SMART SOLAR CBT EXAMINATION MONITORING SYSTEM

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CERTIFICATION

This is certify that this project Smart Solar CBT Examination Monitoring System was successfully carried out by **Saheed Abdul Quadri Kayode** with matriculation number **ND/23/COM/PT/0001** as part of the requirements for the award of the National Diploma (ND) Computer Science, Institute of Information and Communication Technology.

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DEDICATION

This project is dedicated to Almighty God the beginning and the end of all creation.

I also dedicated this to my parent, **MR. / MRS. SAHEED,** and my uncle a person of **Mr. Yusuf Olatunji** and my own soul personally for much endurance and concentration, and to my loving ones who encourage me all the way and whose encouragement has made sure that I give it all it takes to finish that which I have started.

May the blessing of God be with them now and always. (Amin)

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Abstract

The increasing reliance on Computer-Based Testing (CBT) in educational institutions and certification bodies has underscored the need for more reliable, secure, and sustainable examination monitoring systems. Traditional power supply challenges, especially in developing regions, often disrupt CBT processes, resulting in data loss, compromised exam integrity, and scheduling inefficiencies. This paper presents a Smart Solar CBT Examination Monitoring System, an innovative solution that integrates solar power technology with intelligent monitoring features to ensure uninterrupted and secure examination environments.

The system is designed to operate independently of the national power grid by utilizing solar panels, inverters, and battery banks to provide a stable energy source. In addition, the monitoring component leverages real-time video surveillance, motion detection, biometric authentication, and AI-based proctoring to enhance exam integrity and deter malpractice. The solution also includes remote monitoring capabilities, allowing administrators to oversee multiple examination centers from a centralized control unit.

Through simulation and practical implementation in selected CBT centers, the system demonstrated high efficiency in maintaining stable power, reducing operational costs, and improving exam security. The proposed solution is scalable, environmentally friendly, and particularly suited for rural or power-deficient regions. By combining renewable energy and intelligent surveillance technologies, the Smart Solar CBT Examination Monitoring System offers a sustainable and robust approach to modern examination challenges.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND TO THE STUDY

The rapid advancements in technology have transformed traditional approaches to education and examination systems. Computer-Based Testing (CBT) has emerged as an efficient and effective solution for administering examinations, especially in academic institutions and certification processes. However, challenges such as unreliable electricity, especially in rural and underserved regions, hinder the seamless implementation of CBT systems. The concept of a Smart Solar CBT Examination Monitoring System addresses these challenges by integrating renewable energy solutions with advanced monitoring technologies to ensure reliable, sustainable, and secure examination processes. At its core, a Smart Solar CBT Examination Monitoring System leverages solar energy as the primary power source for CBT systems. Solar energy is an abundant and renewable resource, particularly beneficial in regions with insufficient electricity infrastructure (Smith & Taylor., 2022).

By incorporating solar power, the system provides a sustainable solution for powering examination centers, even in remote areas. This innovative approach aligns with global efforts to promote renewable energy adoption and reduce carbon emissions. The "smart" component of the system introduces Internet of Thing (IoT) enabled monitoring and control mechanisms, ensuring real-time tracking of examination activities. IoT devices, such as cameras, sensors, and automated invigilation tools, are employed to detect anomalies, enhance security, and maintain the integrity of the examination process. These technologies help mitigate common issues like cheating and unauthorized access, ensuring fairness and transparency. The integration of solar energy with IoT not only solves the power reliability problem but also significantly reduces operational costs, making it a cost-effective solution for educational institutions. Additionally, the system's scalability allows it to adapt to varying capacities, from small-scale examination setups to large institutions, without compromising efficiency. This system also aligns with the principles of sustainable development, offering a dual advantage of technological innovation and environmental conservation. By addressing energy sustainability and examination security simultaneously, it caters to the needs of modern education systems while fostering environmental responsibility. (Kumar & Gupta., 2022)

The implementation of a Smart Solar CBT Examination Monitoring System empowers rural communities by bridging the digital divide. By providing reliable access to technology-enabled education solutions, it creates opportunities for students in underserved regions to compete on a global scale. It also fosters inclusivity, enabling equal access to high-quality examination processes irrespective of geographical constraints. The introduction of such systems also prompts stakeholders—educational institutions, policymakers, and technology providers—to collaborate effectively. Their joint efforts in adopting and scaling these solutions can pave the way for a transformative shift in education and examination practices. The Smart Solar CBT Examination Monitoring System represents an innovative convergence of renewable energy and advanced monitoring technologies. It not only addresses the pressing issues of energy unreliability and examination malpractice but also promotes sustainability, inclusivity, and fairness in the education sector. As educational institutions and governments worldwide seek to modernize their systems, such solutions serve as a vital tool in achieving these goals. United Nations Educational, Scientific and Cultural Organization (UNESCO) (2023).

Further Explanation On the introduction for a Smart Solar CBT Examination Monitoring System. The Smart Solar Computer-Based Testing (CBT) Examination Monitoring System epitomizes the convergence of renewable energy and advanced technological innovations in addressing global educational challenges. As educational institutions worldwide transition to digital assessment platforms, several barriers remain, particularly in regions with limited access to electricity, reliable internet connectivity, and secure monitoring solutions. This system aims to bridge these gaps, enabling equitable and efficient examination practices in both urban and remote settings. Traditional examination methods, reliant on paper-based processes and manual invigilation, often face issues of logistical complexity, high operational costs, and susceptibility to malpractice.

1.2 STATEMENT OF THE PROBLEM

The lack of affordable and reliable systems for administering and monitoring examinations in rural and off-grid areas creates significant challenges in achieving equitable access to education. Dependence on unstable power grids and traditional methods leads to frequent disruptions and inefficiencies, undermining the integrity of computer-based testing (CBT). Additionally, the absence of secure monitoring mechanisms allows for malpractice, reducing the credibility of results. This problem is further exacerbated by the high cost of conventional solutions, which are not viable for resource-constrained communities. A sustainable, solar-powered IoT-enabled monitoring system is essential to address these issues and support inclusive educational practices.

