West African Journal of Industrial and Academic Research
ISSN : 2276-9129 , Volume 26, No.1, February 29, 2025
https://wajiaredu.com.ng

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Design of Integrated Employee Management Information System (IEMIS) using Fingerprint Biometric Authentication to tract Employees of Biase Local Government Education Authority, Cross River State, Nigeria

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Abstract

Employees are considered the most valuable and dynamic assets within an organization, acting as the foundation upon which its success is built. Their performance, particularly in management, significantly influences the overall success of the organization. A Management Information System (MIS) serves as a comprehensive platform that collects, manages, and tracks information related to all employees within the organization. This study aims to design an Integrated Employee Management Information System (IEMIS) to address the challenges associated with traditional manual record-keeping methods, such as document loss and excessive manpower requirements. The system incorporates fingerprint-based attendance monitoring to enhance employee management. The research utilizes the Object-Oriented Analysis and Design Methodology (OOADM) to tackle the existing issues. The system's Graphical User Interface (GUI) was developed using Visual Basic 6.0, while MYSQL, a Relational Database Management System (RDMS), was employed for database development. For simplicity, the system is structured into various modules. Upon testing, the system successfully facilitated computerized management of employee personnel records, wage computation, and attendance tracking using biometric fingerprint data. The developed system proved to be highly effective, streamlining the staff data processing workflow, and enhancing the efficiency and effectiveness of human resource management. Additionally, the system is user-friendly and offers query capabilities for retrieving information.

Key Words: *Management Information System, Integrated Employee Management Information System, Object-Oriented Analysis and Design Methodology, Graphical User Interface*

1.0 Introduction

The competition among companies today centers around the acquisition and strategic use of human resources to maximize profits. Without skilled and competent personnel, organizations face significant challenges in meeting profit expectations and business objectives. Historically, from ancient times to the modern era, companies have recognized the value of a well-developed workforce, positioning employees as their most valuable assets (Smith & Williams, 2023). In contemporary society, significant changes in the business landscape are evident, especially in the rising costs of goods and services, which have led to increases in employee wages and the cost of living. Employee wage growth is largely influenced by shifts in organizational structure and management practices (Brown, 2022).

Traditional human resource management (HRM) primarily focuses on supporting personnel behavior by collecting employee data, monitoring performance, and ensuring individuals meet organizational goals. To meet these objectives, there is an increased reliance on effective human resource management practices, which not only support the achievement of organizational goals but also drive value through strategic actions, such as adjusting work schedules and fostering professional development within HR management (Ulrich & Dulebohn, 2024).

The widespread adoption of modern Information Technology (IT) has significantly impacted HRM functions. According to Patel & Choudhury (2021) and Larson et al. (2022), the integration of IT has facilitated the sustenance of various HR activities, while enhancing overall HR effectiveness. They also predict that continuous use of Human Resource Information Technology (HRIT) will lead to substantial benefits for HR professionals and further integrate HR services into organizational operations. Ulrich & Dulebohn (2024) concurs, noting that the use of HRIT not only elevates the status of HR professionals but also contributes to the overall importance of HR within the organization.

The Human Resource Management Information System (HRMIS) is designed to streamline and expedite HR processes, improving their quality through automation of essential activities. The adoption of HRMIS has proven advantageous, prompting many organizations to implement it to enhance HR activities. Developing HRMIS as a unified standard is crucial for improving efficiency and transparency in HR management, particularly in public and governmental sectors (Dessler, 2024)."

2.0 Review Of Related Works

In recent years, there has been considerable debate surrounding the nature and role of Human Resource Management (HRM), especially due to the lack of a universally agreed-upon definition and its evolving significance (Storey, 2024, as cited in Bratton & Gold, 2024). While there are various interpretations of HRM, several definitions are widely regarded as foundational (Jones & Liu, 2023).

Haines (2024) defines HRM as an organizational function that focuses on managing people. He further argues that HRM often serves as a supportive function within the broader organizational structure, emphasizing that its effectiveness is critical in addressing human resource-related issues (Haines, 2024).

Bratton and Gold (2024) characterize HRM as a strategic approach to managing employee relations, with the aim of leveraging human capabilities to gain sustained competitive advantage. This is achieved through an integrated set of employment policies, practices, and programs. According to Bratton and Gold (2024), key HR functions include strategic planning, performance appraisals, and employee relations, among others (Bratton & Gold, 2024). **They further identified HRM with the field it covers as shown in figure 1.**

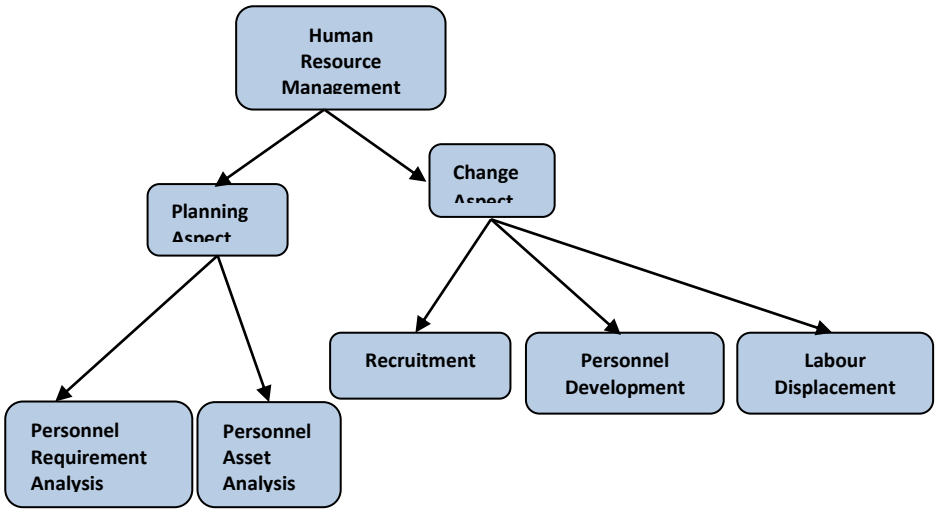

Figure 1: Fields of HRM (Source: Abecker et al., 2004)

3.0 Human Resource Management Processes

This section outlines the key processes involved in Human Resource Management (HRM) duties. These processes include various HR functions such as preparation, employment, career development, and performance assessment. The explanation that follows draws on the work of Dessler et al. (2024) to elaborate on these processes.

The first HRM process is **Planning**. According to Dessler et al. (2024), the primary responsibility of HR is to regularly assess the workforce to ensure that the organization has the right number of employees with the required skills to meet its objectives. Human Resource Planning (HRP) involves forecasting future workforce needs based on projected organizational goals, while also planning for workforce supply to align with those needs. This process requires anticipating labor demand and adjusting the workforce accordingly to ensure that the organization's staffing levels and competencies remain adequate.

The second process is **Recruitment**. Recruitment refers to the process of attracting a sufficient number of qualified candidates to fill job vacancies within the organization (Dessler et al., 2024). The recruitment process begins when a vacancy is identified and ends when candidates have submitted their applications, typically in the form of resumes or application forms. Recruitment involves several steps: identifying job vacancies, determining job requirements, and selecting appropriate recruitment methods.

The HR department, sometimes in collaboration with other departments, identifies these vacancies. Afterward, job specifications and descriptions are reviewed to determine the exact qualifications and competencies required. At this stage, the most suitable recruitment methods are chosen, with no single method being universally best. As Itika (2024) notes, recruitment plays a crucial role in ensuring the organization attracts the right talent, which ultimately impacts the quality of the workforce. Clear policies on recruitment and selection are important to avoid biases and ensure transparency throughout the process.

The third process is **Selection**. Selection involves choosing the most qualified candidates to fill positions within the organization. The process typically begins by reviewing applicants' data, including information about their current employers, whether they are being considered for promotion, or if they are applying as external candidates. The selection process generally follows a structured sequence, starting with receiving applications, screening candidates, conducting aptitude tests, holding interviews (e.g., preliminary, reference checks, and supervisory interviews), and performing job previews. The selection process is governed by legal and managerial frameworks to protect both the candidates and the organization (Dessler et al., 2024).

Finally, the processes of **Orientation, Training, and Development** are essential for integrating and improving employees within the organization. Orientation helps new employees familiarize themselves with the organization's culture, values, expectations, and work environment. It is part of the organization's broader commitment to social responsibility (Dessler, 2024). Training equips employees with the necessary skills and knowledge to perform their current roles effectively, while development focuses on preparing employees for future responsibilities, particularly in management. Training addresses current job needs, while development aims to prepare employees for potential future challenges and enhance their competencies for long-term organizational success. These processes are crucial in ensuring that organizations not only hire the right people but also support their ongoing development to meet both current and future needs.

4.0 Development Of Human Resource Management Information System

Recent advancements in technology have led to the development of real-time, information-based, self-service, and interactive job environments. Human Resource Information Systems (HRIS) have evolved from simple computerized record-keeping systems in the 1960s into comprehensive reporting and decision-making tools in recent years (Gerardine, 2024). Today, both human resource managers and employees are increasingly taking on tasks once considered the exclusive domain of HR experts and administrative personnel. This shift reflects a significant improvement in managerial efficiency and marks a departure from traditional practices. With greater authority and easy access to critical information, decision-making processes are accelerated, allowing both managers and employees to respond to changes more swiftly (Lengnick-Hall & Beck, 2024).

Laudon and Laudon (2024) explain that an information system is technically defined as a set of interrelated components that perform functions such as data processing, storage, retrieval, and sharing of information to support control and decision-making within an organization. They further argue that in addition to these fundamental functions, information systems help managers and employees analyze challenges, envision complex problems, and develop new products.

Kovach et al. (2024) describe HRIS as an organized system that performs key functions such as collecting, storing, maintaining, retrieving, and validating the information needed by organizations to manage human resources, personnel activities, and other organizational requirements. Additionally, HRIS helps to integrate human resource management (HRM) with information technology, enhancing both HR operations and decision-making.

4.1 System Design and Methodology Adopted in the research

Object-oriented analysis and design methodology (OOADM), which is adopted in this work, is seen as a set of standards for application design and system analysis. It employs a formal, systematic approach to the analysis and design of information systems. Object-oriented design (OOD) elaborates the analysis models to create implementation specifications (Smith & Johnson, 2024; Harris, 2024). Figure 2 shows a typical structure of OOADM.

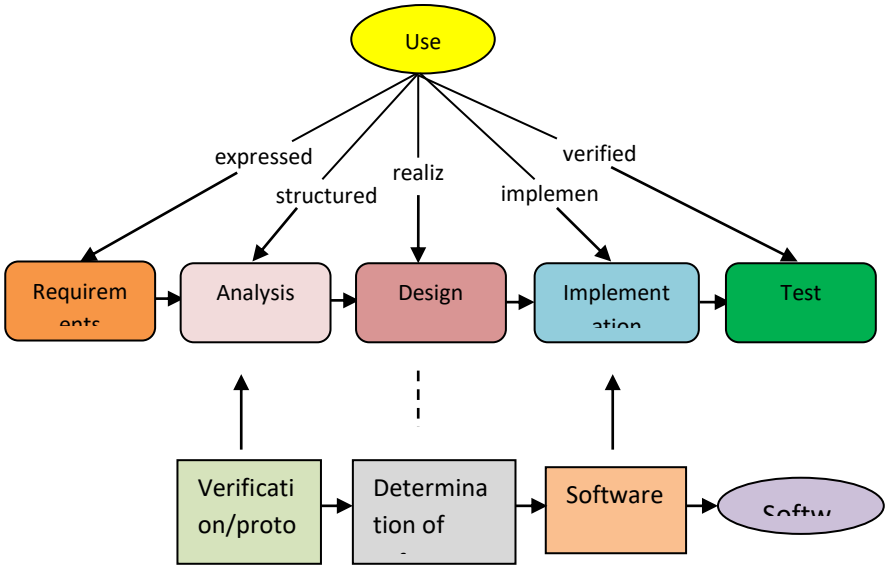

Fig. 2: Typical Structure of OOADM

Object-oriented analysis and design methodology (OOADM) which is adopted for this research, makes use of Object Oriented Programming (OOP), which does not use centralized control, rather, all objects are created equal and control is an interaction between the objects that collaborates to achieve a certain functionality.

4.2 Analysis of the Existing system

The human resources unit is one of the most essential components of any organization. It is managed by an administrator who is typically supported by competent personnel, as shown in the organizational structure of the human resources department (Johnson & Thompson, 2023). These specialized officers include managers responsible for human resource development services, officers in charge of public (social) service sections, the training manager, and the public officer responsible for insurance policies. Additionally, the human resources department houses personnel officers, lawyers, and clerks who handle specific roles within the organization (Martin & Green, 2021). Figure 3 shows the human resources department's organizational structure.

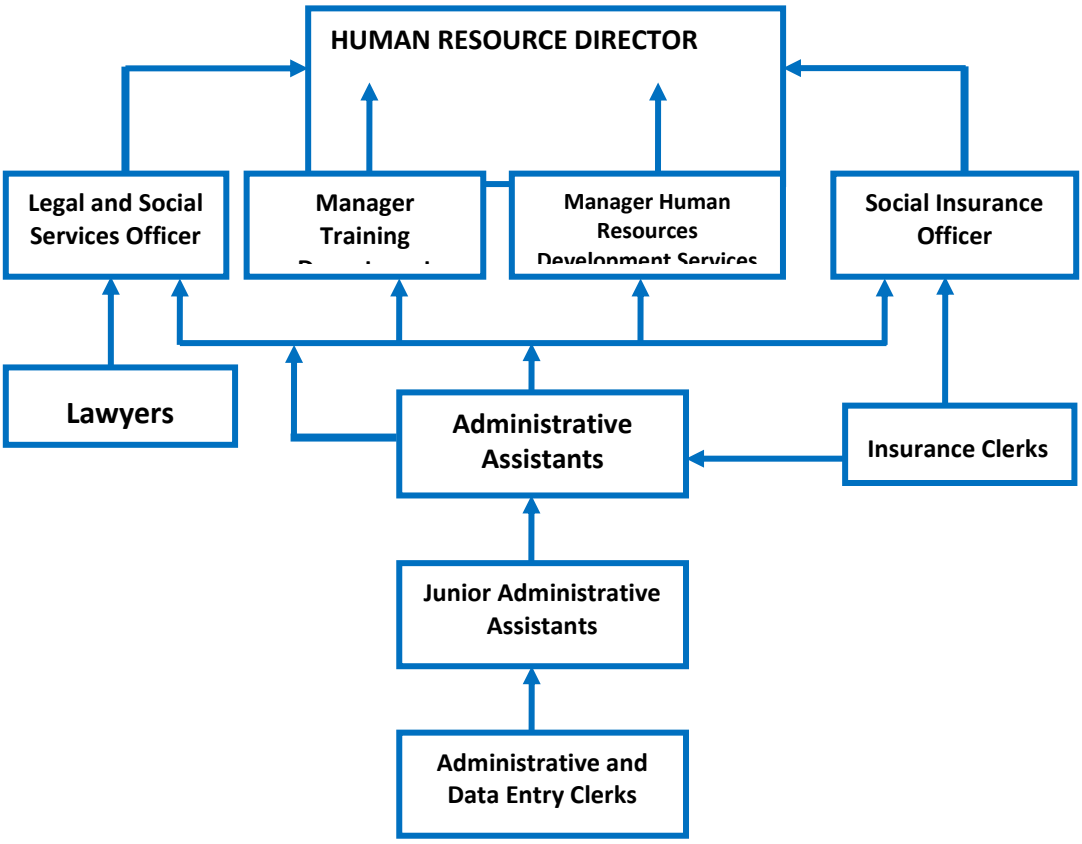

Fig. 3: Human Resources Department's Organizational Structure.

The human resources department's responsibilities in any functional establishment are stated below:

i. advertisement, employment and declaration of vacant posts within the organization.
ii. employee information management.
iii. Manages as well as monitors the progress of employee from their entry point to their retirement, or to other forms of termination.
iv. management of internal and external grievances within the organization.
v. manages labour force. This usually aids them in performing for instance yearly projections for the number of employees who are due retirement.

Formerly, this department depended on Microsoft excel sheets and Microsoft Word for the storage and management of employee data. Most often, because of the dimension of the establishment, the stored files in several cases becomes too large for the organization and then retrieving of data from them for reference purposes or updating is always cumbersome.

4.3 Weakness of the current system

Here are some of the problems associated with the existing systems of employee management information system.

i. Staff file are always large and scattered in different locations that it takes a lot of time to gather the files together and sort out the employee details.
ii. Due to lack of central database for employee information, change of department by an employee, may result in loss of information on his/her previous performance records and attendance monitoring.
iii. Computation of salary is cumbersome and results in most cases to error.
iv. Compiled payroll report may take longer time that payment will be delayed since the computation is done on a Microsoft excel file departmentally.

4.4 Analysis of the Proposed System

The proposed model of HRMIS contains 3 components (i.e. modules):

i. Administrative module;
ii. Attendance module;
iii. Payroll module.

In the new system, increase of the HRMIS essential components is probable, which include performance records, training and learning, task manager etc. The human resource departments still have the ability of handling the huge task of administering information for all the workers irrespective of the fact these departments are independent. So, for the department to be functional and able to meet up with the activities like updating of employee's information which are spread through the whole firms.

The new information system would serve as a major source of information for employee, and would guarantee quick retrieval of information especially to officers that are due retirement. It would also help management to easily and conveniently forecast when an employee is due retirement or due promotions. Ministries Departments and Agencies (MDAs) as well as International Donor Agencies (IDAs) would also depend on these information systems as a source of information for their various functions.

Before now, processed documents were kept in files and stored in file cabinets. This system of storing hard copies files was very primitive and disadvantageous because retrieval of information from them was very difficult. In most cases time consuming, and sometimes leads to lose of employee files hence loose vital information about the employee.

In addition, there may be a common need of identifying an employee full name, especially for elderly employees who cannot retain their identification number. This system would search and fetch the information very easily. The designed system monitors staff attendance using biometric data capture. Staff clocks in and out every day. The system will automatically surcharge a staff once he/she is late to work. It will compile the surcharge and deduct it from the staff salary at the end of the month. Access limitations and database security is highly maintained in the new system. Each user is required to supply his details before having access to the new system. This data is encrypted so as to avoid hackers from gaining access to the system. The administrator can also terminate user's access to the system as the need arises.

Access to reports generated by the new system and the computation platform is shared among various departments that make input to the new system.

4.4.1 Strength of the Proposed system

The new model of an employee management information system developed has so many features that helped to solve the problem with the existing system. The features include:

1. Employee's records are authenticated using fingerprint thereby eliminating impersonation in signing attendance
2. Computations are automatically carried out by the system, here eliminating erroneous computations encountered in manual computations.
3. Staff data is centralized hence it is easy to track records.
4. Compilation of reports is easier and timely

4.4.2 Data collection methods

The researcher relied on the following for the purpose of data collection:

i. Interview Method: Unstructured interview was conducted with a few individual within the sample frame to find out their opinion about the subject matter of the research. The method of staff recruitment, management, and computing payroll in the organization, the formula used for calculating tax, allowances and other deductions was obtained. Also sample employee forms and staff appraisal were collected for the purpose of designing the new system.

ii. Libraries: Intensive and extensive use of the libraries both public and private ones were made. Secondary data were obtained from materials such as books, periodicals, journals, magazines and dailies. Such data were used mainly to provide the theoretical framework for the study. Also materials were downloaded from internet for the purpose of this research work.

4.4.3 Model of the Proposed system

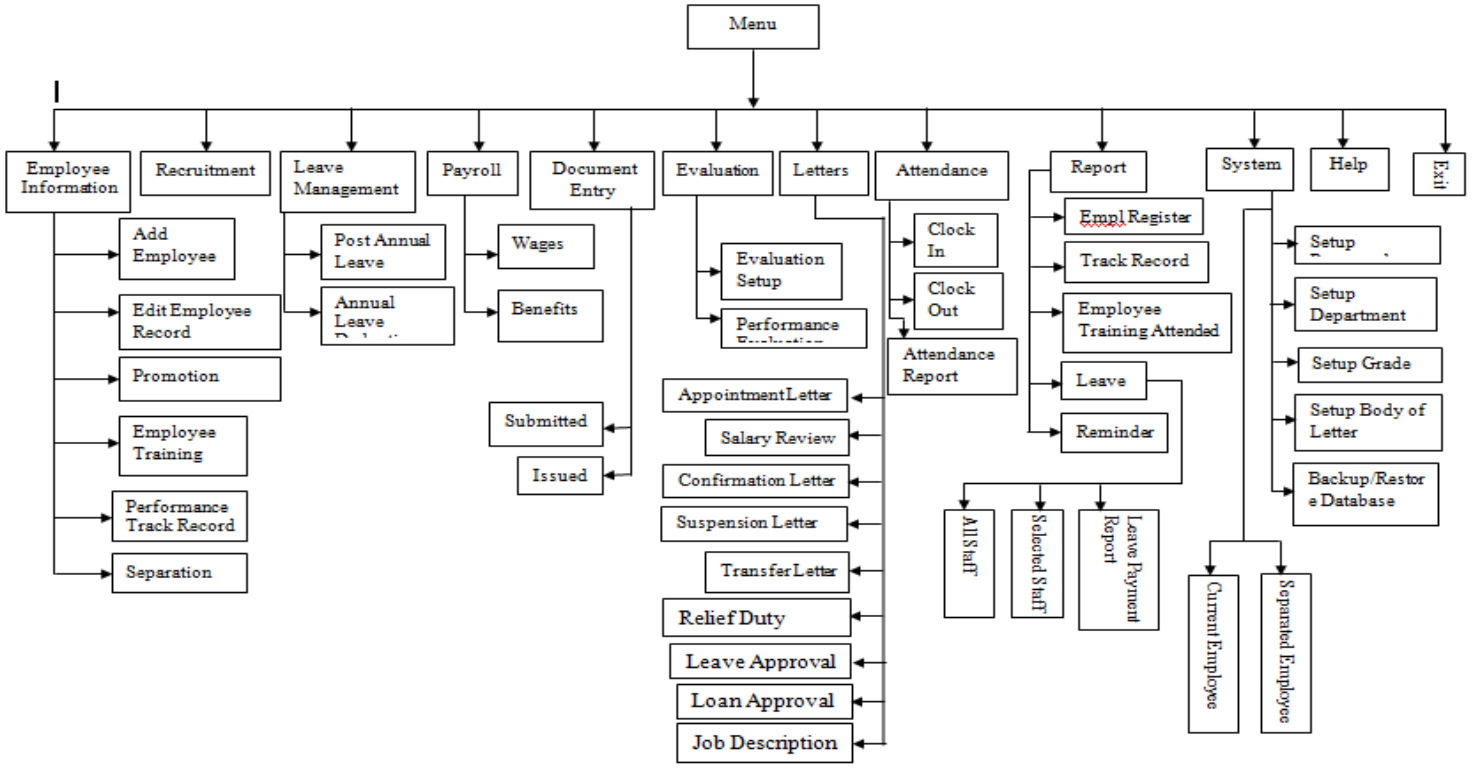

Figure 4: High Level Model diagram of the Proposed System

4.4.4 Data Flow Diagram of the Proposed system

A data flow diagram (DFD) uses a graphical representation to show the "flow" of data through an information system. It is often used as a introductory step for the creation of an overview of a system. DFDs can also be used to show diagrammatically the data structure of the system. It essentially used to show the direction of information in a system. Figure 5 shows the DFD of the proposed employee management information system depicting vividly the flow of information in the system.

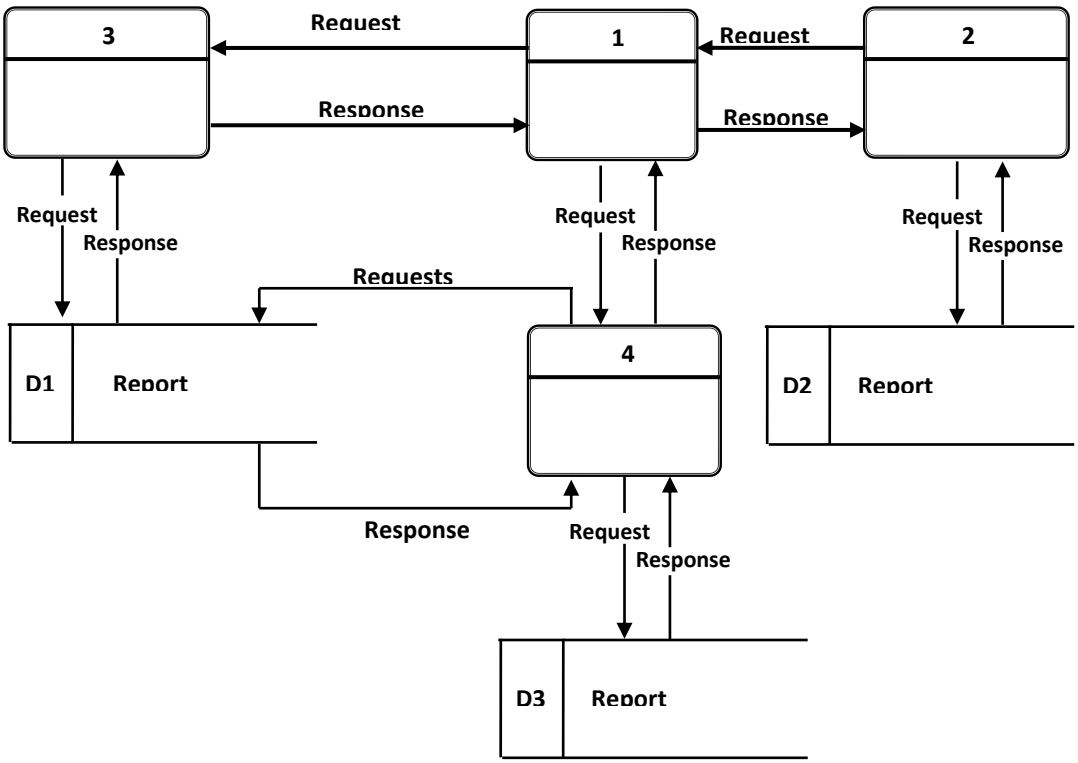

Figure 5: Data Flow Diagram of the Proposed System

4.5
Database Specifications of the Proposed system

The database was designed using Microsoft Structured Query Language (MySQL). The database consists of 11 tables and each table perform specific task in the overall system. Table 1 shows the structure of the attendance table having fields like name, date, time in, time out etc, and the various data types.

Table 2 is the table that clearly shows the performance structure of employee and has attributes like officer reporting, officer concern, report, date etc. Other tables are **Table 3** shows course attended table structure, **Table 4;** leave table structure, **Table 5;** letters table structure, **Table 6;** recruitment table structure, **Table 7**; shows reminder structure, **Table 8;** staff registration table structure, **Table 9;** staff benefits table structure, **Table 10;** performance evaluation table structure and **Table 11** clearly shows the payroll table structure having attributes like name, date, designation, amount etc. For want of space, these tables are not included. But we have included a description of their structure in the explanation for purpose of clarity and better understanding of the functionality of the application.

