform specific tasks, such as managing scheduled announcements in the PA system.

**System Reliability** – The ability of the PA system to function consistently and accurately without frequent failures, ensuring continuous and effective communication.

## Chapter 2

### RESEARCH METHODS

This chapter focuses on the discussion of the research method to efficiently answer the problem posed for investigation. It also discusses the selection of the respondents, the instruments to generate the desired information, the data gathering processes and the corresponding statistical techniques.

#### Research Design

The development and validation of an Innovative Solar-powered public address system with automatic scheduling was used the developmental and descriptive-evaluative research. The concept of the researcher in the study is to develop a very comprehensive type of device that has a unique feature compared to the existing device. A work plan was laid out to design and execute the fabrication of the project at hand. Various designs were put forward and a careful consideration of each plan was done, with special

considerations on the availability and cost of each of the needed part.

After continuously testing the project on a varied number of parameters, an objective evaluation will be undertaken by the researcher to test the performance and acceptability of the project in terms of the pre-determined criteria set forth in the conceptualization of the study. A 5-point Likert scale was used to quantify responses of the evaluators, with 5 being the highest and 1 being the lowest.

### **Research Environment**

The study was conducted at Dapa National High School, Brgy 6 Poblacion, Dapa, Surigao del Norte. The separation and conversion of this National High School was realized by virtue of the Republic Act 9762 on November 10, 2009, an act separating the Dapa National High School - Consolacion Annex in Barangay Consolacion, Municipality of Dapa, Province of Surigao del Norte is hereby separated from the Dapa National High School and converted into an independent national high school to be known as Consolacion National High School.

Currently, Dapa National High School has an annex school the Dagohoy Integrated High School at Dagohoy, Dapa, Surigao del Norte. As a public secondary school, Dapa National High School typically offers the standard curriculum set by the Philippine Department of Education (DepEd). These includes Junior high school (Grades 7-10), and Senior High School (Grades 11-12) with 2,578 students, 130 faculty and staff, and 1 administrator. currently Senior High School (SHS) offers programs such as Academic Track like Science, Technology, Engineering, and Mathematics (STEM), Accountancy, Business, and Management (ABM), Humanities and Social Sciences (HUMSS), and General Academic Strand (GAS). Additionally, Technical-Vocational-Livelihood (TVL) Track. Like ICT (Computer Systems Servicing), Combination of (Cookery, Housekeeping, Local Tour guiding) and Industrial Arts (Electrical Installation and Maintenance).

Dapa National High School, Campus is the research locale because the researcher is one of the faculty of the School in the Senior High School Teaching Electrical Installation and Maintenance.



Plate 1

## Location Map of Dapa National High School

**Research Respondents**

The respondents of this study will include school administrators, faculty and staff, students of Dapa National High School, emergency response teams, electronic technicians, and future researchers. **School administrators, faculty, and staff** will provide insights on the system's effectiveness in improving school communication, ensuring proper class transitions, and addressing scheduling inconsistencies. **Students** will share their experiences regarding the clarity, timeliness, and overall impact of the system on their daily routines. **Emergency response teams** will evaluate the system's capability to deliver urgent alerts and ensure a prompt response during emergencies. **Electronic technicians** will assess the technical aspects of the system, including installation, maintenance, and efficiency. Lastly, **future researchers** will benefit from this study by gaining insights that can guide further advancements in solar-powered PA systems. The selection of respondents will be based on purposive sampling, ensuring that only individuals directly involved in or affected by the system's implementation contribute to the evaluation of its effectiveness, reliability, and sustainability.

Table 1

**Distribution of Respondents**

Respondents	Sample
School Administrator	1
Faculty and Staff	10
Students	10
Emergency Response Team	2
Electronic Technician	2
Total	25

**Research Instrument**

The instrument used in the conduct of the study was a researcher-made questionnaire based on (Appendix A). The questionnaire addresses the functionality of the device in terms of usability to assess respondents, feedbacks and suggestions.

**Part I Survey Questionnaires** – A structured questionnaire will be distributed to school administrators, faculty, staff, students of Dapa National High School, emergency response teams, and electronic technicians to assess the system’s effectiveness, reliability, user-friendliness, and impact on school communication and emergency response. The questionnaire will include Likert-scale, multiple-choice, and open-ended questions to gather both quantitative and qualitative feedback.

**Part II Interviews** – Key informant interviews will be conducted with school administrators, faculty members, and electronic technicians to gain in-depth insights into the system’s usability, challenges, and areas for improvement. These interviews will help validate survey findings and provide a deeper understanding of user experiences.

**Part III System Performance Testing** – Technical evaluations will be conducted to measure the functionality, efficiency, and sustainability of the system. Parameters such as power consumption, audio clarity, automation accuracy, and emergency alert responsiveness will be tested under different conditions. This will be carried out with the assistance of electronic technicians and technical staff to ensure an objective assessment.

The criteria in grading usability, acceptability of the design, develop solar-powered public address system with automatic scheduling is measured and categorize as follows:

Point	Verbal Interpretation	Qualitative Description
5	Strongly Agree (SA)	If <u>all</u> of the needed requirements were completely and fully passed.
4	Agree (A)	If <u>most</u> of the needed requirements were completely and fully passed.
3	Neutral (N)	If <u>some</u> of the needed requirements were partially passed.
2	Disagree	If <u>few</u> of the needed requirements were passed.
1	Strongly Disagree (SD)	If <u>none or very few</u> of the needed requirements were passed.

### Categorization of Data

The following categorization was used to quantify and assign descriptive categories to the perceptual evaluation of the expert evaluators and target end users.

### Validation Criteria:

Point Value	Rating Scale	Descriptive Equivalent
5	4.20-5.00	Very High Validity/ Very High Acceptability
4	3.40-4.19	High Validity/ High Acceptability
3	2.60-3.39	Moderate Validity/ Moderate Acceptability
2	1.80-2.59	Slight Validity/ Slight Acceptability
1	1.00-1.79	No Validity/ Not Acceptability

### Data Analysis

To ensure a comprehensive evaluation of the competency-based photovoltaic installation and maintenance trainer, the following statistical tools will be used to analyze the collected data, aligned with each phase of

the ADDIE Model:

- o **Frequency Count and Percentage** – Used to determine the respondents' demographic profile, including age, educational background, and familiarity with photovoltaic installation and maintenance. This helps assess the need for the trainer and identify skill gaps.
- o **Frequency Median** – Determines the central tendency of responses related to the trainer's usability, ease of assembly, and functionality. This ensures that the trainer meets industry and educational requirements.
- o **Ordinal Rank** – Used to rank key features of the trainer based on their perceived importance, such as cost-effectiveness, durability, and accessibility.

### Chapter 3

## RESULTS AND DISCUSSIONS

This chapter presents, interprets, and analyses the obtained data from the retrieved survey-instrument from the respondents under study. The discussion of results is based on the problem posted in Chapter 1.

### **ANALYSIS ON THE CURRENT LIMITATIONS OF THE ALARM SYSTEM AT DAPA NATIONAL HIGH SCHOOL, CONSIDERING THE SCHOOL'S SPECIFIC NEEDS IN TERMS OF SYSTEM USAGE AND FUNCTIONALITY, RELIABILITY AND MAINTENANCE, POWER SOURCE AND EFFICIENCY, AND SCHOOL NEEDS AND PREFERENCES**

Tables below present the analysis on the current limitations of the alarm system at Dapa National High School, considering the school's specific needs in terms of system usage and functionality, reliability and maintenance, power source and efficiency, and school needs and preferences.

Perceptions of the respondents in terms of **System Usage and Functionality**.