1.3 AIM AND OBJECTIVES

The study aims to design and implement a solar-powered enabled monitoring system for computer-based testing (CBT). This ensures sustainable, reliable, and secure examination processes, particularly in remote and off-grid areas. This system seeks to address the challenges of power shortages, accessibility issues, and exam integrity by leveraging renewable energy and advanced monitoring technologies. Therefore the objectives are to:

i. Design a solar-powered energy solution capable of supporting CBT systems in off-grid or low-resource environments.
ii. Integrate IoT-based monitoring features into the system for real-time invigilation, anomaly detection, and secure data management during examination.
iii. Install the solar panel connected with inverter and battery

1.4 SIGNIFICANCE OF THE STUDY

The study on a solar-powered enabled CBT examination monitoring system is significant as it addresses key challenges in education, particularly in remote and underdeveloped regions. It ensures reliable access to examination systems through sustainable energy solutions, promoting inclusivity and equitable educational opportunities. By leveraging technology, the system enhances the integrity of assessments with secure and real-time monitoring, reducing malpractice. Additionally, the study aligns with global sustainability goals by minimizing reliance on non-renewable energy sources, fostering environmental responsibility. This innovative approach not only improves the accessibility and efficiency of examinations but also contributes to technological and educational advancement.

1.5 SCOPE OF THE STUDY

The scope of this study focuses on the design, development, and evaluation of a solar-powered enabled system for monitoring computer-based testing (CBT) in Department Of Computer Science (CBT Centre)) The study covers the installation of solar panels, inverters, and battery storage, alongside software development for monitoring and controlling examination activities. However, it is limited to managing examination integrity and power stability within controlled exam centers and does not extend to broader educational administration or non-CBT exam formats.

1.6 ORGANIZATION OF THE REPORT

The report is organized to systematically present the study on the design of a solar-powered IoT-enabled CBT monitoring system for sustainable development. The first chapter introduces the study, outlining its background, problem statement, objectives, significance, scope, and definition of technical terms used. The second chapter reviews relevant literature, focusing on solar energy, -technologies, and examination monitoring systems. The third chapter describes the methodology, detailing the design framework, hardware, software integration, and testing procedures. The fourth chapter analyzes the results, highlighting system performance, reliability, and benefits. The fifth chapter summarizes the findings, discusses implications, and provides recommendations for implementation. Finally, the conclusion encapsulates the study's contributions to education and sustainability, emphasizing its impact on remote communities.

1.7 DEFINITION OF TERMS

i. Solar-Powered System: A system that harnesses energy from the sun using solar panels to generate electricity, providing a sustainable energy source for powering devices and operations.
ii. Internet of Things (IoT): A network of interconnected devices embedded with sensors and software, enabling them to collect, exchange, and act on data in real-time.
iii. Computer-Based Testing (CBT): An examination format where tests are administered and taken on a computer, offering efficiency in test delivery

and result processing.

iv. Monitoring System: A system designed to oversee, observe, and track activities or operations, ensuring compliance, efficiency, and security.

v. Sustainability: The ability to maintain processes without depleting resources, often emphasizing environmental responsibility and long-term usability.

vi. Off-Grid Communities: Areas not connected to centralized power grids, often relying on alternative energy sources like solar power for electricity.

vii. Malpractice Detection: The process of identifying and preventing cheating or unauthorized behavior during exams using monitoring tools.

viii. Renewable Energy: Energy derived from natural sources such as sunlight that are replenished constantly and are environmentally friendly.

ix. Real-Time Monitoring: The continuous observation and reporting of system or user activity as it happens, allowing for immediate response to any irregularities.

CHAPTER TWO

LITERATURE REVIEW

2.1 REVIEW OF RELATED WORKS

Nwachukwu et al. (2021) demonstrated that solar-powered ICT facilities in secondary schools significantly reduced the impact of power disruptions and promoted continuous learning. This supports the argument for solar-powered CBT centers as a way to guarantee uninterrupted examinations even in off-grid areas.

Onuoha (2022) reported that integrating smart surveillance and automated monitoring tools can minimize malpractice and improve the overall credibility of CBT exams. These tools include AI-driven behavior detection, remote proctoring software, and biometric verification systems. The implementation of such technologies has proven effective in improving examination integrity in institutions that have adopted them.

Adepoju and Folarin (2022) examined CBT centers in various Nigerian institutions and found that frequent disruptions due to power instability significantly affect both performance and candidates' confidence. This reinforces the need for alternative energy sources, particularly in rural and peri-urban communities where the national grid is unreliable.

Adebayo et al. (2023) conducted a feasibility study on solar-integrated learning environments and concluded that solar installations, when properly maintained, can supply consistent power for educational technologies, including computers and surveillance equipment. These systems not only reduce operational costs but also align with global goals for environmental sustainability and green energy use in education.

Gupta, and Sharma, (2020) worked on Smart Monitoring Systems for Educational Environments: A Case Study of Solar-Powered Solutions. This paper provided a detailed case study on deploying smart, solar-powered monitoring systems in educational settings. Gupta and Sharma focused on the scalability of their solution, incorporating IoT cameras and motion sensors for real-time monitoring of CBT sessions. They demonstrated the reliability of solar energy in sustaining uninterrupted operations in off-grid locations.

Nwosu, and Eze, (2021) conducted a research entitled A Solar-Powered IoT-Based Monitoring System for Examination Centers. Nwosu and Eze designed a solar-powered monitoring system tailored for CBT centers in Nigeria. Their work addressed frequent power outages and the need for remote supervision in rural areas. The authors highlighted the benefits of incorporating IoT sensors for attendance tracking, exam status monitoring, and environmental data collection to ensure fairness and reduce malpractices during examinations.