4.6 Database Entities Relationships

Entity Relationship diagrams is a expert graphics that is used to demonstrate the interrelationship between entities in a database. Here, ER diagrams and symbols
will be used to explain interactions within the database of the proposed system. In figure 6,

linked objects in the database are presented using Cow's Foot Notation. A discretionary association is displayed between employee, attendance and biometric.

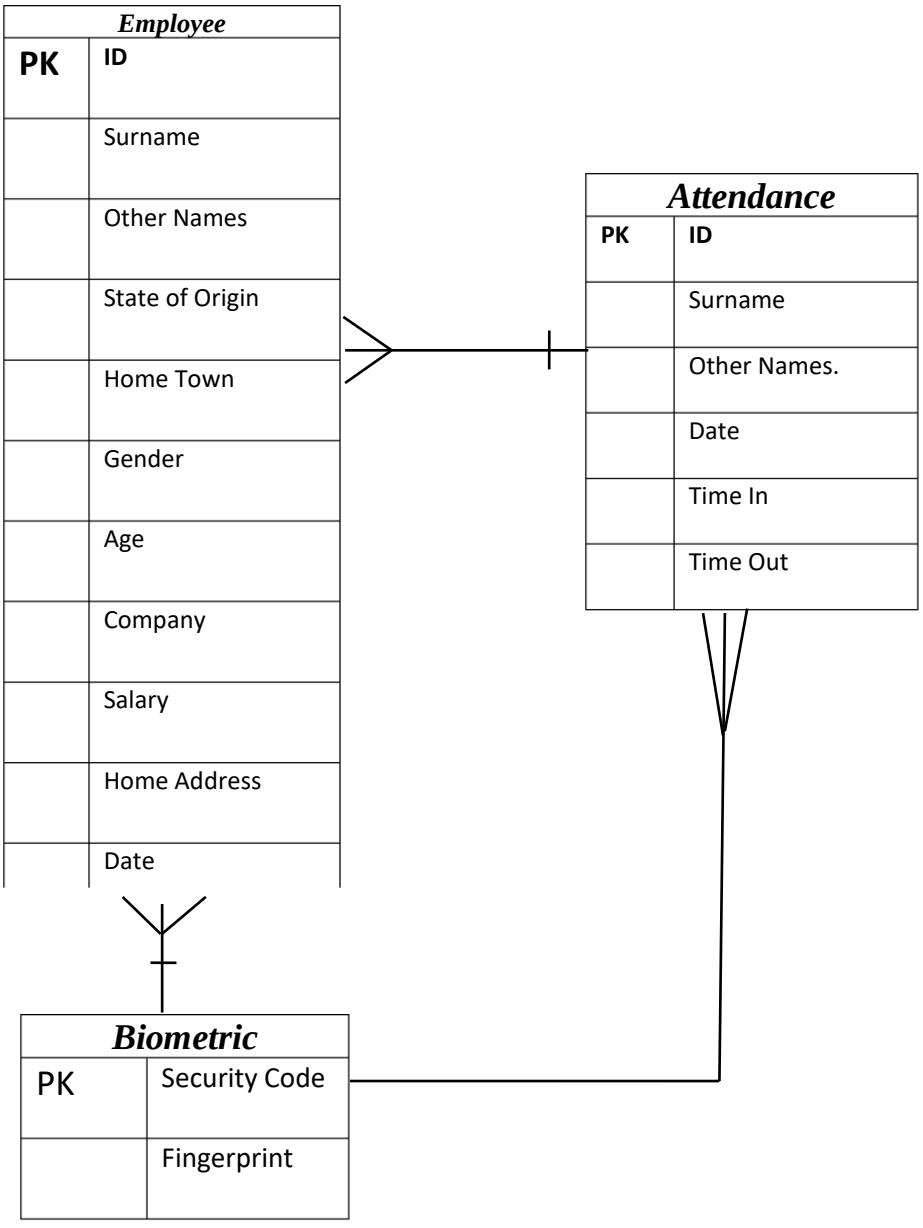

Fig. 6: Database Entity Relationship Model

4.7 Data Dictionary of the Proposed System

Table 1: Data Dictionary

Data Variable	Meaning
Id	Identification no of employee in the database
Name	Name of the employee
Address	Residential address
Phone	Mobile phone number of the person
State	State of origin
Company	Name of the employer
Finger	Fingerprint captured for the individual
Date	Date of employment
Sex	Gender of the employee
Age	Age of the employee
Email	Email address of the registered person
login	This is a module that handles the validation and authentication of user login credentials
pic	This is employee picture or image.
HRMIS	Human Resource Management Information System
HR	Human Resources