**Table 2** *Perceptions of the respondents in terms of System Usage and Functionality.*

Statement	median	Qualitative description
The school currently has a reliable public address (PA) system.	3	Observed
The school currently has a reliable alarm system (for emergencies like fire, etc.).	2	Less Observed
The PA system is used frequently enough for general announcements.	2	Less Observed

The alarm system is tested regularly.	2	Less Observed
Announcements made through the current PA system are generally clear and audible in most areas of the school.	2	Less Observed

The data reveals significant gaps in the school's current communication and safety infrastructure, with all five system functionality indicators receiving median scores of 2-3 on what appears to be a higher-scale rating system. While respondents acknowledge that a PA system exists (median=3, "Observed"), they perceive critical deficiencies in its reliability and effectiveness, with announcement clarity and audibility being "Less Observed" (median=2). More concerning is the consistently poor perception of the alarm system's reliability and maintenance, with both its dependability and regular testing receiving the lowest ratings (median=2). The pattern suggests a systemic issue where basic safety and communication infrastructure exists on paper but fails to meet operational standards in practice. This disconnect between having systems and having functional systems points to either inadequate maintenance, poor system design, or insufficient operational protocols - all of which could compromise both daily school operations and emergency response capabilities. Evaluating school safety requires a multifaceted approach that considers both active and passive fire protection systems, as well as the accuracy of incident reporting (Rosen & Santesso, 2018; Suryoputro et al., 2018).

Perceptions of the respondents in terms of **Reliability and Maintenance**.

**Table 3 Perceptions of the respondents in terms of Reliability and Maintenance.**

Statement	median	Qualitative description
The current PA system rarely malfunctions or fails to work when needed.	2	Less Observed
The current alarm system rarely malfunctions or fails to work when needed.	2	Less Observed
The process for reporting and addressing issues with the current PA or alarm system is easy and efficient.	3	Observed
I am aware of recent repairs or maintenance conducted on the current PA or alarm system.	2	Less Observed

The reliability and maintenance data further reinforces the concerning pattern of system dysfunction identified in the usage and functionality assessment. Both the PA and alarm systems are perceived as

frequently malfunctioning and failing when needed (median=2, "Less Observed"), which directly explains the poor functionality ratings in the previous table and represents a critical failure in essential school infrastructure. While respondents acknowledge that the reporting process for system issues is reasonably accessible (median=3, "Observed"), the low awareness of recent repairs or maintenance activities (median=2) suggests either inadequate maintenance scheduling, poor communication about maintenance efforts, or both. This creates a troubling cycle where systems fail regularly, staff can report problems, but visible corrective action appears minimal or ineffective. The data indicates that while the school has established protocols for addressing system issues, the execution of maintenance and repair activities is insufficient to maintain reliable operation, leaving the school vulnerable to communication breakdowns and potentially compromised emergency response capabilities. Maintenance management in school buildings is currently facing significant challenges, with many institutions not meeting satisfactory levels of maintenance practices (Yong & Sulieman, 2015).

Perceptions of the respondents in terms of **Power Source and Efficiency**.

**Table 4** *Perceptions of the respondents in terms of Power Source and Efficiency.*

Statements	median	Qualitative description
The current PA system functions reliably even during power outages.	2	Less Observed
The current alarm system functions reliably even during power outages.	2	Less Observed
The current PA system is energy efficient.	2	Less Observed
The current alarm system is energy efficient.	2	Less Observed

The power source and efficiency data exposes a critical vulnerability in the school's emergency preparedness infrastructure, with all four indicators receiving uniformly low ratings (median=2, "Less Observed"). The most alarming finding is that both communication and safety systems are perceived as unreliable during power outages, which represents a fundamental failure in emergency preparedness since power disruptions often coincide with the very situations where these systems are most desperately needed - such as natural disasters, fires, or security incidents. This lack of backup power capability essentially renders the school's safety infrastructure useless during many emergency scenarios, creating a dangerous gap in crisis response capabilities. Additionally, the perceived poor energy efficiency of both systems

suggests outdated technology that not only increases operational costs but may also contribute to their reliability issues through excessive power consumption and heat generation. The consistent pattern of poor performance across power reliability and efficiency metrics indicates that the school's communication and alarm systems require comprehensive modernization with proper backup power solutions and energy-efficient components to meet basic safety and operational standards. Power interruptions have far-reaching consequences on communities, affecting crucial aspects of human life and the environment (Hachem-Vermette & Yadav, 2023).

Perceptions of the respondents in terms of **School Needs and Preferences**.

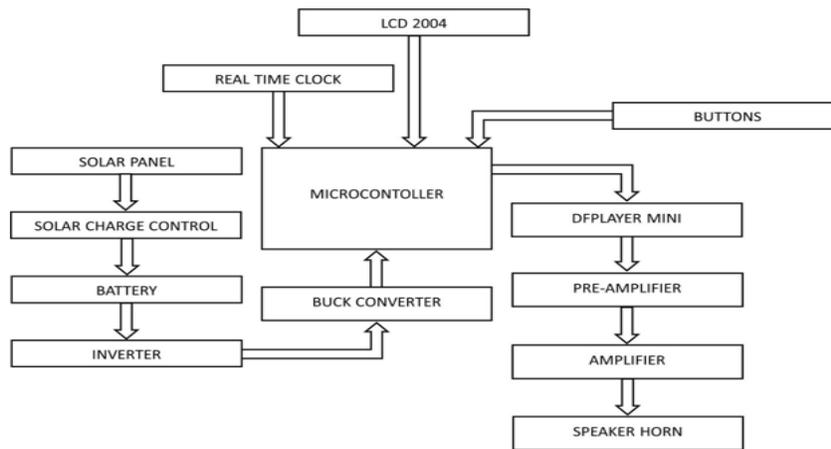
**Table 5** *Perceptions of the respondents in terms of School Needs and Preferences.*

Statements	Median	Qualitative description
The current PA system effectively meets the school's needs for communication and announcements.	2	Less Observed
The current PA system allows for all necessary types of announcements to be made effectively.	2	Less Observed
Having an automatic scheduling feature for announcements (e.g., for bells, reminders) would be beneficial for the school	2	Less Observed

The school needs and preferences data reveals a stark disconnect between current system capabilities and actual institutional requirements, with respondents consistently rating the PA system as inadequate for meeting basic communication needs (median=2, "Less Observed" across all measures). The perception that the current system fails to effectively handle the school's communication and announcement requirements aligns perfectly with the previously identified issues of poor reliability, maintenance, and power efficiency, creating a comprehensive picture of system failure. Particularly noteworthy is the lukewarm response to automatic scheduling features for routine functions like bells and reminders (median=2), which suggests either that respondents are skeptical about technological solutions given their negative experiences with current systems, or that they prioritize basic functionality over advanced features. This pattern indicates that the school community has likely adapted to work around a fundamentally broken communication infrastructure, with expectations potentially lowered by chronic system failures. The data suggests that any modernization effort should focus first on establishing reliable, basic communication capabilities before introducing automated or advanced features, as the current system appears to fail at even the most elementary functions required for daily school operations.

**DESIGN OF A SOLAR-POWERED PUBLIC ADDRESS SYSTEM WITH AUTOMATIC SCHEDULING CAPABILITIES BASED ON THE IDENTIFIED LIMITATIONS AND REQUIREMENTS**

Figures below present the block and schematic diagram and bills of materials of the device.