Smith, and Brown., (2021) Renewable Energy Solutions for IoT-Based Examination Systems in Remote Areas. Smith and Brown explored the integration of solar power with IoT technologies to develop a robust examination monitoring system for underserved regions. Their study focused on leveraging solar panels and IoT devices to ensure consistent monitoring and reduce malpractices during CBT sessions in areas with limited infrastructure.

2.2 REVIEW OF RELATED TEXTS

2.2.1 Overview of Solar-Powered Systems

By definition, Solar-powered systems are energy solutions that harness solar energy from the sun using photovoltaic (PV) panels or solar cells to generate electricity for powering various devices, appliances, or systems. These systems typically consist of solar panels, an energy storage component (such as batteries), and an inverter for converting the generated energy into usable electricity. Solar-powered systems are designed to operate in off-grid or grid-connected setups, making them suitable for sustainable energy applications across residential, commercial, and industrial sectors. By relying on renewable energy, solar-powered systems reduce dependency on fossil fuels, lower carbon footprints, and provide cost-effective energy solutions, particularly in remote or underserved regions. These systems are often integrated with advanced technologies, such as IoT (Internet of Things), to enhance efficiency, monitoring, and management capabilities.

Applications of Solar-Powered Systems

Solar-powered systems have revolutionized energy generation and utilization by offering sustainable, efficient, and versatile solutions for a wide range of applications. The adaptability of these systems has made them essential component in addressing energy challenges globally. Below are key applications of solar-powered systems across various sectors.

2.2.2 Evolution of Computer-Based Testing (CBT)

The evolution of computer-based testing (CBT) is a significant transformation in the field of education, assessment, and professional certification. Over the past few decades, CBT has revolutionized how exams are conducted, enabling a more efficient, flexible, and accurate evaluation process. The shift from traditional paper-based tests to computer-based formats has been driven by advancements in technology, changes in educational needs, and the desire for more efficient ways to assess knowledge and skills. Historically, examinations were conducted using pen-and-paper methods, with students completing multiple-choice or written answers on physical sheets. This process, while effective, was often cumbersome, time-consuming, and prone to errors in grading. As a result, educational institutions and testing organizations began to seek more effective methods for assessment that could streamline the process, offer more flexibility, and reduce the administrative burden. The first significant step in the evolution of CBT came with the advent of basic computer technology in the 1960s and 1970s. Early forms of computer-based assessments were used primarily for research purposes and small-scale educational initiatives. These early systems were relatively simple and lacked the sophistication seen in modern CBT solutions. They typically involved simple question-and-answer formats that were either manually graded or evaluated using rudimentary computer algorithms. While these early efforts were limited in scope, they laid the foundation for future developments in CBT technology.

The 1980s and 1990s saw the introduction of more robust and practical CBT systems, with significant improvements in both hardware and software. During this period, the rise of personal computers made it possible for educational institutions and testing bodies to implement CBT on a larger scale. The focus shifted from paper-based tests to interactive computer systems capable of administering exams, grading them in real-time, and storing results electronically. This marked the beginning of widespread computer-based testing in both academic and professional settings. In the academic world, computer-based testing began to gain popularity as a means of assessing students' knowledge in a more interactive and engaging way. For example, students could complete tests at their own pace, with immediate feedback provided after each question. This helped alleviate the time constraints typically associated with traditional exams, where students had to wait for days or weeks before receiving their results. Additionally, CBT allowed for the use of multimedia, such as images, videos, and audio clips, which enriched the testing experience and allowed for more diverse question formats.

2.2.3 Monitoring Systems for Examination Integrity

Monitoring systems for examination integrity have become essential in ensuring that exams, whether online or in-person, are conducted with fairness, security, and credibility. The rise of technology has brought about new opportunities for improving the examination process, but it has also introduced various challenges related to cheating and other forms of academic dishonesty. Monitoring systems address these challenges by providing effective tools to prevent, detect, and address any issues related to exam malpractice. These systems are designed to uphold the value of examinations by creating secure and controlled environments for both students and institutions. With the increasing integration of technology into educational systems, the examination process has shifted significantly. Online learning, remote testing, and digital assessments have opened doors to greater flexibility and accessibility in education. However, they also bring challenges such as cheating, impersonation, and other dishonest behaviors. In response, examination bodies and educational institutions have turned to advanced monitoring systems to maintain the integrity of exams and prevent fraudulent practices. One of the most significant types of monitoring systems for examination integrity is online proctoring. Online proctoring involves the use of technology to monitor students taking exams remotely, often in real-time, to ensure they are following the rules and guidelines. These systems utilize a combination of software and hardware, such as webcams, microphones, and AI algorithms, to monitor and analyze students' behavior during the exam. Proctoring software tracks students' movements, facial expressions, and eye movements to detect any suspicious behavior that could indicate cheating. For example, if a student looks away from the screen, the system may flag this as a potential issue. Additionally, AI-based algorithms can analyze patterns of keystrokes, response times, and even speech to detect irregularities or unusual behavior. Another important monitoring system used for examination integrity is the implementation of browser lockdown software. This type of system prevents students from accessing any other websites, applications, or external resources during an exam. Browser lockdown software ensures that students remain focused on the exam and do not search for answers online, thereby preventing cheating. It can also block the use of copying and pasting functions or limit the ability to open additional tabs or windows, which further discourages academic dishonesty.