5.0 Results and Discussion

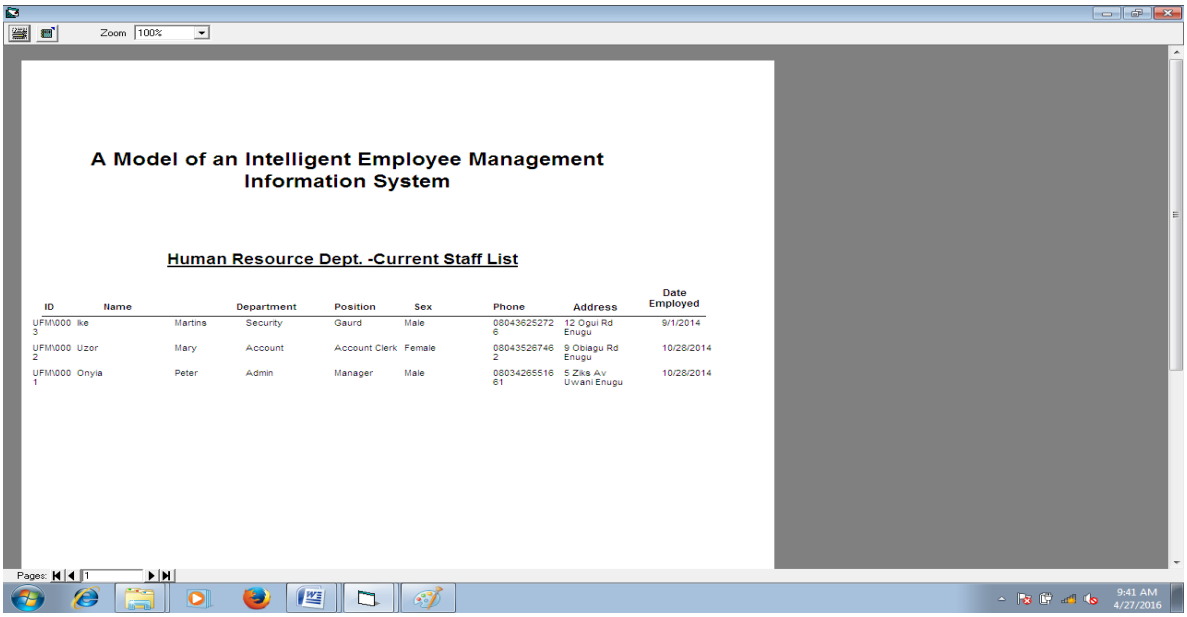

Fig 7: Current Staff Report

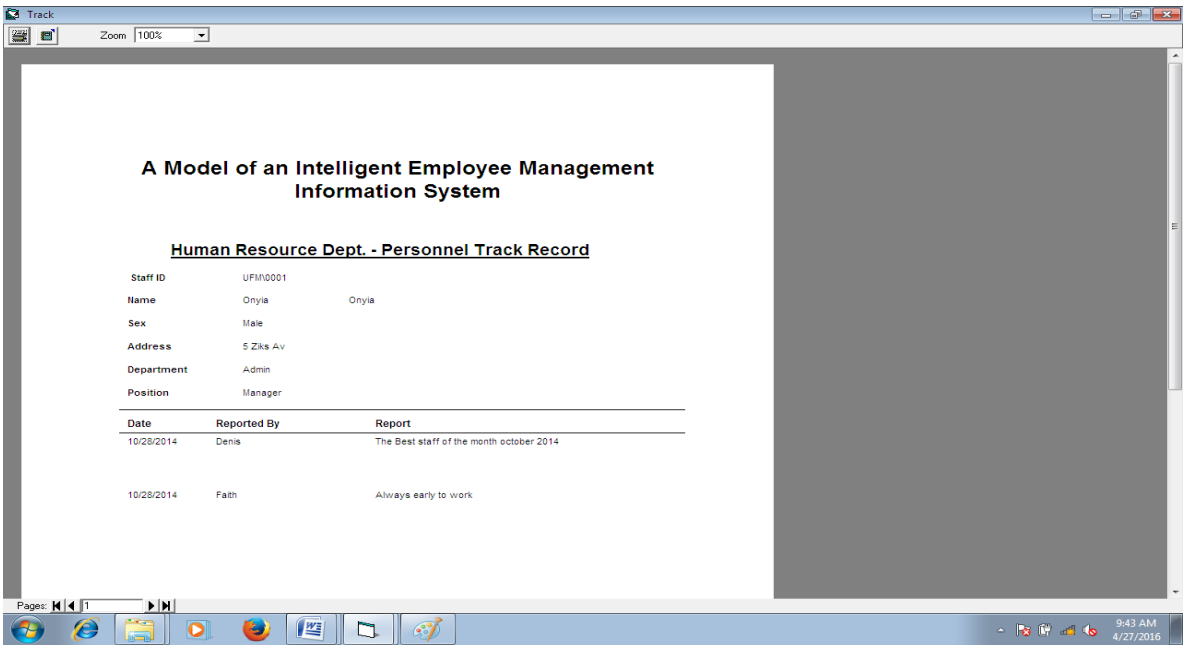

Fig 8: Staff Track record Report

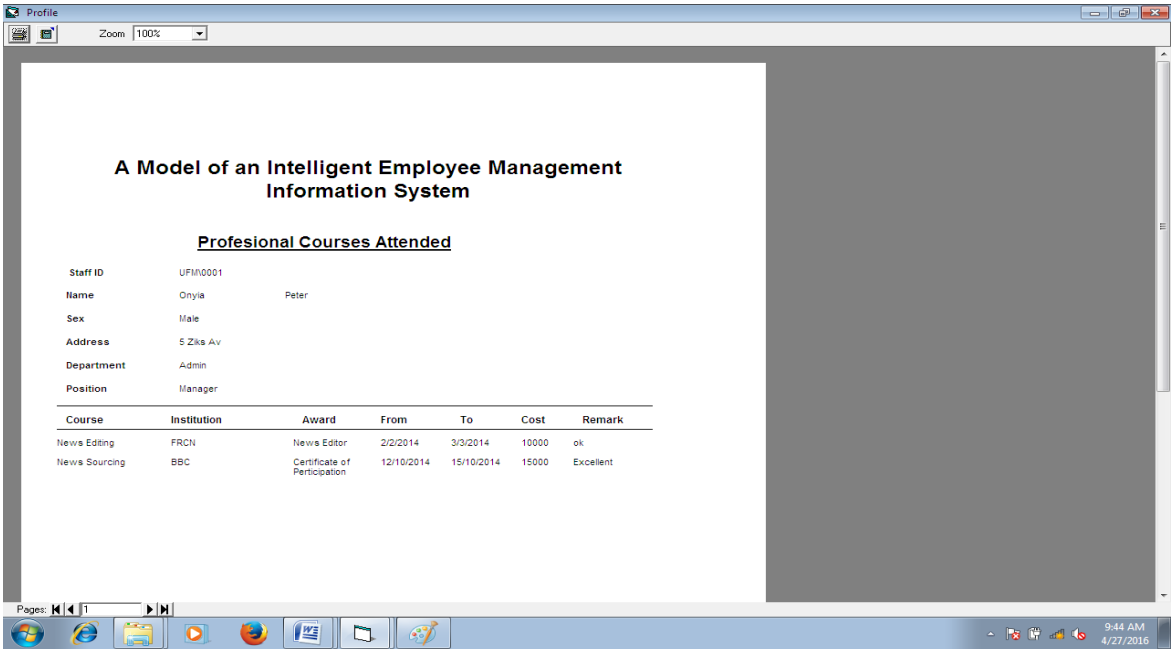

Fig 9: Staff professional courses attended Report

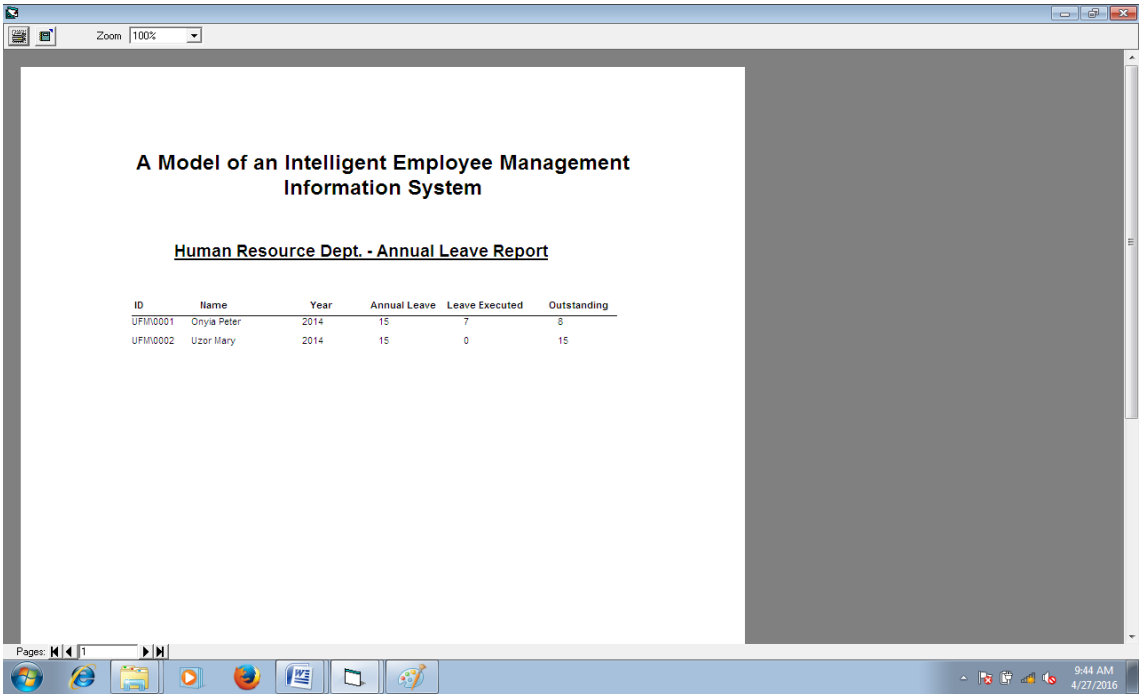

Fig 10: Staff annual leaves Report

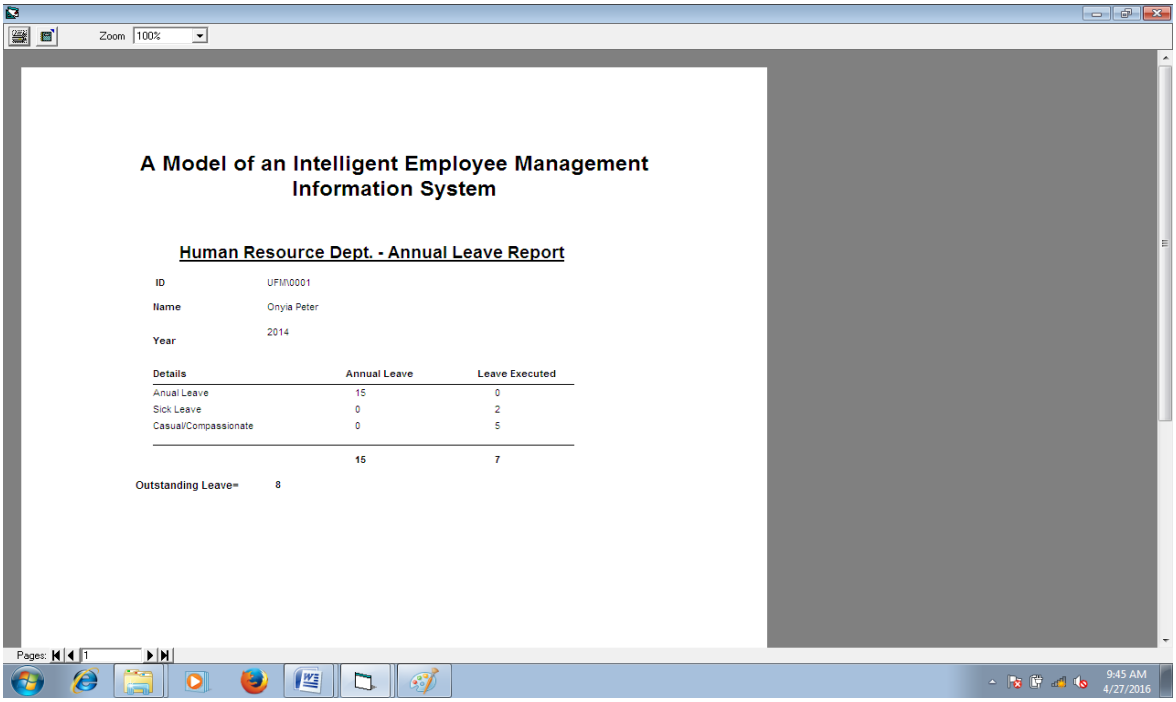

Fig 11: Staff annual leaves details Report

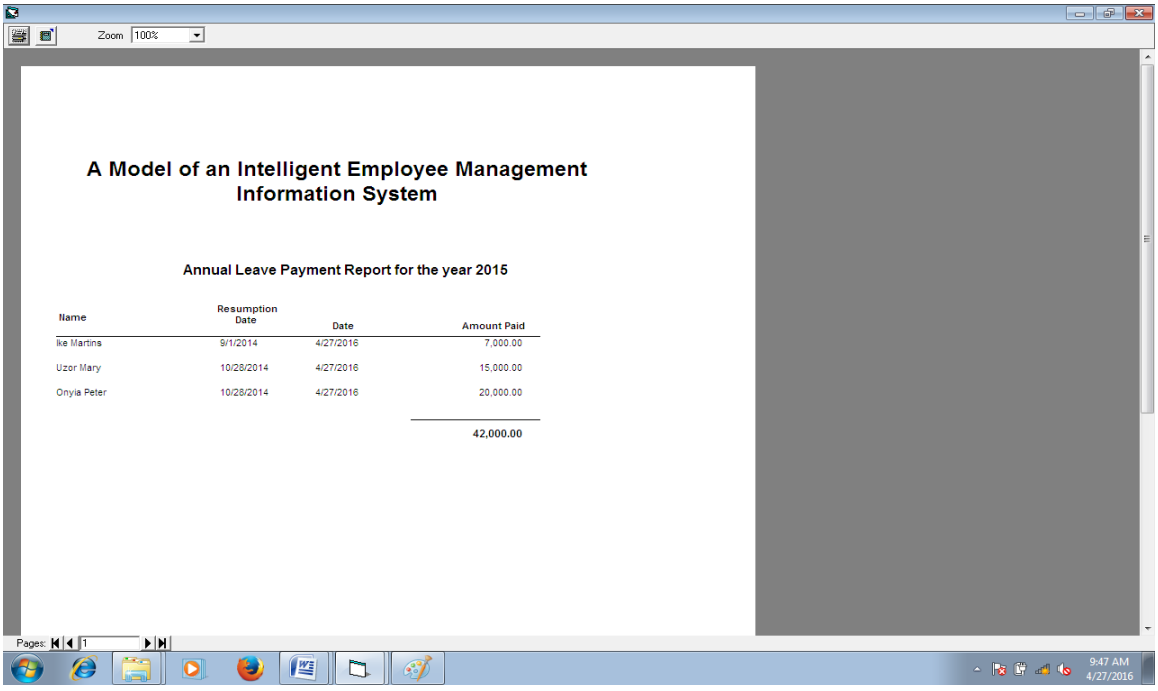

Fig 12: Staff annual leaves payment Report

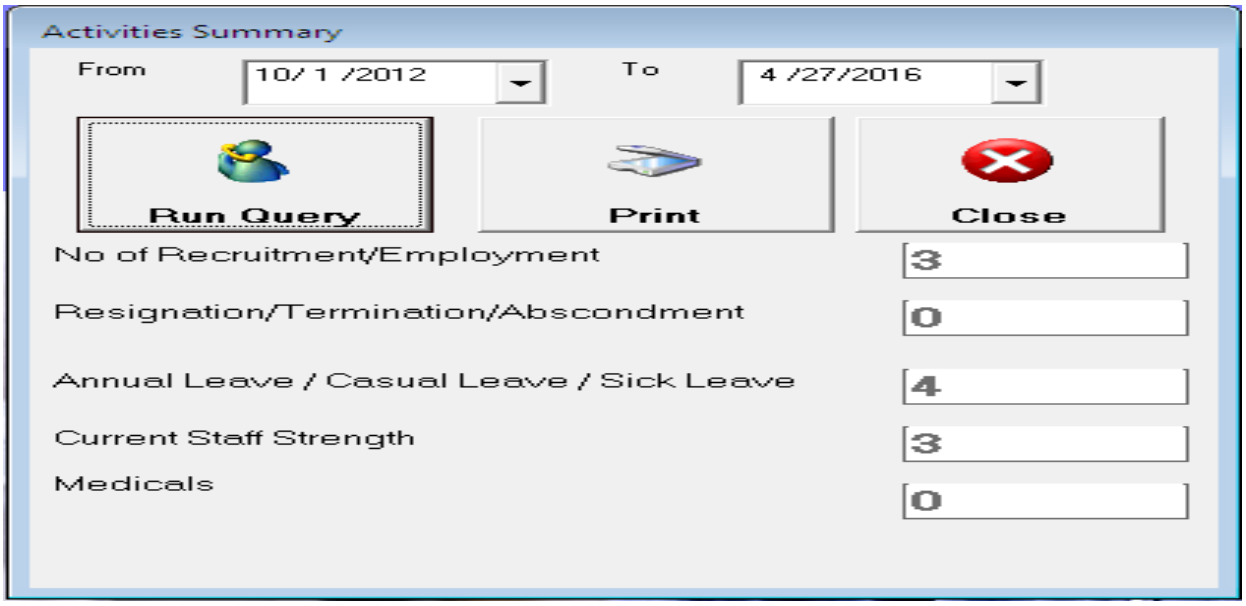

Fig 13: HR Activities Report

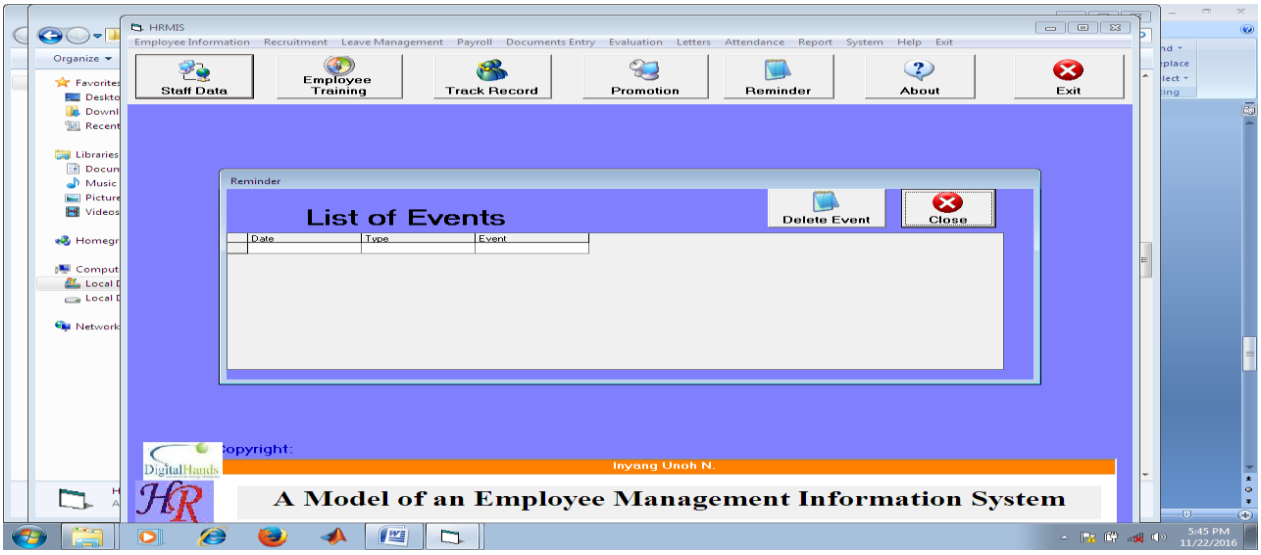

Fig 14: Automatic Events/Document Expiry Alert

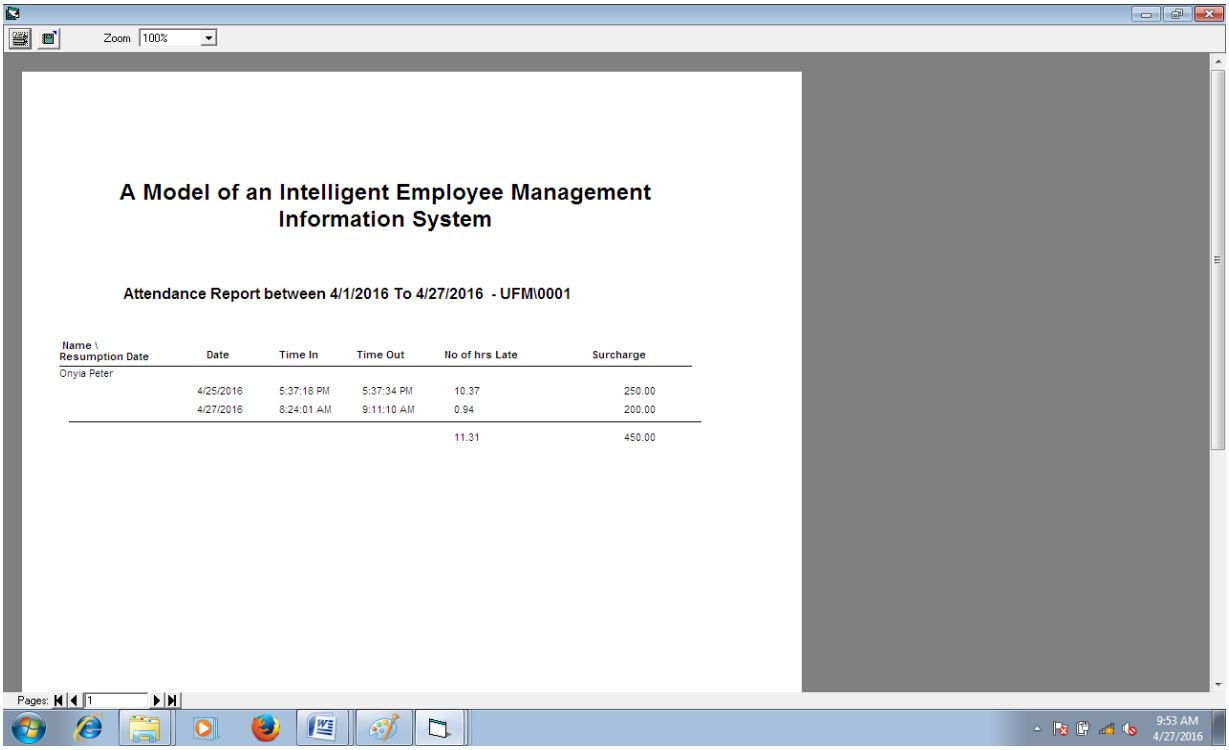

Fig 15: Staff Attendance Report

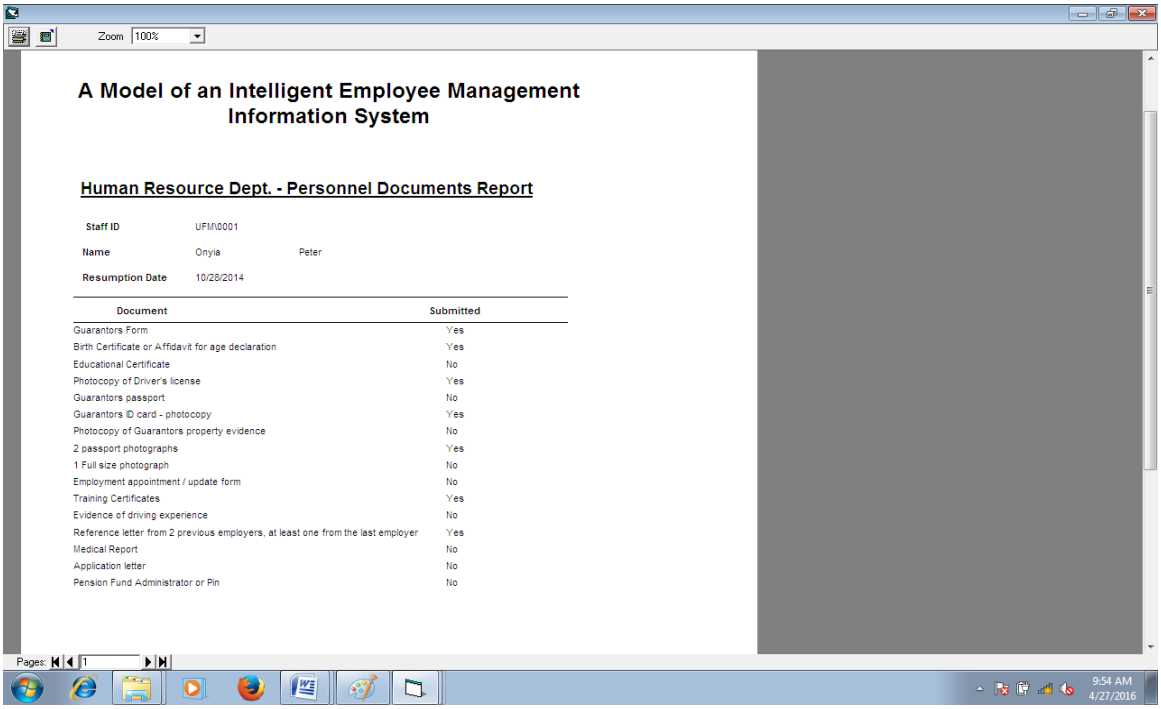

Fig 16: Staff Document Submission Report

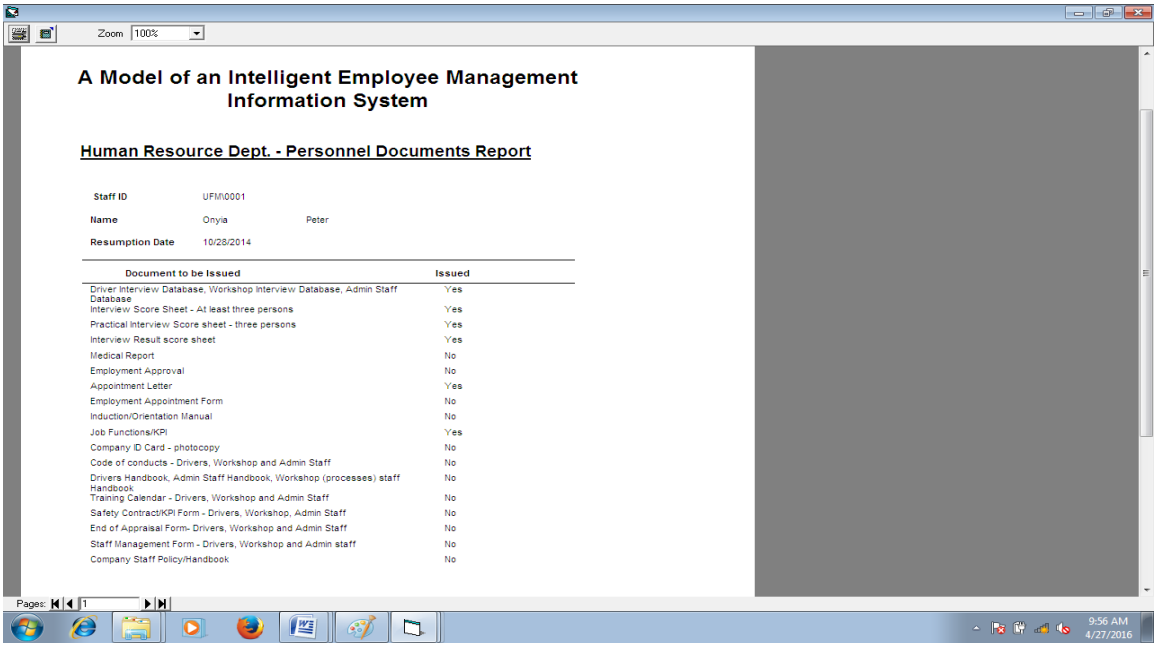

Fig 17: Staff Document Issued Report

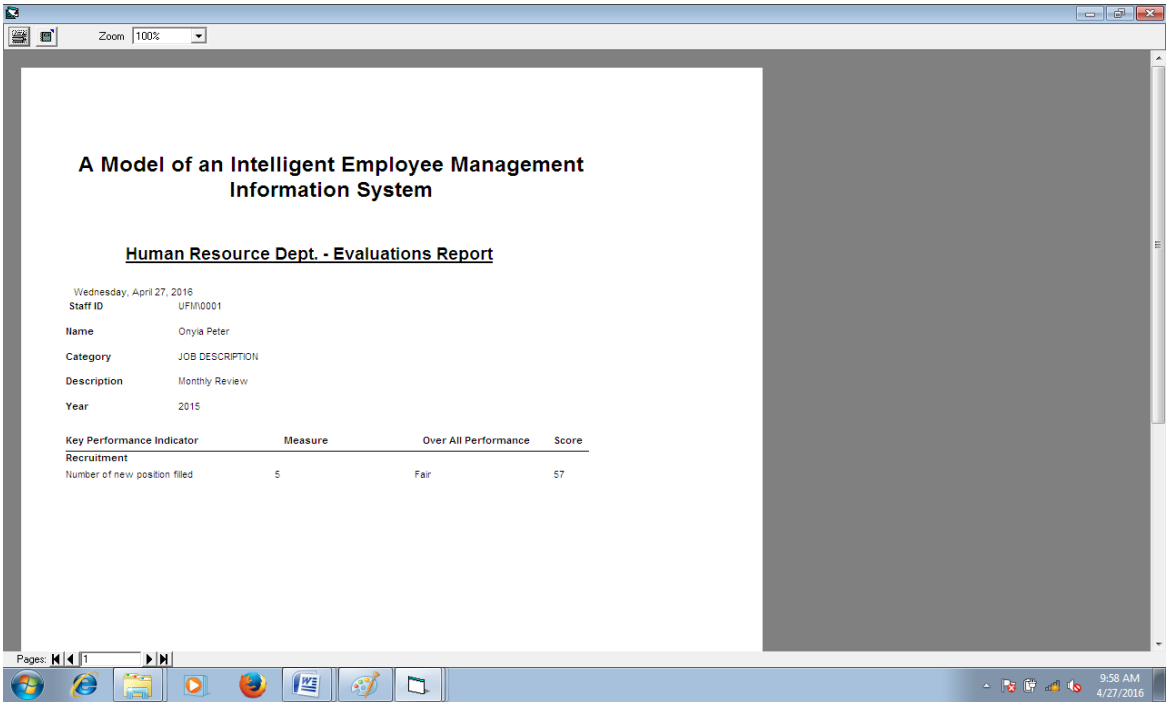

Fig 18: Staff Performance Evaluation Report

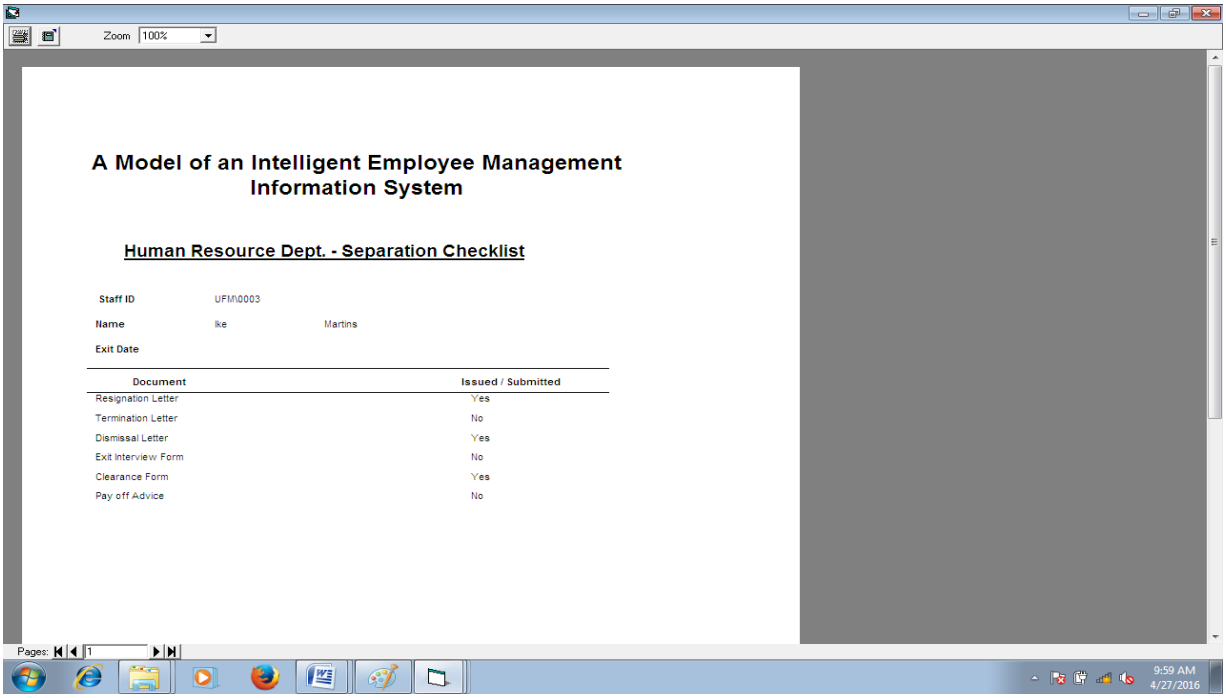

Fig 19: Staff Exit document Report

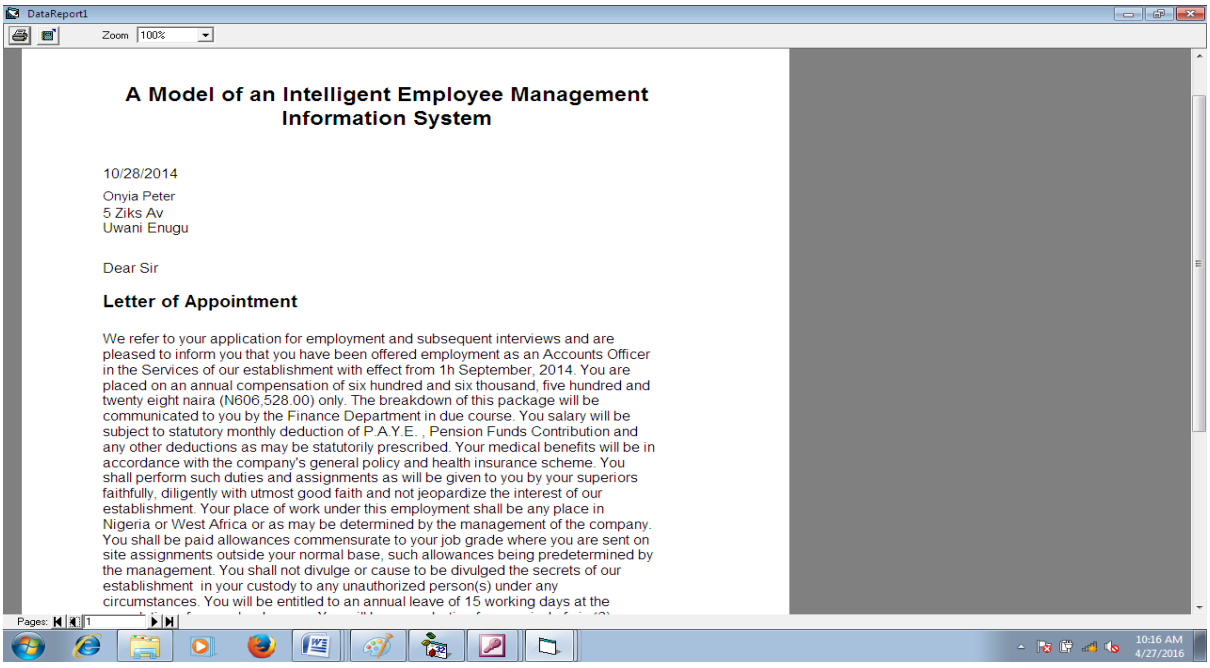

Fig 20: Staff Electronic mail Report

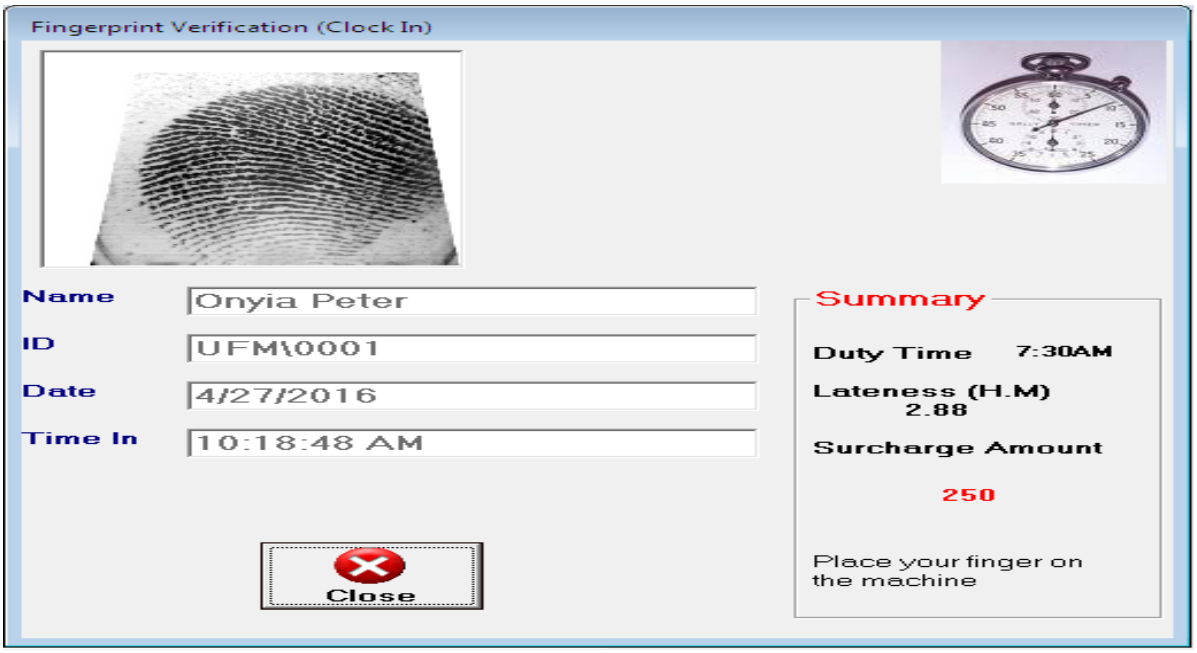

Fig 21: Staff biometric attendance (Clock In)

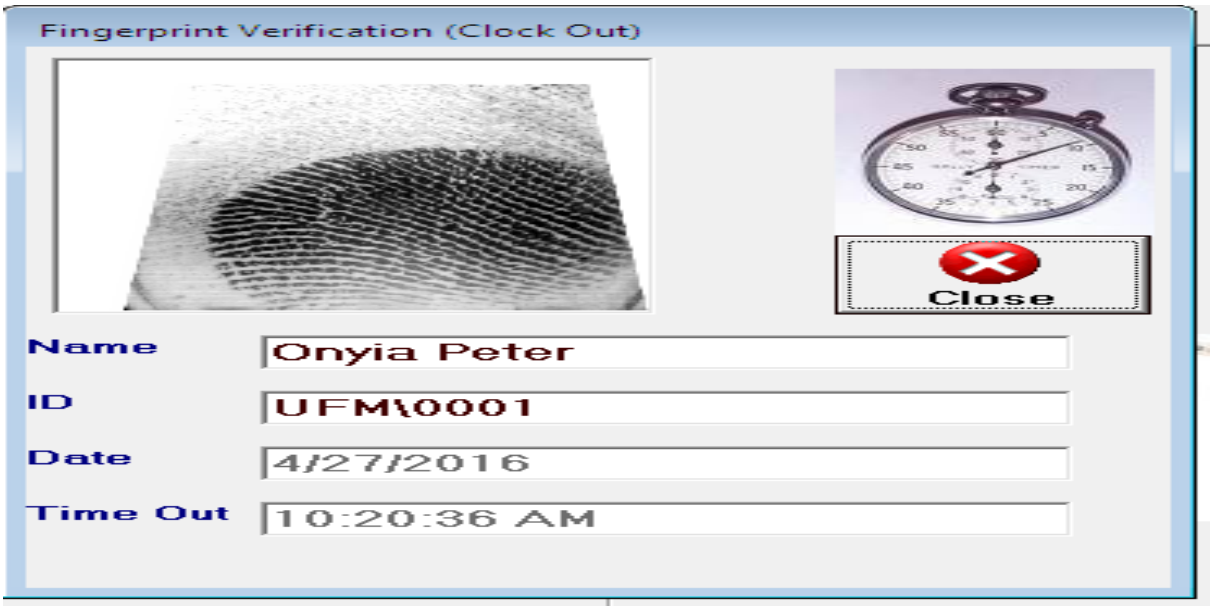

Fig 22: Staff biometric attendance (Clock Out)

6.0 Conclusions and Recommendations

The Human Resource (HR) unit plays a very important role in the administration of every organization. Attention to labour matters on employee recruitment, performance assessment, training, remunerations; issues relating to management and the need to interact effectively with the overall employee management information system are the most crucial ones. Modern employee management information system in large organizations requires the use of electronic device such as computers to cope with these challenges. An employee management information system solution will reduce the costs and errors associated with the collection, submission, approval and administration process, thereby greatly reduce inaccuracies caused by human error, report preparation time, management of labour costs and time misappropriation due to late arrivals and early departure.

The study reveals the fact HR is an integral part of management activities. No doubt, this allows the benefits associated with automation to be exploited to its fullest. It had really assisted many organizations in the areas of communication and or reporting. Management benefits by receiving more accurate, up-to-date information, from which it can forecast, plan and control.

Deadlines on issues relating to the employee management (e.g. recruitment, performance assessment, payment of wages, salaries, allowances, size of staff etc.) and other management issues (e.g. surcharge deductions) become administratively and operationally effective due to benefits derived in automation. The research shows that fingerprint has served several organizations well. No two fingerprints have ever been found identical in many trillions of human and automated computer comparisons. Fingerprints are the basic tool for the identification of people with a criminal history in every security agency. It remains the most commonly gathered forensic evidence worldwide and in most jurisdictions, fingerprints examination out numbers all other forensic examination case work combined together. Moreover, it continues to expand as the premier method for identifying persons, with tens of thousands of people added to fingerprint repositories on daily basis far more than other forensic databases. This facilitated the use of fingerprint in marking daily attendance.

So far, the various modules have been tested and each has proven to be very efficient as an entity (i.e Modules). The system was intergrated and tested which shows all the modules intergrated into subsystem and standing as main system. However, in spite of the success recorded during the test running of this system, future works are hereby recommended:

1. **Improvement on Leave Management:** The leave management module should be improved. This can be achieved by having all leave requests approved by the head of units or departments before submission, rather than going straight to the HR manager. This feature is imperative because the Head of Department should know which of his employees is on leave or to proceed on leave.
2. In future, the system should be implemented using other robust programming tools like Oracle which is more tolerant to many user's access at a time, and more appropriate for a network environment.

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Examining the Relationship between Leadership Styles and, Employee Productivity in the 21st Century

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Abstract

This study explored the critical relationship between leadership styles and employee productivity in the 21st Century. As the global business landscape continued to evolve, effective leadership has become increasingly crucial for driving employee engagement, motivation, and productivity. This study examined the impact of various leadership styles, including transformational, transactional, and servant leadership on employee productivity. Through analytical review of leadership styles and employee productivity in the 21st century, this research revealed that leadership styles significantly influence employee job satisfaction, commitment, and overall performance. Transformational leadership in particular is found to have a positive impact on employee productivity, thus fostering a work environment that encouraged innovation, creativity, and, collaboration. This work is concerned about adopting a transformational leadership approach that would help organizations improve employee productivity, enhance job satisfaction, and drive business success. The researchers recommended amongst others that leadership development programs that focused on building transformational leadership skills should be prioritized.

Keywords: *Leadership styles, employee productivity, transformational leadership, organizational performance, job satisfaction.*

1.0 Introduction

The relationship between leadership styles and employee productivity has become a focal point of organizational research in the 21st century. As the global economy continues to evolve, organizations are seeking ways to optimize their performance and achieve sustainable

competitive advantage. Leadership plays a crucial role in determining the success of an organization, and employee productivity is a key outcome of effective leadership. The background of this study is rooted in the understanding that leadership styles can significantly impact employee motivation, job satisfaction, and overall productivity. With the changing nature of work and the increasing importance of knowledge, workers need to adopt leadership styles that foster a culture of innovation, collaboration, and continuous learning.

Leadership styles refer to the approaches and behaviors that leaders use to motivate, direct, and inspire their followers. Historically, leadership styles have evolved from autocratic and bureaucratic approaches to more participative and transformational styles. The workability of leadership styles depends on various factors, including the organizational culture, employee characteristics, and the nature of the task. Different leadership styles, such as transactional, transformational, and servant leadership, have been studied extensively in the literature. However, the effectiveness of these styles in the 21st century requires further examination, particularly in the context of rapidly changing organizational environments and diverse workforce demographics.

Employee productivity refers to the output and efficiency of employees in achieving organizational goals. In the 21st century, employee productivity is critical for organizational success, particularly in knowledge-intensive industries. The duties of employees have evolved to include more complex tasks, such as problem-solving, critical thinking, and collaboration. The usability of employees depends on various factors, including their skills, motivation, and job satisfaction. Organizations need to adopt strategies that enhance employee productivity, such as providing opportunities for professional development, recognizing and rewarding employee contributions, and fostering a positive work environment.

The impact of leadership styles on employee productivity is a critical area of research in organizational behavior. Leadership styles can influence employee motivation, job satisfaction, and overall productivity. Transformational leadership, for example, has been shown to enhance employee creativity, innovation, and commitment. On the other hand, autocratic leadership styles can lead to decreased employee motivation and productivity. The effectiveness of leadership styles in enhancing employee productivity depends on various factors, including the organizational culture, employee characteristics, and the nature of the task. Organizations need to adopt leadership styles that foster a culture of collaboration, innovation, and continuous learning.

In a depressed economy, productivity is critical for organizational survival and success. Organizations need to adopt strategies that enhance employee productivity, such as reducing costs, improving efficiency, and increasing innovation. Leadership styles play a crucial role in determining employee productivity in a depressed economy. Leaders need to adopt styles that foster a culture of resilience, adaptability, and innovation. The essence of productivity in a depressed economy lies in the ability of organizations to optimize their resources, reduce waste, and improve efficiency.

The inclusion of leadership styles and employee productivity in National Policy on Education is critical for developing a workforce that can drive economic growth and innovation. Educational institutions need to adopt curricula that emphasize leadership development, critical thinking, and problem-solving. Leadership styles that foster a culture of innovation, collaboration, and continuous learning need to be promoted in educational institutions. By incorporating leadership styles and employee productivity in National Policy on Education, governments should develop a workforce that is equipped to drive economic growth and innovation in the 21st century.

2.0 Leadership Styles

Transformational leadership has emerged as a dominant paradigm in the 21st century, characterized by its emphasis on inspiring and empowering followers (Bass & Riggio, 2006). In the digital age, transformational leaders must leverage technology to facilitate communication, collaboration, and innovation. By fostering a culture of experimentation and learning, transformational leaders can drive organizational growth and success in a rapidly changing environment.

Servant leadership has gained significant attention in recent years, with its focus on prioritizing the needs of followers and promoting a culture of service (Greenleaf, 1970). In the 21st century, servant leaders must balance the needs of various stakeholders, including employees, customers, and the wider community. By doing so, they can create a positive organizational culture that fosters engagement, motivation, and productivity

Authentic leadership has become increasingly important in the 21st century, given the complexity and uncertainty of the global business environment (Walumbwa, 2008). Authentic leaders prioritize transparency, honesty, and integrity, which can foster trust and credibility among followers. By being true to themselves and their values, authentic leaders can navigate complex challenges and make informed decisions that benefit their organizations.

Emotional intelligence has been recognized as a critical component of effective leadership in the 21st century (Goleman, 1995). Leaders with high emotional intelligence can understand and manage their own emotions, as well as those of their followers. By doing so, they can create a positive work environment that fosters collaboration, creativity, and productivity.

Globalization has created new challenges and opportunities for leaders in the 21st century. Leaders must navigate diverse cultural contexts, manage global teams, and make decisions that balance local and global priorities (House, 2004). By developing a global mindset and being sensitive to cultural differences, leaders can effectively lead their organizations in a globalized world.

Leaders play a critical role in fostering a culture of innovation, which involves encouraging experimentation, taking calculated risks, and learning from failure (Amabile, 1993). By creating an environment that supports innovation, leaders can drive growth and stay ahead of the competition.

The COVID-19 pandemic has accelerated changes in the business environment, highlighting the need for leaders to be adaptable, resilient, and visionary. In a post-pandemic world, leaders must prioritize the well-being of their followers, foster a culture of collaboration and innovation, and leverage technology to drive growth and success. By doing so, they can create organizations that are agile, responsive, and sustainable in the face of uncertainty.

2.1 Employee

Employee engagement has become a critical aspect of organizational success, with research suggesting that engaged employees are more productive, innovative, and committed to their organizations (Berdahl, 2016). However, the nature of employee engagement is evolving, with the rise of remote work and the gig economy. Employees are increasingly seeking flexibility, autonomy, and purpose in their work, and organizations must adapt to meet these changing needs.

The increasing use of artificial intelligence (AI) in the workplace is transforming employee roles and responsibilities. While AI has the potential to automate routine tasks and enhance productivity, it also poses challenges for employees who must adapt to new technologies and workflows (Aguinis, 2017). Organizations must invest in employee training and development to ensure that their workforce remains relevant in an AI-driven economy.

