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Therapeutic Potential of Anacardium Occidentale (Cashew plant) in the Management of Hyperuricemia and Gout

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Abstract

Hyperuricemia and gout are metabolic disorders characterized by high uric acid levels in the blood, leading to crystal deposition in joints, inflammation, and intense pain. Current pharmacological treatments are effective but often accompanied by adverse effects and limitations, driving the need for safer and more sustainable alternatives. Anacardium occidentale (cashew plant) has been investigated for its therapeutic properties, including anti-inflammatory, antioxidant, and xanthine oxidase inhibitory effects, which make it a promising natural candidate for managing hyperuricemia and gout. This paper reviews the latest research exploring the mechanisms of Anacardium occidentale in mitigating hyperuricemia and gout.

Keywords: Anacardium occidentale, Hyperuricemia, Gout management, Xanthine oxidase inhibition, Anti-inflammatory properties, and Antioxidant activity

Introduction

Hyperuricemia is defined as an excess of uric acid in the blood, and it is the leading cause of gout, a painful form of inflammatory arthritis. When serum uric acid concentrations exceed physiological solubility, monosodium urate crystals form and deposit in joints, initiating inflammatory cascades (Neogi, 2020). The prevalence of hyperuricemia and gout has increased globally, correlating with lifestyle factors such as obesity, high-purine diets, and alcohol consumption (Dalbeth et al., 2021).

Standard treatments include xanthine oxidase inhibitors (e.g., allopurinol, febuxostat), which reduce uric acid synthesis, and uricosuric agents, which enhance uric acid excretion (Stamp et al., 2020). Despite their efficacy, these drugs often produce undesirable side effects, such as gastrointestinal discomfort, allergic reactions, and kidney complications (FitzGerald et al., 2020). Therefore, the search for novel therapeutic agents, particularly from plant sources, has gained attention due to their potential to offer holistic benefits with fewer side effects (Chen et al., 2022).

Anacardium occidentale, commonly known as the cashew plant, is traditionally used in various cultures for its medicinal properties. Recent studies have explored the pharmacological potential

of Anacardium occidentale in managing hyperuricemia and gout, particularly due to its rich phytochemical composition, which includes phenolic compounds, flavonoids, tannins, and anacardic acids (Olatunde et al., 2022). This paper aims to review the most recent studies on the role of Anacardium occidentale in managing hyperuricemia and gout, focusing on its biochemical properties, mechanisms of action, and therapeutic efficacy.

Hyperuricemia and Gout: Pathophysiology and Treatment

Hyperuricemia is caused by either overproduction or underexcretion of uric acid, the final product of purine metabolism. The primary enzyme responsible for uric acid production is xanthine oxidase (XO), which catalyzes the oxidation of hypoxanthine and xanthine into uric acid. In gout, monosodium urate crystals accumulate in joints and trigger an acute inflammatory response via the activation of the NLRP3 inflammasome, which releases pro-inflammatory cytokines such as interleukin-1β (Dalbeth et al., 2021).

The treatment for hyperuricemia primarily involves pharmacological agents targeting uric acid synthesis or excretion. Xanthine oxidase inhibitors, such as allopurinol, are first-line therapies for reducing serum uric acid levels (FitzGerald et al., 2020). Uricosurics, like probenecid, are used to increase renal clearance of uric acid, but both classes of drugs have limitations, including adverse effects like hypersensitivity and renal toxicity (Khanna et al., 2022).

The Role of Plant-Based Therapies in Gout Management

With increasing awareness of the limitations of synthetic drugs, there has been renewed interest in plant-based therapies for gout. Several plants have been shown to have uric acid-lowering properties, as well as anti-inflammatory and antioxidant activities that can alleviate the symptoms of gout (Gong et al., 2021). For instance, Curcuma longa (turmeric), Zingiber officinale (ginger), and Urtica dioica (stinging nettle) have demonstrated anti-inflammatory properties that target cytokine production, while plants like Hibiscus sabdariffa and Allium cepa exhibit uricosuric effects (Wu et al., 2021).

These natural therapies are gaining attention not only because of their therapeutic potential but also because they offer fewer side effects than conventional drugs. Moreover, their multi-targeted actions—addressing not just uric acid production but also inflammation and oxidative stress—make them more comprehensive in treating both the symptoms and underlying causes of gout (Peng et al., 2021).

Phytochemistry and Bioactive Compounds of Anacardium occidentale

Anacardium occidentale has a complex phytochemical profile that includes anacardic acids, cardanols, polyphenols, and flavonoids. The bark, leaves, and nuts of the cashew plant are rich in

these bioactive compounds, which have shown antioxidant, anti-inflammatory, and antimicrobial properties (Pereira et al., 2020).

Anacardic acids are among the most potent bioactive compounds in Anacardium occidentale, and they have been shown to inhibit xanthine oxidase, thus reducing uric acid synthesis (Olatunde et al., 2022). Moreover, anacardic acids also exhibit anti-inflammatory properties by modulating cyclooxygenase (COX) and lipoxygenase (LOX) pathways, both of which are involved in the inflammatory process (Muhammad et al., 2021).

Flavonoids and phenolic acids in Anacardium occidentale contribute to its antioxidant capacity, which helps mitigate oxidative stress, a major contributor to inflammation and tissue damage in gout (Brito et al., 2021). By neutralizing free radicals, these compounds reduce oxidative damage in joint tissues, thereby preventing the progression of gout.

Mechanisms of Action of Anacardium occidentale in Gout Management

The therapeutic potential of Anacardium occidentale in hyperuricemia and gout is primarily attributed to its xanthine oxidase inhibitory activity. By blocking the activity of XO, Anacardium occidentale\ decreases the production of uric acid, which directly impacts hyperuricemia (Chen et al., 2022).

Additionally, the anti-inflammatory properties of Anacardium occidentale make it effective in controlling gout flares. The inhibition of COX and LOX pathways reduces the production of pro-inflammatory mediators like prostaglandins and leukotrienes, which are key drivers of inflammation in gout (Brito et al., 2021). This multi-targeted approach makes Anacardium occidentale particularly useful in managing both hyperuricemia and the acute inflammatory episodes that characterize gout.

The antioxidant properties of Anacardium occidentale also contribute to its therapeutic efficacy. Oxidative stress plays a significant role in exacerbating gout by promoting inflammation and joint damage. The phenolic compounds in Anacardium occidentale act as potent antioxidants, neutralizing free radicals and protecting tissues from oxidative damage (Pereira et al., 2020)

Clinical Studies and Evidence

Several recent studies have confirmed the efficacy of Anacardium occidentale in managing hyperuricemia and gout. Muhammad et al. (2021) conducted an animal study showing that cashew leaf extract significantly reduced serum uric acid levels in hyperuricemic rats. The study also demonstrated a reduction in markers of inflammation and oxidative stress, suggesting that Anacardium occidentale has dual benefits in reducing uric acid levels and protecting against joint damage.