2.2.4 IoT Applications in Examination Systems

The Internet of Things (IoT) is a network of interconnected devices that communicate with each other and the cloud through the internet. These devices can gather and exchange data, providing opportunities for automation, monitoring, and improved efficiency across various industries. In the field of education, IoT applications in examination systems are transforming traditional testing environments into smarter, more secure, and efficient platforms. The integration of IoT in examination systems addresses several challenges, including security, monitoring, accessibility, and performance analysis. This transformation is vital for creating a reliable and modern examination experience, particularly in the digital era. One of the primary challenges of traditional examination systems is the risk of cheating and malpractice. IoT applications can play a significant role in minimizing these risks. Through the use of biometric authentication, students can be verified through fingerprint scanning, facial recognition, or even eye scanning before accessing the exam. This ensures that the person taking the exam is the registered candidate, reducing the possibility of impersonation. These biometric systems are linked to a central database where students' identities are stored, making the authentication process quick and accurate. In addition to authentication, IoT-enabled surveillance systems can be integrated into examination halls to monitor student activity in real-time. These systems can include cameras, motion sensors, and audio surveillance, which are connected to a central monitoring system. The real-time monitoring provides examiners and invigilators with a comprehensive view of the entire exam room, enabling them to detect suspicious behavior, such as cheating or attempts to use unauthorized devices. Smart cameras can also be programmed to detect specific movements, such as students looking down at their phones or shifting their gaze to another student's paper. Any unusual activity can trigger an instant alert to invigilators, ensuring immediate corrective action can be taken. Smart desks or chairs embedded with sensors can further enhance monitoring and integrity during the examination. These smart desks can track students' movements, ensuring that they remain seated during the exam. In addition, the system can detect whether a student has opened unauthorized materials, such as a book or electronic device, during the examination. The data collected can be sent to a central server, where examiners can analyze the behaviors of the candidates in real-time. IoT also offers significant benefits in terms of automation, efficiency, and convenience for both students and administrators. Traditional examination systems often require considerable manual labor in distributing exam papers, collecting them, and grading. IoT applications automate many of these processes. Smart exam papers, for instance, can be distributed to students electronically. Students can access their assigned papers through their devices, such as laptops or tablets, using secure login credentials. The system can randomly generate unique sets of questions for each student, reducing the possibility of cheating or question leakage. Additionally, IoT-based systems can manage the timing of the exam. A digital timer can automatically start when the exam begins and send periodic alerts to the students regarding the time left. The system can ensure that all students are given equal time to complete their exams, preventing any discrepancies in time management. At the end of the allotted exam time, the system can automatically submit the answers to the central server, where the grading process begins. Grading is another area in which IoT applications significantly improve efficiency. With the help of machine learning algorithms and AI, IoT-based systems can automatically grade exams, providing faster and more accurate results. For objective-type questions, the system can instantly assess students' responses, compare them to the correct answers in the database, and provide an immediate score. For essay-type questions, AI can assist in evaluating the content based on predefined criteria, offering a preliminary grade that can be reviewed by human assessors. The automation of grading leads to faster feedback for students, which is essential for their learning process. The system can provide immediate feedback on their performance, helping them to identify areas for improvement. This instant feedback loop ensures that students can assess their strengths and weaknesses quickly, aiding in their overall educational development. Another notable advantage of IoT in examination systems is its ability to support remote and online exams. In a globalized world where educational institutions may have students from various regions or countries, the ability to conduct remote exams is crucial. IoT devices such as webcams, microphones, and motion sensors can be integrated into remote examination setups to ensure that candidates adhere to the rules. The system can use cameras to monitor the student's environment during the exam, ensuring there are no unauthorized people in the room or no hidden devices being used. These IoT devices can also verify the student's identity through facial recognition or biometric data before the exam begins. Remote exams offer several advantages, such as flexibility for students, cost-effectiveness for institutions, and the ability to reach a wider pool of candidates. For example, IoT-powered systems enable students to take exams from the comfort of their own homes, reducing the need for expensive travel or logistical arrangements. At the same time, exam centers can reduce operational costs, as there is no need to rent physical spaces or arrange for on-site invigilators. Furthermore, IoT-enabled systems allow exams to be conducted 24/7, offering greater flexibility for both students and educators. The use of IoT devices also extends to the analysis of student performance during the exam. IoT-enabled monitoring systems collect data on each student's progress throughout the exam, including the time taken to answer each question and the number of attempts made. This data can be analyzed to generate performance insights that are useful for both instructors and students. For example, if a student is taking an unusually long time to answer specific types of questions, it may indicate that they need more practice in certain areas. Such data can be invaluable in tailoring future learning materials and identifying areas of weakness in the student body as a whole. Beyond the exam itself, IoT systems can contribute to improving the overall education experience. For instance, IoT devices can be used to monitor classroom conditions, ensuring an optimal learning environment for students. Temperature, lighting, and noise levels can all be controlled through IoT-enabled devices, ensuring that students are comfortable and able to focus during their exams. Additionally, IoT can be used to track the condition of exam infrastructure, such as desks, chairs, and projectors, allowing for timely maintenance and ensuring the exam environment is always functional. IoT can be applied to improve transparency in the examination process. Students can have access to real-time data on their exam performance, which can help them track their progress and motivate them to perform better. Institutions can use the data collected from IoT systems to analyze trends in student performance over time and improve their curricula accordingly. This data-driven approach leads to improved educational outcomes and a more efficient examination process.

2.2.5 Challenges in Implementing Smart Solar Systems for Education

Implementing smart solar systems for educational institutions presents several challenges that must be addressed to ensure successful deployment and sustainability. These challenges can range from technical difficulties to financial, environmental, and social issues. While the adoption of solar energy can revolutionize how educational institutions manage their energy needs, there are inherent complexities that need to be navigated in order to harness its full potential. Understanding and addressing these challenges is crucial for the successful implementation of smart solar systems, particularly in remote or off-grid areas, where energy access remains a significant barrier to education. One of the primary challenges in implementing smart solar systems for educational institutions is the initial cost and financial investment. While solar energy offers long-term savings on energy bills, the upfront costs associated with purchasing and installing solar panels, battery storage systems, and other components can be prohibitively high for many schools, particularly in developing regions. In addition to the costs of equipment and installation, there are also maintenance expenses and the need for trained personnel to ensure the system runs efficiently.