Employee well-being has become a critical concern in the modern workplace, with research suggesting that happy and healthy employees are more productive, creative, and engaged

(Lyubomirsky, 2005). Organizations must prioritize employee well-being by providing resources and support for mental health, work-life balance, and physical health. By doing so, they can create a positive work environment that fosters employee satisfaction and retention.

Employee autonomy has been recognized as a key driver of innovation and creativity in the workplace. When employees are given the freedom to make decisions and take risks, they are more likely to develop novel solutions and ideas (Amabile, 1993). Organizations must balance the need for control and accountability with the need for employee autonomy, providing employees with the freedom to innovate and experiment.

The future of employee development will be shaped by technological advancements, demographic changes, and shifting workforce needs. Organizations must prioritize continuous learning and development, providing employees with opportunities to upskill and reskill in response to changing job requirements (Goleman, 1995). By investing in employee development, organizations can build a future-ready workforce that is adaptable, resilient, and equipped to thrive in a rapidly changing world.

2.2 Productivity

Productivity is a complex and multifaceted concept that encompasses various aspects of work performance, including efficiency, effectiveness, and quality (Sink & Tuttle, 1989). While traditional measures of productivity focus on output per hour, modern approaches recognize the importance of factors such as employee well-being, job satisfaction, and organizational culture. By adopting a more holistic view of productivity, organizations can create a work environment that supports both employee and organizational success.

Technology has transformed the way we work, with digital tools and platforms enabling greater flexibility, collaboration, and productivity (Autor, 2015). However, the impact of technology on productivity is not uniform, and organizations must carefully consider the benefits and drawbacks of different technologies. By investing in technologies that support employee needs and workflows, organizations can unlock productivity gains and improve overall performance.

Employee autonomy has been recognized as a key driver of productivity, with research suggesting that employees who are given greater freedom and flexibility are more likely to be motivated and engaged (Hackman & Oldham, 1976). Organizations can foster employee autonomy by providing opportunities for job crafting, flexible work arrangements, and participative decision-making. By empowering employees to take ownership of their work, organizations can unlock productivity gains and improve job satisfaction.

Workplace culture plays a critical role in shaping productivity, with research suggesting that positive cultures can enhance employee engagement, motivation, and performance (Schein, 2010). Organizations can create a positive work culture by prioritizing employee well-being, recognizing and rewarding employee contributions, and fostering a sense of community and collaboration. By investing in a positive work culture, organizations can improve productivity and drive business success.

Leadership plays a critical role in driving productivity, with effective leaders able to motivate, inspire, and empower their employees (Bass & Riggio, 2006). Organizations can develop productive leaders by providing training and development opportunities, setting clear goals and expectations, and fostering a culture of accountability and feedback. By investing in leadership development, organizations can unlock productivity gains and drive business success.

Employee well-being has become a critical concern in the modern workplace, with research suggesting that happy and healthy employees are more productive, creative, and engaged (Lyubomirsky et al., 2005). Organizations can prioritize employee well-being by providing resources and support for mental health, work-life balance, and physical health. By investing in

employee well-being, organizations can improve productivity and drive business success.

The COVID-19 pandemic has accelerated changes in the way we work, with remote work and digital technologies becoming increasingly prevalent. As organizations look to the future, they must prioritize productivity strategies that support employee well-being, flexibility, and autonomy. By investing in technologies, cultures, and leadership practices that support productivity, organizations can thrive in a post-pandemic world and drive business success.

3.0 A Critical Analysis of Leadership Styles

According to Bass, (1985) in Benson(2022), transformational leadership is a style that inspires and motivates followers to achieve exceptional results. Transformational leaders empower their followers, foster a sense of community, and encourage innovation. However, critics have argued that this style can be overly dependent on the leader's charisma and may not be effective in all contexts. Bass's work has been influential in shaping our understanding of transformational leadership, but further research is needed to explore its limitations and potential applications.

Greenleaf (1970) in Eze, (2021), a pioneer of servant leadership, emphasized the importance of prioritizing the needs of followers and fostering a sense of community . Servant leaders prioritize the well-being and growth of their followers, which can lead to increased job satisfaction and commitment. However, critics have argued that this style can be challenging to implement in practice, particularly in organizations with limited resources. Recent research has explored the benefits and challenges of servant leadership that highlighted the need for further study on its applications and limitations.

Yukl (2010), a leadership researcher, noted that autocratic leadership involves making decisions without input from followers. While this style can be effective in certain contexts, such as crisis situations, it can also lead to decreased motivation and job satisfaction among followers. Critics have argued that autocratic leadership can stifle creativity and innovation, leading to negative outcomes for organizations. Further research is needed to explore the contexts in which autocratic leadership is most effective and its potential limitations.

Bennis (2003), a leadership expert, emphasized the importance of involving followers in decision-making processes. Democratic leaders foster a sense of ownership and accountability among followers, which can lead to increased motivation and job satisfaction. However, critics have argued that this style can be time-consuming and may not be effective in situations requiring rapid decision-making. Recent research has explored the benefits and challenges of democratic leadership that highlighted the need for further study on its applications and limitations.

Judge (2000), a leadership researcher, noted that laissez-faire leadership involves giving followers a high degree of autonomy and minimal supervision. While this style can be effective for highly motivated and experienced followers, it can also lead to confusion and lack of direction among followers. Critics have argued that laissez-faire leadership can result in a lack of accountability and decreased productivity. Further research is needed to explore the contexts in which laissez-faire leadership is most effective and its potential limitations.

Avolio (2005), a leadership researcher, emphasized the importance of setting clear expectations and providing rewards for performance. Transactional leaders focus on exchanging rewards for desired behaviors, which can lead to increased productivity and performance. However, critics have argued that this style can be overly focused on short-term gains and may not promote long-term growth and development. Recent research has explored the benefits and limitations of transactional leadership that highlighted the need for further study on its applications and potential drawbacks.

George (2003), a leadership expert, emphasized the importance of leaders being true to themselves and their values. Authentic leaders foster a sense of trust and respect among followers, which can lead to increased loyalty and commitment. Critics have argued that authentic leadership can be challenging to develop and maintain, particularly in complex and dynamic environments. Further research is needed to explore the development and impact of authentic leadership, as well as its potential applications and limitations.

3.1 Intersectionality of Leadership Styles and Employee Productivity

Grant (2013), a renowned leadership researcher, noted that transformational leadership is positively related to employee productivity, as it inspires and motivates employees to achieve exceptional results. Transformational leaders empower their employees, foster a sense of community, and encourage innovation that would lead to job satisfaction and productivity. However, Hogan's research emphasized the importance of considering the context in which transformational leadership is implemented, as its effectiveness may vary depending on organizational culture and employee characteristics.

Schein (2020), a servant leadership researcher emphasized the importance of prioritizing employee needs and fostering a sense of community in enhancing productivity. Servant leaders prioritize the well-being and growth of their employees, which can lead to job satisfaction, engagement, and productivity. Sendjaya's research is centered on the potential benefits of servant leadership in promoting employee productivity, particularly in organizations with a strong focus on employee development and well-being.

Aguinis (2019), a leadership researcher, maintained that autocratic leadership can have a negative impact on employee productivity, as it can lead to decreased motivation and job satisfaction .Autocratic leaders make decisions without input from employees, which can result in a lack of ownership and accountability among employees. Aguinis's research highlighted the importance of considering the potential drawbacks of autocratic leadership and exploring alternative leadership styles that prioritize employee involvement and empowerment.

Berdahl (2016), a leadership researcher, emphasized the benefits of democratic leadership in enhancing employee productivity, as it fosters a sense of ownership and accountability among employees. Democratic leaders involve employees in decision-making processes, which can lead to increased motivation, job satisfaction, and productivity. Berdahl's research highlighted the potential benefits of democratic leadership in promoting employee productivity, particularly in organizations with a strong focus on teamwork and collaboration.

Grant (2013), an organizational psychologist, noted that laissez-faire leadership can have a negative impact on employee productivity, as it can lead to confusion and lack of direction among employees. Laissez-faire leaders give employees a high degree of autonomy, which can be beneficial for highly motivated and experienced employees but may not be effective for all employees. Grant's research highlighted the importance of considering the potential drawbacks of laissez-faire leadership and exploring alternative leadership styles that provide more guidance and support.

Judge (2017), a leadership researcher, emphasized the importance of setting clear expectations and providing rewards for performance in enhancing productivity. Transactional leaders focus on exchanging rewards for desired behaviors, which can lead to increased productivity and performance. Judge's research highlighted the potential benefits of transactional leadership in promoting employee productivity, particularly in organizations with a strong focus on performance and results.

Luthans (2015), a leadership researcher, was of the view that authentic leadership is positively related to employee productivity, as it fosters a sense of trust and respect among employees.

Authentic leaders prioritize the well-being and growth of their employees, which can lead to increased job satisfaction, engagement, and productivity. Luthans's research highlighted the potential benefits of authentic leadership in promoting employee productivity, particularly in organizations with a strong focus on employee development and well-being.

4.0 Conclusion

This study explored the complex relationship between leadership styles and employee productivity that highlighted the importance of considering the intersectionality of leadership styles and employee characteristics. The findings suggested that different leadership styles can have varying impacts on employee productivity, depending on the context and employee characteristics.

The study's results have implications for organizational leaders, and emphasized the need for adaptable and flexible leadership approaches that take into account the unique needs and characteristics of employees. By understanding the intersectionality of leadership styles and employee productivity, leaders should develop more effective strategies for promoting employee productivity and achieving organizational goals.

The study's findings also highlighted the importance of considering the potential drawbacks of certain leadership styles, such as autocratic leadership, and exploring alternative leadership styles that prioritized employee involvement and empowerment. By doing so, leaders should create a more positive and productive work environment that supported the well-being and growth of employees.

Furthermore, the study's results suggested that authentic leadership is positively related to employee productivity that emphasized the importance of leaders being true to themselves and their values. Authentic leaders foster a sense of trust and respect among employees, which should lead to increased job satisfaction, engagement, and productivity.

In conclusion, this study contributed to our understanding of the complex relationship between leadership styles and employee productivity, and highlighted the importance of considering the intersectionality of leadership styles and employee characteristics. By developing more effective leadership strategies, organizations should promote employee productivity, achieve organizational goals, and create a more positive and productive work environment.

4.1 Recommendations

The researchers therefore recommended as follows:

1. To adopt Flexible
2. Leadership Approaches
3. To foster Employee Empowerment Initiatives
4. To Promote Authentic Leadership Practices
5. To Develop Contextual Leadership Strategies
6. To Enhance Employee Engagement Programmes

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Mitigating Social Engineering Attacks Using Machine Learning and Artificial Intelligence

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Abstract

This study examined how social engineering attacks can be mitigated using machine learning and artificial intelligence. Secondary data was collected for this study from previously published literature, which was based on the inclusion and exclusion criteria identified by the researcher. Using specified inclusion and exclusion criteria, only five (5) articles were selected for the study from different databases. The study revealed that AI and machine learning models have proven highly effective in detecting and preventing various forms of social engineering, with phishing emerging as the most commonly used attack method. AI-driven algorithms are capable of analyzing large volumes of data to identify patterns of malicious behavior, such as scam messages or suspicious social media posts, thereby reducing the risk of security breaches. The study recommends that individuals should actively engage in cybersecurity education, making use of free online resources and training courses to stay informed about the latest social engineering tactics. Also, the study recommends that future studies should look into how artificial intelligence and machine learning can be utilized in preventing social engineering attacks, with a specific focus on data privacy efficacy.

Keywords: *Cyber security, Artificial Intelligence, Social Engineering, Machine Learning, Cyber Threat Prevention, Information Assurance*

1.0 Introduction

Every organization's hardware, software, personnel, services, and information are its assets. These resources are vulnerable to intrusions and unlawful access, which might jeopardize the availability, confidentiality, and integrity of the data. The purposeful manipulation of people into disclosing sensitive information or doing acts that usually lead to unauthorized access and possible breaches is known as "social engineering," a phrase that has been firmly ingrained in the vocabulary of cyber security (Sood et al., 2017). This type of cyber threat exploits human weaknesses by preying on psychological and behavioral tendencies rather than systemic ones. Social engineering has become prevalent and dangerous in today's digital age, which concerns the exploitation of human psychology rather than

technical vulnerabilities to breach security systems (Wang et al., 2021).

Cyber attacks are often made feasible by the human layer due to their great complexity and ability to exploit human weaknesses (Kaushalya et al., 2018). Organizations must be aware of and prepared for social engineering (SE) attacks, which include fraud, infiltration, extortion, espionage, and identity theft. These actions thus have a significant effect (Edward et al., 2017).

However, the current initiatives that have been made to quantify these assaults and the resulting effects they have on a large number of individuals are unknown. Drew and Cross (2016) claimed that a business would suffer greatly from successful SE, including: lost data, financial losses, poor staff morale, and diminished consumer loyalty. In rare circumstances, there may even be problems with legal and regulatory compliance.

Due to their manipulation of human nature rather than the imposed security mechanism, SE attacks are difficult to detect even with the most sophisticated security software and hardware (Bhusal, 2021). This has made it difficult to identify this assault. False memories, difficulty focusing for extended periods of time or in a different stimulus environment, and an innate propensity to trust and assist others are some of the reasons why people tend to be more vulnerable to social engineering attacks (Conteh & Royer, 2016). Meanwhile, these factors are common among people and organizations that make use of different hardware and software for information management, service provision, and personnel as the case may be. Over the last years, attackers' methods and techniques for executing social engineering attacks have changed, which reflect the complexity of our society growing reliance on technology (Nicholson et al.,2017).

As a result, businesses need to make sure that staff members are aware of the dangers of social engineering and how to protect themselves from falling victim. In order to reduce the social engineering assaults, Aldawood and Skinner (2019) stressed the need for the implementation of regulations and training Social engineering attacks have become prevalent in virtually all parts of the world due to increasing access to technology and fraudsters' ability to leverage the human mind's susceptibility (Montañez et al., 2020). This is evident in the numerous studies (Salahdine & Kaab, 2019; Siddiqi et al., 2022; Wange et al., 2020) conducted around the world on social engineering attacks and the need to contain them. For instance, programs, among other instruments and strategies. These training programs and regulations can help to alleviate the occurrence and prevalence of social engineering attacks among businesses or organizations. In the present global climate, the cyber security infrastructure is continually in need of upgrading (Carter, 2021). As attackers' methods evolve, businesses or organizations must focus on employee education and awareness to mitigate risks. With tailored education and awareness programs, employees and other stakeholders can be guided in the use of systems in ways that would not make them fall prey to cyber security issue of social engineering (SE).
There are many efforts to prevent SE, or at least reduce its damage. Studies (Bullée et al.,2015; Ghafir et al., 2016) have confirmed the importance of people's awareness in reducing their interaction with criminals on the Web, which has made entrenching people's awareness an important proposed solution to social engineering attack. Using machine learning to train different devices to detect and flag social engineering attacks that occur through it is another proposed method (Alsufyani & Alzahrani, 2020). Also, artificial intelligence's (AI) unique capability to analyze enormous datasets, recognize intricate behavioral patterns, and facilitate real-time decision- making offers an arsenal of tools invaluable for mitigating the risks associated with social engineering attacks (Fakhouri et al., 2024). AI system may be configured to manage incoming calls and evaluate the content of work emails before an employee reads them, therefore preventing social engineering in the corporate sector (Fakhouri et al., 2024). Given this context, this study seeks to understand how AI and machine learning might be used to mitigate the impact of social engineering attacks.

Salahdine and Kaab (2019) suggested that social engineering attacks are the most potent since they Pose a danger to all networks and systems because of these human connections. Siddiqi et al. (2022) highlighted that social engineering-based cyber attacks can be countered by addressing human vulnerabilities through the use of machine learning-based methods. The study established that these methods can help counter

the highly effective and obscure approaches that may compromise organizations or businesses' vulnerabilities through social engineering attacks. According to Wang et al. (2020), in order to generate believable and focused social engineering assaults, particular targets must be carefully chosen. According to Siddiqi et al. (2022), the bulk of cyber attacks based on SE depend on real communications between the attacker and the victim. SE assaults may consist of a simple phone call when a person pretends to be an employee in order to obtain information, such as a PIN or password. According to Leonhardt (2021), Americans lost over USD 29.8 billion to phone scammers in 2020. This necessitates the use of modern, effective security technologies to combat and prevent cybercrime. Rather than relying just on stand-alone products, a comprehensive approach is required to manage and lessen the constantly changing risks associated with the digital age.

Large-scale, automated, and advanced social engineering attacks are made probable by technologies like machine learning and artificial intelligence, which can make social engineering attacks more sophisticated, successful, and directed (Wang et al., 2020). This is because these attacks can be launched semi-automatically using some open-source tools, and a large number of victims can be contacted simultaneously. Based on the foregoing, this study aims to examine how social engineering attacks can be mitigated using machine learning and artificial intelligence. Premised on this, specific objectives for this study are to:

1. Identify the patterns of social engineering attacks in cyber security;

2. Examine the effectiveness of machine learning algorithms and AI models for detecting social engineering attacks

3. Determine the effectiveness of machine algorithms and AI-based models for preventing social engineering attacks.

2.0 Review of Related literature

This section presents the conceptual clarification with respect to social engineering attacks, social engineering attacks in cyber security, artificial intelligence (AI), and machine learning (ML). Also the review discusses detecting social engineering attacks using machine learning and artificial intelligence. Also, the review provides past literature on mitigating social engineering attacks using artificial intelligence. The section is presented under different sub-headings.

2.1 Social Engineering Attacks

Attackers who use social engineering rely primarily on their ability to persuade and inspire trust. People are more prone to take actions that normally would not be appropriate to take when they come across these strategies. Social engineering attackers hunt victims to get nonpublic information that may be utilized for particular goals or vended on the black market and dark web (Manyam, 2022). Scams using social engineering target people's thoughts, feelings, and behaviors. If an attacker may readily alter a user's behavior if they understand what causes them to respond in certain ways. Most social engineering schemes depend on the victim and the attacker having direct contact (Chetiouia et al., 2022). Malicious individuals may easily use SE attacks to weaken communication networks. These assaults aim to trick individuals or groups into taking actions that will aid the attackers or get them access to personal data (Lopes et al., 2024). One of the biggest risks to network security is SE, which exploits the innate inclination of humans. Due to the fast rise of socio-technical systems, people are simultaneously becoming an essential component of the system and having a greater role in the information system (Patcha & Park, 2007).

According to Salahdine and Kaabouch (2019), social engineering assaults have the same structure with comparable stages despite their differences. The typical pattern consists of four stages: gathering data about the target; establishing rapport with the target; using the

information at hand to launch the assault; and leaving no trace behind. In order to achieve certain goals, social engineering often uses dishonest techniques, including impersonation and false identity, to obtain assets, systems, or sensitive data. Social engineering assaults may have serious repercussions, including monetary losses, reputational harm, and heightened susceptibility to cybercrime, for individuals, enterprises, and society as a whole (Schneier, 2021). The 21st Century has seen changes in businesses, media, social interactions, education, and internet platforms. As a result, there has been a significant increase in the amount and importance of information flowing through the digital world. As a result, increasing cybercriminal activities have resulted in data breaches, malware, ransom ware, and phishing attempts (Gupta et al., 2023).

2.2 Social Engineering Attacks in Cyber security

This section examines the different types of engineering attacks that are common in cyber security. This literature reviews three, namely phishing, tailgating, and pretexting.

2.2.1 Phishing

Phishing is the most common method-based social engineering attack. Its goal is to trick or mislead the target in order to get private or sensitive data (Chang et al., 2013). Attackers reroute links on the Internet using a range of techniques, including emails and SMS messages sent to phones. These strategies are intended to persuade the recipient that the sender is a reputable organization, bank, or credit card company that requests "verification" of personal information and threatens dire consequences if the request is not fulfilled (Abass, 2018; Thapar, 2007).

Typically, the sender includes a link in the email that takes the recipient to a fake website that is dangerous (Lohani, 2019). Phishing may appear in the form of fake websites, advertisements, emails, PayPal pages, antivirus software, and misleading promises of freebies. Attackers may utilize emails or phones to lure victims into divulging personal information by promising a big reward (Mishra and Soni, 2019). According to Williams, Hinds, and Joinson (2018), phishing emails encourage workers to download malicious attachments and links, which give hackers access to an organization's network. An employee may be the target of a phishing email, which may also include a believable logo, a URL that takes the recipient to a login page where they must validate their credentials, or a message that should be responded to right away.

2.2.2 Tailgating

Tailgating, commonly known as "piggybacking," is a social engineering method that includes attackers who have no valid authentication in an organization (Jeevetha, 2023). This kind of assault is characterized by the attacker creating a character and fabricating a tale about the figure in an attempt to take advantage of the victim's innate compassion, fear, and greed (Workman, 2008). According to Chetiouia (2024), it is used to trick you into thinking a hacker really belongs in a protected facility by fitting in. The method simply involves tracking an individual who has been granted permission to enter a restricted area. Employees with little experience might be duped easily. Less senior employees may worry about being refused access by senior managers and the possible (undue) retaliation that may follow. To gain access to the location, the social engineer can employ a number of strategies, including talking to the victim and showing empathy to earn their trust, convincing them that he has misplaced or forgotten his card, posing as a new coworker, using a fictitious card and justifying it with a potential malfunction, or posing as an authority figure (Mitnick & Simon, 2006).

2.2.3 Pretexting

Pretexting is an attack tactic wherein attackers fabricate circumstances that seem plausible in order to get personal information from a victim (Workman, 2008). In order to gain the trust of the victim and trick them into disclosing sensitive information or taking actions, attackers typically concentrate on fabricating a plausible story or a convincing pretext by posing as coworkers, police officers, bank employees,

or tax officials (Yasin et al., 2019). These scams are primarily carried out via phone calls or emails. They acquire information from a variety of sources, including phone books, websites, business conferences, social media platforms, and corporate profiles, in order to be ready for the assault (Thilakarathne & Samarasinghe, 2022).

2.3 Artificial Intelligence

Artificial intelligence refers to computer programs that use methods similar to human intellect to resolve complex problems. This area of computer science focusses on the research and creation of intelligent software and hardware. Robinson (2018) claims that after decades of study, one of the most challenging subjects in digital computing is artificial intelligence (AI). Nevertheless, given its innovative uses in every industrial area, it is sweeping the world. According to Singh (2019), the area of research was established on the premise that intelligence, or human understanding, is a fundamental human attribute that can be accurately characterized to the point that a computer might replicate it. This brings up philosophical themes that literature, philosophy, and folklore have explored since antiquity, including the nature of reality and the behaviors of constructed objects. Artificial intelligence has resulted in both significant advancements and noteworthy modifications (Lexcellent, 2019). It now has a big impact on the technology industry and offers strong answers to a lot of challenging informatics issues. O'Leary (2013) states that understanding, reasoning, organization, study, perception, communication, and object manipulation and movement are among the main objectives of AI research.

2.4 Detecting Social Engineering Attacks Using Artificial Intelligence

The capacity to quickly identify threats is at the core of every effective cybersecurity plan. Conventional systems, which depend on pre-established signatures, often collapse when faced with new or evolving threats. AI is excellent in this area since it is based on data-driven decision- making (Fakhouri et al., 2024). Furthermore, a lot of the automation involved in incident response and danger hunting depends on AI. Because cyber threats are changing so quickly, human error may occur in manual detection and response systems, making them insufficient. AI- driven automation streamlines these processes and allows cyber security experts to respond more rapidly and expertly (Khan et al., 2024). AI systems may automatically correlate information from several sources, including firewalls, intrusion detection systems, and antivirus software, to identify such dangers. According to You and Darling (2019), artificial intelligence has the capability to identify potential threats and trigger automatic reactions, such as IP address filtering, system isolation, and security personnel alerts. Being able to react quickly is critical for preventing damage and danger from spreading across a company's network.

2.5 Mitigating Social Engineering Attacks Using Artificial Intelligence

Although technology undoubtedly plays a significant part in cyber security, people continue to be both an important resource and a possible weakness. Training programs and user awareness campaigns have historically been critical in strengthening this human firewall. However, due to the wide range of dangers and the ever-changing nature of cyber hazards, conventional training approaches may not adequately prepare users. A paradigm change is provided by the incorporation of AI into awareness and training programs. AI makes it possible to create customized, adaptive training experiences rather than generic, one-size-fits-all training modules.

AI is able to create training scenarios that are specific to each user's level of skill and weakness by assessing their individual behavior, prior interactions, and even their reaction times to simulated dangers (Precup and David, 2019). One person who downloads attachments regularly may get training on malware concerns, while another who clicks on embedded links in emails frequently would be exposed to more realistic phishing simulations. These AI-powered simulations are dynamic, changing in reaction to user input to keep

training interesting, demanding, and relevant. Moreover, real-time data may be used by AI-enhanced awareness campaigns to notify users of new dangers. Users may stay informed and attentive by receiving

just-in-time warnings about new vulnerabilities, attack vectors, or recommended practices in place of periodic, planned updates (Javad & Koofigar, 2017).

2.6 Machine Learning

The simplest definition of machine learning (ML), a subset of artificial intelligence, is the ability of systems to learn from the past in order to forecast the future (Data Robot AI Experience, 2018). To "learn" the link between data variables, algorithms are used. Another description offered by Prado (2018) is that an ML algorithm learns patterns in a high-dimensional space without being particularly instructed. These correlations may then be used to forecast outcomes in predictive analytics or predictive modelling for a fresh data set. In contrast to conventional statistical modelling, it doesn't assume any prior knowledge of the "rules." The capacity of a computer to mimic intelligent human behavior is known as machine learning, which is a subset of artificial intelligence (Brown, 2021). Complex tasks are carried out by artificial intelligence systems in a manner akin to human problem-solving. According to Mitchell (1997), if a computer program's performance at a task increases with experience as measured by, then it is said to have learnt from experience E with regard to that class of tasks and performance measure.

2.7 Detecting Social Engineering Attacks Using Machine Learning

Hemali et al. (2008) on the detection of phishing websites using machine learning proposed two methods for detection that is classification and association which will optimize the system. The proposed model focuses on identifying the phishing attack based on checking phishing website features, blacklist and WHOIS database. Selected features can be used to differentiate between legitimate and spoofed web pages. Features of URLs and domain names are checked using several criteria. These features are inspected using a set of rules in order to distinguish URLs of phishing webpages from the URLs of legitimate websites. Phishing is another common technique in which fraudulent emails are used to launch these assaults. By combining machine learning (ML) techniques with natural language processing (NLP), it is possible to create a system that can classify emails by extracting information from their content and detecting spam (Sathvik et al., 2023).