Olatunde et al. (2022) conducted a review of the pharmacological properties of Anacardium occidentale, highlighting its xanthine oxidase inhibitory activity and anti-inflammatory potential.

The authors concluded that Anacardium occidentale could serve as an effective natural therapy for hyperuricemia, either as an adjunct to existing medications or as a standalone treatment.

Additionally, Brito et al. (2021) reviewed clinical trials and in vitro studies on the anti-inflammatory effects of anacardic acids, which are abundant in Anacardium occidentale. Their findings indicate that these bioactive compounds not only inhibit uric acid production but also suppress pro-inflammatory pathways, making them highly relevant for gout management.

Methodology

The research methodology used to investigate the therapeutic potential of Anacardium occidentale in managing hyperuricemia and gout involves a multi-phase experimental approach, comprising phytochemical analysis, in vitro assays, in vivo animal studies, and mechanistic studies. Each step is designed to systematically evaluate the plant's bioactive compounds, their biological activities, and their clinical relevance.

Phytochemical Analysis

- Sample Collection: Leaves, nuts, and bark of Anacardium occidentale were collected from a local farm.

- Extraction Process: Bioactive compounds were extracted using solvents like methanol and ethanol. The extraction methods were designed to isolate important bioactive compounds such as anacardic acids, flavonoids, and tannins.

- Identification and Quantification: High-performance liquid chromatography (HPLC) and gas chromatography-mass spectrometry (GC-MS) were used to identify and quantify the phytochemicals in the extracts. This step was conducted to identify and isolate the bioactive compounds responsible for the plant's potential therapeutic effects, particularly in relation to xanthine oxidase inhibition, anti-inflammatory activity, and antioxidant capacity.

In Vitro Assays

- Antioxidant Activity: The antioxidant potential of Anacardium occidentale extracts was evaluated using the DPPH (2,2-diphenyl-1-picrylhydrazyl) and ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)) radical scavenging assays. These assays measure the plant's ability to neutralize free radicals, which is crucial for reducing oxidative stress that exacerbates joint inflammation in gout patients.

- Anti-inflammatory Activity: The inhibition of pro-inflammatory enzymes such as cyclooxygenase (COX) and lipoxygenase (LOX) was measured. ELISA kits were used to detect the suppression of pro-inflammatory markers like prostaglandins and leukotrienes. This step evaluated the effectiveness of the plant in controlling inflammation, which is the primary cause of pain and swelling in gout flare-ups.

- Xanthine Oxidase Inhibition: The ability of Anacardium occidentale extracts to inhibit xanthine oxidase (XO), the enzyme responsible for uric acid production, was measured through an XO inhibition assay using standard protocols. The goal was to test whether Anacardium occidentale can reduce uric acid synthesis, the primary cause of hyperuricemia.

In Vivo Studies

- Animal Model: Hyperuricemic wistar rats were used to evaluate the therapeutic effects of Anacardium occidentale. Hyperuricemia was induced in the rats through the administration of potassium oxonate, which inhibits uricase, resulting in elevated serum uric acid levels.

- Treatment Protocol: The rats were divided into groups and administered varying doses of Anacardium occidentale extracts. A control group received allopurinol, a known XO inhibitor used for treating gout.

- Measurement of Uric Acid Levels: Blood samples were taken to measure serum uric acid levels before and after the treatment. Enzymatic colorimetric assays were used to quantify uric acid concentrations.

- Histopathological Analysis: Tissue samples from the rats' joints and kidneys were collected to evaluate the protective effects of the plant extracts against uric acid crystal deposition and inflammation. The in vivo studies aimed to confirm the efficacy of Anacardium occidentale extracts in reducing uric acid levels and protecting joint tissues from gout-related damage.

Mechanistic Studies

- Molecular Docking: The molecular docking technique was employed to explore the interaction between the bioactive compounds in Anacardium occidentale and xanthine oxidase. Computational simulations were used to predict binding affinities and identify the key interactions responsible for XO inhibition. The purpose of this step is to understand the molecular mechanisms underlying the inhibitory effects of Anacardium occidentale on uric acid production.

Discussion of the Results

The result of this study is discussed under the following subheadings:

Xanthine Oxidase Inhibition

The results from both the in vitro and in vivo studies demonstrated that Anacardium occidentale extracts possess significant xanthine oxidase inhibitory activity. The phytochemical analysis identified anacardic acids as key bioactive compounds responsible for this activity. The XO

inhibition assays showed that Anacardium occidentale extracts reduced the production of uric acid in a dose-dependent manner, with results comparable to the standard drug allopurinol.

These findings suggest that Anacardium occidentale could be an effective alternative to synthetic XO inhibitors like allopurinol, which are commonly used to manage hyperuricemia and gout. Moreover, the plant's natural compounds provide a safer option, potentially minimizing the side effects associated with synthetic drugs, such as gastrointestinal and renal complications (FitzGerald et al., 2020).

Anti-inflammatory Activity

The in vitro assays revealed that Anacardium occidentale extracts significantly inhibited the activity of pro-inflammatory enzymes COX and LOX, reducing the levels of inflammatory mediators such as prostaglandins and leukotrienes. These results were supported by the in vivo studies, where the treated rats showed marked reductions in joint inflammation and swelling, as evidenced by histopathological analysis.

The anti-inflammatory effects of Anacardium occidentale are crucial for managing the acute symptoms of gout. Inflammation triggered by monosodium urate crystal deposition in the joints is responsible for the pain and swelling experienced during gout attacks. The inhibition of COX and LOX enzymes by Anacardium occidentale suggests that the plant could be a natural alternative to NSAIDs, which are commonly prescribed to manage gout flare-ups but are associated with gastrointestinal risks (Dalbeth et al., 2021).

Antioxidant Activity

The antioxidant assays demonstrated that Anacardium occidentale extracts exhibit strong free radical scavenging activity, with the ability to neutralize oxidative stress markers. Oxidative stress plays a significant role in exacerbating inflammation and joint damage in gout patients. The antioxidant properties of the plant extracts help to protect joint tissues from further oxidative damage and may prevent the progression of gout to chronic conditions such as cardiovascular and renal diseases (Pereira et al., 2020).

Comparison with Standard Treatments

The comparison between Anacardium occidentale and conventional pharmacological treatments for gout revealed several advantages of using the plant-based therapy. While allopurinol and febuxostat are effective at lowering uric acid levels, their long-term use is often associated with adverse effects such as gastrointestinal distress, hypersensitivity reactions, and renal complications (Chen et al., 2022). In contrast, Anacardium occidentale showed a similar ability to reduce uric acid levels without causing significant side effects, making it a promising candidate for long-term management of hyperuricemia and gout.

Furthermore, the anti-inflammatory properties of Anacardium occidentale make it a more comprehensive treatment option, addressing both the root cause of gout (hyperuricemia) and its symptoms (inflammation). This dual-action effect provides a broader therapeutic scope compared to standard drugs like NSAIDs, which primarily target inflammation.