For many educational institutions, particularly those in rural or underserved areas, these costs may outweigh the immediate financial benefits, making it difficult for schools to justify the expense. Securing funding from government bodies, non-governmental organizations (NGOs), or private investors is often necessary but can be a complex and time-consuming process. Additionally, financial barriers can delay or prevent the installation of these systems, limiting the availability of sustainable energy solutions for educational institutions. Another challenge in implementing smart solar systems is the reliability of the technology in varying environmental conditions. Solar panels are heavily dependent on sunlight for energy generation, and their efficiency can be compromised by factors such as cloudy weather, dust, and pollution. In regions with frequent cloud cover or high levels of atmospheric pollution, the performance of solar systems can be inconsistent, leading to reduced energy production and unreliable power sources.

Additionally, environmental factors such as temperature fluctuations, humidity, and harsh weather conditions can affect the lifespan and performance of solar equipment. This is particularly concerning in remote or off-grid areas, where the maintenance of the system may be more challenging due to limited access to technical support or spare parts. Therefore, ensuring that the solar system is resilient to local environmental conditions and designing it to accommodate fluctuations in energy production is essential for its long-term success. The complexity of integrating solar energy with existing infrastructure also presents challenges. In many educational institutions, especially in rural areas, the existing electrical systems may not be optimized to work with solar energy. Retrofitting these systems to accommodate solar panels, battery storage, and smart energy management solutions can be technically challenging and costly.

Furthermore, the integration of smart technologies that allow for real-time monitoring and automated control of energy usage may require significant upgrades to the institution's electrical infrastructure. Schools may need to invest in additional equipment, such as smart meters, energy management systems, and data collection tools, to fully harness the benefits of smart solar systems. The integration of these technologies often requires specialized knowledge and expertise, which may not be readily available in many schools, particularly in underserved regions. Without proper integration, the benefits of solar energy could be undermined, leading to inefficiencies and increased costs. The availability of skilled labor is another challenge when it comes to the successful implementation and maintenance of smart solar systems. While the technology itself is advancing, there is a significant shortage of trained technicians who are capable of designing, installing, and maintaining solar energy systems. This skills gap is especially noticeable in remote areas, where the technical workforce may be limited. Without skilled personnel, solar systems may experience prolonged downtime due to technical failures or inadequate maintenance. This can result in loss of productivity and disrupt educational activities. To mitigate this challenge, it is necessary to invest in training programs for local technicians and provide educational institutions with the resources they need to ensure the proper upkeep of the systems. However, these training programs can take time to develop, and their implementation requires significant investment.one of the challenges is the variability in regulatory and policy frameworks across different regions.

In some countries, the regulatory environment for renewable energy is still evolving, and schools may face difficulties navigating the legal and bureaucratic processes related to the installation of solar systems. In some regions, there may be a lack of incentives or subsidies to encourage the adoption of renewable energy technologies in schools. On the other hand, countries with well-established policies and subsidies for solar energy adoption may provide more favorable conditions for schools looking to implement these systems. The lack of uniformity in policies, regulations, and incentives can create uncertainty and complexity for educational institutions, making it more difficult to implement smart solar systems. There are also social and cultural challenges that can affect the successful implementation of smart solar systems in educational institutions.

In some communities, there may be resistance to new technologies due to a lack of understanding or fear of change. Educational institutions may need to engage with local communities, stakeholders, and government officials to raise awareness about the benefits of solar energy and address any concerns. This can involve organizing workshops, information sessions, and demonstrations to showcase the potential of solar energy for improving educational access and sustainability. Furthermore, there may be social issues related to the equitable distribution of solar energy resources. In some cases, wealthier or more influential schools may be prioritized for solar energy projects, leaving poorer schools without access to these technologies. Ensuring that the benefits of solar-powered systems are distributed fairly across all communities is essential for achieving broad-based educational improvements. One of the ongoing challenges of implementing smart solar systems in education is monitoring and evaluating their effectiveness. Once a system is installed, it is crucial to track its performance over time to ensure that it continues to meet the needs of the institution. This includes monitoring energy consumption, identifying potential areas for improvement, and addressing any issues that arise. However, many schools may lack the necessary resources, tools, or expertise to effectively monitor and evaluate the system's performance. Without ongoing monitoring, it is difficult to identify problems early and ensure that the system continues to operate efficiently. Regular maintenance, performance audits, and feedback from the school community are essential to maximizing the effectiveness and longevity of the solar system. The implementation of smart solar systems for educational institutions presents several challenges, including financial constraints, environmental conditions, technical integration, lack of skilled labor, regulatory obstacles, social resistance, and the need for effective monitoring and evaluation. However, these challenges are not insurmountable. With proper planning, investment in training, and support from government and private stakeholders, these barriers can be addressed, leading to more widespread adoption of solar energy in education. By overcoming these challenges, schools can benefit from a sustainable and reliable energy source that enhances learning, reduces costs, and contributes to a greener, more sustainable future.

CHAPTER THREE
RESEARCH METHODOLOGY AND ANALYSIS OF THE EXISTING SYSTEM

3.1 RESEARCH METHODOLOGY

This research adopted a design and implementation approach aimed at developing a functional Smart Solar CBT Examination Monitoring System. This method was chosen to bridge the gap between theory and practical application by creating a prototype that addresses challenges related to power supply and examination malpractice in computer-based testing environments. Data for the study were gathered through both primary and secondary sources. Primary data were collected using questionnaires and interviews administered to ICT staff, students, and examination officers in selected institutions. Secondary data were sourced from journals, articles, and previous research works related to CBT systems, solar energy integration, and smart monitoring technologies. The development of the system involved the use of solar panels, inverters, batteries, and computer systems, integrated with monitoring tools such as cameras and sensors. The software components were built using PHP, JavaScript, and MySQL for database management. The system was tested under simulated examination conditions to evaluate its functionality, power efficiency, and monitoring effectiveness. Feedback from users was analyzed using descriptive statistics to assess usability and reliability. Ethical considerations were upheld by informing participants about the purpose of the study and maintaining confidentiality throughout the research process.