In order to determine which machine learning algorithm is best at identifying phishing websites, Miyamoto, Hazeyama, and Kadobayashi (2008) examined and compared nine different algorithms: adaboost, bagging, support vector machines, logistic regression, random forests, neural networks, naive bayes, and Bayesian additive regression trees. Three thousand samples made up the dataset that these techniques were applied to. The above algorithm has proved successful. Ahingöz et al. (2017) provide a real-time phishing detection system that uses a number of machine learning classification methods, including Naive Bayes, KNN, and Adaboost, and depends on the natural language processing (NLP) of URLs. Following the creation of a balanced dataset including 73,575 harmful and benign URLs, the researchers preprocess the data and extract three different kinds of characteristics: word-based, hybrid, and natural language processing (NLP) features. Random Forest had the best accuracy of 97.98\% when the classifiers evaluated the features. Parekh et al. (2018) used machine learning approaches to identify phishing websites. This paper's dataset was gathered from the Phishtank website. First, the URL characteristics were extracted. Next, for the purpose of classification, the Random Forest algorithm was used. The machine learning model that was developed had a high accuracy rating. Each stage used a different data processing approach in order to improve performance.

3.0 Methodology

This study employs a qualitative research

design to collect secondary data from existing articles. Cleland (2017) contends that qualitative research is concerned with understanding people's experiences in a simple, easy and analytical way and is especially effective in obtaining information about behavior, opinions and social contexts of a particular population (Bhandari, 2022). It can be applied to reveal various aspects of a particular scenario or as new ideas for further research. The researchers typically investigate on how changes in one variable affect another or related variables. Study population refers to a larger group with similar features within a specific context (Willie, 2022). The population includes all studies published on the mitigation Machine Learning and Artificial Intelligence. All the published articles used for this study are within the range of secondary source of information since they are not primary data or information. In simple terms, secondary data is a source of data set that is not obtained by the author, or "the analysis of data gathered by someone else", which are reused for new purposes (Boslaugh, 2007; Vartanian, 2010).

The study considered studies focused on the mitigation of social engineering attacks using machine learning and artificial intelligence. Therefore, data that focuses on mitigation of social engineering attack using other means apart from ML and AI were excluded. As a result, only peer- reviewed journal articles, conference papers/proceedings, and technical reports that focused on mitigation of social engineering attack using ML and AI are selected. These criteria suggest that the current study is limited to findings from peer-reviewed articles, not from thesis, books or others and must be within the last five years. Also, only studies conducted over the last five years were included in this study.

of social engineering attacks through the use of AI and ML, however the population is confined to the findings made within the American cybersecurity environment, mainly because of the differences in the technology, society and legal systems for adoption of AI and ML for counter social engineering attacks.

The method of data collection includes the use of secondary sources, which involves the use of published research works whether journal articles, conference papers/proceeding, and technical reports. The published research works address social engineering attacks leveraging

Moreover, only studies that were conducted in English language were added in the study. Meanwhile, a total of five (5) studies were finally selected for this review. The collected data was analyzed using narrative analysis to perform a subjective analysis and evaluation of a body of literature while describing what is known about how social engineering attacks can be mitigated using machine learning and artificial intelligence. In doing the analysis, the author ensured that subjective bias was minimized.

DATA EXTRACTION TABLE

Author (year)	Title	Summary of the Findings
Saeed and Shareef (2020)	Implementation of artificial intelligence to predict threats in social media based on user's behavior	To demonstrate how an AI-based algorithm of the user's behavioral traits, perceptions, and socio-emotions would aid in identifying features that further become highly relevant in determining an individual's vulnerability to social engineering threats and attacks, the research employs machine learning techniques. Studying habitual and permanent viewpoint responses to socially produced hazards on a daily basis is the main goal. In order to demonstrate that certain Facebook user actions pose a risk to other users, this study compares the ideas with the results from the main data. The results have shown how artificial intelligence (AI) computers detect fraudulent texts and con artists using machine learning approaches.
Akinsuli (2024)	AI security in social engineering: Mitigating risks of data harvesting and targeted manipulation	The Cambridge Analytica case and Meta's Ray Ban augmented reality spectacles are two real- world instances that are discussed in the paper to highlight the consequences of tampering with AI. Therefore, before stressing the need to strike the ideal balance between security advantages and worries for users' freedom and privacy, the study examines the ethical dilemma of AI exploitation. In order to counter some of those dangers, we put out a four- part strategy that includes general user education, ethical use of the developed AI framework, and enhanced data security. Social media firms, legislators, and creators of these
Lansley et al. (2020)	SEADer++: social	The researchers created a technique based on artificial neural networks and

	engineering attack detection in online environments using machine learning	natural language processing that can identify social engineering assaults. This technique may be used to identify if a discussion is a social engineering assault or not in both offline and online settings. An artificial neural network is used to categorize potential assaults after the chat text has first been processed and examined for grammatical problems using natural language processing methods. With extremely good accuracy results, the suggested approach has been tested on both actual and partially synthetic datasets. Furthermore, other categorization algorithms have been applied for comparisons in both datasets.
Adekunle et al. (2024)	The use of AI to analyze social media attacks for predictive analytics	To identify hidden SE risks in social network conversations, a new SE model was trained using Recurrent Neural Network Long Short- Term Memory (RNN-LSTM). A range of postings, including text, photos, and videos, are included in the dataset. In order to make sure that it is reflective of the kinds of material that are usually shared on social media, it was meticulously chosen over the course of many months. First, the social engineering attacks detection (SEAD) pipeline is designed to filter out malicious social postings by using domain heuristics. Each social media post is tokenized into phrases and then analyzed by a sentiment analyzer to identify if it is an anomaly or a normal training data set. An RNN-LSTM model is then trained to identify five types of social engineering attacks, some of which could include signals that collect information. The SEA model obtained 0.82 classification accuracy and 0.79 recall when compared to the ground truth labeled by

		network experts (based on the experimental results).
Huseynov and Kose (2022)	Using machine learning algorithms to predict individuals' tendency to be victim of social engineering attacks	This research predicted people's vulnerability to social engineering scams using machine learning algorithms. Participants in the research were shown simulated situations and asked to determine whether or not each one constituted a social engineering assault. Social engineering simulations were included with a variety of assaults from different businesses. Various social engineering scores were computed for each participant based on their answers. Participants completed questionnaires on their demographics, technology use, and personality factors in addition to the simulations. Machine learning models for regression and prediction classification were constructed using all of the data that was gathered. It was intended to proactively forecast people's social engineering risk levels and categorize them into various risk categories according to various attack kinds using regression and classification algorithms. According to this study, people's susceptibilities to social engineering may be predicted in advance. This significant discovery implies that such assaults may be avoided by alerting professionals before the attack takes place (based on the experimental findings).

Source: Author's Fieldwork (2025)

4.0 Results and Discussion

The results and discussion of this study are presented simultaneously owing to the nature of this research. This is presented based on the relevant theme in the study. Thus, the results and discussion sub-heading will be based on different thematic discussion. This section presents the findings of the study conducted. It entails the presentation of findings of the previous studies that were selected for the current study, which are regarded as secondary data on how social engineering attacks can be mitigated using machine learning and artificial intelligence. Since the study used the "a priori" thematic analysis, the presentation of the research findings is guided by the research questions that guide this study.

4.1 Patterns of Social Engineering Attacks in Cyber security

This sub-section presents the findings of existing studies on the various types of social engineering attacks utilized by cybercriminals. The study conducted by Akinyuli (2024) revealed that phishing is one of the most common types of social engineering attacks employed by cybercriminals. In addition to this, Adekunle et al. (2024) revealed that phishing, pre-texting, scare ware, click bait, and quid pro quo are employed by cybercriminals. The researchers ranked phishing as the highest occurring type of social engineering attack. This reinforces the findings of Akinyuli (2024) on the occurrence of phishing. Accordingly, Huseynov and Kose (2022) revealed that phishing and spoofing are the commonest types of social engineering attacks, most especially in the social media era. With these findings, it is evident that there are different patterns employed by cybercriminals when engaging in social engineering attacks; however, phishing was reported by each of the studies consulted, making it the most common type of social engineering attack.

4.2 Effectiveness of Machine Learning Algorithms and AI Models for Detecting Social Engineering Attacks

The efficiency of artificial intelligence and machine learning models in identifying social engineering assaults has been the subject of several studies. Once the patterns of social engineering assaults have been identified, this becomes required. According to Saeed and Shareef's (2020) study, artificial intelligence algorithms are effective at spotting fraudulent mail and con artists. The researchers noted that most participants disagreed with the notion that AI might increase cybercrimes, which helped them come to the conclusion that AI can really assist lower social network crimes. As a result, social media companies now use trained AI algorithms to identify fraudster messaging patterns and warn potentially fraudulent content. Likewise, Akinsuli (2024) disclosed that machine learning models have shown the ability to examine big datasets in order to spot trends and malevolent behavior before they result in serious security breaches. This implies that machine learning is a powerful way to identify social engineering scams.

A technique based on artificial neural networks and natural language processing was created by Lonsley et al. (2020) to identify social engineering assaults. The technique, which is mostly used for phishing assaults, analyzes a conversation before producing a dataset that may be used for categorization. In order to identify potentially harmful postings on social media, Adekunle et al. (2022) created an AI model called the social engineering attack detection (SEAD) tool. The first step in the procedure is gathering a large dataset of social media postings by crawling Facebook. The model fared better than the other algorithms in terms of both accuracy and recall, the researchers said. This implies that the model is resilient to noise and data variance and can generalize to new data. These results show that artificial intelligence models and machine learning algorithms are quite effective at identifying social engineering assaults.

4.3 Effectiveness of Machine Learning Algorithms and AI Models for Preventing Social Engineering Attacks

According to Saeed and Shareef's (2020) study, Facebook has so far effectively used artificial intelligence that aims to anticipate dangers and stop assaults. Facebook does, however, have its own restrictions, which are based on user privacy concerns and global laws that shield users from violations of their private rights. The findings of Akinsuli (2024) also show that artificial intelligence is successful, as shown by the two-thirds decrease in data breach incidents that followed the implementation of the solutions. This demonstrates how AI may enhance security by successfully preventing unauthorized access to private data. In order to stop social engineering assaults, Huseynov and Kose (2022) created a risk assessment tool that uses machine learning algorithms. In order to categorize users into various risk categories according to the sorts of attacks they may face, the program first predicts their social engineering risk levels. The results showed that people's risk levels for social engineering may be predicted in advance. These demonstrate how well machine learning and artificial intelligence work to stop social engineering scams. However, the use of AI and machine learning to stop social engineering attempts raises worries about data privacy. According to Akinsuli (2024), large-scale platforms that manage increased or expanding amounts of user data may leverage AI's ability to improve security measures to be sure that protection from new threats is not a luxury they will have to give up.

5.0 Conclusion

This study examined how social engineering attacks can be mitigated using machine learning and artificial intelligence. The data collected for the study was secondary data from published literature, which was selected based on specified inclusion and exclusion criteria. The study recognized that AI and machine learning models have proven highly effective in detecting and preventing various forms of social engineering, with phishing emerging as the most commonly used attack method. AI-driven algorithms are capable of analyzing large volumes of data to identify patterns of malicious behavior, such as scam messages or suspicious social media posts, thereby reducing the risk of security breaches. Additionally, the effectiveness of machine learning models extends beyond detection, as predictive tools can assess individual vulnerability to social engineering attacks and offer proactive risk assessments. These tools can categorize users based on their susceptibility to different types of attacks, enabling tailored preventive measures. Additionally, AI's ability to optimize security measures across large datasets ensures that platforms handling sensitive user data can better defend against emerging threats. While there are ongoing concerns regarding privacy and the ethical use of AI, the study established that the potential of these technologies to enhance cyber security.

6.0 Limitations of the Study

This study was limited to the application of artificial intelligence and machine learning in detecting and preventing social engineering attacks. The study was also limited to the findings from previously published research studies, which are regarded as secondary data. This implies that the findings were based on the articles consulted for the study. Also, since the study focuses on secondary data, the findings cannot be completely reliable since the primary data that led to the findings of the used studies may not be accessed. Meanwhile, the future directions of research in the study area include to:

i. Investigate how artificial intelligence and machine learning can be utilized to prevent social engineering attacks, with a specific focus on the efficacy of data privacy measures;
ii. Examine ways to improve artificial intelligence models in detecting and preventing social engineering attacks beyond phishing;
iii. Conduct longitudinal studies to explore the long-term effects of artificial intelligence and machine learning in detecting and preventing social engineering attacks; and
iv. Develop a framework to guide the use of these tools in detecting social engineering attacks, ensuring that the models avoid ethical concerns.

7.0 Recommendations

The following strategies are recommended for action based on the findings of the study. Individuals should actively engage in cyber security education by making use of free online resources and training courses to stay informed about the latest social engineering tactics. They should also remain vigilant and proactive in recognizing suspicious online content, utilizing AI- driven tools such as spam filters and phishing detectors available on many social media platforms and email services to help identify and avoid falling victim to social engineering attacks. As data privacy concerns grow, industry actors should focus on developing and deploying AI systems that protect user data while simultaneously preventing social engineering attacks. Additionally, organizations should implement robust multi-factor authentication (MFA) and advanced access control mechanisms to reduce the impact of social engineering attacks.

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Perceived Effect Of School Medical Care On Pupils' Academic Performance In Selected Public Primary Schools In Ijebu North-East LGA, Ogun State

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Abstract

This study examines the perceived impact of school medical care on pupils' academic performance in selected public primary schools in Ijebu North-East Local Government Area (LGA), Ogun State. It seeks to understand how the availability of basic health care in schools, such as first aid and nursing presence, relates to pupils' academic outcomes. As healthcare becomes increasingly recognized as a factor in educational achievement, this study aims to evaluate the significance of school-based medical support and the importance pupils place on their health.

Keywords: *School health care, Academic performance, Public primary schools, Well-being Ijebu North-East; Educational outcomes.*

1.0 Introduction

Over time, it has become evident that several factors beyond the school's control influence students' academic performance, either directly or indirectly. One such factor is student health. According to Haas (2006), education and health are closely linked aspects of child development. Health problems create distractions, disruptions, and barriers that can hinder learning. Experts have long emphasized that children in good health learn more quickly and effectively than those dealing with health challenges. Given their daily contact with students, schools are often seen as ideal environments for delivering health services, which, in turn, can support academic goals. Since educational inequalities often reflect health disparities, addressing health inequities may also reduce educational gaps (Crosnoe, 2006).

Guo, Wade, and Keller (2008) argue that students' physical, mental, and social health significantly influence educational outcomes. Children who are malnourished, physically challenged, abused, exposed to drugs, or dealing with family issues

often struggle to learn. The CDC (2010) also highlights the mutual reinforcement between health and education, noting that students in good health perform better academically. Tyson (1999) further points out that physical and mental health issues can lead to absenteeism, poor concentration, destructive behavior, and increased dropout rates, key barriers to educational attainment. Therefore, addressing health-related challenges is crucial for any meaningful education reform.

A school clinic is a medical facility that offers basic treatment and referrals for students when needed. These clinics help protect the health of students and those around them. As Crosnoe and Robert (2006) observe, health concerns can place students at a disadvantage in learning. School-based clinics, therefore, provide a practical means of promoting student well-being and academic success. The Federal Ministry of Health (2009)

notes that school health services encourage collaboration between school, home, and community; promote health consciousness; and build the capacity of students and staff for health promotion.

Sherwood-Samuel (2016) argues that school-based clinics enable students to access healthcare while remaining in school. Research shows that students who utilize these services experience better attendance, improved health, and stronger academic outcomes. For such results to be sustained, qualified personnel such as nurses and their assistants must be available throughout the school day.

Academic performance refers to the extent to which a student has achieved set educational goals, typically assessed through examinations and continuous assessments. Given the documented link between health and learning, this study seeks to examine the perceived effect of school medical care on pupils' academic performance in selected public primary schools in Ijebu North-East LGA, Ogun State.

The health status of pupils is as critical as their academic standing. Without good health, students cannot attend school regularly or engage effectively. While schools are expected to offer at least basic healthcare such as first aid, many public schools lack functional clinics. As Franklin and Gerlach (2006) note, while access to clinical care in schools is effective for monitoring children's health needs, implementing it broadly has been limited by funding constraints. Consequently, only a small percentage of pupils in public schools have access to in-school health services.

Students face various health risks in the school environment, including injuries, illness, and psychological issues. These can be addressed through school clinic services, which typically provide first aid, health education, protection, promotion, prevention, emergency services, and counselling. Despite the essential role school clinics can play, the incidence of preventable conditions such as diarrhoea, the common cold, injuries, and malaria remains high in schools. These could be better managed with school-based medical care and trained school nurses.

This study, therefore, aims to determine the perceived effect of school medical care on the academic performance of pupils in public primary schools in Ijebu North-East LGA, Ogun State. Specifically, the research questions are:

1. What is the available medical care in public primary schools in Ijebu North-East?
2. What is the level at which public primary school pupils attach importance to healthcare?
3. To what extent can school medical care affect the academic performance of public primary school pupils in Ijebu North-East?
4. What strategies can be employed by public primary schools to improve school medical care?

2.0 Research Hypotheses

The following null hypotheses are formulated for the study:

H_{o1}: There is no significant relationship between school medical care and academic performance.

2.1 Literature Review for School-Based Health

Children need good health to learn effectively, and education, in turn, promotes health (FME, 2006). Schools expose students to physical, mental, and emotional risks, and the school health program addresses this through counselling, first aid, and emergency services. School health services aim to maintain student well-being, allowing them to gain the most from education while also supporting the health of staff and the wider school community (FME, 2006).

These services, delivered by health professionals and teachers, include early detection and treatment of illnesses, disease prevention, and referrals. Teachers observe students' hygiene and development regularly, checking for signs of illness and tracking growth through height and

weight measurements. Schools are expected to provide basic health facilities, first aid kits, and access to counselling services. A healthy student is more attentive and capable of learning, and school health services help reduce learning disruptions caused by illness.

2.2 Historical Background of the School Health Programme

School health services began in Europe, with school meals in Bavaria (1790) and student medical exams in the UK by 1908. In the U.S., daily nurse inspections began in 1890. Over time, the emphasis shifted from contagion control to broader health support. In Nigeria, Dr. Oluwole initiated school health in 1929. Despite efforts, including the National School Health Policy (2006) and national implementation guidelines (2007), Nigeria still faces challenges in consistent execution. Section 8 of the National Policy on Education (2013) mandates school health facilities, meals, and sanitation, but many schools still lack these essential services.

2.3 Benefits of School-Based Health Clinics

SBHCs offer on-site health services to pre–K–12 students, especially in low-income areas, often run by health departments or local hospitals (Keeton et al., 2012). They provide treatment for chronic conditions, mental health issues, and preventive care, integrating well with the school environment. These services improve access to healthcare, boost vaccination rates, and support student wellness factors in both academic and social development (Knopf et al., 2016). The FRESH framework launched in 2000, and the National School Health Policy emphasizes the role of schools in delivering these services to enhance student outcomes (FME, 2006a).

Having treatment options on campus improves access, particularly for working families. Basic care includes treatment for mild conditions using first aid kits, while more advanced setups include sickbays and partnerships for specialized services like vision and hearing care.

Teachers, parents, and the wider community all play roles in promoting student health. Family involvement reinforces healthy behaviours and supports student success. School visits and community engagement strengthen mutual understanding and shared goals. Partnerships can provide resources and facilities when schools cannot, while schools also contribute to broader community health. Effective communication and collaboration among all stakeholders are crucial for a successful school health program (FME, 2006).

3.0 Health and Learning

Given the strong connection between health and learning, addressing one without the other is rarely effective. Effective education must consider the often unmet and interconnected health needs that impact school achievement (Council of Chief State School Officers, 1991). Children need to build a strong sense of self, critical thinking, emotional security, and a sense of belonging from an early age. While formal education lays a solid intellectual foundation, external factors, such as home life and social pressures, significantly influence academic success (Koppich & Kirst, 1993).

Chinn's (1973) study revealed that health challenges are closely tied to academic performance. Students with untreated health issues scored lower on assessments, especially those from single-parent or low-income families. This emphasizes the need for school involvement in preventive care, nutrition, and health education. Emotional and social indicators also affect classroom performance (Brown et al., 1985).

Educators recognize that academic performance is shaped by various factors, including health. School-based health centres (SBHCs) provide a coordinated approach to supporting both health and learning (Basch, 2011; Brindis, 2005). Research by Walker et al. (2010) found that students who accessed mental health services through SBHCs saw academic gains, while other studies showed improved school attachment, better grades, and increased college readiness among SBHC users (Strolin-Goltzman et al.,

2014; Bersamin et al., 2016). Foy and Hahn (2009) noted fewer absences and improved results when students had access to on-site clinics, and Soleimanpour et al. (2010) reported that over half of the students said SBHCs improved their attendance, stress management, and academic effort.

Academic performance remains the central way to assess students' development, intellectual, emotional, and social, throughout their educational journey. It reflects not only cognitive skills but also how well schools and systems meet students' broader developmental needs. Parenting style and school leadership attitudes toward academics and extracurriculars also influence performance (Schibeci & Riley, 1986).

Integrating health into education is not optional; it is essential. Students thrive academically when they are healthy, supported, and engaged, and SBHCs offer an effective model to promote both well-being and learning success.

3.1 Factors Affecting School-Based Medical Care

Like many other developing countries, the problem for Nigeria has never been that of policy development but that of implementation. Factors identified as militating against implementation of policies especially in Sub-Saharan Africa include: lack of coordination between the national and provincial departments; management problems in states ministries; and lack of capacity on the ground (Stack & Hlela, 2002); weaknesses in forecasting capacity, dependency on volatile and unpredictable aid flows, slow project execution, less stable political systems (Lledo & Poplawski-Ribeiro, 2011), bad governance and lack of political will (Federal Ministry of Health, 2011).

It is sad to observe that education is one sector that governments at all levels in Nigeria have continuously neglected. Even when international non-profit agencies like UNICEF have continued to show interest in developing education in Nigeria, the governments often times are unwilling to join resources in partnership with them. UNICEF, after helping Nigeria to develop the National School Health Policy, embarked on the training of desk officers and other relevant personnel in the Ministry of Education and other line Ministries; develop sports in schools and distribute copies of the NSHP. In all these, governments at different levels have continued to default in making available their counterpart fund, thereby limiting the initiated school health programmes.

Lack of knowledge and skills among policy implementers in implementing the content of the policy is a major stumbling block in the effective implementation of the school health programme. Findings from research, as shown in previous discussions, reveal that few teachers and head teachers were aware of the existence of the school health programme; most of them do not possess knowledge about the school health programme and its components. Meanwhile, they are supposed to be the grassroots implementers of the programme. Various personnel in the relevant ministries who should play important roles in the implementation of the school health programme also lack the needed knowledge and skills in implementing the program.

4.0 Materials And Methods

This descriptive cross-sectional study was conducted to investigate the relationship between school medical care and academic performance among pupils in public primary schools of Ijebu North-East Local Government Area, Ogun State, Nigeria.

i. **Study Design:** A Descriptive survey research design was employed to systematically assess teachers' perceptions of school-based healthcare and its influence on pupil academic outcomes. The survey method was selected due to its strength in capturing contemporary issues through quantitative data from structured questionnaires, allowing for statistical interpretation and hypothesis testing.

ii. **Study Location:** The study was conducted in selected public primary schools within Ijebu North-East LGA of Ogun State, Nigeria. This location was chosen for its relevance to the study objectives and diversity in school environments. School names were anonymized using codes to ensure confidentiality.

iii. **Study Duration:** November 2022 - March 2023

iv. **Target Population:** All teachers in the thirty-four (34) public primary schools within Ijebu North-East.LGA.

v. **Sampling and Sample Size:** A two-stage sampling technique was used. In Stage 1, five schools were purposively selected based on accessibility and geographical distribution. In Stage 2, ten teachers were randomly selected from each school, totaling 50 respondents. This sampling approach aligned with Aderemo's (1985) guidance that 30% of a large population provides sufficient representation. The schools included were:

- Baptist Primary School, Ogbogbo (10 teachers)
- Moslem Primary School, Ilese (10 teachers)
- Epiphany Anglican Primary School, Erunwon (10 teachers)
- Bethelem Anglican Community Primary School, Odopotu (10 teachers)
- Christ Church School, Odosenlu (10 teachers)

4.1 Inclusion Criteria:

i. Public primary school teachers in Ijebu North-East LGA
ii. Minimum of one year of teaching experience
iii. Willingness to participate and provide informed consent

4.2 Exclusion Criteria:

i. Non-teaching staff
ii. Teachers from private schools
iii. Teachers on leave during the study period

4.3 Procedure Methodology: The study adhered to established ethical guidelines throughout the research process. Written consent was obtained from school authorities and participating teachers after explaining the study's purpose and procedures. Confidentiality was maintained through anonymous data collection, with no personal identifiers recorded on questionnaires. Participants were informed of their voluntary participation rights and freedom to withdraw at any stage. Data security was ensured through restricted access to completed questionnaires and secure electronic storage of digital records. These measures protected participants' rights while maintaining the integrity of the research process.

Data was collected using a structured instrument titled *School Medical Care on Pupils' Academic Performance Questionnaire (SMCPAPQ)*. The tool had five sections:

- Section A: Demographic information
- Section B: Available medical care services in schools
- Section C: Pupils' perception of healthcare importance
- Section D: Comparison with standard medical care practices
- Section E: Perceived impact on academic performance

Responses were measured on a 4-point Likert scale (Strongly Agree to Strongly Disagree). The questionnaire was pretested with 20 teachers from non-participating schools, and reliability was confirmed with a Cronbach's Alpha of 0.78, exceeding the 0.50 threshold (Bennett, 2006). Data collection involved official permission letters, training of research assistants, and administration during staff meetings to optimize response rates.

5.0 Statistical Analysis:

Data were analyzed using SPSS Version 23. Descriptive statistics (frequency, percentage, mean, and standard deviation) summarized respondent characteristics and item responses. Inferential statistics included Pearson's Product-Moment Correlation (PPMC) to test the relationship between variables and independent

samples t-tests for group comparisons. Significance was determined at $p < 0.05$.

5.1 Results Demographic Characteristics of Respondents

The study collected complete responses from 30 teachers across Ijebu North-East public primary schools. As shown in Table 1, the majority were young professionals aged 25-35 years (66.7%, n=20) with bachelor's degrees (83.3%, n=25) and 3-5 years teaching experience (46.7%, n=14).

Table 1: Percentage Distributions of Respondents' Demographic Profiles

S/N	Variables		Frequency	Percentage %
1	**Age**	**<25 years**	***1***	**3.3**
		25-35 years	***20***	**66.7**
		36 -45 years	***6***	**20**
		46-55 years	***1***	**3.3**
		>56 years	***2***	**6.7**
2	**Years of Experience**	**<2 years**	***3***	**10.0**
		3-5 years	***14***	**46.7**
		6-7 years	***5***	**16.7**
3	**Highest Educational Qualification**	**NCE**	***2***	**6.7**
		BSc/BA/Bed	***25***	**83.3**
		MSc/MA/Med	***3***	**10.0**

Source: Field work, 2022

Availability of School Medical Services

Table 2 presents frequency distributions of medical resources. While basic first aid boxes were available in most schools (80%, n=24) and 53.3% (n=16) had nurses, critical services remained limited: only 30% (n=9) maintained sick bays, 36.7% (n=11) conducted immunizations, and merely 10% (n=3) performed routine health inspections. Emergency care (30%, n=9) and referral systems (16.7%, n=5) were notably inadequate.