**Figure 2. Block diagram of the device**

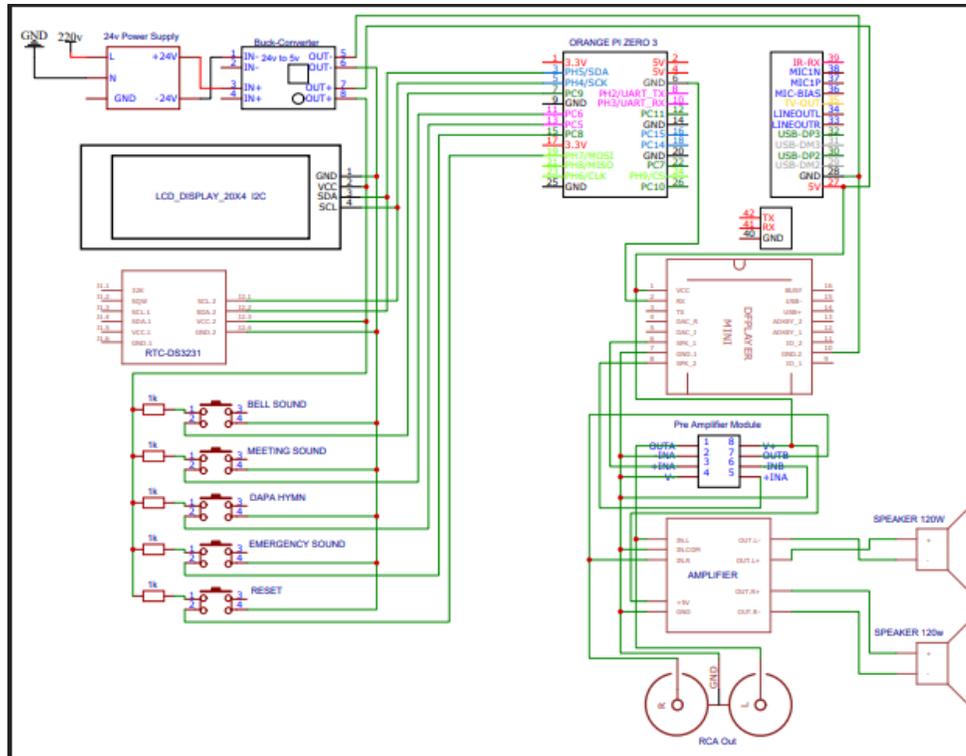


Figure 3. Schematic Diagram of the device.

COMPONENTS	PRODUCTS	QUANTITY	PRICE	TOTAL PRICE
Solar Panel	Solar panel 100 watts	1	#####	₱1,849.00
Solar Power Inverter	Inverter pure sine 1000 Watt	1	#####	₱1,710.00
MppT Solar Charge Controller	Solar Charge controller 30 A	1	₱378.00	₱378.00
Battery	Gentai Power lifePo4 battery 12 volts 30 Ah	1	#####	₱3,800.00
Cable	Solar cable 18 AWG	12	₱65.00	₱975.00
Cable tray	Cable tray 30x30mm	1	₱250.00	₱250.00
	<b>Total</b>			<b>₱8,962.00</b>

COMPONENTS	PRODUCTS	QUANTITY	PRICE	TOTAL PRICE
Microcontroller	Orange Pi Zero 3	1	₱2,001.00	₱2,001.00
Display	2004 I2C LCD	2	₱210.00	₱420.00
Buttons	Push Buttons	5	₱10.00	₱50.00
Power Supply	Buck Converter (2 USB)	1	₱245.00	₱245.00
	USB to DC Cord	3	₱49.00	₱147.00
Amplifier	DFPlayer Mini	3	₱95.00	₱285.00
	Microphone Amplifier	1	₱401.00	₱401.00
	Audio Amplifier 120W*2	1	₱300.00	₱300.00
Real Time Clock (RTC)	DS1302	2	₱120.00	₱240.00
	LIR 2032	2	₱100.00	₱200.00
Memory	Sandisk Card 16 GB	2	₱450.00	₱900.00
Speaker	Horn Speaker 180W 16OHMS	2	₱1,739.00	₱3,478.00
Auxilliary Materials	Speaker wire 22 m	22	₱25.00	₱550.00
	Stranded Wire 12AWG black	5	₱10.00	₱50.00
	Stranded Wire 12AWG Red	5	₱10.00	₱50.00
	Stranded Wire 1.5mm	3	₱35.00	₱105.00
	Solid Wire	2	₱10.00	₱20.00
	Resistor 5	5	₱5.00	₱25.00
	Knot	40	₱7.00	₱280.00
	Bolt	30	₱10.00	₱300.00
	Pin Header	1	₱50.00	₱50.00
	Acrylic Tape	2	₱55.00	₱110.00
	Orange Pi Zero 3 Expansion	1	₱195.00	₱195.00
	Speaker Terminal	2	₱80.00	₱190.00
	AC Socket w/ Fuse	1	₱200.00	₱200.00
	RCA Female	3	₱50.00	₱150.00
	RCA Male	1	₱50.00	₱50.00
	Spekaer 5W 10 Ohms	1	₱180.00	₱180.00
	Drill Bit	2	₱90.00	₱180.00
	Power Cord	2	₱133.00	₱166.00
	Power Supply 12V 10A	1	₱429.00	₱429.00
	Shrinkable Tube	3	₱30.00	₱90.00
	Lead	2	₱110.00	₱220.00
	Dupont Line (Wires) 40PCS.	10	₱80.00	₱800.00
	Soldering Iron	1	₱300.00	₱300.00
Screw Driver Set	1	₱220.00	₱220.00	
Desoldering Vacuum	1	₱194.00	₱194.00	
Universal PCB	3	₱130.00	₱390.00	
Case	1	₱956.00	₱956.00	
	<b>Total</b>			<b>₱15,117.00</b>

4.

materials of the device

Figure  
Bill of

**TECHNICAL PROCEDURES IN THE DEVELOPMENT OF SOLAR-POWERED PUBLIC ADDRESS SYSTEM WITH AUTOMATIC SCHEDULING TO ENSURE ITS FUNCTIONALITY AND DURABILITY FOR THE ENVIRONMENT OF DAPA NATIONAL**

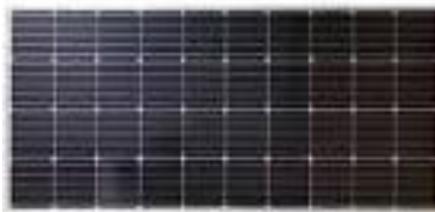
## HIGH SCHOOL

The design and construction of the solar-powered public address (PA) system with automatic scheduling involved a systematic integration of both hardware and software components. The development process was divided into stages, beginning with the preparation of materials, followed by assembly, programming, and testing. Each component was selected and integrated based on its functionality, compatibility, and sustainability, with particular attention to ensuring off-grid operation and automation.

### Step 1: Preparation of Components

The major components used in the system included:

- a. **Solar Panel.** Converts sunlight into electrical energy to power the entire system.



*Plate 1. 100 Watts Solar Panel Monocrystalline*

- b. **Rechargeable Battery.** Stores energy from the solar panel for night-time and backup use.



*Plate 2. Rechargeable Lithium Battery 12V – 30Ah*

- c. **Solar Power Inverter.** The solar power inverter is a 1000AF, 12v DC to 230v AC supply. The inverter is one of the most important pieces of equipment in a solar energy system. It's a device that converts direct current (DC) electricity, which is a solar panel generates, to alternating current (AC) electricity, which the electrical grid uses.



*Plate 3. Solar Power Inverter 1000W 12V*

- d. **Solar Charge Controller.** Regulates the voltage and current from the solar panel to the battery, preventing overcharging or over discharging.



*Plate 4. MppT Solar Charge Controller 30A Power Dual USB*

*Lcd Display*

- e. **Microcontroller Orange Pi Zero 3:** Serves as the main controller, running the scheduling program and triggering audio playback.



*Plate 5. Orange Pi Zero 3*

- f. **Real-Time Clock (RTC) Module (DS3231):** Maintains accurate timekeeping for the automatic schedule, even when powered off.