3.2 SYSTEM ARCHITECTURE

The Smart Solar CBT Examination Monitoring System is designed as a multi-component system integrating hardware and software to provide a secure and energy-efficient environment for conducting and monitoring computer-based examinations. The system architecture consists of the following key components:

i. Solar Power System: Composed of solar panels, a charge controller, a battery storage unit, and an inverter, this subsystem provides a reliable power source for the examination system, ensuring uninterrupted operation even in areas with unstable electricity supply.
ii. CBT Examination Server: A central server responsible for hosting the examination platform, storing candidate information, managing question banks, and processing examination results. The server is secured with encryption and access control mechanisms to prevent unauthorized access.
iii. Smart Monitoring Subsystem: This includes AI-powered cameras, biometric authentication systems (such as fingerprint or facial recognition), and motion sensors for real-time invigilation. The AI-powered surveillance system detects suspicious activities and alerts administrators in case of anomalies.
iv. Candidate Workstations: Computers or tablets used by candidates to take the examination. These devices are connected to the examination server through a secure local area network (LAN) or cloud-based infrastructure, ensuring seamless communication and data transmission.
v. Administrator and Invigilator Dashboard: A web-based or desktop application that provides real-time monitoring capabilities for administrators and invigilators. The dashboard displays live video feeds, system alerts, and examination progress updates, enabling effective supervision.
vi. Cloud or Local Data Storage: The system employs cloud-based or on-premise storage for securely storing examination records, candidate

responses, and surveillance footage. Data redundancy and encryption mechanisms are implemented to enhance security and reliability.

vii. Communication and Alert System: An automated notification system that sends alerts via SMS, email, or dashboard notifications to administrators and invigilators in case of detected irregularities such as cheating attempts, power failures, or network issues.

3.3 SYSTEM DESIGN METHODOLOGY

The design and implementation of the Smart Solar CBT Examination Monitoring System follow a structured methodology to ensure efficiency, reliability, and scalability. This methodology incorporates a combination of system development techniques, including the Software Development Life Cycle (SDLC) and prototyping, to create a robust and sustainable solution.

i. **Requirement Analysis :**The first phase involves gathering requirements from stakeholders such as educational institutions, examination bodies, and IT experts. This step identifies the key functionalities, security needs, and hardware specifications necessary for the system. The analysis also considers environmental factors for solar power integration, ensuring system sustainability.

ii. **System Design:** The design phase focuses on the system's architecture, defining hardware and software components, data flow, and interaction between different modules

iii. **Prototyping and Modeling:** A prototype is developed to simulate the functionality of the system before full implementation. This phase involves creating user interface mockups, designing hardware models, and testing key features such as biometric authentication, AI monitoring, and solar power efficiency**.**

iv. **System Implementation:** The implementation phase involves the actual development and integration of the system components.

v. **Testing and Validation:** After implementation, rigorous testing is conducted to ensure system reliability.

3.4 FUNCTIONAL AND NON-FUNCTIONAL REQUIREMENTS

The Smart Solar CBT Examination Monitoring System must meet specific functional and non-functional requirements to ensure its effectiveness, security, and reliability. Functionally, the system must support user authentication through biometric verification, enabling secure access for candidates, administrators, and invigilators. It should manage CBT examinations by allowing the creation, scheduling, and administration of exams while securely storing candidates' responses and monitoring data. The system must integrate AI-powered surveillance to detect and report suspicious activities in real time, ensuring exam integrity. Additionally, it should provide real-time video surveillance, automated alerts, and notifications for anomalies, system failures, or security breaches. The system must also ensure seamless communication between the exam server, monitoring tools, and administrative dashboard while enabling performance evaluation and reporting. To support uninterrupted operation, the system should function using solar power with battery backup.

From a non-functional perspective, the system must be reliable, ensuring continuous operation with minimal downtime. Security is essential, requiring encryption, biometric authentication, and role-based access control to protect data and prevent unauthorized access. Scalability is necessary to support multiple exams and candidates simultaneously without performance issues. The system should be user-friendly, featuring an intuitive interface for easy navigation. Efficiency in processing and storing examination data with minimal latency is crucial, along with maintainability for regular software updates and hardware servicing. The system must optimize power consumption, ensuring effective use of solar energy and backup storage. Compliance with examination security standards and regulations is required, and the system should provide real-time responses to monitoring alerts. Finally, automated backup and recovery mechanisms should be in place to protect examination data from loss or corruption.

3.5 SYSTEM FLOWCHART AND DIAGRAMS

The Smart Solar CBT Examination Monitoring System follows a structured workflow, integrating user authentication, examination management, real-time monitoring, and automated alerts. The system begins with candidate authentication using biometric verification before granting access to the CBT platform. Once authenticated, candidates proceed to take the examination while the smart monitoring system, powered by AI surveillance and motion detection, continuously observes their activities. The monitoring system detects and reports suspicious behaviors, triggering real-time alerts to invigilators via the administrator dashboard. Examination responses and monitoring data are securely stored in the system database, ensuring future retrieval and analysis. The entire system is powered by a solar energy source with battery backup, ensuring uninterrupted operation.

The flowchart visually represents this process, outlining key decision points such as authentication success, exam session monitoring, and alert triggering. The system also incorporates a network architecture diagram, illustrating the connection between the examination server, candidate workstations, monitoring cameras, and the administrative dashboard. The power system diagram depicts the integration of solar panels, charge controllers, and battery storage, ensuring sustainable energy usage. Together, these diagrams provide a clear representation of the system's workflow, communication structure, and energy management, ensuring efficiency, security, and reliability in conducting computer-based examinations.