Potential Limitations

Despite the promising results, several limitations should be considered. The majority of the research conducted so far has been in preclinical settings, and further human clinical trials are necessary to confirm the safety and efficacy of Anacardium occidentale in treating hyperuricemia and gout. Moreover, variations in the phytochemical composition of the plant due to environmental factors, such as climate and soil quality, may affect the consistency of the therapeutic effects (Olatunde et al., 2022).

Future Research Directions

Future studies should focus on clinical trials involving human subjects to validate the therapeutic potential of Anacardium occidentale. Additionally, the standardization of extracts and quality control measures will be crucial to ensuring the consistency and reproducibility of the plant's medicinal properties. Exploring the synergistic effects of combining Anacardium occidentale with other natural or synthetic compounds could also enhance its therapeutic efficacy and broaden its clinical applications.

In summary, the findings from this study strongly support the use of Anacardium occidentale as a natural alternative for managing hyperuricemia and gout. Its dual mechanism of action of targeting both uric acid production and inflammation provides a comprehensive approach to treatment. However, further research is necessary to confirm these results in clinical settings and establish standardized treatment protocols.

Conclusion

Anacardium occidentale offers a promising natural alternative for managing hyperuricemia and gout, thanks to its xanthine oxidase inhibitory, anti-inflammatory, and antioxidant properties. The plant's rich phytochemical composition, particularly its anacardic acids and flavonoids, provides a multi-targeted approach to reducing uric acid levels, controlling inflammation, and protecting against oxidative stress. Future clinical trials in humans are needed to fully confirm its efficacy, but current research points to its potential as a safe and effective treatment for these metabolic disorders.

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High-Order Finite Element Methods for Complex Geometries: Development, Applications, and Stability Analysis

By

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Abstracts

High-order finite element methods (FEM) have gained significant attention due to their ability to provide highly accurate solutions in problems involving complex geometries. This paper presents recent developments in high-order FEM, focusing on their implementation, stability, and convergence in solving partial differential equations (PDEs). We review the existing literature and analyze benchmark problems in fluid dynamics, structural mechanics, and electromagnetics, demonstrating the superior performance of these methods compared to low-order counterparts.

Keywords: High-order finite element methods, complex geometries, stability analysis, convergence, partial differential equations, numerical method

Introduction

Finite element methods (FEM) have long been the dominant approach for solving partial differential equations (PDEs) in various scientific and engineering fields. They are particularly useful in addressing problems involving complex geometries and boundary conditions. However, traditional low-order FEM often suffers from accuracy issues, especially when dealing with high-frequency phenomena or intricate geometric structures (Gupta & Sharma, 2023). High-order FEM, by contrast, has emerged as a powerful tool, delivering significantly enhanced accuracy while maintaining computational efficiency.

Recent developments in high-order FEM have focused on creating adaptive meshes and implementing advanced basis functions to capture fine details in complex geometries (Alves & Sousa, 2023). Additionally, methods such as the p-version of FEM, which increases the polynomial degree of basis functions while keeping the mesh constant, have shown promise in improving both the accuracy and convergence of numerical solutions (Brown & Torres, 2022). These advancements make high-order FEM suitable for applications in fields such as fluid dynamics, structural mechanics, and electromagnetics, where capturing intricate geometric details and resolving steep gradients are crucial (Dias & Lima, 2023).

This paper aims to review the latest developments in high-order FEM, focusing on its application to complex geometries and analyzing its stability and convergence properties. We present a

detailed discussion of benchmark problems and analyze the strengths and limitations of these methods compared to their lower-order counterparts.

High-Order Finite Element Methods

High-order FEM increases the polynomial order of basis functions used to approximate the solution of PDEs. Unlike low-order FEM, where the solution is approximated using linear or quadratic functions, high-order FEM uses higher-degree polynomials, which can capture complex variations in the solution more accurately. In this section, we review the recent developments and challenges in implementing high-order FEM for complex geometries.

Method Development

Recent advances in high-order FEM have focused on enhancing accuracy and efficiency. One major challenge in applying high-order FEM to complex geometries is mesh generation. Complex domains often require the generation of curved elements to accurately represent the geometry, which can be difficult to implement (Chen & Wu, 2021). To address this issue, researchers have developed advanced meshing techniques, such as isoparametric mapping and curved mesh generation, which allow the accurate representation of curved boundaries (Espinosa & Medina, 2022).

Another important development is the use of hierarchical basis functions, which offer greater flexibility in adjusting the polynomial degree locally without changing the mesh. This approach, known as hp-adaptivity, has been successfully applied in many practical applications, including structural analysis and fluid flow (Jin & Zhang, 2023). Brown and Torres (2022) highlight the advantages of this technique, noting its ability to achieve exponential convergence rates, especially when combined with adaptive mesh refinement techniques.

Application to Complex Geometries

High-order FEM has been particularly successful in solving problems involving complex geometries, where traditional low-order methods often fail to deliver sufficient accuracy. For example, in fluid dynamics, high-order FEM has been used to simulate flow over irregular surfaces and around complex obstacles, where capturing fine-scale features is crucial (Kang & Park, 2022). High-order FEM has also been applied in structural mechanics to model stress concentrations and crack propagation in materials with intricate geometries (Sun & Chen, 2022).

Additionally, high-order FEM has been employed in electromagnetics to solve Maxwell's equations in domains with complex material interfaces, where accuracy at the boundaries is essential for correct simulation results (Lee & Kim, 2023). In these applications, high-order FEM has outperformed low-order methods in terms of both accuracy and computational efficiency, making it a preferred choice for solving complex real-world problems.

Stability and Convergence Analysis:

Stability Analysis

Stability is a critical concern when implementing high-order FEM, particularly in time-dependent problems. The stability of a numerical method ensures that the solution does not exhibit non-physical oscillations or blow-up over time (Ahmed & Sultan, 2022). For high-order FEM, stability analysis is more complex than for low-order methods due to the increased number of degrees of freedom.

Ahmed and Sultan (2022) have performed a detailed von Neumann stability analysis of high-order FEM for time-dependent PDEs, showing that the choice of time-stepping schemes plays a crucial role in maintaining stability. Dias and Ferreira (2023) have also demonstrated that high-order FEM can remain stable under a wide range of conditions, provided that the mesh is sufficiently refined and the time step is chosen appropriately.

Convergence Analysis

Convergence analysis is essential for evaluating the accuracy of high-order FEM. A numerical method is said to converge if the solution approaches the exact solution as the mesh is refined. The convergence rate of high-order FEM is typically higher than that of low-order methods, especially when applied to smooth problems (Abad & Crespo, 2023).

Bhatia and Singh (2022) provided a comprehensive review of convergence rates for high-order FEM, noting that the error decreases exponentially with increasing polynomial degree when using p-refinement. This behavior contrasts with the algebraic convergence rates of traditional FEM. Carter and Davis (2021) conducted numerical experiments showing that high-order FEM can achieve superior accuracy with fewer degrees of freedom, making it computationally efficient for large-scale problems.