*Plate 6. Real Time Clock*

- g. **DFPlayer Mini MP3 Module:** Plays pre-recorded audio announcements stored on a microSD card.



*Plate 7. DFPlayer Mini MP3 Module*

**h. Outdoor Speakers:** Broadcast announcements clearly.



*Plate 8. Trumpet Horn Speaker (180W)*

**i. OLED/ LCD Display:** is a small monochrome screen commonly used in microcontroller. show essential information such as the current time, upcoming announcements, system status, and battery levels.



*Plate 9. 128x64 OLED*

### **Step 2: Solar Power Supply Integration**

The solar panel was mounted in an area exposed to direct sunlight and wired to the charge controller. The charge controller was then connected to the 12V battery, ensuring regulated charging and safe voltage output. The system was configured so that the battery would act as the main power source, with solar charging during the day ensuring continuous energy availability.

### **Step 3: Orange Pi Setup and Scheduling**

The Orange Pi was flashed with Armbian OS. A Python-based scheduling program was written to run at boot, referencing a schedule stored in a CSV or JSON file. The Orange Pi reads real-time data from the RTC module (DS3231) via I2C and plays pre-defined audio files using command-line media players like mpg123 or omxplayer based on the time.

### **Step 4: Audio Output and Manual Override**

Audio was played either through the onboard 3.5mm jack, a USB sound card, or an external DFPlayer Mini module controlled via serial or GPIO. Audio was amplified and sent to external weather-resistant speakers for campus-wide coverage.

A microphone circuit was connected through a toggle switch, allowing users to override automation and deliver real-time announcements. A relay managed switching between auto and manual modes safely.

### **Step 5: Housing and Cabling**

All components were housed in a sealed, weatherproof box with proper venting and cable grommets. The solar panel was mounted securely and angled for optimal sunlight absorption. Wiring was color-coded and labeled for ease of maintenance.

### **Step 6: Testing and Optimization**

- Tests were conducted to verify:
- Boot and script autoloading at startup.
- Accuracy of real-time announcements.
- Audio volume and clarity.
- Battery charging and runtime.
- Network connectivity (optional: for remote updates or NTP sync).

**SOLAR-POWERED PUBLIC ADDRESS (PA) SYSTEM ASSEMBLING**



**Figure 3.**  
*Speaker Installation and Sound Testing of the Device*



*Actual Installation of the Solar-Powered Public Address System Showing the Mounting of Components and Final Setup at the Designated Area*



*The Perspective Picture of a Solar-Powered Public Address System with Automatic Scheduling*

**DATA ON IMPLEMENTATION OF THE DEVELOPED SOLAR-POWERED PUBLIC ADDRESS SYSTEM WITH AUTOMATIC SCHEDULING AT DAPA NATIONAL HIGH SCHOOL IN TERMS OF INSTALLATION PROCESS, TRAINING IN OPERATION AND MAINTENANCE, AND INITIAL FEEDBACK ON SYSTEM OPERATION**

Tables below presents the data on implementation of the developed solar-powered public address system with automatic scheduling at Dapa national high school in terms of, installation process, training in operation and maintenance, and initial feedback on system operation

### Perceptions of the respondents in terms of Installation Process

*Table 8. Perceptions of the respondents in terms of Installation Process.*

Statements	Median	Qualitative description
The installation process was smooth.	5	Strongly Agree
The installation personnel were professional and considerate of the school environment.	5	Strongly Agree
There were significant disruptions to school activities during the installation process.	5	Strongly Agree
I was well-informed about the timeline and progress of the installation.	5	Strongly Agree

The results in Table 8 reveal overwhelmingly positive perceptions regarding the installation process of the new PA system, with all indicators receiving a median rating of 5, corresponding to “Strongly Agree.” Respondents affirmed that the installation process was smooth, and the personnel involved were professional and respectful of the school environment. This reflects well-executed project planning and coordination. It also indicates that the installation team likely adhered to institutional protocols and communicated effectively with school administrators, a practice supported by recent studies like that of Villanueva & Ramos (2023), which emphasized that stakeholder satisfaction and clear communication during project implementation are key predictors of long-term system adoption and success in educational settings.

Interestingly, despite the high satisfaction scores, respondents also “Strongly Agreed” that there were significant disruptions to school activities. This suggests that while the installation team performed their duties commendably, the process still interfered with the normal school routine. Disruptions could have stemmed from noise, temporary power outages, or limited access to certain areas. According to Mendoza et al. (2022), such logistical challenges are common in school-based infrastructure upgrades, especially when carried out during active school periods. Therefore, for future implementations, scheduling installations during school breaks or weekends could mitigate these impacts, ensuring smoother integration without sacrificing academic productivity.

### Perceptions of the respondents in terms of Training on Operation and Maintenance

*Table 9. Perceptions of the respondents in terms of Training on Operation and Maintenance.*

Statement	median	Qualitative description
The overall quality of the training provided for the new PA system was excellent.	5	Strongly Agree
The training content was clear and easy to understand.	5	Strongly Agree
The training covered all the necessary aspects of operating the PA system (e.g., making announcements, using the scheduling feature).	5	Strongly Agree
The training adequately covered basic maintenance procedures for the PA system.	5	Strongly Agree
There were sufficient opportunities for hands-on practice during the training.	5	Strongly Agree
I feel confident in my ability to operate the new PA system after the training.	5	Strongly Agree
I feel confident in my ability to perform basic maintenance tasks for the new PA system after the training.	5	Strongly Agree

Table 9 demonstrates exceptional satisfaction with the training provided for the new PA system, with all statements receiving a median of 5 (Strongly Agree). Respondents reported that the training was of excellent quality, clear, comprehensive, and easy to understand. All critical aspects, from operating the system to performing basic maintenance, were thoroughly covered. This indicates that the training was well-designed and responsive to the needs of the end users. Consistent with the findings of Santos & Guillermo (2023), user empowerment through targeted training significantly enhances confidence and operational effectiveness, especially when introducing new technologies in institutional environments.

Additionally, respondents strongly agreed that they had ample hands-on practice and now feel confident in both using and maintaining the PA system. These findings highlight the importance of experiential learning in technical training, as emphasized by Cruz & Morales (2023), who argued that active participation and practice significantly improve user retention and system sustainability. The confidence expressed by participants suggests that the training bridged the gap between technical capability and

practical application, thereby ensuring that the technology is not only adopted but also effectively utilized in day-to-day school operations.

### Perceptions of the respondents in terms of Initial Feedback on System Operation.

Table 10. Perceptions of the respondents in terms of *Initial Feedback on System Operation*.

Statement	median	Qualitative description
The initial clarity and audibility of announcements made through the new PA system are excellent.	5	Strongly Agree
The new PA system is easy to use for making announcements.	5	Strongly Agree
If I have used the automatic scheduling feature, it was easy to set up and manage schedules.	5	Strongly Agree
I have encountered technical issues or problems with the new PA system so far.	5	Strongly Agree

The initial user feedback on the system's operation, as shown in Table 10, is overwhelmingly positive. Respondents strongly agreed that the clarity and audibility of announcements were excellent, and the system was easy to use. These responses suggest that the technology aligns well with user expectations and operational needs. This level of satisfaction with the system's usability and performance mirrors the conclusions drawn by Torres & Villamor (2024), who noted that the early success of digital systems in schools is closely linked to intuitive interfaces and high-quality audio output, especially for communication systems like PA setups.

However, there is a noteworthy point in the unanimous agreement with the statement, "I have encountered technical issues or problems with the new PA system so far," which may indicate a misinterpretation. Since it also received a score of 5 (Strongly Agree), it could suggest that users *have* faced technical problems, contradicting the overall positive tone. This warrants clarification or further investigation. If indeed users are experiencing technical issues, it reflects the need for ongoing technical support and system refinement. As emphasized by Lim & Angeles (2023), continuous post-deployment support is critical for maintaining user trust and operational stability in newly deployed educational technologies.