Table 2: Frequency count of available medical care

S/N	Variables	Yes (%)	No (%)
1	Nurse	16 (53.3)	**14 (46.7)**
2	Routine Inspection	3 (10.0)	**27 (90.0)**
3	Pre-entry screening	5 (16.7)	**25 (83.3)**
4	Medical Exam	2 (6.7)	**28 (93.3)**
5	Referrals	5 (16.7)	**25 (83.3)**
6	First aid box	24 (80.0)	**6 (20.0)**
7	Sick bay	9 (30.0)	**21 (70.0)**
8	Immunization	11 (36.7)	**19 (63.3)**
9	Care of emergency	9 (30.0)	**21 (70.0)**
10	Transport ailing pupils to clinic	3 (10.0)	**27 (90.0)**
11	Transport ailing pupils' home	3 (10.0)	**27 (90.0)**
12	**Counseling**	**14 (46.7)**	**16 (53.3)**

Field Survey, 2022

5.2 Pupils' Health Awareness and Practices

Analysis of health behaviors (Table 3) revealed moderate student engagement, with mean scores exceeding the 2.5 threshold for positive responses. Pupils demonstrated medication adherence (Mean=2.7, SD=.915) and voluntary sick bay use (Mean=3.2, SD=.898), though pre-school hygiene practices scored lower (Mean=2.1, SD=.607). These findings suggest students recognize the health importance but require reinforcement of preventive habits.

Table 3: Mean Score, Standard Deviation, and Remarks on the level at which public primary school pupils attach importance to healthcare.

N	Items	Mean	SD	Remark
1	Most of the pupils take their bath before coming to school	2.1	.607	Disagreed
2	Most of the pupils brush their teeth before coming to school	2.5	.731	Agreed
3	The pupils eat healthy meals	2.7	.651	Agreed
4	Pupils go to the sickbay willingly without being forced to	3.2	.898	Agreed
5	Pupils use the medication given to them according to the instructions	2.7	.915	Agreed
6	Pupils take their health serious since it affects their participation in extra-curricular activities	3.0	.765	Agreed

Field Survey, 2022

5.3 Impact on Academic Performance

Table 4 demonstrates strong consensus that medical services enhance learning outcomes (all means >2.7). Key facilitators included: immediate treatment access (Mean=3.1, SD=.900), environmental sanitation (Mean=3.5, SD=.937), and sick bay availability (Mean=3.2, SD=.874). Teachers particularly noted that health services reduced absenteeism (Mean=3.5, SD=.777), directly supporting academic continuity.

Table 4: Mean Score, Standard deviation, and Remarks on the extent at which school medical care affects the academic performance of public primary school pupils in Ijebu North-East

N	Items	Mean	SD	Remark
1	Pupils have quick access to drugs for immediate treatment, which keeps them healthy for learning	3.1	.900	Agreed
2	Fumigation and regular cleaning of the environment is done from time to time to prevent disease.	3.5	.937	Agreed
3	Dust bins for refuse disposal are available at strategic locations in the school to keep the environment clean and safe for learning	2.7	1.149	Agreed
4	Sickbay is in the school for treating of ailing pupils, and in turn boosts pupils' performance	3.2	.874	Agreed
5	Sickbay is equipped with resources and equipment to facilitate first aid administration and treatment of minor illnesses	3.3	.980	Agreed
6	Learners come to school even when they are sick due to the capacity of the sickbay	3.5	.777	Agreed

Field Survey, 2022

5.4 Hypothesis Testing Results

The correlation analysis (Table 5) confirmed a statistically significant relationship between health prioritization and academic performance (r=.499, p=.005). With the calculated r-value (.499) exceeding the critical value (.306) at 28 degrees of freedom, we reject the null hypothesis, concluding that health awareness significantly predicts school medical care's educational impact.

Table 7: Correlation Result of the importance attached to healthcare and school medical care impact on academic performance.

Status		Mean $\grave{\chi}$	SD	dF	Cal. r-value	Crit. r-value	p value	Remark
Importance attached to healthcare		2.7	.520					
	30			28	.499	.306	.005	Significant
School medical care and academic performance		3.2	.744					

Significant at p<0.05

Field Survey, 2022

The findings of this study are summarized as follows:

- Most of the schools can provide basic medical needs such as first aid box, availability of nurse, among others most of the schools can provide basic medical needs such as first aid box, availability of nurse, among others.
- Most of the public primary school pupils in Ijebu North East LGA attach moderate importance to their healthcare.
- Availability of school medical care positively affects the academic performance of primary school pupils in Ijebu North East.
- There was a significant relationship between the importance attached to healthcare and school medical care impact on academic performance.

6.0 Discussion

The findings of this study provide valuable insights into the perceived impact of school

medical care on academic performance in public primary schools in Ijebu North-East LGA, Ogun State. The results align with existing literature while also revealing critical gaps in healthcare provision within Nigerian public primary schools.

While most schools had basic first aid boxes (80%) and over half had nurses (53.3%), more advanced medical services such as sick bays (30%), immunization programs (36.7%), and emergency care (30%) were notably lacking. This supports the findings of Franklin and Gerlach (2006), who highlighted how public schools in developing countries often struggle with inadequate healthcare infrastructure due to funding constraints. The absence of routine health inspections (10%) and referral systems (16.7%) further reflects systemic weaknesses in preventive healthcare, echoing the Federal Ministry of Health's (2011) concern about policy implementation challenges in Nigeria.

Although some basic services exist, they fall short of the comprehensive school health programs envisioned by the National School Health Policy (2006). The lack of services such as pre-entry medical screenings (16.7%) and transportation for ailing pupils (10%) indicates that many schools are ill-equipped to manage emergencies or chronic health conditions, which can hinder pupils' attendance and engagement in school activities.

Pupils demonstrated moderate health awareness, particularly in taking prescribed medication (Mean=2.7) and voluntarily using sick bays where available (Mean=3.2). However, pre-school hygiene practices (Mean=2.1) were weak, pointing to the need for more focused health education. This supports Basch's (2011) argument that health literacy is essential for academic success, as students who are more aware of health risks are more likely to adopt preventive behaviors.

The moderate health awareness aligns with findings by Guo, Wade, and Keller (2008), which suggest health behaviors significantly influence learning outcomes. Yet, the relatively low scores in hygiene practices imply that schools and parents need to collaborate more closely to build healthy habits early, reinforcing the importance of integrating health education into the curriculum (FME, 2006a).

Teachers strongly agreed that accessible medical care improves academic performance, especially by reducing absenteeism (Mean=3.5) and supporting a healthier learning environment (Mean=3.5). The presence of sick bays (Mean=3.2) and access to immediate treatment (Mean=3.1) were seen as key in sustaining participation in school activities. This is consistent with the CDC's (2010) stance that healthy students perform better academically.

Findings are also in line with previous research (Bersamin et al., 2016; Soleimanpour et al., 2010), which reported that school-based health centers (SBHCs) improve attendance, concentration, and academic performance. A significant positive correlation ($r = .499$, $p = .005$) between prioritizing health and academic performance further confirms that investing in school healthcare services yields educational benefits alongside medical ones.

6.1Conclusion

Being one of the major determinants of growth, the importance of good health cannot be underestimated, most especially in education. It is of utmost importance to be in a good state of health to be functional in school and concentrate on studies. The current study sought to determine the perceived effect of school medical care on pupils' academic performance in selected public primary schools in Ijebu North-East LGA, Ogun State. It was discovered that most of the schools have basic healthcare facilities. Also, the study demonstrated that school medical care has a positive relationship with academic performance. However, most of these schools lack the facilities needed to take care of their ailing pupils.

One major limitation of this research is that it focuses solely on public primary schools in Ijebu North-East Local Government Area, Ogun State. This choice was made to minimize the cost and logistical challenges that would come with covering a larger or more diverse area, especially as the study is being conducted by an individual

researcher. Furthermore, narrowing the scope makes it possible to carry out a meaningful and manageable investigation within the limited time available for this academic programme.

6.2 Recommendations

Based on the findings of this study, the following recommendations are made:

1. Schools should develop a budget to cater to the basic medical needs of the learners and other members of the school community.
2. Teachers should encourage learners to take their health seriously, and it shouldn't serve as an impediment to concentrating in class.
3. The Parents-Teachers Association (PTA) should contribute to the development of the school through the provision of basic medical facilities and by continually providing the necessary supplies.
4. School leaders are encouraged to ensure that the available basic medical care facilities in their schools are functional.
5. The government should inject more funds into education so that schools will have the capacity to provide for their needs.
6. The inclusion of health education in the curriculum should be prioritized so that learners can take charge of their health and understand what to do when ailing.

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Effect of Mental Mathematics Instructions on Primary Pupils" Mathematics Achievement and Retention in South -Eastern Nigeria.

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Abstract

The study investigated the effects of mental mathematics instruction on learners retention and achievement in primary mathematics in South-Eastern Nigeria for present business World. The study was a quasi - experimental which adopted pre-test, post-test experimental groups where two intact classes received treatment. The population of the study was 870 , which comprised all primary four learners from Government owned schools . The purposive and simple random sampling techniques were used to select schools and intact classes for the study .The sample was 87 which is 10% of the entire population. The instrument for data collection was Researcher made mental mathematics test (RMMMT) which was duly validated and reliability coefficient of 0.83 established from Crombach Alpha. The data obtained were analysed using the Mean, Probability Analysis and Analysis of covariance (ANCOVA) F-test ,tested at 0.05 level of significance. The major findings of the study are :Teacher conventional instruction and Mental mathematics instruction have influence on learners achievement in mental mathematics prolonged retention ,but the two approaches combined yielded a more positive result. Recommendations are made, among which is that Education stake holders , Administrators of schools and Ministry of Education should include mental mathematics text books in their list of recommended text book for primary school pupils and also assign time to mental mathematics teaching in their school time table.

Key words : *Mental Mathematics Instruction ,Retention , Achievement And Business Education.*

1.0 Introduction

This 21st Century termed Global Era has greatly recorded massive use of Calculators as part of classroom instructions even at the primary level of education. It is evident that the use of Calculators help both teachers and learners to carry out hard and complicated mathematical operations quickly and more accurately.

(Nwachukwu ,2016) emphasized that use of Calculators make tasks easy for both teachers and learners, help them to understand problems at hand, find out best methods to solve the problems and make them to spend less time in calculations. Despite the above observations, teachers and researchers like Marvel, (2021), Ekenma, (2018) and Nwoke ,(2015) still maintain that mental Mathematics is very important and helpful in understanding mathematical skills and concepts and generally in the teaching and learning of mathematics especially at the primary level. The is true in the sense that the brain needs activities to help it's Dendrite grow into forest and mental mathematics is one of such activities. Mental mathematics which is also known as Mental calculation is the ability of an individual to perform mathematical calculations in his / her head without using any helping aid like Calculator. (Onyewu, 2019) , defined Mental Mathematics as the ability to calculate mentally without the use of memory help. One of the major benefits of mental mathematics according to Marvel (2021) is that mental mathematics take shorter time to complete a task than calculator and mental mathematics help in computing answers to questions and also help in checking the correctness of answers obtained. For instance, learning to multiply 7 by 3 is easily done by putting 7 together into 3 places. The objectives of teaching and learning mental mathematics according to Reye & Reye (1998) as cited in Sani, (2015) include the following

i. It is a prerequisite for successful development of all written arithmetic algorithm.
ii. It promotes greater understanding of the structure of numbers and their properties.
iii. It promotes creative and independent thinking and encourage students to create ingenious ways of handling number
iv. It contributes to the development of better problem solving skills.

It is the basis for development of computation and estimation skills. Mental Mathematics is needed in daily life transactions. It is highly needed in Business Education, Science and Technology. Mathematics has been identified as one of the major bedrock subjects for the transformation of our nation's economy and hence must be accorded adequate attention. Science and technical education are the factory for the production of the needed technologists, technicians and craftsmen as well as skilled artisans and professionals who are required to turn the nation's economy around and usher in the desired technological advancement. Mathematics at the primary level is the solid foundation on which other subjects are built. It is one subject that has a lot of relevance in the life of everyone and in the study of all other subjects and the entire business world. It contributes immensely to all human endeavours. It is seen as the science of counting, measuring, and describing the shape of objects. It deals with logical reasoning and quantitative calculations. (Akakpo, 2016). (Al-Takhyneh, 2018) indicated that mathematics is one of the most important subjects in the field of education , business , science and technology where develop the ability to think, solve problems, and develop the skills of arithmetic and engineering principles, analysis, induction, and the use of mathematical rules in various areas of knowledge, such as trade, technology, engineering, and other natural sciences. Mathematics as a subject is seen as the queen of all sciences and the fulcrum on which all science subjects revolve. It is very useful in the development of creative thinking and self-confidence.

Retention which is defined by Bright, (2021) as the ability to store learned materials in the long term memory of the brain is also an important psychological concept that must be put into consideration during the teaching and learning process. If there is no retention, it means teaching and learning was not effective and this affects achievement and every other aspect of life. The measurement of retention is possible by the use of explicit and implicit measures. Explicit measures require that a learner must remember

some given information that is stored in the long term memory. The learner makes deliberate efforts to recall the details of the previously experienced events or materials. This is a direct measure of retention. The implicit measure of retention is one in which the learner has to perform some tasks in which no deliberate or intentional effort is made to retrieve information from the memory.

Achievement is a very important psychological variable that must be put into consideration anytime teaching and learning process are into play. Achievement is a complex and dynamic concept that extends far beyond mere accomplishment. It's a testament to human capacity for growth, perseverance, and aspiration. Achievement motivation is a driving force that propels individuals to set objectives, overcome challenges, and persist in the face of adversity. Some of the key Elements of Achievement are - Effort: Dedication and hard work required to pursue a goal, involving consistent application of skills, knowledge, and resources. - Aspiration: The desire or ambition that motivates an individual to strive for something better, fuelling necessary effort.- Resilience: The ability to bounce back from setbacks and failures, crucial for maintaining momentum when faced with challenges.

Understanding Gender: Male and Female Gender is a complex and multifaceted concept that encompasses various aspects of an individual's identity, experience, and social interaction. Typically, individuals are assigned a biological sex at birth based on their physical characteristics, such as chromosomes, genitalia, and reproductive anatomy and gender identity which refers to an individual's internal sense of being male, female, or something else. Nbisike (2020). Research suggests that gender differences in mathematics achievements among learners in Nigerian are subtle, with some studies indicating that the gap is disappearing. Some researchers like (Nwachukwu , 2016) and (Marvel, 2021), pointed out the following as key finding - that male and female students perform similarly in mathematics, with no significant differences in achievement , that the gender gap in mathematics achievement is dissipating, even at the subscale level, suggesting that female students are catching up with their male counterparts. They therefore said that the following strategies can help in the Improvement of mathematics achievement - Multimedia Instructional Approach: Using multimedia instructional approaches can promote gender equity in mathematics achievements, - Promoting Mathematical Proficiency: Fostering mathematical proficiency, including conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition, can improve achievement in mathematics.

Business education is designed to equip students with the knowledge, skills, and competencies required to succeed in the present business world. It encompasses various aspects of business, including daily buying and selling, management, marketing, finance, and accounting e.t.c. The goal of business education among others is to prepare learners for everyday buying and selling transactions. The importance of mental mathematics to business education for the present business world can never be over emphasised .Some of the importance are - Mental mathematics skills are essential for business professionals to perform quick calculations, such as calculating profits, losses, and percentages, Business professionals need to estimate costs, revenues, and profits, which requires mental mathematics skills, Entrepreneurs need to calculate prices, discounts, and profit margins, which requires mental mathematics skills. Mental mathematics skills enhance problem-solving abilities, which are essential for the present business world ,Mental mathematics skills help business people to analyse data, identify trends, and make informed decisions. Developing mental mathematics skills can increase confidence in business, enabling people to tackle complex business problems. Giving special attention to mental mathematics especially at the primary level, will help develop essential skills for success in science and technology and also in the business world.

Objectives of the Study: The objectives of the study are to

i. Ascertain the effects of combined mental mathematics instruction (MMI) and teacher conventional instruction (TCI) on Learners achievements in primary mathematics.
ii. Determine the comparative effects of the two treatments on Learner's retention in mathematics after treatment.
iii. Ascertain the mean scores of male and female learners taught mathematics with combined mental mathematics instruction and teacher conventional instruction (TCI/MMI)

Research Questions

The following research questions were used in the conduct of this study

i. What difference exists in the Pre-test and Post- test mean of learners taught mathematics with TCI and combined TCI/MMI
ii. What differences exist in the mean in mathematics retention test of learners taught with combined mental mathematics instruction and teacher conventional instruction.(MMI/TCI)
iii. What is the mean achievement scores of male and female learners taught Mathematics with combined TCI/MMI.

Hypotheses

The hypotheses, below were formulated based on the above research question to guide this study.

The hypotheses were tested at 0.05 level of significance

i. There is no significant difference in the Pre-test and Post- test mean of learners taught with combined TCI/MMI
ii. There is no significant differences in the mean in mathematics retention test of learners taught with combined mental mathematics instruction and teacher conventional instruction.
iii. There is no significant difference in the mean achievement scores of male and female learners taught Mathematics with combined mental mathematics instruction and teacher conventional instruction.

Research Method

Two intact classes of primary 4 were classified into Two groups; group A and group B Experimental groups and they were taught the selected learning contents using combined mental mathematics instruction / teacher conventional instruction and Teacher conventional instruction respectively. Prior to the teaching, Pre-Test Was administered to both groups to ascertain their background knowledge while the Mental Mathematics Test (MMT) was administered after the teaching to ascertain the students' achievement in both groups. Teaching experiments lasted for 4 weeks. Each teaching group met 4 times, in a week in a single period of one hour. One Mathematics teacher and the researcher engaged in the exercise. The first week of the period was used to acquaint the participating teachers and students with the methods of their groups. It was also used to administer the pre-test and was rearranged for post -test and retention. The participating teachers who were the Mathematics teachers of the school of the study acted as research assistants while the researcher was the main teacher. During the study, the researcher assistant performed some roles which include, minding and supervising the groups and helping to administer the different tests. The researcher wrote the lesson notes and produced copies for the participating teachers. All the tests were conducted by both teachers i.e. the Mathematics teachers and the researcher and were marked and secured.

Instrumentation

A Mental mathematics text book for elementary schools book 4 was used as the course text for the lesson while the pre- test, post- test and retention tests were NAPPS centrally set paper third term examination questions for primary 4 2024.The test items were rearranged and were printed out for the post –test and retention tests. The instrument was given to experts in Mathematics Education and experts in measurement and evaluation for validation. The Cronbach Alpha was used to establish a reliability coefficient of 0.83.

Results and Discussion of Findings

Research Question 1. What difference exists in the Pre-test and Post-test mean of learners taught mathematics with TCI and combined TCI/MMI

Table 1 : Mean scores in Mental Mathematics learner's pre-test scores and their scores at post-test when taught through TCI, and combined TCI/MMI

TCI Group	**Means**	**SD**	**Mean Difference**
Pre-test	16.10	3.48	42.94
Post-test	58.04	8.70	
TCI/MMI Group	**Means**	**SD**	**Mean Difference**
Pre-test	17.03	4.37	50.73
Post-test	67.76	10.60	

Table 1 shows that the mean scores of the pretest and posttest mean when learners are taught with TCI are 16.10 and 58.04 respectively, and that the difference in the means is 42.94. It can be therefore inferred that there is a difference in mean scores of the pretest and posttest when used TCI and posttest group achieved higher than the pretest group meaning that using TCI was effective by gaining a mean of 42.94

Also that the mean scores of the pretest and posttest when used TCI/MMI are 17.03 and 67.76 respectively and that the difference in the means is 50.73. It can be therefore inferred that there is a difference in mean scores of the pretest and posttest when used TCI/MMI and posttest group achieved higher than the pretest group. This means that using TI/PI there was effective by gaining a mean of 50.73. The results above show that the mean-gain of the methods TCI/MMI and TI are 50.73 and 42.94, respectively. Meaning that TCI is effective but TCI/MMI is most effective in this experiment.

Hypothesis One: There is no significant difference in the pre-test and post- test mean taught with TCI, and MMI at post-test.

Table 2: Mean and probability analysis of the pre-test and post-test mean of Learners taught with TCI, and TCI/MMI at post-test.

GROUP	Means	Mean Difference	Probability Y	Significant (p<0.05)?
TCI Group Pre-test	16.10	42.94	0.00	Yes
Post-test	58.04			
TCI/MMI Group				
Pre-test	17.03			
Post-test	67.76	50.73	0.00	Yes

Table 2 shows that for TCI pretest and TCI posttest groups, probability (0.00) is less than the level of significance (0.05). This implies that TCI teaching method at (p>0.05) achieves significant learning outcome in Learners Mathematics.

Table 2 shows that for TCI/MMI pretest and TCI/MMI posttest groups, probability (0.00) is less than the level of significance (0.05). This implies that TI/PI teaching method at (p>0.05) achieves significant learning outcome in Learners' Mental Mathematics.

Research Question 2

What differences exist in the mean in Mental mathematics retention test of learners taught with combined mental mathematics instruction and teacher conventional instruction.(MMI/TCI).

Table 3: Mean in Mental Mathematics Retention Test of learners taught with combined mental mathematics instruction and teacher conventional instruction. (MMI/TCI).

GROUP	Retention test means	SD	mean Difference
TCI	70.80	9.74	10.08

TCI	70.80	9.74	7.21
TCI/MMI	78.01	8.26	

Table 3 shows that The mean scores of the TCI and TCI/MMI groups at retention test are 70.80 and 78.01 respectively. The difference in the means is 7.21 It can therefore be inferred that there is a difference in the mean scores of the TCI and TCI/MMI , TCI/MMI group achieved higher than the TCI group at retention test.

Hypothesis 2: There is no significant differences in the mean in Mental mathematics retention test of Learners taught with TCI and combined TCI/MMI.

Table 4: Analysis of Covariance (ANCOVA) F-test on the mean scores of the two treated groups in the researcher made retention test.

Source	Sum of Squares	df	Mean Square	Com-F	Cri-F	L s	Probability
Corrected Model	1031.80	2	1111.75				
Intercept	25429.20	1	25429.20				
Pretest	52.31	1	52.31				
Group	117.52	2	578.61	4.03	3.80	0.05	.021
Error	14185.52	115	128.01				
Total	5590871.00	120					
Correct total	17488.70	117					

Table 4 shows that the F-computed (4.03) is greater than F-critical (3.80) and the level of significance (0.05) is greater than the probability (0.021). This result rejects the null hypothesis that there are no significant differences in the mean scores of the two treated groups. Therefore there are significant differences in the mean scores of the two treated groups in the retention test.

Research Question 3 : What is the mean achievement scores of male and female learners taught Mathematics with combined TCI/MMI.

Table 5 : Mean Achievement Scores of Male and Female Learners in the Group taught with combined TCI/MMI.

Sex	**N**	**Pretest Mean**	**Mean Achievement Score**	**Std. Deviation**	**Mean Gain**
Male	17	16.15	55.19	11.143	39.04

Female	29	16.29	52.14	14.559	35.85

The numerical strength of the data collected, in table 5 indicates that the male and female students have equivalent mean scores 55. 19 and 52.14 as well as equivalent mean gain of 39.04 and 35.85respectively, which shows that male students have 3.05 higher than the female students. However, the difference is subject to ANCOVA result tested at 0.05 level significance.

Hypothesis 3: There is no significant difference in the mean achievement scores of male and female learners taught Mental Mathematics with combined TCI/MMI

Table 6 : ANCOVA of Male and Female learners Post-Test of the Group taught with combined TCI/MMI

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	7463.741	4	1865.935	13.475	.000	.418
Intercept	8246.255	1	8246.255	59.553	.000	.443
Pre-test	3942.316	1	3942.316	28.471	.000	.275
Method	5510.788	1	5510.788	39.798	.000	.347
Gender	158.005	1	158.005	1.141	.289	.015
Method Gender	1.663	1	1.663	012	913	.000
Error	10385.246	75	138.470			
Total	199205.000	80				
Corrected Total	17848.988	79				
a. R Squared 418	(Adjusted R Squared = .387)					

Decision: Null hypothesis accepted

The summary table 6 shows that p-value (Sig.) is 913 while the result was tested at 0.05 level of significance. Hence, the null hypothesis was accepted and the alternative hypothesis rejected. Since the p-value is greater than 0.05, the researcher therefore, upholds that there is no significant difference between the mean scores of male and female students in terms of Mental Mathematics achievement of group taught with combined TCI/MMI in the post-test. This implies that the mean difference between male and female students in the post test is not significant. Hence the method of combined TCI/MMI is not gender biased as it is favorable to both gender.

The findings of this study agrees with that of Suleiman & Hammed (2019) which says that the reason why most students fail to learn mathematics well is due to their poor mastery of mental computational skills at the lower level. (Guskov ,2004) as cited in Sani, (2015).concluded that if a child completed primary school without sound mastery of elementary mental computational skills, the child has no chance of learning higher mathematics.

Conclusion

This study from it's findings has established that Mental Mathematics instruction enhances achievement, facilitates the acquisition of Mental mathematics skills which enhances problem-solving abilities needed for the present business world , Mental mathematics skills increase self-confidence and retention and it is gender friendly. Giving special attention to mental mathematics especially at the primary level is a welcome development because it will help learners develop essential skills for success in science and technology and also in the business world. A lot of people especially authors, parents and teachers do not really see the need of mental mathematics and this may be the reason for very few mental mathematics text books available for use in South-Eastern Nigerian schools, libraries and book shops and negligence to the teaching of mental mathematics in this part of the world. Teachers focus more on paper and pen work whereas mental mathematics is the type of mathematics used most often in our everyday real life situations and mental mathematics is also used to check the correctness of answers obtained from paper and pen work and also the answers obtained from calculators. Mental mathematics lessons help teachers to revisit what they have already taught learners.

Recommendations

Based on the findings and conclusions drawn from the study, the following recommendations were made.

i. Education stake holders , Administrators of schools and Ministry of Education should include mental mathematics text books in their list of recommended text book for primary school pupils and also assign time to mental mathematics teaching in their school time table.

ii. Primary school teachers and the learners should be encouraged to participate actively in mental mathematics activities in the classroom.

iii. Regular seminars and workshops on the importance of mental mathematics should be organized for primary school teachers and sponsored by Government for massive attendance.

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Blood Cancer Diagnostic System using Deep Learning

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Abstract

Blood cancer is currently the seventh most common type of cancer and the ninth leading cause of cancer-related deaths in both males and females. In medical diagnosis, time and accuracy are critical factors. Traditional pathological diagnostic methods are often expensive, time-consuming, and prone to human error. As a result, the use of deep learning algorithms for detection and diagnosis is becoming increasingly prevalent due to their high performance and accuracy. We developed a system that effectively diagnoses two types of blood cancer, leukemia and lymphoma. In order to test the accuracy of lymphoma and leukemia diagnosis, other kinds of cells were added into our dataset such as lymphocytes, which are not very easy for doctors to distinguish. Each type of blood cancer has distinct characteristics. Deep learning techniques enable the development of automated and effective systems for their identification. In this study, pre-trained convolutional neural networks (CNNs) including ResNet50 (a 50-layer Residual Network), Google Inception, and VGG16 (a 16-layer model from the Visual Geometry Group) were utilized through transfer learning. These models were fine-tuned using a dataset of blood cell images and trained using an end-to-end method. An ensemble model was developed by averaging the predictions of the three individual classifiers. All models were evaluated, and a comparative analysis was conducted to determine the most effective classifier. This ensemble approach achieved higher accuracy of 91%, sensitivity 100%, f1 score 100% and precision 95% which outperformed the individual models. The final diagnostic system was deployed as an offline application to ensure accessibility for medical personnel.