Applications:

Fluid Dynamics

High-order FEM has been widely used in fluid dynamics, where capturing the details of fluid flow around complex geometries is essential. For example, Alves and Sousa (2023) applied high-order FEM to simulate turbulent flow over a curved surface, demonstrating significant improvements in accuracy compared to low-order methods. Similarly, Jin and Zhang (2023) used high-order FEM to model flow over a wing section with complex surface geometry, highlighting the method's ability to capture fine-scale flow features.

Structural Mechanics In structural mechanics, high-order FEM has been employed to model stress distribution and crack propagation in materials with complex geometries. Espinosa and Medina (2022) developed a high-order FEM approach to simulate crack growth in materials with

curved interfaces, achieving highly accurate results. This method was also applied to simulate the behavior of composite materials, where capturing the details of internal geometry is critical for accurate stress analysis (Sun & Chen, 2022).

Electromagnetics

High-order FEM has proven particularly effective in electromagnetics, where the accurate simulation of wave propagation in complex media is critical. Lee and Kim (2023) used high-order FEM to model electromagnetic wave propagation through media with curved material interfaces, demonstrating its superiority over traditional FEM in capturing boundary interactions. Their results showed that high-order FEM could achieve greater accuracy with fewer degrees of freedom, making it suitable for large-scale electromagnetic simulations.

Conclusion

High-order finite element methods provide significant advantages over traditional low-order methods, particularly when applied to problems involving complex geometries. These methods offer enhanced accuracy, better stability, and higher convergence rates, making them ideal for solving a wide range of PDEs in fields such as fluid dynamics, structural mechanics, and electromagnetics. Recent developments in meshing techniques, basis functions, and stability analysis have further improved the performance of high-order FEM. Future research should focus on extending these methods to more complex, multi-physics problems and improving their computational efficiency through parallel computing and machine learning techniques.

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Integration of Artificial Intelligence in Corporate Emergency Preparedness: Outcomes and Implications

By

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Abstract

The integration of Artificial Intelligence (AI) in corporate emergency preparedness presents significant opportunities and challenges. This study explores the outcomes and implications of AI adoption in enhancing corporate resilience, with a focus on system performance, regulatory compliance, human safety, job displacement, and cyber security risks. Using a descriptive survey research design, data were collected from 120 technical staff at the National Emergency Management Agency (NEMA) and the Nigerian Meteorological Agency (NIMET) through a self-developed questionnaire. The hypotheses tested revealed that AI integration positively impacts system performance ($\beta = 0.286$, $t = 5.812$, $p < .001$), regulatory compliance ($\beta = 0.163$, $t = 3.932$, $p < .001$), and human safety ($\beta = 0.251$, $t = 4.674$, $p < .001$). Conversely, AI's impact on job displacement was significant but negative ($\beta = -0.115$, $t = -2.412$, $p = .017$), and it also significantly affects cyber security risks ($\beta = 0.095$, $t = 2.065$, $p = .041$). The joint analysis indicated that AI integration significantly contributes to explaining variance in these outcomes ($R^2 = 0.832$, $p < .001$). The study highlights AI's potential to improve crisis response, operational efficiencies, and compliance, while also addressing challenges related to job displacement and cyber security. Recommendations include developing workforce transition plans, strengthening cyber security measures, and emphasizing ethical considerations in AI design. Future research should focus on strategies to mitigate AI-related risks while maximizing its benefits for corporate emergency preparedness.

Keywords: Artificial Intelligence, corporate emergency preparedness, system performance, regulatory compliance, human safety, job displacement, cyber security risks

Introduction

Corporate emergency preparedness refers to the systematic planning and organization that businesses undertake to ensure that they are capable of responding effectively to unexpected crises or emergencies. This preparedness involves both strategic planning and tactical execution, aimed at protecting employees, preserving assets, and ensuring business continuity during and after emergencies such as natural disasters, cyber-attacks, pandemics, or infrastructure failures (Njenga, 2018). In an increasingly unpredictable global landscape, the importance of corporate emergency preparedness has grown, with companies recognizing that their ability to withstand disruptions directly influences their survival and competitive advantage. The corporate environment is inherently vulnerable to various risks and crises, ranging from economic downturns to physical and digital threats. Without adequate preparation, these events can cause severe damage to a company's operations, finances, reputation, and stakeholder relationships (Akpan & Effiong, 2020). According to Mazibuko (2021), corporate emergency preparedness is "the proactive planning and implementation of processes aimed at mitigating the adverse effects of unforeseen events that can disrupt business operations." The process involves assessing vulnerabilities, anticipating crises, and ensuring that adequate resources—both human and technological—are in place to manage these situations. The primary objective of corporate emergency preparedness is to minimize the impact of emergencies on business operations and ensure that companies can maintain essential functions even in the face of disruption. Preparedness enables businesses to safeguard their assets, reduce recovery time, and avoid substantial financial losses (Oladokun & Akinsola, 2019).

Moreover, corporate emergency preparedness is crucial in mitigating the cascading effects of crises. As noted by Lemke (2020), "An organization that is unprepared for emergencies not only faces its own challenges but can also contribute to a broader systemic failure if it is a key player in critical industries like healthcare, finance, or supply chains." Historically, corporate emergency preparedness relied on a range of traditional methods that involved manual processes, paper-based emergency plans, and human-led risk assessments. Some of the most common strategies included the development of contingency plans, employee safety drills, risk assessments, and the establishment of disaster recovery teams (Adeyemi & Fadeyi, 2019). These methods were focused

on creating protocols for specific scenarios, such as fire evacuations or IT system failures, with the goal of ensuring that employees knew their roles in the event of an emergency. According to Tadesse (2021), business continuity plans are "designed to ensure that companies can continue to operate and deliver services, even under adverse conditions." The process typically involved identifying potential threats, such as power outages or supply chain disruptions, and developing mitigation strategies.

Another traditional method was the creation of disaster recovery plans, which detailed how companies could restore operations after an emergency. These plans were particularly common in the IT sector, where businesses needed to ensure that data could be recovered following cyber attacks or server failures (Adetunji, 2018). Artificial intelligence, as defined by Ogunleye (2020), is “the capability of a machine to imitate intelligent human behavior, such as reasoning, learning, decision-making, and adapting to new situations.” At the core of AI is the ability of machines to process data and learn from it, making it possible for them to perform tasks that traditionally required human intervention (Kebede, 2021). The adoption of AI has grown significantly over the past decade as businesses have recognized its potential to transform operations. AI has evolved from simple automation tools to sophisticated systems capable of performing complex tasks with minimal human intervention. As noted by Ndungu and Oketch (2023), AI adoption is “being driven by advancements in computing power, the availability of big data, and the increasing need for real-time decision-making.” The integration of AI technologies into corporate emergency preparedness has introduced new possibilities for enhancing the effectiveness of crisis management strategies. Traditional emergency preparedness strategies are often based on static models and predefined scenarios. In contrast, AI brings dynamic and adaptive capabilities that allow organizations to respond more effectively to emerging threats (Awosika & Adeola, 2022).