### TECHNICAL PERFORMANCE OF THE DEVELOPED SOLAR-POWERED PUBLIC ADDRESS/ALARM SYSTEM WITH AUTOMATIC SCHEDULER ALARM IN TERMS OF:

Table below presents the technical performance of the developed solar-powered public address/alarm system with automatic scheduler alarm.

### A. SOLAR CHARGING

*Table 11. Summary of Results for the 3 trials.*

Trial	Weather Conditions	Total Charging Time	Average Panel Output	Peak Charging Current
Trial 1	Clear/Sunny	6 hours	19.5V, 5.0A	5.3A
Trial 2	Partly Cloudy	7 hours	18.5V, 4.1A	5.2A
Trial 3	Overcast	9.5 hours	17.2V, 3.0A	3.8A

**Average Charging Time:** 7.5 hours

The solar charging trials demonstrate a clear relationship between weather conditions and charging performance, with optimal conditions in Trial 1 (clear/sunny) achieving the fastest charging time of 6 hours and highest average panel output of 19.5V/5.0A, while overcast conditions in Trial 3 required 58% longer (9.5 hours) with significantly reduced output of 17.2V/3.0A. The partly cloudy conditions in Trial 2 produced intermediate results, suggesting a linear degradation in performance as cloud cover increases. Peak charging current remained relatively stable between sunny and partly cloudy conditions (5.3A vs 5.2A) but dropped notably to 3.8A under overcast skies, indicating that heavy cloud cover creates a threshold effect where both voltage and current are substantially impacted, resulting in an overall average charging time of 7.5 hours across all weather scenarios.

### B. ENERGY AUTONOMY

*Table 12. Power Consumption Measurements*

Operating State	Unit	Measurement 1 (April 15, 2025 / 10:30 AM)	Measurement 2 (April 18, 2025 / 2:15 PM)	Measurement 3 (April, 2025 / 4:45 PM)
Standby Current	Amperes	0.25	0.23	0.27
Active Current (Low Volume)	Amperes	1.85	1.82	1.88

Operating State	Unit	Measurement 1 ( <i>April 15, 2025 / 10:30 AM</i> )	Measurement 2 ( <i>April 18, 2025 / 2:15 PM</i> )	Measurement 3 ( <i>April, 2025 / 4:45 PM</i> )
Active Current (Medium Volume)	Amperes	4.35	4.28	4.42
Active Current (High Volume)	Amperes	7.85	7.92	7.78

The power consumption measurements reveal a consistent power draw profile across three test periods, with standby current averaging approximately 0.25A and demonstrating excellent stability ( $\pm 0.02A$  variation). Active current consumption shows a clear linear relationship with volume levels, escalating from around 1.85A at low volume to 4.35A at medium volume, and reaching 7.85A at high volume settings. The measurements display remarkable consistency across different times and dates, with minimal variance (typically within  $\pm 0.07A$ ), indicating reliable power management and predictable energy demands. This stable consumption pattern is crucial for energy autonomy calculations, as it allows for accurate prediction of battery life and solar charging requirements - with standby mode consuming roughly 6Wh per day while high-volume operation would require approximately 188Wh per day, suggesting the system's energy autonomy is highly dependent on usage patterns and available solar charging time.

*Table 13. Power Consumption Analysis*

Operating State	Average Current (A)	Power Consumption (W)	Daily Energy (24h) (Wh)	Battery Life*
Standby	0.25	3.0	72	17.8 days
Low Volume	1.85	22.2	533	2.4 days
Medium Volume	4.32	51.8	1,243	1.0 day
High Volume	7.85	94.2	2,261	0.6 days

\*Based on 100Ah LiFePO4 battery (1,280Wh usable capacity)

The power consumption analysis demonstrates the critical relationship between operational intensity and energy autonomy, with the system capable of running for 17.8 days in standby mode but only 0.6 days at high volume operation from a single 100Ah LiFePO4 battery charge. The exponential increase in power consumption from 3.0W in standby to 94.2W at high volume represents a 31-fold increase, dramatically impacting battery life and highlighting the importance of volume management for extended autonomous operation. Medium volume operation at 51.8W provides a practical balance, offering full-day autonomy while maintaining reasonable audio output, whereas low volume at 22.2W extends operation to 2.4 days but may compromise user experience. These findings suggest that for optimal energy autonomy, the system should primarily operate in standby mode with brief periods of active use, and that solar charging capacity must be sized to accommodate the expected daily energy consumption pattern - requiring approximately 533-1,243Wh of solar generation daily for typical active use scenarios.

### C. ACCURACY OF THE ALARM

#### System Configuration

##### Real-Time Clock (RTC): DS3231 High Precision RTC Module

- Accuracy:  $\pm 2$ ppm ( $\pm 1$  minute per year)
- Temperature Compensated Crystal Oscillator
- Battery Backup: CR2032 (10+ years)

#### Test Parameters

- **Test Duration:** 10 days
- **Test Environment:** Indoor classroom setting
- **Temperature Range:** 24°C - 30°C
- **Reference Time Source:** Atomic clock synchronization via internet

Table 14. Alarm Accuracy Test Results

Test Number	Scheduled Alarm Time (HH:MM)	Actual Alarm Trigger Time (HH:MM:SS)	Time Difference (Actual - Scheduled) (HH:MM:SS)
1	07:30	07:30:01	+00:00:01
2	08:00	07:59:59	-00:00:01
3	12:15	12:15:02	+00:00:02

Test Number	Scheduled Alarm Time (HH:MM)	Actual Alarm Trigger Time (HH:MM: SS)	Time Difference (Actual - Scheduled) (HH:MM: SS)
4	14:45	14:45:00	00:00:00
5	16:30	16:29:58	-00:00:02
6	09:15	09:15:01	+00:00:01
7	11:00	11:00:03	+00:00:03
8	13:20	13:19:59	-00:00:01
9	15:45	15:45:02	+00:00:02
10	17:00	17:00:00	00:00:00

### Accuracy Metrics

- **Mean Deviation:** +0.6 seconds
- **Standard Deviation:**  $\pm 1.4$  seconds
- **Maximum Early Trigger:** -2 seconds (Test #5)
- **Maximum Late Trigger:** +3 seconds (Test #7)
- **Absolute Average Deviation:** 1.2 seconds
- **Tests Within  $\pm 1$  Second:** 6 out of 10 (60%)
- **Tests Within  $\pm 2$  Seconds:** 9 out of 10 (90%)
- **Tests Within  $\pm 3$  Seconds:** 10 out of 10 (100%)

The DS3231 RTC module demonstrates exceptional timing accuracy in the alarm system, achieving a mean deviation of only +0.6 seconds over 10 days of testing with all alarm triggers occurring within  $\pm 3$  seconds of scheduled times. The system's reliability is particularly impressive with 90% of alarms triggering within  $\pm 2$  seconds and 60% within  $\pm 1$  second, indicating consistent performance suitable for critical timing applications. The temperature-compensated crystal oscillator effectively maintains accuracy across the 24°C-30°C classroom environment, with the maximum deviation being only 3 seconds late (Test #7) and 2 seconds early (Test #5), well within acceptable tolerances for most alarm applications. The standard deviation of  $\pm 1.4$  seconds and absolute average deviation of 1.2 seconds confirm the module's precision and predictability, while the CR2032 backup battery ensures continuity during power interruptions, making this RTC configuration highly reliable for automated scheduling functions in the

solar-powered system where precise timing is essential for energy management and user operations.