Keywords: *Blood cancer, Leukemia, Lymphoma, Lymphocytes, Medical diagnosis, Cancer detection, Diagnostic accuracy, Sensitivity, Precision, F1 score*

Technical & Methodological Keywords: *Deep learning, Convolutional neural networks (CNNs), Transfer learning, ResNet50, Google Inception, VGG16, Ensemble model, End-to-end training, Image classification, Model evaluation*

1.0 Introduction

In Watine (2021), medical diagnosis means not only detection or exclusion of disease but also evaluation of disease risk, prognostic assessment and therapeutic monitoring. There was a substantial interest in studying decisions in the early 1970's by experts without the utilization of statistical instruments, and figuring out whether and how such choices could be demonstrated in a personal computer. Specifically, there was an enthusiasm for researching conceptual and symbolic strategies suitable for displaying doctor and other expert decision making (O'Leary, 2013).

As a standard practice in clinical medicine, microscopic examination of peripheral blood plays an important role in the field of diagnosis and control of major diseases. It is uniquely capable of discerning clinically relevant morphologic features of hematopoietic cells, including abnormal white blood cells (WBCs, also known as leukocytes) in lymphoma, leukemia, dysplasia and other diseases (Bain *et al*., 2015). Gold-standard morphologic profiling of blood cells relies heavily on manual smear processing techniques and visual inspection with limitations from quality-control and economic scalability (Durant *et al*., 2017). Blood smear preparation and interpretation are negatively affected by observer bias, slide distribution errors, statistical sampling error, recording error, and also involve labor-intensive processes that require highly skilled technicians. As such, there has been considerable interest in developing systems for automated classification of digital images of peripheral blood smears with high sensitivity and specificity (Ceelie *et al*., 2017). The widespread adoption of electronic medical records contributes to the exponential generation of biomedical data in size, dimension and complexity (Livieris *et al*., 2018).

Due to all the drawbacks of traditional recognition systems, there is an urgent necessity to develop more adaptive and practical high-performance recognition systems.

Casey (2019) views deep learning as an essential branch of Artificial Intelligence (AI) that closely tries to mimic how the human brain works. CNN-motivated deep learning algorithms have become the standard choice for medical image classifications. State-of-the-art CNN-based classification deep learning solutions has the potential not just to aid human experts in image diagnosis but also has the capability to replace human experts (Bennur, 2019).

The deep learning technologies have shown impressive performance in various vision tasks such as image classification, object detection and semantic segmentation. The core of the deep learning technology is automatic feature extraction which is a critical step in image processing. It involves the identification and extraction of significant attributes from an image. In the field of deep learning, Convolutional Neural Networks (CNNs) have achieved excellent performance in image analysis. It makes it possible to avoid complications and error associated with hand-crafted features.

2.0 Related works

Several notable deep learning systems have been developed in recent years. The success of this project will depend greatly on the review of existing literatures on deep learning models especially in the areas of diagnosis.

In Anwar and Alam (2020), a convolutional neural network-based learning approach to acute lymphoblastic leukemia detection with automated feature extraction was proposed. The objective of this study is to detect acute lymphoblastic leukemia using a convolutional neural network model. The dataset includes 368 microscopic blood smeared images and 736 after data augmentation (360 blast cells and 376 non-blast cells). A softmax classifier was used to classify the images into blast cells (leukemia) and non-blast cells (not leukemia). The proposed model yields an outstanding accuracy between 99 and 100% in most of the trials. Although a high accuracy was achieved in the classification task and the model eliminated the need for any segmentation or extraction technique, the model

is trained to diagnose only one type of blood cancer (leukemia). Also, limited dataset was used to train the model which could decrease robustness and increase chances of over-fitting.

Similarly, Brancati *et al*. (2019), a deep learning approach for breast invasive ductal carcinoma detection and lymphoma multi-classification in histological images. The goal of this paper is to address two different use cases: the detection of invasive ductal carcinoma in breast histological images and the classification of lymphoma sub-types using deep learning. For invasive ductal carcinoma, total of 162 whole slide images were obtained which when divided into patches representing IDC and non-IDC is 46, 633 and 124, 011, respectively (public dataset). For the lymphoma multi-classification, a total of 374 images were generated, containing 113, 139 and 122 images of chronic lymphocytic leukemia, follicular lymphoma and mantle cell lymphoma respectively. A Supervised Encoder FusionNet (SEF) method based on a Residual CNN (the encoder of FusionNet) and a softmax classifier was used to address the two use cases. The SEF method significantly outperformed the other deep learning approaches with an overall increment of 4.86%, 5.52%, 3.7% and 2.33% in accuracy as compared to FusionNet, Unet, SEU and ResNet-34, respectively. This study also goes a long way in reducing the inter- and intra-reader variability among pathologists and also accelerates the diagnosis process. Nevertheless, there is the possibility of over-fitting because large dataset was used in training the model and no data augmentation was performed on the datasets. Also, the scope is limited to only one type of blood cancer.

Boldu *et* al. (2021), a deep learning model (ALNet) for the diagnosis of acute leukemia lineage using peripheral blood cell images. This study aims to develop a deep learning based system to predict acute leukemia using blood cell images. A set of 731 blood smears containing 16, 450 single-cell images was analyzed. To find the best architecture for acute leukemia classification, VGG16, ResNet101, DenseNet121 and SENet154 (CNNs) were evaluated. Once chosen, a system with two modules working sequentially was configured (ALNet). The proposed system, ALNet, obtained 94.2% accuracy for myeloid leukemia detection and 89.5% accuracy for lymphoid leukemia. This system can distinguish neoplastic (leukemia) and non-neoplastic (infections) diseases and can assist clinical pathologists in the diagnosis of acute leukemia during blood smear review. Nevertheless, by not sourcing data from different institutions, accuracy could be negatively affected. Also, this study was not extended to cover other kinds of white blood cancers, only leukemia.

Saleem *et al*. (2021), in their paper on deep network designed for the segmentation and classification of leukemia using fusion of the transfer learning models proposes a modified deep learning approach for the accurate segmentation of leukocytes and their classification. Two public datasets were utilized; LISC and ALL-IDB. The LISC dataset includes 250 images while the ALL-IDB contains 367 images. Generative Adversarial Network (GAN) was used to preprocess the datasets. Deep models (Darknet-53 and ShuffleNet) were used for classification of white blood cells. Finally, a CNN (ResNet-18) was used for semantic segmentation. Classification accuracy achieved with ALL-IDB and LISC dataset is 100% and 99.70% for leukocytes whereas semantic segmentation achieved 99.10% and 98.60% for average and global accuracy respectively. The increase in size of datasets by using GAN network with selected learning parameter ultimately increases the performance of classification accuracy but this study was not extended to accommodate other types of blood cancer. Also, the use of limited number of dataset and no data augmentation techniques could lead to over-fitting.

In Kassani (2019), a hybrid deep learning architecture for leukemic B-lymphoblast classification, an automated deep learning-based method was proposed to distinguish between immature leukemic blasts and normal cells. The dataset contains 7272 Acute Lymphoblastic

Leukemia cell images and 3389 normal cell images. Two CNN model architectures (VGG16 and MobileNet) were trained. Prediction accuracy of 96.17% was achieved for leukemic B-lymphoblast classification. By proposing a hybrid CNN model that combines low-level features from intermediate layers, high-level discriminative feature maps can be generated for immature leukemic blast classification. On the other hand, this study was not extended to accommodate other types of blood cancer and the proposed hybrid CNN model requires a lot of computational time and memory space.

Pang *et al*. (2017), a novel end-to-end classifier using domain transferred deep convolutional neural networks for biomedical images. This study proposes an end-to-end classifier for all kinds of biomedical images through deep learning and transfer learning. Data was gotten from three well known public biomedical image databases; NEMA-CT database (696 training images and 95 testing images), TCIA-CT database (744 training images and 117 testing images) and OASIS-MRI database (452 training images and 82 testing images). Domain transferred deep convolutional neural network (DT-DCNN) was applied in classification of biomedical images. The classification accuracy of the proposed CNN model architecture for the NEMA-CT, TCIA-CT and OASIS-MRI datasets are 100%, 100% and 93.767%, respectively. Even though this model shows a highly reliable and accurate performance which has been confirmed on several public datasets, it is domain based and so can only be used to classify a particular disease at a time. Moreover, convergence speed for the OASIS-MRI is slow and reflects in the accuracy and limited number of dataset used which could cause over-fitting.

Hasan *et al*. (2020) proposed an accurate recognition of leukemia sub-types by utilizing a transfer learning deep convolutional neural network. The objective of this research is to analyze a leukemia sub-type dataset which has samples from three sub-types of leukemia. The dataset includes 334 images and 3600 after augmentation. CNN architecture (DenseNet-201) was used for classification and an overall accuracy of 99.56% was realized. From the result, this approach can be employed for precise recognition of leukemia. However, this work was not extended to recognize and classify other types of blood cancer and the dataset used is limited since it is a multi-class classification and could lead to over-fitting.

Shafique and Tehsin (2018) proposed an acute lymphoblastic leukemia (ALL) detection and classification of its subtypes using pre-trained deep convolutional neural networks. This research is aimed at utilizing deep convolutional neural network for automated detection of acute lymphoblastic leukemia and classification of its subtypes into 3 classes. The dataset includes 368 images and softmax was used as the classifier. Sensitivity of 100%, specificity of 98.11% and accuracy of 99.50% was achieved for acute lymphoblastic leukemia detection. Sensitivity of 96.74%, specificity of 99.03% and accuracy of 96.06% was achieved for acute lymphoblastic leukemia subtype classification. This automated diagnostic system can help in early diagnosis of leukemia. It is also able to detect and classify three subtypes of acute lymphoblastic leukemia. This approach made use of one deep learning model for classification. There was no comparison with other deep learning architectures to check which model performs better than the others. Also, it can only diagnose one type of blood cancer and limited number of images in the dataset could lead to over-fitting.

Current automated systems basically depend on traditional machine learning and image processing techniques which involves more computational time, relatively high error rate in terms of recognition and mostly suited for small datasets (Yu *et al*., 2017). In addition, deep learning systems are mostly suited for large data with low recognition error rate. With this current trend in artificial intelligence, it is possible to automatically detect and diagnose diseases using deep learning (Lee *et al*., 2017).

3.0 Deep Learning Models

i. ResNet-50**:** ResNet-50 model is a convolutional neural network (CNN) that is 50 layers deep and stacks residual blocks on top of each other to form a network. It is an innovative neural network that was first introduced in computer vision research paper research titled 'Deep Residual Learning for Image Recognition' (He *et al.,* 2016). Residual Networks (ResNet50) are deep convolutional networks where the basic idea is to skip blocks of convolutional layers by using shortcut connections. It was pre-trained for object detection task on the ImageNet dataset. This model was immensely successful, as can be ascertained from the fact that its ensemble won the top position at the ILSVRC 2015 classification competition with an error of only 3.57%. Additionally, it also came first in the ImageNet detection, ImageNet localization, COCO detection, and COCO segmentation in the ILSVRC & COCO competitions of 2015 (Boesch, 2022). The ResNet-50 is used as the first classifier for this research.

ii. VGG-19: Visual Geometry Group Network (VGGNet) was introduced by Karen Simonyan and Andrew Zisserman from the Visual Geometry Group (VGG) of University of Oxford in 2014 to examine the effect of the depth of a convolutional network on the final classification accuracy. This architecture achieved one of the top performances, with better feature extraction in the ILSVRC 2014 challenge, using a 3 × 3 convolution filter size. In this architecture, small filters increase the depth of the network instead of its width, which plays a critical role in gaining higher performance. There are two versions of this architecture: VGG16 and VGG19, with different depth and layers (Simonyan and Zisserman, 2015).

iii. Inception V3: The InceptionV3 architecture, proposed by Szegedy *et al.*2016, won the ImageNet ILSVRC 2014 competition. It is a very deep network, consisting of 22 layers and having fewer parameters than AlexNet. The Inception module is able to extract multi-level features in parallel, making it considerably more efficient and faster (Szegedy *et al.,* 2016). The Inception-v3 Convolutional Neural Network is used as the third classifier for the research work. The Inception V3 has 48 layers and is trained with more than a million images from the dataset. Inception V3 module has pooling layers and convolutional filters and Softmax activation function. Two Dense layers are added at the end. The fine-tuning parameters are same as the previous architecture VGG-19.

iv. Ensemble: The weights of each image classifiers are saved and are ensembled. In this method, the average predictions of all the three image classifiers are taken to make the final prediction.

According to Kasani *et al.* (2020), transfer learning is a common strategy in deep learning, where a large dataset from a source task is used for training another target task, leading to not only overcoming the problem of small datasets but also accelerating the learning process and improving the accuracy. Transfer learning approach enables one to adopt a pre-trained network that has already learned a rich set of low-level features from layers that are closer to the input image. Though the dataset is not the same, the low-level features produced by the source CNN are mostly of general shapes, for example, edges, contours and curves, which are similar to the low-level features of the target dataset, while high-level features at the final layers concentrate on complex class-level characteristics, which are needed to differentiate between classes. With the use of transfer learning, training of a CNN is a practical strategy with promising results and significantly more cost-effective than training from scratch. Previous studies also showed that transfer learning also has the potential to prevent over-fittings (Lu *et al.,* 2019).

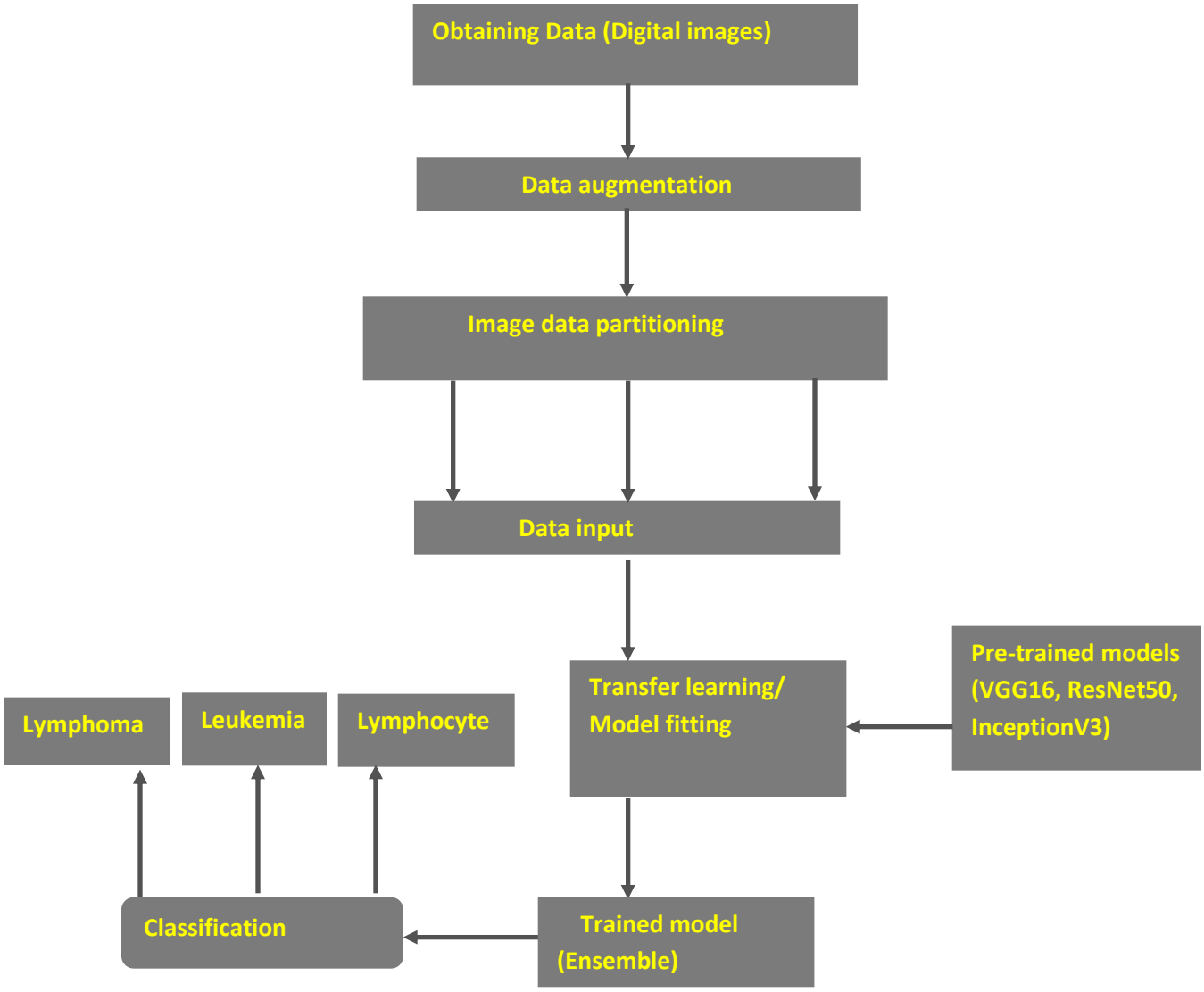

Figure 1: Detailed work flow diagram of blood cancer diagnostic system

4.0 Dataset

The images used in training the deep learning model were gotten from kaggle.com. They were prepared in the bone marrow laboratory of Taleqani Hospital (Tehran, Iran). The acquired data consists of labeled 2231 blood smear microscopic images, categorized into leukemia/ lymphoma/ lymphocyte. Another datasets include 1538 images of malignant cancer and 693 of benign non-cancerous images. The third dataset consists of 3256 PBS images from 89 patients suspected of ALL, whose blood samples were prepared and stained by skillful laboratory staff. The last dataset is divided into two classes of benign and malignant. The former comprises of hematogones and the latter is the ALL group with three subtypes of malignant lymphoblasts: Early Pre-B, Pre-B, and Pro-B ALL. All the images were taken by using a Zeiss camera in a microscope with a 100x magnification and saved as JPG files. A specialist using the flow

cytometry tool made the definitive determination of the types and subtypes of these cells.

Three types of malignant lymphoma are represented in the third dataset:

i. CLL (chronic lymphocytic leukemia);

ii. FL (follicular lymphoma);

iii. MCL (mantle cell lymphoma).

The ability to distinguish classes of lymphoma from biopsies sectioned and stained with Hematoxylin/Eosin (H+E) would allow for more consistent and less demanding diagnosis of this disease. Only the most expert pathologists specializing in these types of lymphomas are able to consistently and accurately classify these three lymphoma types from H+E-stained biopsies. The standard practice is to use class-specific probes in order to distinguish these classes reliably. This dataset is a collection of samples prepared by different pathologists at different sites. There is a large degree of staining variation that one would normally expect from such samples.

5.0 Methods

5.1 Data Preprocessing

Some of the images collected could have non-uniform illumination across all regions and some could be blurred due to focusing problem. These problems can be solved by employing pre-processing tasks such as the rolling-ball background subtraction method and using a sharpening filter to increase the contrast for the images (Cai and Verbeek, 2019). Generally, some of the pre-processing tasks performed on blood cancer images include data normalization, data augmentation, scaling, staining, cropping, resizing and image registration. However, not applying these pre-processing tasks on the raw images may distract the classification model which can lead to high misclassification rate (Murtaza *et al*., 2019). This stage is required to increase the overall performance of the model and to avoid over-fitting (Tessema *et al*., 2021).

The performance of deep learning models may degrade due to imbalanced datasets or small numbers of training data. This normally occurs where data dimensionality is much larger than the number of samples or due to an imbalance in the number of training samples of each class. In order to avoid over-fitting of the classification model which usually arise from small sized and/or imbalanced data, different strategies of data augmentation were employed, such as horizontal and vertical flips, contrast adjustments and brightness correction to enlarge the dataset. Employing data augmentation techniques enables the model to yield better performance compared to non-augmented data. Data augmentation is employed as a pre-processing step to avoid over-fitting as well as boost classification performance.

Before the augmented data is further processed, some morphological features of these blood cancer types (lymphoma and leukemia) are first extracted from the images (feature extraction) in Google colaboratory (CoLab) environment which is a free Jupiter notebook interactive development environment. These features include:

i. Contour: For lymphoma, the nuclei are large and often rounded in contour with a prominent, often irregular nuclear membrane, pale chromatin and usually one prominent eosinophilic nucleolus. Mononuclear variants of reed-sternberg cells (lymphoma cells) are characterized with a rounded contour or oblong nucleus with large inclusion-like nucleoli. For leukemia, the nuclei are eccentric and often bilobed with a folded contour or a squishy contour and a reniform nuclear shape.
ii. Color**:** In lymphoma, reed-sternberg cells may have condensed cytoplasm and pyknotic reddish nuclei called mummified cells. However, in leukemia, the blasts are large cells with abundant cytoplasm, light gray to deep blue (purple) with possible rare azurophilic granules.
iii. Size: In lymphoma, classical diagnostic reed-sternberg cells are large (15 to 45 micrometers). In leukemia, blasts are often larger than a lymphocyte and at least the size of a monocyte. They are usually medium to large cells (14 to 18 micrometers).
iv. Edges**:** In the case of lymphoma, reed-sternberg cells appear as large cells of delicate edge with a perinuclear clearing (halo), resembling a viral inclusion. They are also mostly found at the edge of the smear. For leukemia, the edge of the nucleus is rounded with a delicate lacy chromatin with one or more large prominent nucleoli. Most times, they present themselves as large cells with the same chromatin pattern but with convoluted/ indented nuclear shape.

5.2 Feature extraction and Classification:

According to Phung and Rhee (2019), convolutional neural network consists of five different layers: an input layer, a convolution layer (Acevedo *et al*., 2019), a pooling layer, a fully-connected layer and an output layer. These layers are divided into two parts: feature extraction and classification layers. Feature extraction consists of an input layer, a convolution layer, and a pooling layer, while classification consists of a fully-connected layer and an output layer. Feature extraction facilitates the accurate classification of blood cancer by presenting the dimensionally reduced significant features (Praveena and Singh, 2020). In computer vision, a feature is a measurable piece of data in an image, which is unique to that specific object. It can be a distinct color in an image or a specific shape such as a line, edge, corner, or an image segment. A good feature is used to distinguish objects from one another.

Table 1: Some notable key contributions of different deep learning models for blood cancer classification.

Author (Reference)	Feature extraction method/ classifier	Accuracy
Kasani *et al*., 2020	Ensembled CNN (NASNetLarge & VGG19)	96.58%
Anwar and Afrin, 2020	10 layers CNN	99 - 100%
Mao *et al*., 2016	DCNN	97% f1 score
Brancati *et* al., 2019	SEF based on residual CNN & softmax classifier	97.6%
Boldu *et al*., 2021	CNN (ALNet)	89.5 - 94.2%
Saleem *et al*., 2021	CNN (DarkNet-53, ShuffleNet & ResNet-18)	99.70 - 100%
Kassani, 2019	CNN (VGG16 & MobileNet)	96.17%
Pang *et al*., 2016	5 layers DT-DCNN	93.77 - 100%
Hasan *et al*., 2020	CNN (DenseNet-201)	99.56%
Shafique and Tehsin, 2018	CNN (AlexNet)	96.06 - 99.50%
Genovese *et al*., 2021	CNN (VGG16)	96.84%
Kasani *et al*., 2020	Ensembled CNN (NASNetLarge & VGG19)	96.58%
Ridoy and Islam, 2020	8 layers CNN (LeNet-5)	92.15 - 98.31%
Banik *et al*., 2020	5 Layers CNN	96%
Das and Meher, 2021	CNN (MobilenetV2 and ResNet18).	97.18 – 99.39%
Qiao *et al*., 2021	3 layers CNN	99.21% Sensitivity

Tsykunov *et al*., 2020	CNN (ResNet34).	92.42%
Zhao *et al*., 2020	Lightweight CNN	86.29%
Khandekar *et al*., 2021	CNN (YOLOV4)	95.57 – 98.57% MAP
Anilkumar *et al*., 2021	DCNN (pre-trained CNN; AlexNet and custome-made DL network; LeukNet.)	94.12%

5.3 Model Training

The dataset was split into 3 separate segments for training, validation, and testing. The training data (80%) is for model learning, validation data (10%) is for model evaluation and model parameters tuning. Test data (10%) is for the final evaluation of our model. Deep learning frameworks and libraries were used in the training to achieve good results. The training involves object detection using blood smear images. This was carried out with python language using Keras library which uses Tensorflow at the backend. The data is transformed from 3D to 4D tensor with shape 1, 120, 120, 3. The augmented data is processed through the pretrained image classifiers ResNet-50, Inception V3 and VGG-19. Final layers of all the three image classifiers were fine-tuned by adding two dense layers. Global Average Pooling and softmax were used as the active function. Adam optimizer with learning rate of 0.001 is used which has the fastest convergence and lower loss during the training. The images were processed in the batch of 8 and the loss function being categorical cross-entropy. All classifiers were trained for 10 epochs. The Inception V3 achieved an accuracy of 85%, ResNet-50 model trained with an accuracy of 86.19% and VGG-19 with training accuracy of 90.06% which is the best among the three. The ensemble model which is the average prediction of the three models achieved an accuracy of 91%.

6. Results

The model was evaluated using accuracy, sensitivity/recall, precision and F1 score. These evaluation metrics helps to determine the reliability of the model. The ideal model classifies true positive and true negative efficiently.

i. Accuracy

Model	ResNet-50	VGG-19	Inception V3	Ensemble
Accuracy in %	**86.19**	**90.06**	**85.08**	**91**

Although all the four models performed well, from the above chart it is obvious that the VGG-19 classifier performed well in terms of accuracy and ensemble method performed slightly better.

ii. Sensitivity or Recall or True positive rate

Model	ResNet-50	VGG-19	Inception V3	Ensemble
Sensitivity	**0.88**	**0.96**	**0.87**	**1**

Sensitivity in this research work denotes what proportion of images that had blood cancer being classified as blood cancer. Sensitivity is given by the equation: Sensitivity = TP / (TP + FN)

iii. Precision

Model	ResNet-50	VGG-19	Inception V3	Ensemble

Precision	**0.91**	**0.92**	**0.90**	**0.95**

Precision = TP/ (TP+FP)

Precision is the measure that tells us what proportion of images that we classified as having blood cancer, actually had blood cancer. Ensemble model has precision value of 0.95 followed by VGG-19 with precision value of 0.92.

iv. F1 score

Model	ResNet-50	VGG-19	Inception V3	Ensemble
F1 score	**0.90**	**0.94**	**0.88**	**1**

F1 score is a measure of test's accuracy that considers both the precision and recall of the test to compute the score. It is given by the formula: F-measure = 2*Recall*Precision / Recall + Precision

v. Confusion Matrix

Figure 2 below shows the confusion matrix of the proposed model. The deep colored diagonal boxes in our confusion matrix show the count of True Positive (TP) items in each class.