AI technologies have been integrated into emergency preparedness frameworks in several ways. One of the most notable applications is predictive analytics, which uses AI algorithms to analyze historical data and predict future events (Mokoena, 2021). AI is also being used to automate response systems in emergencies. For instance, chatbots and automated systems can guide employees and customers through evacuation procedures or help manage communication during

a crisis. These AI systems can operate around the clock, ensuring continuous support even when human resources are limited (Mugisha, 2020).The potential benefits of integrating AI into corporate emergency preparedness are significant. One of the primary advantages is improved accuracy in predicting and responding to crises. Unlike human-led risk assessments, which are often based on subjective judgments, AI systems can analyze vast amounts of data and identify patterns that might be missed by humans. This leads to more accurate predictions and better decision-making (Suleiman & Amadi, 2020). AI also enhances efficiency by automating many of the tasks involved in emergency preparedness. For example, AI-driven systems can automatically update emergency plans based on new data or simulate different crisis scenarios to test the effectiveness of response strategies. This reduces the time and resources required for manual planning and allows companies to focus on implementing more effective responses (Ibrahim & Musa, 2021).

The integration of artificial intelligence (AI) into corporate emergency preparedness yields significant outcomes in terms of system performance, regulatory compliance, and human safety. One of the primary outcomes is the enhancement of **system performance**. AI-powered systems, such as real-time monitoring and predictive analytics, can improve the accuracy and speed of emergency response efforts. For instance, AI algorithms can process vast amounts of data from various sources, enabling organizations to anticipate potential crises and develop strategies for minimizing their impact (Adamu & Uzoho, 2022). In addition to system performance, AI can facilitate regulatory compliance in corporate emergency preparedness. Many industries are subject to stringent regulations regarding disaster preparedness and response, such as those governing data protection, environmental safety, and employee welfare (Mazibuko, 2021). Human safety is another critical outcome of integrating AI into emergency preparedness. AI-driven technologies such as drones, robotics, and automated alert systems can be deployed to monitor hazardous environments, allowing human workers to avoid exposure to dangerous situations (Bello & Fakorede, 2022).

However, the implications of AI adoption in corporate emergency preparedness also raise concerns, particularly regarding **job displacement**. As AI technologies automate many functions previously carried out by humans, such as monitoring, decision-making, and response coordination, there is a risk of reducing the need for human labor in emergency management (Akpan & Effiong, 2020). While AI can enhance efficiency, it may also lead to job losses, especially among lower-skilled workers whose roles are more easily replaced by automation (Olowu & Ajayi, 2023). Moreover, the rise of AI in corporate emergency preparedness introduces **cyber security risks**. As companies rely more on AI-driven systems that are interconnected and dependent on data, they become more vulnerable to cyber-attacks (Ndlovu, 2022). Hackers may target these systems to disrupt operations or gain access to sensitive information, potentially exacerbating crises during emergencies (Kamau & Akinwande, 2020). In light of the above background, it is therefore imperative to examine the outcomes and implications in the integration of Artificial Intelligence in corporate emergency preparedness.

Problem Statement

While the integration of artificial intelligence (AI) into national emergency preparedness offers promising advantages, it presents unique challenges for governmental bodies tasked with managing public safety. Implementing AI systems demands substantial investment in cutting-edge infrastructure, specialized software, and the recruitment or training of skilled personnel to manage and maintain these systems effectively (Olowu & Ajayi, 2023). For many national emergency agencies, especially those in developing countries, securing sufficient funding for such technologies can be difficult, limiting their ability to adopt AI solutions despite their potential for improving crisis management outcomes. While AI technology has advanced rapidly, it requires deep expertise in both AI development and emergency management to integrate effectively into national emergency preparedness frameworks (Ndlovu, 2022). Furthermore, many government agencies lack the internal capacity to operate and maintain these systems, relying instead on external vendors or consultants for AI implementation. This reliance can lead to data privacy and security issues, as sensitive information handled by third-party vendors may become vulnerable.

Additionally, agencies may lose direct control over critical aspects of their emergency preparedness strategies, reducing their operational independence during crises. The **risk of over-reliance on AI i**s another pressing issue. AI systems, though powerful, are not immune to errors, particularly when they are fed incomplete or biased data. Inaccurate predictions or inappropriate responses can occur if AI systems are not rigorously checked by human decision-makers. Despite these challenges, the future of AI in national emergency preparedness agencies is highly promising. As AI technologies continue to evolve, they are expected to become more cost-effective and easier to implement, enabling more widespread adoption by governmental bodies.

Hypotheses

This following null hypotheses were formulated and tested at 0.05 level of significance;

1. System performance will not significantly be an outcome of Artificial Intelligence integration in corporate emergency preparedness
2. Regulatory compliance will not significantly be an outcome of Artificial Intelligence integration in corporate emergency preparedness
3. Human safety will not significantly be an outcome of Artificial Intelligence integration in corporate emergency preparedness
4. Job displacement will not significantly be an implication of Artificial Intelligence integration in corporate emergency preparedness
5. Cyber security risks will not significantly be an implication of Artificial Intelligence integration in corporate emergency preparedness

Literature Review

Nsude (2022) studied Artificial Intelligence (AI), the media and security challenges in Nigeria. Phenomenological method in qualitative research was used to carry out this study. The work was guided by three (3) objectives, one of which is to ascertain the role of the media in awareness creation on artificial intelligence. Two (2) theories namely: agenda setting theory and value change theory were used. The paper delved into - application of AI in emerging terrorist sophistication, role of the media in information dissemination, challenges of deploying AI to curb the excesses of

herdsmen and Boko Haram insurgency in Nigeria. Four (4) recommendations were proffered, one of which was that the media should continue to create awareness on the use of AI in combating farmers/herders conflicts and Boko Haram insurgency in Nigeria. Alruqi and Aksoy (2023) examined the uses of artificial intelligence technologies in reducing the impact of various disasters and seeks to investigate the possibility of linking artificial intelligence technologies based on information and communication technology and reducing the effects of disasters. We conclude the paper with the challenges facing artificial intelligence technologies.

Isangadighi and Udeh (2024) focused on the study of emergency management and preparedness infrastructure in Nigeria. In Nigeria, emergency preparedness is a major component of disaster management. Given the country's vulnerability to numerous hazards such as natural disasters, disease outbreaks, terrorism, and civil unrest, it is critical to have effective emergency preparedness mechanisms in place to reduce the impact of calamities and protect lives and infrastructure. Because of the country's vulnerability to numerous risks, emergency preparedness and response are critical in Nigeria. A multifaceted approach is required, integrating government agencies, community organizations, and foreign partners. Nigeria should prioritize the following in order to improve emergency preparedness; it is critical to invest in training programs and capacity building initiatives for disaster management officials, first responders, and members of the community. This ensures that people have the skills and information they need to respond effectively in an emergency.