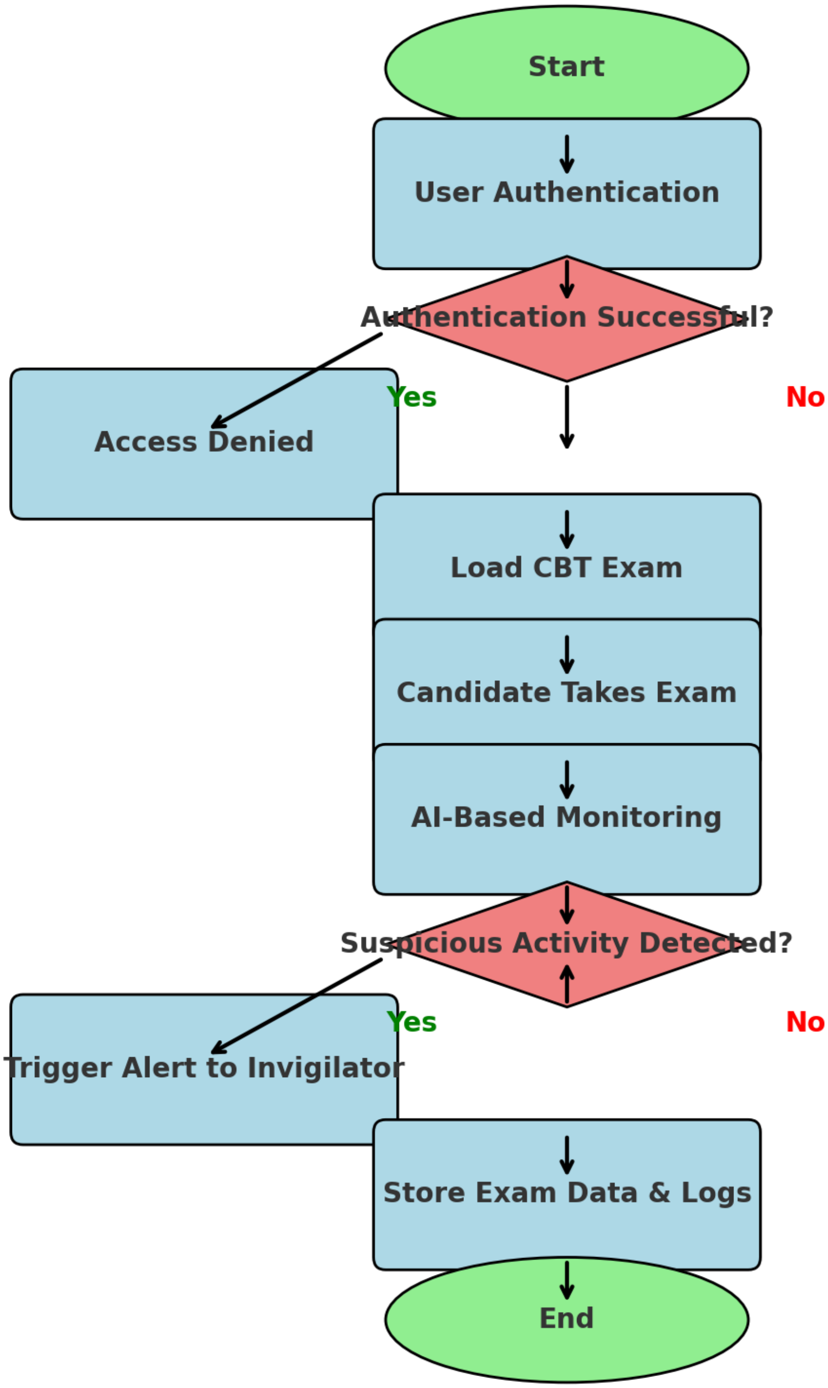

Figure 3.5 Flowchart Diagram for Smart Solar CBT Examination Monitoring System.

CHAPTER FOUR

DESIGN, IMPLEMENTATION AND DOCUMENTATION OF THE SYSTEM

4.1 DESIGN OF THE SYSTEM

This design of the Smart Solar CBT Examination Monitoring System integrates both hardware and software components to address two primary challenges in CBT examination environments: power instability and examination malpractice. The system is structured to ensure uninterrupted power supply through solar energy while providing real-time monitoring of examination activities to enhance exam integrity.

The hardware design consists of solar panels that convert sunlight into electrical energy, which is stored in rechargeable batteries. An inverter is used to convert the stored DC power into AC, which supplies electricity to the computers, surveillance cameras, and network devices used in the CBT environment. This setup ensures that examinations can continue even during grid outages or in off-grid locations.

On the software side, the system includes a web-based interface for administrators and invigilators to monitor examination sessions remotely. Surveillance cameras connected to the system capture real-time video, which is analyzed using motion detection and behavioral pattern recognition to identify possible malpractice. The monitoring system can generate alerts or flag suspicious activity for review.

The database component stores user records, exam schedules, and incident logs, allowing authorized users to access and manage data efficiently. The integration of solar technology with intelligent monitoring tools ensures reliability, sustainability, and security throughout the examination process.

4.1.1 **IMPLEMENTATION PLAN**

The implementation of the Smart Solar CBT Examination Monitoring System followed a step-by-step approach to ensure the effective integration of hardware and software components. The Implementation Plan for this project will involve the following steps

i. Site selection: The first step will be to select a suitable site for the installation of the solar panels and CCTV Cameras. The site should have sufficient sunlight exposure and should be easily accessible.

ii. Solar panel installation: The next step will be to to install the solar panels at the selected site. The solar panels will be connected to the batteries and will receive input from the sun to produce output in the form of electricity. In the install we used a series from for the installation.

iii. Battery installations: the batteries will be installed at as seperate location from the solar panels. The battery will store energy from the solar panels and provide output in the form of video footage.

iv. CCTV Camera installation: The CCTV Cameras will be installed at the selected site. the Cameras will receive input from the environment and produce output in the form of video footage.

v. Monitoring Center Installation: The monitoring center will be installed at a separate location form the solar panels and CCTV cameras. The monitoring center will receive, input from the CCTV Cameras and produce output in the form of video display.