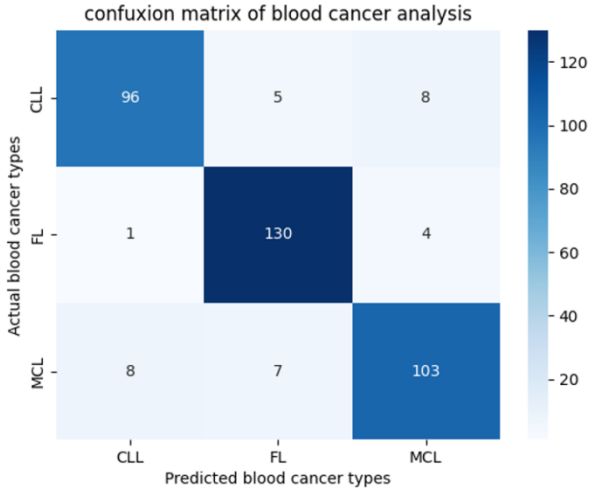

Figure 2: Confusion matrix obtained for the new model

From the above metrics, it is evident that the ensemble architecture outperforms the other deep learning models in image classification. It achieved an accuracy of 91%, sensitivity 100%, f1 score 100% and precision 95%.

7. Conclusion and Recommendations

The system equipped us with the idea of replacing the manual method of diagnosing blood cancer into a computerized approach. Medical personnel are advised to exploit the opportunity which this software offers. There is no gainsaying the fact that reliable software of

this sort which can perform the following tasks is needed.
More deliberation can be made which can even lead to the development of better systems like the one which can diagnose any type of disease in the world. In future, it is also recommended to explore the application of our approach to other use cases for histological image analysis and also with a different training strategy that is not end-to-end. For future research directions, it is recommended to employ the ensemble of other CNN architectures to further increase the accuracy and sensitivity values.

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Unshackling the Future: Overcoming Historical Limitations in Nigeria's Education System

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Abstract

Nigeria's education system has been shaped by a complex interplay of historical, cultural, and socio-economic factors, resulting in persistent challenges that hinder its development. This study critically examines the historical limitations that have impacted Nigeria's education system, including the legacy of colonialism, inadequate funding, and poor infrastructure. The research aims to identify the historical roots of these challenges and explore strategies for overcoming them, with a focus on promoting inclusive, quality education for all Nigerians. A qualitative approach was employed, analyzing historical documents, academic literature, and stakeholder perspectives to understand the complexities of Nigeria's education system. The study reveals that Nigeria's education system is still grappling with the consequences of historical limitations, including inadequate infrastructure, poor teacher quality, and inequitable access to education. However, the research also highlights opportunities for reform and innovation, including the potential for technology-enhanced learning, community-based initiatives, and contextually relevant curricula. Based on the findings, the study recommends that policymakers prioritize contextually relevant education policies, increase funding for education, and promote inclusive and equitable access to quality education for all Nigerians.

***Keywords**: Education system, Nigeria, historical limitations, inclusive education, policy reform.*

1.0 Introduction

The education system in Nigeria has been a subject of concern for decades, with various stakeholders calling for reforms to improve its quality and accessibility (Adeyemi, 2010). Despite efforts to address these challenges, the system continues to grapple with issues such as inadequate infrastructure, poor teacher quality, and inequitable access to education (Federal Ministry of Education, 2013). This study aims to contribute to the ongoing conversation on education reform in Nigeria by examining the historical limitations that have impacted the system and exploring strategies for overcoming them.

The legacy of colonialism has had a profound impact on Nigeria's education system, shaping its curriculum, pedagogy, and governance structures (Ajayi, 2003). The colonial authorities imposed a Western-style education system that prioritized the needs of the colonial administration over those of the local population (Fafunwa, 1974). This legacy continues to influence the system today, with many arguing that it remains overly Westernized and disconnected from the needs and contexts of Nigerian society (Okeke, 2015).

In addition to the colonial legacy, Nigeria's education system has faced numerous other challenges, including inadequate funding, poor infrastructure, and a lack of qualified teachers (World Bank, 2018). These challenges have resulted in poor learning outcomes, high dropout rates, and limited access to education for many Nigerians (UNICEF, 2019).

To address these challenges, the Nigerian government has implemented various policy reforms aimed at

improving the quality and accessibility of education (National Policy on Education, 2013). However, many of these reforms have been criticized for being overly ambitious, poorly implemented, or disconnected from the needs of the system (Adeyinka, 2007).

This study aims to contribute to the ongoing conversation on education reform in Nigeria by examining the historical limitations that have impacted the system and exploring strategies for overcoming them. By analyzing the complex interplay of historical, cultural, and socio-economic factors that have shaped the system, this study seeks to identify opportunities for reform and innovation that can promote inclusive, quality education for all Nigerians.

The significance of this study lies in its potential to inform policy decisions and interventions aimed at improving the quality and accessibility of education in Nigeria. By understanding the historical limitations that have impacted the system, policymakers can develop more effective strategies for addressing the challenges facing the system and promoting positive change (Fullan, 2007).

This study aims to contribute to the ongoing conversation on education reform in Nigeria by examining the historical limitations that have impacted the system and exploring strategies for overcoming them. By analyzing the complex interplay of historical, cultural, and socio-economic factors that have shaped the system, this study seeks to identify opportunities for reform and innovation that can promote inclusive, quality education for all Nigerians.

2.0 Unshackling the Future: Overcoming Historical Limitations in Nigeria's Education System

The education system in Nigeria has been shaped by a complex array of historical, cultural, and socio-economic factors. For decades, the system has struggled with issues such as inadequate infrastructure, poor teacher quality, and inequitable access to education. These challenges have resulted in poor learning outcomes, high dropout rates, and limited opportunities for many Nigerians.

One of the primary historical limitations facing Nigeria's education system is the legacy of colonialism. The colonial authorities imposed a Western-style education system that prioritized the needs of the colonial administration over those of the local population. This legacy continues to influence the system today, with many arguing that it remains overly Westernized and disconnected from the needs and contexts of Nigerian society.

In addition to the colonial legacy, Nigeria's education system has faced numerous other challenges, including inadequate funding, poor infrastructure, and a lack of qualified teachers. These challenges have resulted in a system that is unable to provide quality education for all Nigerians, perpetuating inequality and limiting opportunities for social mobility.

To overcome these historical limitations, it is essential to develop a new vision for Nigeria's education system. This vision should prioritize the needs and contexts of Nigerian society, promoting a more inclusive and equitable approach to education. By valuing and incorporating local cultures, languages, and knowledge systems, the education system can become more relevant and effective in meeting the needs of Nigerian students.

A key aspect of this new vision is the need for contextually relevant education policies. Policymakers should engage with local communities and stakeholders to develop policies that are responsive to the unique challenges and opportunities facing Nigeria's education system. By prioritizing the needs and contexts of Nigerian society, policymakers can create a more effective and sustainable education system.

Another critical aspect of unshackling the future of Nigeria's education system is the need for increased funding and resources. The government should prioritize education in its budget, allocating sufficient resources to support the development of infrastructure, teacher training, and student support services. By investing in education, the government can promote economic growth, reduce poverty, and improve the overall well-being of Nigerian citizens.

Furthermore, technology can play a vital role in promoting access to quality education in Nigeria. By leveraging digital platforms, online resources, and mobile technologies, educators can reach more students, improve learning outcomes, and enhance the overall quality of education. Technology can also help bridge the gap between urban and rural areas, promoting more equitable access to education.

Unshackling the future of Nigeria's education system requires a multifaceted approach that addresses the historical limitations and challenges facing the system. By developing a new vision for education, prioritizing contextually relevant policies, increasing funding and resources, and leveraging technology, Nigeria can create a more inclusive, equitable, and effective education system that promotes opportunities for all citizens.

2.1 Historical Narratives of Nigeria's Education System

The history of Nigeria's education system is a complex and multifaceted narrative that reflects the country's diverse cultural, social, and economic contexts. From the pre-colonial era to the present day, the education system has undergone significant transformations, shaped by various historical events, policies, and ideologies.

In the pre-colonial era, education in Nigeria was largely informal, with children learning traditional skills and values from their families and communities. However, with the arrival of European colonizers, the education system began to take on a more formal structure, with the introduction of Western-style schools and curricula. This marked the beginning of a new era in Nigeria's education history, one that would be shaped by the complex and often conflicting influences of colonialism and indigenous culture.

The colonial era had a profound impact on Nigeria's education system, shaping its curriculum, pedagogy, and governance structures. The colonial authorities imposed a Western-style education system that prioritized the needs of the colonial administration over those of the local population. This legacy continues to influence the system today, with many arguing that it remains overly Westernized and disconnected from the needs and contexts of Nigerian society.

Despite the challenges posed by colonialism, Nigeria's education system has also been shaped by the country's rich cultural heritage. Traditional values and practices continue to play an important role in shaping the education system, with many schools and communities incorporating local customs and knowledge into their curricula. This blending of traditional and Western influences has resulted in a unique and complex education system that reflects Nigeria's diverse cultural contexts.

In the post-colonial era, Nigeria's education system has undergone significant reforms and transformations. The government has implemented various policies aimed at improving access, quality, and equity in education, including the Universal Basic Education (UBE) program. However, despite these efforts, the system continues to face numerous challenges, including inadequate infrastructure, poor teacher quality, and inequitable access to education.

The history of Nigeria's education system is also marked by regional and cultural differences, with different regions and communities having unique educational experiences and traditions. For example, the Hausa-Fulani region in the north has a strong tradition of Islamic education, while the Yoruba region in the southwest has a rich history of Western-style education. These regional differences have contributed to the complexity and diversity of Nigeria's education system.

Today, Nigeria's education system continues to evolve, shaped by global trends, technological advancements, and changing societal needs. As the country looks to the future, it is essential to understand the historical narratives that have shaped its education system, in order to build a more inclusive, equitable, and effective system that promotes opportunities for all Nigerians. By acknowledging and learning from the past, Nigeria can create a brighter future for its citizens and contribute to the development of a more just and prosperous society.

3.0 Challenges Faced by Nigeria's Education System

Nigeria's education system is one of the largest in Africa, with over 30 million students enrolled in primary and secondary schools. However, despite its size and potential, the system faces numerous challenges that hinder its effectiveness and quality. One of the major challenges is inadequate funding, which has resulted in poor infrastructure, inadequate teaching materials, and insufficient technology. Many schools lack basic facilities such as classrooms, libraries, and laboratories, making it difficult for students to learn effectively.

Another significant challenge facing Nigeria's education system is the shortage of qualified teachers. Many teachers in Nigeria are not adequately trained, and some schools lack teachers in critical subjects such as mathematics and science. This shortage of qualified teachers has resulted in poor teaching quality, which in turn affects student learning outcomes. Additionally, many teachers in Nigeria are underpaid and overworked, leading to low morale and high turnover rates.

Inadequate access to education is also a major challenge facing Nigeria's education system. Many children in Nigeria, particularly in rural areas, do not have access to quality education due to poverty, lack of schools, and cultural barriers. Girls and women are disproportionately affected, with many facing significant barriers to accessing education. This lack of access to education perpetuates poverty and inequality, limiting opportunities for social mobility and economic development.

The quality of education in Nigeria is also a significant concern. Many students in Nigeria perform poorly in

national and international assessments, indicating a lack of mastery of basic skills such as reading and mathematics. This poor performance is attributed to a range of factors, including inadequate teacher training, poor teaching quality, and lack of resources. Additionally, the curriculum in Nigeria's schools is often outdated and not relevant to the needs of the labor market, making it difficult for graduates to secure employment.

The education system in Nigeria is also plagued by corruption and inefficiency. Funds allocated for education are often misappropriated, and there are reports of ghost teachers, fake certificates, and other forms of corruption. This corruption undermines the quality of education and perpetuates inequality, as those with the means to pay for private education are able to access better quality education.

Nigeria's education system faces numerous challenges that hinder its effectiveness and quality. Addressing these challenges will require a multifaceted approach that includes increased funding, improved teacher training and support, increased access to education, and a more relevant and effective curriculum. By addressing these challenges, Nigeria can build a more effective and equitable education system that promotes opportunities for all citizens and contributes to the country's economic and social development.

4.0 The Futuristic Interpretation of Nigeria's Education System

As Nigeria looks to the future, its education system is poised to undergo significant transformations. With the rapid advancement of technology and the increasing demand for skilled workers, the education system will need to adapt to meet the changing needs of the labor market. In the future, Nigeria's education system will likely prioritize Science, Technology, Engineering, and Mathematics (STEM) education, as well as digital literacy and entrepreneurship.

One potential future direction for Nigeria's education system is the integration of technology into the classroom. With the proliferation of mobile devices and internet connectivity, online learning platforms and digital resources can provide students with access to high-quality educational content, even in remote and underserved areas. This can help bridge the gap in access to quality education and promote more equitable learning outcomes.

Another potential future direction is the emphasis on vocational and technical education. As the global economy continues to shift towards automation and artificial intelligence, Nigeria's education system will need to prioritize skills training and vocational education to prepare students for the changing job market. This can include programs in areas such as renewable energy, agriculture, and entrepreneurship, which can help drive economic growth and development.

In the future, Nigeria's education system may also prioritize more personalized and flexible learning pathways. With the use of artificial intelligence and machine learning, educational platforms can be tailored to meet the individual needs and learning styles of each student. This can help improve learning outcomes and increase student engagement, particularly for students who may not thrive in traditional classroom settings.

The future of Nigeria's education system will also likely be shaped by global trends and partnerships. With the increasing globalization of education, Nigerian students will have access to a wider range of educational opportunities, including online courses and degree programs from international institutions. This can help promote cultural exchange and collaboration, as well as provide Nigerian students with the skills and knowledge needed to compete in the global economy.

However, the future of Nigeria's education system will also be shaped by the country's unique cultural and social contexts. The education system will need to prioritize the preservation and promotion of Nigerian culture and languages, while also preparing students to engage with the global community. This can include incorporating local content and perspectives into the curriculum, as well as promoting cultural exchange programs and international partnerships.

Ultimately, the future of Nigeria's education system will depend on the country's ability to invest in and prioritize education. With increased funding and support, the education system can be transformed to meet the changing needs of the labor market and promote more equitable learning outcomes. By prioritizing education and skills training, Nigeria can build a more prosperous and sustainable future for its citizens, and contribute to the development of a more just and equitable society.

5.0 Conclusion, Recommendations

In conclusion, the education system in Nigeria is a complex and multifaceted entity that has been shaped by a rich history, cultural diversity, and socio-economic challenges. Despite the challenges it faces, the system has made significant progress in recent

years, with increased access to education and improvements in educational outcomes. However, there is still much work to be done to ensure that Nigeria's education system is able to meet the needs of its citizens and drive economic growth and development.

One of the key takeaways from this work is the importance of understanding the historical context of Nigeria's education system. The legacy of colonialism and the impact of cultural and linguistic diversity have all played a significant role in shaping the system, and it is essential to acknowledge and learn from this history in order to build a more effective and equitable system.

Another important conclusion is the need for increased investment in education. Nigeria's education system is underfunded, and this lack of resources has significant consequences for the quality of education and the opportunities available to students. By prioritizing education and increasing funding, the government can help to drive economic growth, reduce poverty, and promote more equitable outcomes.

The future of Nigeria's education system is also likely to be shaped by technological advancements and global trends. The increasing use of digital technologies and online learning platforms has the potential to expand access to education and improve learning outcomes, particularly in rural and underserved areas. However, it will be essential to ensure that these technologies are used in a way that is culturally relevant and responsive to the needs of Nigerian students.

Ultimately, the conclusion of this work is that Nigeria's education system has the potential to be a powerful driver of economic growth, social mobility, and human development. By prioritizing education, increasing funding, and promoting more equitable access to quality education, Nigeria can build a brighter future for its citizens and contribute to the development of a more just and prosperous society. With careful planning, investment, and commitment, Nigeria's education system can be transformed to meet the needs of the 21st century and beyond.

The researcher recommends as follows;

1. Increase funding for education sector development nationwide always.
2. Improve teacher training, quality, and welfare significantly always.
3. Enhance access to quality education for all Nigerian citizens.
4. Promote STEM education and digital literacy nationwide always.

Encourage public-private partnerships in education development always.

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Building Digital Trust: Strategies for Enhancing Cyber security and Data Protection in a Hyper connected World

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Abstract

In an increasingly hyperconnected world, digital trust has emerged as a cornerstone for the secure and sustainable growth of digital ecosystems. As individuals, organizations, and governments rely more heavily on interconnected technologies, the threats to cyber security and data privacy continue to evolve in complexity and scale. This paper explores strategic approaches to building digital trust by enhancing cyber security and data protection measures. It critically analyzes key components including secure infrastructure, data governance, user education, and regulatory frameworks. The paper emphasizes the need for a proactive, multi-stakeholder approach to security where transparency, accountability, and innovation converge. By redefining how trust is established and maintained in digital interactions, this study offers a roadmap for organizations and policymakers aiming to foster safer, more resilient digital environment.

Keywords*: Digital trust, Cybersecurity, Data protection, Hyperconnected world, Secure infrastructure, Data governance, User education, Regulatory frameworks, Transparency, Accountability, Innovation, Multi-stakeholder approach, Digital ecosystems, Privacy threats, Trust in digital interactions, Resilient digital environment, Strategic security measures, Policy roadmap, Sustainable digital growth*

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1. Introduction

In today's hyperconnected world, digital transformation is accelerating across every sector, bringing with it unprecedented opportunities and risks. As societies increasingly rely on interconnected systems for communication, commerce, governance, and critical infrastructure, the security and privacy of digital data have become foundational to global stability and economic resilience (World Economic Forum, 2022). However, this dependency also exposes vulnerabilities to sophisticated cyber threats, ranging from state-sponsored attacks to breaches in software supply chains. At the core of this evolving landscape is the concept of digital trust, the belief that digital systems are secure, reliable, and respect user privacy. Without this trust, the adoption of digital services can falter, eroding public confidence and impeding technological innovation (OECD, 2021). Establishing and maintaining digital trust is therefore not only a technical challenge but strategic imperative requiring coordinated efforts in cyber security, transparent data governance, and user empowerment. This paper examines key strategies for strengthening cybersecurity and data protection to build digital trust.

2.0 Literature Review

Recent research highlights digital trust as a multidimensional construct combining secure technology, human behavior, and organizational accountability. Zhang et al. (2024) demonstrate that secure infrastructure is crucial for maintaining the confidentiality, integrity, and availability of digital assets, forming the bedrock of trust. Data governance frameworks have expanded to integrate security, compliance, and data quality management, with a growing emphasis on AI-driven mechanisms to enforce policies and ensure legal compliance across jurisdictions (Adelakun et al., 2024). User education is increasingly recognized as vital, with studies showing that informed users significantly reduce the success of cyber-attacks by mitigating human error such as phishing susceptibility and weak password use.

2.1 The Concept of Digital Trust

Digital trust refers to the confidence users place in digital technologies and the organizations that deliver them to safeguard their data, ensure system integrity, and uphold ethical standards (Sloan & Warner, 2021). As the digital economy grows, so does the need for robust mechanisms that ensure privacy, security, and transparency. According to the World Economic Forum (2022), digital trust is essential for enabling innovation and sustaining social contracts in a data-driven world. It is built on four pillars: **security, privacy, accountability, and reliability**, which must be continuously reinforced in an evolving technological landscape.

2.2 The Impact of Hyperconnectivity on Cyber security

The proliferation of IoT devices, cloud computing, and AI has led to an unprecedented level of global connectivity. While this hyper connected environment fosters innovation and efficiency, it also expands the **attack surface** for malicious actors (Chatterjee et al., 2020). Cyber threats have become more frequent and sophisticated, targeting critical infrastructure, financial systems, and personal data. Studies have shown a direct correlation between increasing connectivity and the rise in data breaches and ransomware incidents (IBM Security, 2023). The **Ponemon Institute's Cost of a Data Breach Report in 2023** highlights how organizations with poor cyber security practices suffered significantly higher financial losses than those with mature security frameworks. Moreover, organizations with remote work arrangements and widespread device use were particularly vulnerable, underscoring the challenges of maintaining digital trust in decentralized environments.

3. Strategies for Enhancing Cyber security

Cyber security refers to the practices and technologies designed to protect systems, networks, and data from cyber threats such as hacking, phishing, malware, and ransomware. In parallel, data protection focuses on the responsible handling, storage, and processing of personal and organizational data to prevent loss, theft, misuse, or unauthorized access.

3.1 Strengthening Cyber security Infrastructure

Zero trust architecture (zta): "never trust, always verify". The Zero Trust assumes that no user or device internal or external should be trusted by default. Every access request must be continuously authenticated, authorized, and encrypted, based on identity, device health, and context, not just network location. This minimizes the risk of insider threats and lateral movement by attackers. Multi-Factor authentication (mfa) and end-to-end encryption. MFA enhances access security by requiring multiple forms of identity verification, significantly reducing the risk of unauthorized access even when credentials are compromised. End-to-end encryption (E2EE) ensures data remains secure from sender to recipient, protecting it from interception or tampering during transit.Regular vulnerability assessments and incident response planning. Routine security assessments, such as penetration testing and vulnerability scanning, help identify weaknesses before they are exploited. Organizations should also develop and test incident response plans to ensure fast, coordinated, and transparent responses to cyberattacks.

3.2 Establishing Robust Data Governance

Clear data classification and access policies. Classifying data based on sensitivity (e.g., public, confidential, restricted) enables organizations to assign access controls based on roles and responsibilities, enforcing the principle of least privilege (Gartner, 2023).

1. Data minimization and retention principles. Organizations should only collect data that is necessary for a specific, lawful purpose and retain it only as long as needed for legal, regulatory, or operational requirements. Secure disposal methods should follow once data is no longer needed.

2. Encryption in transit and at rest. Data should be encrypted both in transit (via SSL/TLS protocols) and at rest (in databases or storage devices) to reduce exposure in case of interception or breach.

3.3 Fostering Transparency and Accountability

1. Publish data usage policies in plain language. Transparency begins with clearly written privacy policies that explain what data is collected, why, how it is stored, and with whom it is shared. Avoiding legal jargon helps build user trust.

2. Adopt transparent AI and algorithm governance frameworks. AI systems should be explainable and accountable. Frameworks such as "Explainable AI" and AI auditing mechanisms help ensure fairness, mitigate bias, and build public trust in automated decision-making.

3. Implement audit trails and third-party oversight. Maintaining logs of data access and audit trails enhances accountability. External audits and regulatory oversight further strengthen trust and ensure compliance with data protection laws.

3.4 Building Public Awareness and Digital Literacy

Cyber hygiene campaigns for individuals and small businesses. Basic cybersecurity practices such as installing updates, using strong passwords, and avoiding suspicious links should be actively promoted, especially among SMEs, which often lack formal IT security frameworks.Education on recognizing phishing and social engineering. Training users to detect deceptive messages and social engineering tactics (like phishing, vishing, and smishing) is essential. Simulated attacks can help build situational awareness.

1. Training for employees on safe data handling practices: Regular staff training on data protection principles, secure file sharing, and acceptable technology use significantly reduces human error, which remains one of the leading causes of data breaches.

3.5 Legal and Regulatory Alignment

Align with global frameworks: GDPR, CCPA, NDPR: Regulatory compliance with frameworks like the General Data Protection Regulation (GDPR) in the EU**,** California Consumer Privacy Act (CCPA) in the U.S., and Nigeria Data Protection Regulation (NDPR) strengthens accountability and grants user's rights over their data, including access, deletion, and consent.

1. Encourage international collaboration on cyber norms: Global cooperation is essential for combatting cross-border cyber threats. Sharing threat intelligence and harmonizing security standards are key to effective defense and global trust-building.

2. Promote legislation that balances innovation with protection: Forward-thinking legislation should support innovation through regulatory sandboxes, while also enforcing strong privacy protections and ethical standards in digital services and AI development.

3.6 Regulatory and Ethical Considerations

The regulatory landscape plays a crucial role in shaping digital trust. Legal frameworks like GDPR have set global benchmarks for data protection, but enforcement and compliance remain uneven across jurisdictions (Kuner et al., 2020). Meanwhile, ethical concerns about surveillance, algorithmic bias, and data monetization continue to challenge trust in digital ecosystems. Binns (2018) argues that digital trust must go beyond compliance and include ethical design and accountability mechanisms. Transparency reports, ethical AI principles, and privacy-by-design practices are increasingly being adopted to address user concerns and societal expectations.

3.7 Building Trust through Transparency and Collaboration

Research highlights that transparency about cyber security practices, breach notifications, and incident response plans significantly enhances user trust (Lacey & Salmon, 2015). Furthermore, collaborative approaches such as industry partnerships, public-private information sharing, and international cooperation are vital for addressing global cyber threats. The **Cyber security and Infrastructure Security Agency (CISA)** and similar entities promote collaboration across sectors to enhance situational awareness and response capabilities. According to Accenture (2022), organizations with strong external partnerships and adaptive cyber resilience strategies outperform their peers in maintaining trust during crises.

4.0 Challenges

As digital technologies continue to advance and become increasingly embedded in personal, social, and professional spheres, the world is now more connected than ever. The exponentially growing attack surface, driven by the proliferation of IoT devices, cloud adoption, and remote work, raises the risk of vulnerabilities and sophisticated cyber threats leveraging AI (AllstarsIT, 2024). This hyperconnectivity offers immense opportunities for innovation and efficiency, but it also introduces a new set of complex and serious challenges. Cyber threats are evolving rapidly, becoming more sophisticated, targeted, and difficult to detect. Threat actors including cybercriminals, hacktivists, and state-sponsored groups are constantly adapting their tactics to bypass traditional security mechanisms (Center for Strategic and International Studies, 2023). These challenges threaten not only user confidence but also organizational security and the broader stability of global digital ecosystems (World Economic Forum, 2022). Lastly, insufficient digital literacy hampers widespread adoption of security best practices, exacerbating risks from social engineering and human error despite advanced technological protections (Protegent360, 2023; CybSafe, 2023).

Key examples of emerging cyber threats include:

1. Ransomware: Malicious software that encrypts data and demands payment for decryption. Recent attacks have targeted critical infrastructure such as hospitals and energy grids.
2. Phishing: Deceptive emails or texts that trick recipients into revealing sensitive data or installing malware. These attacks are now often tailored using personal data.
3. Social Engineering: They are sophisticated psychological manipulation using social media, deepfakes, and AI chatbots to trick victims.
4. Insider Attacks: These are malicious or negligent insiders (employees or contractors) misuse access to steal data or compromise systems.
5. Nation-State Attacks: Government-backed cyber operations that aim to steal intelligence, disrupt systems, or influence political outcomes as seen in the SolarWinds and Microsoft Exchange attacks.

5.0 Conclusion

Building and sustaining digital trust in today's hyperconnected environment demands an integrative approach that combines advanced security technology, comprehensive data governance, continuous user education, and agile regulatory frameworks. Trust must be redefined as a dynamic, multidimensional concept involving transparency, accountability, and ethical stewardship across all digital touch points. Organizations and policymakers must embrace multi-stakeholder collaboration to design resilient ecosystems adaptable to evolving cyber threats while fostering innovation and compliance. Through this proactive strategy, digital trust can serve as the cornerstone for secure, sustainable digital interactions essential for economic growth and societal well-being in the digital age.

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