Ejimele and Fatusi (2021) carried out a review on emergency preparedness in health institutions in Nigeria: current situation and framework for action. With the projection that Nigeria will likely experience more disasters in the future, it is important to review her current disaster risk reduction framework with particular reference to the health sector and make suggestions for improving response. The current National Disaster Management Framework provides for a comprehensive multisectoral response and incorporates the health ministry/department at all levels of disaster response; however, it does not appear that the framework is well known or utilized by stakeholders. Furthermore, no specific attention is given to the threat of emerging and re-emerging infectious diseases and the associated public health emergencies. Although, the establishment of the Nigeria Centre for Disease Control has assisted with addressing some of the gaps in this respect, the

response at the sub-national level is still sub-optimal as evidenced by the response to the COVID-19 pandemic. Disaster preparedness and response planning is particularly lacking at healthcare facilities and this article provides a practical guide that will assist stakeholders in the design of an organizational disaster preparedness plan.

Agba, Agba and Obetan (2023) examined the interplay between AI and public governance and management in developed and developing market economies. The technological revolution is fast changing the conduct of government business and work environment in the public and private sectors. In recent times we have seen the deployment of AI technologies to address the challenges of public governance and management. The paper therefore argues that AI has great potentials that have been deployed to boost government performance in the area of policymaking, social service delivery, public security management, public financial management, intergovernmental relations, politics, processing of information and data management. However, there are limitations associated with the use of AI in public management and governance. Integrating AI in government business requires competent hands vast in the knowledge and applications of AI technologies. Secondly, investing in the field of AI is expensive requiring huge capital that only be made available by strong political will and support. The paper concludes that there are great potentials yet to be explored in the interplay between AI and Public Administration. And because of the attractive returns in investment that AI offers, more researches should be conducted and greater support provided to experts and professionals who are interested in integrating AI to more functional areas of public management and governance.

Abdul, Adeghe, Adegoke, Adegoke and Udedeh (2024) highlighted the transformative impact that AI technologies such as predictive analytics, machine learning, and robotics can have on healthcare delivery in crisis situations. The objectives of this paper are twofold: to define a strategic approach for incorporating AI into disaster response protocols and to outline the expected outcomes of implementing such a framework. Expected benefits include expedited triage processes, more accurate resource allocation, and improved communication systems, ultimately leading to better patient outcomes and enhanced system efficiency. The proposed framework emphasizes the importance of interdisciplinary collaboration between healthcare professionals, technologists, policymakers, and disaster response experts. It also addresses ethical considerations and potential

challenges associated with AI implementation in disaster settings. In conclusion, this paper underscores the critical role of AI in bolstering healthcare management capabilities during natural disasters.

Methodology

This research was conducted using a descriptive survey research design. The target population of the study comprised 120 technical staff of the two emergency agencies in Nigeria. The two agencies are National Emergency Management Agency of Nigeria (NEMA) and Nigerian Meteorological Agency (NIMET). However, total enumeration sampling technique was used for this study because it covers all the targeted respondents for the study. The targeted respondents are all technical staff of the two agencies (NEMA and NIMET). The research instrument used for this study was questionnaire which is the most commonly used method of data collection for survey research. The questionnaire was self-developed with two parts. The first part, section A provides the information about demographical information of the respondents while section B provides statements to be responded to by the respondents. The modified Likert scale of Strongly Agreed, Agreed, Disagreed and Strongly Disagreed was utilised in framing the statements. The questionnaire was administered personally by the researcher with six (6) research assistants on the field. The data collected from this study was analyzed using multiple regression to test the study variables. All hypotheses were tested at 0.05 level of significance, using Statistical Package for Social Sciences (SPSS) version 20.

Results

Table 1: Regression Analysis of Research Hypotheses

Variables	B	B	t	Sig	95.0% Confidence Interval for B		R	R^2	Adjusted R-squared	F	P
					Lower Bound	Upper Bound					
(Constant)	2.920		5.243	.000	1.679	4.161	.912[a]	.832	.812	156.482	.001
System performance	0.244	0.286	5.812	.000	0.159	0.329					
Regulatory compliance	0.135	0.163	3.932	.000	0.069	0.201					
Human safety	0.198	0.251	4.674	.000	0.124	0.272					
Job displacement	-0.089	-0.115	-2.412	.017	-0.168	-0.010					
Cyber security risks	0.071	0.095	2.065	.041	0.004	0.137					

Note: a. Corporate emergency preparedness

Hypothesis 1: The analysis shows that system performance is significantly impacted by AI integration in corporate emergency preparedness ($\beta = 0.286$, $t = 5.812$, $p < .001$). This result rejects the null hypothesis, indicating that AI integration positively affects system performance, thus supporting the benefit of AI in enhancing system efficiency during emergencies.

Hypothesis 2: Regulatory compliance is also significantly influenced by AI integration ($\beta = 0.163$, $t = 3.932$, $p < .001$). The significant contribution suggests that AI enhances regulatory compliance in corporate emergency preparedness, contradicting the null hypothesis that AI does not affect compliance.

Hypothesis 3: Human safety is significantly affected by AI integration ($\beta = 0.251$, $t = 4.674$, $p < .001$). This indicates that AI plays a critical role in improving human safety during emergencies, refuting the null hypothesis that AI does not impact human safety.

Hypothesis 4: The impact of AI on job displacement is found to be significant but negative ($\beta = -0.115$, $t = -2.412$, $p = .017$). This result implies that while AI integration may cause job displacement, the effect is moderate. Therefore, the null hypothesis is rejected, indicating that AI does have a significant impact on job displacement.

Hypothesis 5: AI integration affects cyber security risks significantly ($\beta = 0.095$, $t = 2.065$, $p = .041$). Although the impact is not as strong as other factors, it is statistically significant, meaning that AI has a notable effect on cyber security risks, contrary to the null hypothesis.

Joint Influence Hypothesis: Collectively, AI integration in corporate emergency preparedness shows significant explanatory power ($R = 0.912$, $R^2 = 0.832$, $F = 156.482$, $p < .001$). This joint model indicates that AI integration significantly contributes to explaining variance in system performance, regulatory compliance, human safety, job displacement, and cyber security risks. The high R^2 value suggests that the model effectively captures the effects of AI integration on these outcomes.

In summary, the study reveals that AI integration significantly impacts system performance, regulatory compliance, human safety, job displacement, and cyber security risks in corporate emergency preparedness, thus supporting the integration of AI for enhanced preparedness and resilience.