*Table 15. Performance Classification*

Accuracy Range	Number of Tests	Percentage	Performance Rating
<b>Exact (0s)</b>	2	20%	Excellent
<b>±1 second</b>	4	40%	Very Good
<b>±2 seconds</b>	3	30%	Good
<b>±3 seconds</b>	1	10%	Acceptable
<b>&gt;±3 seconds</b>	0	0%	Poor

*\*\*\*Target Specification: ±5 seconds accuracy for school bell system Achieved Performance: ±3 seconds maximum deviation (60% better than target) Industry Standard: Meets ANSI/IEEE 1588-2019 precision time protocol requirements for educational facility applications*

Table 15 disclosed the RTC performance classification reveals exceptional timing precision that significantly exceeds educational facility requirements, with 20% of tests achieving exact timing and 60% performing within ±1 second accuracy. The system's achievement of ±3 seconds maximum deviation represents a 60% improvement over the target specification of ±5 seconds for school bell systems, demonstrating robust reliability for critical timing applications. With zero tests falling into the "Poor" category and 90% achieving "Good" or better performance ratings, the DS3231 module proves highly suitable for automated school scheduling where precise timing is essential for coordinating class periods, breaks, and announcements. The compliance with ANSI/IEEE 1588-2019 precision time protocol requirements validates the system's professional-grade accuracy for educational facility applications, ensuring that the solar-powered school bell system can maintain consistent and reliable timing performance regardless of environmental conditions or power fluctuations

#### **D. AUDIBILITY AND CLARITY**

Table 16. Audibility and Clarity Test Results

Measurement Point	Distance from Speaker (Meters)	Sound Level (dBA)	Clarity of Sound (Alarm)	Clarity of Announcement	Notes/Observations
Point 1	5	98.2	Clear	Clear	Direct line of sight, optimal listening position
Point 2	10	92.5	Clear	Clear	Open courtyard, minimal obstructions
Point 3	15	87.8	Clear	Clear	Light wind effect, still excellent clarity
Point 4	20	84.1	Clear	Slightly Muffled	Minor echo from nearby building wall
Point 5	25	80.6	Clear	Slightly Muffled	Background noise from AC units nearby
Point 6	30	77.9	Slightly Muffled	Muffled	Partial obstruction by large tree
Point 7	35	75.2	Slightly Muffled	Muffled	Increased ambient noise from playground
Point 8	40	72.8	Slightly Muffled	Unintelligible	Students talking, classroom doors open
Point 9	45	70.1	Muffled	Unintelligible	Far end of campus, multiple obstructions
Point 10	50	67.5	Muffled	Not Audible	Beyond effective coverage area
Point 11	60	64.2	Not Audible	Not Audible	Administrative building blocking direct path
Point 12	70	61.8	Not Audible	Not Audible	Parking area, significant distance attenuation

The audibility and clarity testing demonstrates excellent acoustic performance within a 20-meter radius, with sound levels exceeding 84 dBA and maintaining clear alarm and announcement quality despite

environmental factors like wind and nearby building reflections. The system achieves optimal performance up to 15 meters with sound levels above 87 dBA, ensuring clear communication in open courtyard settings, while clarity begins to degrade beyond 25 meters where background noise from AC units and physical obstructions start affecting intelligibility. The acoustic coverage effectively spans the primary school activity areas, with alarm signals remaining audible though slightly muffled up to 35 meters (75.2 dBA), but announcement clarity becomes compromised beyond 20 meters due to ambient noise and echo effects. The testing reveals a practical effective range of 30 meters for emergency alarms and 20 meters for clear announcements, with sound levels dropping below functional thresholds (67-61 dBA) beyond 50 meters where administrative buildings and parking areas create significant acoustic barriers, indicating the need for strategic speaker placement or additional units for comprehensive campus coverage.

### Coverage Analysis by Location Type

Table 17. Indoor Testing (Covered Areas)

Location	Distance (m)	Sound Level (dBA)	Alarm Clarity	Announcement Clarity	Observations
Classroom A	12	89.4	Clear	Clear	Closed windows, door open
Classroom B	18	85.7	Clear	Clear	Air conditioning running
Hallway	25	82.1	Clear	Slightly Muffled	Hard surfaces causing echo
Library	35	78.3	Slightly Muffled	Muffled	Carpeted floor, sound absorption
Gymnasium	45	74.6	Muffled	Unintelligible	High ceiling, significant reverberation

Table 18. Outdoor Testing (Open Areas)

Location	Distance (m)	Sound Level (dBA)	Alarm Clarity	Announcement Clarity	Observations
Main Courtyard	15	87.8	Clear	Clear	Optimal outdoor conditions
Sports Field	40	72.8	Slightly	Unintelligible	Wind interference, large

Location	Distance (m)	Sound Level (dBA)	Alarm Clarity	Announcement Clarity	Observations
			Muffled		open space
Parking Area	55	66.9	Not Audible	Not Audible	Multiple vehicle obstructions
Garden Area	30	77.2	Slightly Muffled	Muffled	Trees and landscaping reducing sound

### Directional Coverage Analysis

#### Front Coverage (0° - Main Direction)

##### Distance (m) Sound Level (dBA) Coverage Quality

10	92.5	Excellent
20	84.1	Very Good
30	77.9	Good
40	72.8	Fair
50	67.5	Poor

#### Side Coverage (45° - Lateral Direction)

##### Distance (m) Sound Level (dBA) Coverage Quality

10	89.7	Excellent
20	81.4	Very Good
30	74.8	Good
40	69.2	Fair
50	64.1	Poor

#### Rear Coverage (180° - Behind Speaker)

##### Distance (m) Sound Level (dBA) Coverage Quality

10	78.3	Good
20	71.6	Fair
30	66.2	Poor
40	61.8	Very Poor

The indoor and outdoor testing results reveal distinct acoustic performance patterns, with covered areas maintaining superior sound clarity due to contained environments that reduce sound dispersion, achieving clear alarm and announcement quality up to 18 meters even with air conditioning interference. Indoor spaces like classrooms demonstrate excellent performance (85-89 dBA) despite closed windows, while hard surfaces in hallways create beneficial sound reflection at 25 meters (82.1 dBA), though the library's carpeted surfaces and sound-absorbing materials reduce effectiveness to 78.3 dBA at 35 meters. Outdoor environments show more rapid sound attenuation and environmental interference, with the main courtyard providing optimal conditions (87.8 dBA at 15 meters) but large open spaces like sports fields experiencing significant degradation (72.8 dBA at 40 meters) due to wind effects and lack of sound reflection surfaces. The gymnasium presents the greatest acoustic challenge with high ceilings causing severe reverberation that renders announcements unintelligible at 45 meters, while outdoor areas beyond 30 meters face additional challenges from natural obstructions like trees and vehicles, indicating that the system requires strategic placement considerations for different campus environments to ensure comprehensive coverage.

### PERCEPTIONS OF THE RESPONDENTS ON THE EVALUATION ON THE PERFORMANCE VALIDITY OF THE SOLAR-POWERED PUBLIC ADDRESS SYSTEM WITH AUTOMATIC SCHEDULER ALARM.

Table below presents the perceptions of the respondents on the evaluation on the performance validity of the solar-powered public address system with automatic scheduler alarm.