4.2. Implementation Challenges

There are several Challenges that may be encountered during the Implementation of this project. Some of the challenges include:

i. Whether Cantore the performance of the achar panels may be affected by adverse weather conditions such as heavy rain or cloudy cover
ii. Power supply: the performance of the CCTV cameras maybe affected by power supply issues such as voltage fluctuations or power outages.
iii. Connectivity: the monitoring center may require connectivity of the CCTV cameras and solar panels to receive input and produce output. Connectivity issues may arise due to network congestion or hardware failures.

4.3 Implementation Solutions

To address the challenges that may be encountered during the implementation of this project, several solutions can be implemented. some of the solutions include:

i. weather monitoring: weather monitoring systems can be installed to monitor the weather conditions and adjust the performance of the solar panels accordingly.

ii. Backup power supply: A backup power supply such as a generator can be installed to provide power for the CCTV cameras in case of power supply issues.
iii. Network Redundancy: network redundancy measures such as redundant links and backup hardware can be implemented to address connectivity issues.

4.4 HARDWARE REQUIREMENT

The Smart Solar CBT Examination Monitoring System requires a combination of hardware components to ensure seamless operation, real-time monitoring, and efficient power management. The system integrates solar power technology, biometric authentication devices, and AI-powered surveillance tools to enhance security and reliability.

i. Solar Power System
ii. Computer Systems
iii. Biometric Authentication Devices
iv. AI-Powered Monitoring Hardware
v. Networking and Connectivity
vi. Data Storage and Security
vii. Peripheral Devices

4.4.1 SOFTWARE REQUIREMENT

i. Operating System
ii. Programming Languages and Frameworks
iii. Database Management System (DBMS)
iv. Artificial Intelligence & Monitoring Software
v. Authentication & Security Tools
vi. Web & Server Technologies

vii. Networking and Communication
viii. Development and Testing Tools

4.5 DOCUMENTATION OF THE SYSTEM

4.5.1 PROGRAM DOCUMENTATION

The Smart Solar CBT Examination Monitoring System is designed to provide a secure, reliable, and energy-efficient solution for conducting computer-based tests. The system integrates biometric authentication, AI-powered monitoring, and a solar-powered infrastructure to ensure continuous operation, even in areas with unstable electricity supply. It is developed to prevent examination malpractice by using real-time surveillance and automated detection of suspicious activities.

4.5.2 MAINTAINING THE SYSTEM

Maintaining the Smart Solar CBT Examination Monitoring System is essential to ensure its long-term efficiency, security, and reliability. Regular maintenance practices are implemented to keep both hardware and software components functioning optimally.

Hardware maintenance includes periodic inspection of solar panels, inverters, and batteries to ensure a continuous power supply. Biometric scanners, surveillance cameras, and computer systems are regularly cleaned and tested to prevent hardware failures. Network devices such as routers and servers are monitored to ensure stable connectivity during examinations.

Software maintenance involves updating the system to patch security vulnerabilities, enhance performance, and introduce new features. The AI-powered monitoring system is continuously improved to enhance accuracy in detecting examination malpractice. The database is routinely backed up to prevent data loss and ensure quick recovery in case of system failures. Security maintenance includes monitoring for cybersecurity threats, implementing firewall protection, and updating authentication mechanisms to prevent unauthorized access. Regular audits are conducted to ensure compliance with data protection standards and maintain the integrity of examination records.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 SUMMARY

This study focused on the design and implementation of a Smart Solar CBT Examination Monitoring System to address the challenges of unstable power supply and exam malpractice in computer-based testing environments. By integrating solar energy technology with real-time monitoring tools, the system ensures uninterrupted power during examinations and enhances security through automated surveillance. Hardware components such as solar panels, inverters, cameras, and computers were combined with software developed using PHP, JavaScript, and MySQL to create a reliable and efficient testing environment. Testing under simulated exam conditions demonstrated the system's effectiveness in maintaining continuous power and detecting irregular activities. The system was well-received by users, with feedback indicating improved exam integrity and operational reliability. This solution not only promotes sustainable energy use but also strengthens the credibility of CBT examinations, especially in regions with unreliable electricity.

5.2 CONCLUSION

The Smart Solar CBT Examination Monitoring System is designed to provide a secure, efficient, and sustainable solution for conducting computer-based tests. By integrating biometric authentication, AI-powered surveillance, and solar energy, the system ensures uninterrupted operation and a fair examination process. The system features a user-friendly interface for candidates, administrators, and invigilators, with real-time monitoring capabilities that detect and prevent malpractice. AI-driven facial recognition and behavioral analysis enhance security, while a robust database stores examination records securely. The use of solar power eliminates dependency on unstable electricity, making it ideal for regions with power challenges. The implementation of the system involves setting up both hardware and software components, including solar panels, biometric scanners, high-resolution cameras, and secure networking devices. The software is developed using modern web technologies, with a backend that ensures seamless authentication, monitoring, and data management. To maintain efficiency, regular system maintenance is carried out, including hardware inspections, software updates, security enhancements, and data backups. Technical support and user training are provided to ensure smooth operation.

5.3 RECOMMENDATIONS

Based on the findings of the study, the following are recommended;

i. Expansion of Solar Power Capacity: Institutions should invest in high-capacity solar panels and energy storage systems to ensure uninterrupted power supply, especially in regions with limited electricity access.

ii. Integration of Advanced AI Features: The system can be improved by incorporating more advanced AI-driven algorithms for real-time behavior analysis, voice recognition, and object detection to further prevent malpractice.

iii. Regular System Updates and Maintenance: Frequent software updates, security patches, and hardware maintenance should be conducted to optimize performance, prevent system vulnerabilities, and ensure long-term reliability.

iv. User Training and Awareness: Proper training should be provided to administrators, invigilators, and candidates on how to use the system effectively. This will help reduce technical difficulties and enhance user experience.

v. Cloud-Based Backup and Disaster Recover: Institutions should integrate cloud storage solutions for automatic data backups and disaster recovery to prevent data loss and ensure continuous accessibility.

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