Discussion of Findings

The study showed that system performance will not significantly be an outcome of Artificial Intelligence integration in corporate emergency preparedness. This finding contrasts with previous research that highlights AI's potential to significantly improve system performance. For instance, Adamu and Uzoho (2022) emphasized that AI-powered systems enhance real-time monitoring and predictive analytics, leading to improved system performance. AI's ability to process vast amounts

of data and anticipate potential crises is seen as a major advancement over traditional methods, which rely heavily on manual processes and static models. Moreover, Kebede (2021) discussed how AI's dynamic and adaptive capabilities offer significant improvements in operational efficiency, suggesting that AI should indeed have a notable impact on system performance. The discrepancy in our findings may arise from differences in AI implementation approaches or the specific contexts of the studies.

The study showed that regulatory compliance will not significantly be an outcome of Artificial Intelligence integration in corporate emergency preparedness. This outcome is at odds with the literature, which often highlights AI's role in facilitating compliance with stringent regulations. Mazibuko (2021) and Oladokun & Akinsola (2019) argue that AI can streamline compliance by automating data management and reporting processes, thus ensuring adherence to regulatory standards more efficiently than traditional methods. AI systems' ability to continuously monitor and update compliance status in real-time is expected to significantly enhance regulatory adherence. The lack of significant findings in our study might suggest that while AI has potential, its current application may not fully exploit these benefits or that additional factors are influencing regulatory compliance in the studied context.

The study showed that human safety will not significantly be an outcome of Artificial Intelligence integration in corporate emergency preparedness. Previous studies have emphasized AI's role in enhancing human safety during emergencies. Bello and Fakorede (2022) highlight how AI-driven technologies such as drones and automated alert systems can monitor hazardous environments and protect human workers from dangerous situations. AI's ability to automate and enhance safety protocols aligns with the expectation that it would significantly improve human safety. The current study's result may reflect limitations in the AI technologies deployed or the scope of their application. It is possible that the integration of AI in safety protocols is still in its nascent stages and not yet fully realized in practice.

The study showed that job displacement will not significantly be an implication of Artificial Intelligence integration in corporate emergency preparedness. This result is consistent with some studies that suggest the impact of AI on job displacement can vary widely. Akpan & Effiong (2020)

and Olowu & Ajayi (2023) indicate that while AI has the potential to displace certain jobs, particularly those involving routine tasks, it can also create new opportunities and roles that require human oversight and management. The moderate effect observed in our study might imply that while AI is automating some functions, the overall impact on employment is not as pronounced as anticipated. This could be due to adaptive strategies adopted by organizations, such as retraining employees or redeploying them to new roles within the organization.

The study showed that cyber security risks will not significantly be an implication of Artificial Intelligence integration in corporate emergency preparedness. This finding contrasts with concerns raised in the literature about the increased cyber security risks associated with AI. Ndlovu (2022) and Kamau & Akinwande (2020) highlight that as organizations integrate more AI-driven systems, they become more vulnerable to cyber attacks due to the interconnectedness and data dependencies of these systems. The lack of significant impact in our study could be attributed to the robustness of the cyber security measures in place or to the current stage of AI integration, which may not yet fully reflect the potential vulnerabilities associated with advanced AI systems.

Conclusion and Recommendations

In conclusion, the study highlight the potential of AI to improve corporate resilience by offering faster and more accurate crisis response, enhancing operational efficiencies, and ensuring compliance with industry regulations. While AI can streamline processes and automate tasks, it may lead to job displacement, especially in roles traditionally reliant on manual interventions. Furthermore, the increasing reliance on AI technologies presents cyber security challenges, as the sophistication of AI systems can expose corporate infrastructures to new vulnerabilities. Despite these risks, the overall benefits of AI in emergency preparedness are clear. The technology enhances organizational responsiveness, reduces human error, and allows for proactive decision-making in high-pressure situations. As AI continues to evolve, it is essential for corporations to balance the integration of these technologies with ethical considerations, including workforce transition plans and robust cyber security protocols. In conclusion, while AI integration presents some challenges, its role in transforming corporate emergency preparedness is undeniable. Organizations that embrace AI can significantly improve their preparedness for crises, ensuring more effective responses, better protection of human lives, and improved operational continuity.

Future research should focus on long-term strategies for mitigating the risks of job displacement and cyber security, ensuring that the advantages of AI integration are maximized while addressing its potential downsides. The following recommendations are suggested:

(i) Corporate leaders should prioritize the development and implementation of comprehensive workforce transition plans to address the potential job displacement caused by AI integration. These plans should include retraining programs, career counseling, and strategies to help employees transition into new roles or industries.

(ii) IT and cyber security professionals must focus on strengthening cyber security measures to protect against vulnerabilities introduced by sophisticated AI systems. This involves continuous monitoring for potential threats, updating security protocols, and implementing advanced encryption techniques.

(iii) AI developers and researchers should place a strong emphasis on ethical considerations during the design and implementation of AI systems. This includes addressing potential biases in algorithms, ensuring transparency in AI decision-making processes, and developing guidelines for ethical AI use.

(iv) Policymakers need to formulate and enforce regulations that govern the integration of AI technologies within corporations. These regulations should address key areas such as data privacy, AI accountability, and compliance with industry standards.

(v) Corporate risk managers should regularly assess and enhance their crisis response strategies in light of AI advancements. This involves integrating AI tools to improve response times and accuracy while continuously evaluating and updating response plans based on emerging threats and technological capabilities.

(vi) Future researchers should focus on long-term studies examining the impacts of AI on job displacement, operational efficiencies, and cyber security. These studies should aim to identify trends, assess the effectiveness of mitigation strategies, and explore new ways to leverage AI for corporate resilience.

(vii) NEMA and NIMET should enhance their collaborative efforts to integrate AI technologies into emergency management and weather forecasting systems. By working together, these

agencies can develop and deploy AI-driven tools to improve real-time data analysis, predict disaster events more accurately, and streamline response efforts.

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The Inclusion of some Important Chemical Practical Skills to the Curriculum

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Abstract

The study was on the need for the inclusion of important chemistry practical skills to the curriculum, and the knowledge level of chemical educators of such skills. Survey design was used and three research questions guided the study. A total of 40 chemistry educators were sampled from the schools in Yobe State. The data collected were analyzed using descriptive statistics of mean. The results of the study showed that chemistry teachers have low level of competence required to impact the necessary skills that can bridge the gap between theory and practice, and they also agreed that nine out of the ten listed skills be included in the curriculum.

Keywords: chemistry practical skills, chemistry curriculum, knowledge level, and chemical educator,

Introduction

Nigeria is getting saturated with young graduates that are unemployed. [he number of young graduates produced from Nigerian Universities yearly is so enormous that absorbing them into the labor market is becoming quite impossible. Unemployment has assumed serious dimensions in recent times and therefore needs urgent attention, (Fayomi 2007).

One possible way of solving this problem is through arousing youths' interest to appreciate self-employment by applying their acquired skills in participating in the private sector. Unfortunately, it has been revealed that Nigerian contemporary graduates are apparently not well prepared to meet the challenges of participation in the private sector that is becoming the dominant sector to the Nigerian economy (Fayomi, 2007).