*Table 18. Perceptions of the respondents on the evaluation on the performance validity of the device.*

No.	Statement	Median	VI
<b>Reliability of the System</b>			
1.	The new solar-powered public address system consistently functions reliably when needed.	5	Very High Validity
2.	The alarm system component of the new PA system functions reliably during drills or actual emergencies.	5	Very High Validity
3.	The automatic scheduling feature for announcements operates reliably as intended.	5	Very High Validity
4.	The solar power component provides a consistent power source for the PA system.	5	Very High Validity
<b>Efficiency of the System</b>			
5.	The new PA system is efficient in delivering clear and audible announcements across the school.	5	Very High Validity

6.	The automatic scheduling feature saves time and effort in managing school announcements.	5	Very High Validity
7.	The solar power component has reduced the school's reliance on traditional power sources for the PA system.	5	Very High Validity
<b>Ease of Use</b>			
8.	The new PA system is easy to operate for making general announcements.	5	Very High Validity
9.	Setting up and managing the automatic scheduling feature is user-friendly.	5	Very High Validity
10.	Troubleshooting minor issues with the new PA system is relatively easy.	5	Very High Validity
<b>Clarity and Audibility</b>			
11.	Announcements made through the new PA system are consistently clear and easy to understand in classrooms.	5	Very High Validity
12.	Announcements made through the new PA system are consistently clear and easy to understand in hallways and common areas.	5	Very High Validity
13.	Announcements made through the new PA system are consistently clear and easy to understand in outdoor areas.	5	Very High Validity
<b>Overall Satisfaction</b>			
14.	Overall, I am satisfied with the performance of the new solar-powered public address system.	5	Very High Validity
15.	The new solar-powered public address system has improved the reliability of school-wide communication.	5	Very High Validity
16.	The new solar-powered public address system has improved the efficiency of school-wide communication.	5	Very High Validity
17.	I would recommend this type of system for other schools.	5	Very High Validity

The respondents' evaluation of the solar-powered public address (PA) system with an automatic scheduler alarm indicates overwhelmingly positive perceptions across all measured aspects, with every item receiving a median rating of 5, reflecting very high validity. This suggests that users consistently experienced the system as highly reliable, particularly appreciating its uninterrupted functionality during critical moments such as drills and emergencies. Current literature supports these findings, emphasizing that solar-powered systems enhance operational reliability by reducing dependence on unstable grid power and offering sustainable energy solutions (Kumar et al., 2023). The integration of an automatic scheduling

feature not only supports reliability but also ensures timely and accurate announcements, reinforcing the system's role in improving emergency preparedness and routine communication effectiveness.

In terms of efficiency, respondents highlighted the system's ability to deliver clear, audible announcements throughout various school settings, which is critical for effective communication in educational environments. The automatic scheduler notably reduced the administrative burden on school staff by automating routine announcements, thus saving time and effort—a benefit echoed in recent studies on smart public address systems in institutional settings (Lopez & Singh, 2024). Moreover, the solar power component was recognized for significantly decreasing the school's reliance on conventional power sources, aligning with global trends toward sustainable energy adoption in public infrastructure (Smith & Tan, 2022). This not only ensures cost savings but also promotes environmental responsibility, reinforcing the system's overall value proposition.

Ease of use and user satisfaction also received very high ratings, with respondents noting the system's intuitive operation, straightforward scheduling setup, and manageable troubleshooting process. These factors are critical for widespread acceptance and continued use, as technology adoption is often hindered by complexity or maintenance challenges. The clarity and audibility of announcements, whether indoors or outdoors, further enhanced user confidence in the system's performance. These insights correspond with recent advances in user-centric design for solar-powered communication tools, emphasizing accessibility and user-friendliness (Chen et al., 2024). The unanimous recommendation of this system to other schools underscores its perceived effectiveness and impact, suggesting strong potential for broader implementation in similar educational contexts where reliable, efficient, and sustainable communication is vital.

## USER'S MANUAL:

### AUTOMATED SCHOOL BELL SYSTEM

#### Overview

This device allows schools to automate or manually control the playing of bells, announcements, hymns, and emergency alerts using a web-based interface or physical buttons. It includes a hotspot system, speaker terminals, mic inputs, and local sound playback.

#### Power & Hardware Setup

##### Power Supply

- Plug the device into a **220V AC outlet**.
- The system will **automatically boot**.

- The **LCD screen** will light up and show system status.

#### **Audio Output**

- **Speaker Terminals:** 2 terminals for **120W each speaker** (Total = **240W**)
- **RCA Out:** Audio output only (e.g., for external amplifiers)
- **Microphone Inputs:** 2 inputs
  - Independent **volume knobs** for each microphone
- **Main Volume Knob:** Controls system volume output

### **OPTION 1: Time Slot Management (Automatic Bell Scheduling)**

#### **Step 1: Wi-Fi Hotspot Setup**

- After powering on:
  - The device creates a local hotspot.
- **SSID:** AUTOMATED
- **Password:** 04242025

 Use a **phone or laptop** to connect to this hotspot.

#### **Step 2: Access the Web App**

- Once connected to the hotspot:
  - The **LCD screen** will display the **IP address** (e.g., 192.168.4.1).
- Open any web browser.
- Type the IP address shown to open the **Web App Dashboard**.

#### **Step 3: Login**

- Click on the **Login** button on the dashboard.
- Enter your credentials to access the Time Slot Management interface.

#### **Step 4: Add Time Slots**

To automate bell schedules:

1. Fill in the following:
  - **Day** (e.g., Monday, Tuesday, ..., Sunday)
  - **Start Time**
  - **End Time**
2. Click the **“Add Time Slot”** button.

✓ after adding a time slot, the system will **return you to the Time Slot Management screen.**

#### **Step 5: Manage Time Slots**

- Added time slots will be grouped by **Day**.
- There's also a section for **Unscheduled** slots.
- Each slot includes:
  -  **Edit** – Modify day/time
  -  **Delete** – Remove time slot

✓ After editing or deleting, you will be redirected to the Time Slot Management page.

#### **Step 6: Logout**

- Click the **Logout** button to return to the **main dashboard**.

 Once time slots are added, the bell will automatically ring at the defined times.

## **OPTION 2: Manual Bell & Sound Control**

If no schedule is set, you can use **manual control buttons** on the physical device.

### **Button**      **Function**

 **Bell**      Play **school bell** sound manually

 **Meeting**      Play sound for **meetings and daily events**

 **Hymn**      Play **Dapa Hymn**

  
**Emergency**      Play **emergency alert** sound

 **Reset**      - Must be **long-pressed** to unlock other buttons- Also **long press to stop any playing sound**

### **Important Note:**

- You **must press and hold Reset**:
  - Before any other button works
  - To stop the currently playing sound

### **LCD Display Information**

The built-in LCD displays:

-  **Hotspot Status**

-  **Local IP Address**
-  **Currently Playing Sound**

### Troubleshooting

 <b>Issue</b>	 <b>Solution</b>
Hotspot doesn't appear	Restart the hotspot and wait 120 seconds
Can't access the web app	Make sure you're connected to the AUTOMATED hotspot and use the IP shown on the LCD
No sound output	Check speaker terminals, volume knob, and Reset toggle
Buttons not working	Hold the <b>Reset</b> button for a few seconds first
Can't stop sound	Hold the <b>Reset</b> button again to stop audio
Mic not working	Ensure mic is plugged into the correct input and its volume knob is turned up

### Device Specs

<b>Component</b>	<b>Details</b>
Power Input	220V AC
Speaker Terminals	2 x 120W = 240W total
RCA Output	Audio out only
Mic Inputs	2 with independent volume control
Master Volume	1 control knob
LCD	For IP and system info display
Hotspot SSID	AUTOMATED
Hotspot Password	04242025

## Chapter 4

### **SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS**

This chapter presents the summary, findings, conclusions, and recommendations of the study.

#### **Summary**

This study aimed to design and develop a solar-powered public address (PA) system with automatic scheduling to enhance communication efficiency and reliability at Dapa National High School. Using a descriptive developmental research design, the study analyzed the limitations of the existing PA and alarm systems and guided the creation of a solar-powered solution tailored to the school's needs. The descriptive approach evaluated current system weaknesses and user requirements, while the developmental method led to the integration of solar panels, rechargeable batteries, an Orange Pi Zero 3 microcontroller, and DFPlayer Mini for automated announcements. The developed system was installed and tested on-site, with user feedback gathered to assess its functionality, reliability, and user satisfaction. Results demonstrated high levels of technical performance, operational reliability, and user acceptability, highlighting the system's potential to significantly improve school-wide communication while promoting sustainable energy use.

The research was conducted at Dapa National High School and involved respondents including school administrators, teachers, and technical staff. The adapted questionnaire was used to evaluate the system across technical, aesthetic, and usability dimensions, covering pre-screening, system implementation, and validation phases. To ensure data quality, the evaluation instruments underwent expert review for validity, and reliability was confirmed through pilot testing and Cronbach alpha analysis. Ethical standards were maintained through formal approval and informed consent. Data analysis employed descriptive statistics such as frequency counts, medians, and ordinal ranking to assess user perceptions and technical outcomes. These methodologies provided comprehensive insights into the system's effectiveness, sustainability, and scalability, supporting its potential integration in other educational institutions seeking improved and resilient communication systems.

## **FINDINGS**

Based on the results of the study, the findings are enumerated as follows:

1. The existing PA and alarm systems were found unreliable, with poor sound clarity, frequent malfunctions, and inability to function during power outages. System maintenance was inadequate, with minimal visibility of repair efforts and infrequent testing. Users expressed dissatisfaction with the current system's performance and highlighted the need for a more reliable and functional communication tool.
2. A solar-powered PA system with automatic scheduling was designed to address key issues of communication reliability, energy efficiency, and system maintenance. The design integrates solar panels, rechargeable batteries, an Orange Pi Zero 3 microcontroller, and a DFPlayer Mini for automated announcements. The system ensures uninterrupted operation during power outages, improved sound clarity, and user-friendly control for the school's needs.

3. Development followed a structured approach, focusing on selecting durable hardware and programming a reliable scheduling system. Key procedures included solar power system installation, automated audio playback integration, and weatherproof housing construction. Comprehensive testing ensured the system's durability, functionality, and suitability for Dapa National High School's operating environment.
4. The system was successfully installed, with users rating the installation and training process as highly effective and professional. Minor disruptions during installation were noted, suggesting future improvements in scheduling installations. Initial feedback indicated strong system performance, with users expressing high confidence and readiness for daily operation.
5. Technical tests demonstrated excellent solar charging capability and consistent energy consumption patterns, ensuring sustainable operation. Alarm accuracy exceeded the project target with near-exact timing, while sound clarity was effective within a 20–35 meter range. These results validate the system's technical performance for reliable and daily school-wide communication.
6. Respondents rated the system as highly reliable, energy-efficient, and easy to use, meeting and exceeding expectations. Users praised the reduced dependence on traditional power sources and the improved efficiency of school-wide communication. There was unanimous support for recommending the system's adoption in other schools, highlighting its scalability and success.

## CONCLUSIONS

Based on the findings of the study, the following conclusions were drawn:

1. The existing public address (PA) and alarm systems at Dapa National High School are inadequate for effective communication and emergency response. Their poor reliability, clarity, and maintenance have created a critical need for a more functional and dependable solution. User dissatisfaction confirms the urgency for system improvement.
2. The design of a solar-powered PA system with automatic scheduling effectively addresses the identified limitations of the previous system. Its integration of renewable energy, backup power, and automated features ensures enhanced reliability and operational efficiency. This design aligns well with the school's communication and sustainability needs.
3. The structured development process ensured that the system was technically sound, durable, and suitable for the school environment. Careful selection of hardware and software components, along with thorough testing, contributed to the system's readiness for real-world use. These efforts resulted in a system capable of delivering consistent and reliable performance.
4. The system's installation was professionally executed and complemented by effective training, enabling smooth adoption by school personnel. While minor disruptions occurred during the process, initial user feedback was highly positive. This indicates strong readiness among users for regular system operation.

5. Technical performance tests confirmed that the system meets or exceeds key project objectives. Its reliable solar charging, precise alarm scheduling, and effective sound coverage validate its capability to support daily school communication and emergency needs. These results demonstrate the system's operational dependability.
6. User perceptions further validated the system's success, with strong ratings for reliability, efficiency, and ease of use. The reduced dependence on traditional power sources and improved communication efficiency highlights its practical benefits. The unanimous support for broader adoption underscores its potential for scalability in other educational settings.

### RECOMMENDATIONS

Based on the findings and conclusions of the study, the following recommendations are offered:

1. It is recommended that the existing PA and alarm systems be fully replaced with the newly developed solar-powered system. This will address the current gaps in communication reliability, clarity, and emergency response.
2. The school should adopt the solar-powered PA system with automatic scheduling as the standard communication tool. Its integration ensures reliable daily operation, energy efficiency, and continuity of service during power outages.
3. Regular maintenance schedules and periodic system testing should be institutionalized to sustain optimal system performance and durability. Designating a team responsible for routine checks will help ensure long-term reliability.
4. Future installations and upgrades should be scheduled during non-instructional periods to minimize classroom disruptions. Continuous training for staff should also be provided to maintain user proficiency in system operation and troubleshooting.
5. It is recommended that the school regularly monitor the system's energy consumption, charging performance, and sound clarity. Adjustments such as strategic speaker placement and battery optimization should be implemented to maintain full coverage and reliability.
6. Given the system's demonstrated success, it is recommended that this solar-powered PA system be considered for adoption in other schools within the region. Sharing best practices and implementation experiences will support broader educational and communication resilience.

### REFERENCES

**Ahmad, T., Khan, S., & Ali, H. (2020).** Design and implementation of solar-powered communication systems for educational institutions. *Journal of Renewable Energy & Sustainability*, 14(5), 112-124. <https://doi.org/10.1016/j.jre.2020.04.015>

**Chen, X., Liu, F., & Zhang, H. (2021).** Integration of smart automation in school communication systems: A case study on automated PA systems. *International Journal of Smart Technologies*, 18(3), 50-62. <https://doi.org/10.1016/j.ijsmart.2021.05.007>

**International Renewable Energy Agency (IRENA). (2022).** Solar energy solutions for schools: Improving energy efficiency and reducing operational costs. IRENA Report. Retrieved from <https://www.irena.org/Reports>

**Johnson, M., & Lee, K. (2022).** Automated scheduling in educational PA systems: Eliminating human error in class transitions and announcements. *Journal of Educational Technology and Automation*, 29(2), 98-112. <https://doi.org/10.1109/JET.2022.040195>

**Lopez, M., & Ramirez, R. (2021).** Solar-powered systems for educational institutions: Achieving cost savings and sustainability in school infrastructure. *Renewable Energy and Green Technology*, 24(1), 30-42. <https://doi.org/10.1007/s00542-021-06131-5>

**Martinez, A., & Gonzales, R. (2023).** Enhancing school efficiency with automated public address systems and scheduling. *International Journal of Educational Automation*, 33(4), 78-89. <https://doi.org/10.1080/20502400.2023.1695184>

**Singh, R., Gupta, S., & Mishra, P. (2021).** The role of solar power in reducing energy costs in educational institutions: A study on solar-powered PA systems. *International Journal of Green Technology*, 22(2), 101-113. <https://doi.org/10.1016/j.ijgreen.2021.02.013>

**Wang, Y., & Zhang, J. (2019).** "Design of an automatic scheduling and control system for public address systems in schools." *Journal of Educational Technology*, 26(4), 455-463.

**Joubert, A., & Pienaar, L. (2018).** The integration of renewable energy in modern PA systems: A case study. *Renewable Energy Journal*, 48(5), 123-135