It is expected that Science, Technology and Mathematics (STM) education would help to ameliorate the situation since science is for life and technology is the bedrock of societal growth and transformation, and this will be actualized through the kind of approach science teaching adopts. Selecting skills for particular concept for classroom lesson delivery is an important aspect of teachers' lesson plans that helps to integrate effectively, skills that heighten students' interest towards productivity. Olayiwola and Adedibu (2008), suggested that there is a missing link in the selection and application of resources for meaningful results requiring skills.

The 21st century students centered approach to learning should involve novel ways of teaching and learning in classroom situation for skill development, using well developed lesson

contents that stimulate, orientate and motivate students interest towards skill acquisitation and individual sustainability. Umeron (1998) suggested that it is necessary to provide students an accurate picture of the requirements and opportunities involved in the multitude of carriers available in chemistry education. Consequently, upon this, the researcher think that chemistry lessons should evolve creative ways of including practical skills into curriculum contents, involving models of learning as a challenge to helping teachers/learners think about teaching and learning for self-reliance.

The Purpose of the Study

The general purpose of this paper is to determine the inclusion of some important chemical practical skills to the curriculum. Specifically, the study aim is to determine:

1. The knowledge level of Chemistry educators of some important chemical practical skills.
2. The kind of chemical practical skills that need to be included in the curriculum because of their vast industrial application.
3. The strategies that are needed for effective implementation of these skills.

Research Questions

The following research questions were used to guide the study.

1. What are the chemistry educators' knowledge level of important practical skills?
2. What are the practical skills that needed to be included in the chemistry curriculum, because of their vast industrial application?
3. What are the strategies needed for effective instruction of these practical skills to the learner?

Research Method

The survey research design was used for the study. The population comprised of all the Chemistry educators in the secondary schools of Yobe state of Nigeria.

Sample and Sampling Technique

Random sampling was used to select 40 chemistry educators in the schools located

Instrument for the Study

The instrument used for the study was a questionnaire called Chemical Practical skill Inclusion to the Curriculum Questionnaire (CPSIQ) adapted from Entrepreneur Skill Integration in chemistry Questionnaire (ESICO) in Ugwu

(2009). Three experts in science education validated the instrument consisting of 26-items with four points modified Likert response alternatives as follows; SA=4, A=3, D=2, SD=l.

Reliability of the Instrument

The questionnaire was administered to 20 teachers from Bauchi state schools to determine its internal consistency. Analysis of the data obtained from the trial test using Cronbach Alpha gave an internal consistency index of 0.72 thus the instrument was considered fit for the study.

Procedure

The questionnaire was administered to the subjects through three 3 research assistants and was collected on the sport. This ensured 0% mortality.

Data Analysis

The data were collected and analyzed using descriptive statistics of mean. The mean was interpreted using the following guide; 2.50-4.00 good and very good or agree and strongly agree for the tables 1,2 and 3, 1.00-2.49 poor and very poor or disagree and strongly disagree respectively.

Results

Table I

Questionnaire
The chemistry educators' knowledge level of the following chemical practical skills

S/No	PRACTICAL SKILLS	V.GOOD	GOOD	POOR	V.POOR	X
1	Ethanol production from palm wine, Cassava, Potatoes - and other Stem tubers	08	20	12	00	2.90
2	Soap and detergent making from seeds of palm, groundnut and coconut	12	20	08	00	3.20
3	Fish culture and farming for the study of pH and buffer Solution	04	12	20	04	1.90
4	Production of pomades From carbonated materials of shelled animals	04	12	24	00	2.50
5	Pulp and paper from gmelina plants	02	08	28	02	2.40
6	Fibres from plantain, banana plants peel	04	10	24	02	2.40
7	Food additives from plant acids and dyes	08	20	06	06	2.25
8	Reagent making from bark of trees, flower and organic compounds	05	15	13	07	2.25
9	Glass making from glazed sand, clay	08	16	08	08	2.60
10	Plastic containers from waste polybags and styrene for polymer study and vulcanization	06	10	20	04	2.45

Results on table 1 showed that four out of the ten chemical skills enumerated had mean ratings of 2.50 and above. The chemistry teachers' level of knowledge on ethanol production from cassava, potatoes and other stern tubes, soap and detergent making from seeds of palm, groundnut, production of pomade from carbonated materials of shelled animals shelled animals, cocoa and cashew nuts, glass making from glazed sand and clay arc good. The knowledge level of the teachers on the other six listed chemical skill is poor or low.

Table 2

Rating of chemistry educators on the Inclusion of some practical chemical Skills in the curriculum.

S/No	CHEMICAL SKILLS	SA	A	D	SD	X
1	Ethanol production from palm wine, Cassava, Potatoes - and other Stem tubers	20	16	04	00	3.40
2	Soap and detergent making from seeds of palm, groundnut and coconut	20	20	00	00	3.50
3	Fish culture and farming for the study of pH and buffer Solution	04	28	08	00	2.90
4	Production of pomades From carbonated materials of shelled animals	08	16	12	04	2.90
5	Pulp and paper from gmelina plants	08	28	00	04	3.00
6	Fibres from plantain, banana plants peel	04	20	12	04	2.30
7	Food additives from plant acids and dyes	04	12	08	04	3.00
8	Reagent making from bark of trees, flower and organic compounds	28	12	00	00	3.70
9	Glass making from glazed sand, clay	12	20	04	04	3.00
10	Plastic containers from waste polybags and styrene for polymer study and vulcanization	08	28	04	00	3.10

Result on table 2 showed that nine out of the ten enumerated chemical skills had mean ratings of between 2.90 and 3.70, while only one chemical skill which is fibers from plantain had a mean rating of 2.30. the teachers are of the opinion that all the chemical skills listed out except one should be included in the chemistry curriculum.

Table 3

S/No	STRATEGIES FOR EFFECTIVE INSTRUCTION OF THE CHEMICAL/ PRACTICAL SKILLS	SA	A	D	SD	X
1	Employing a team-teaching approach to the teaching of the topics involving Uncommon chemical practical skills.	12	20	04	04	3.00
2	Inviting resource personnel with different chemical skills related to those in chemistry curriculum to come and teach students	20	16	04	00	3.40
3	Preparing holiday programmes for teachers in the field to receive training from resource personnel.	20	16	04	00	3.40
4	introducing chemical skills programme into the curriculum of teachers on in service training	16	12	12	00	3.10
5	Adequate funding of schools for the provision of all the necessary requirements for practical chemical skill training	28	08	04	00	3.72
6	Employing field trips to industrial sites as a teaching approach for topics with practical skill	20	16	04	00	3.40

Result of table three showed that all the listed mean had mean rating of 3.00-3.72, showing that 75% and above of the teachers accepted each of the listed strategies as effective means of instruction of the listed skills.

Discussion

The results of the findings indicate that chemistry teachers are of the view that nine out of the ten chemistry practical skills listed by the researcher should be included in the chemistry curriculum. This is an indication that some important chemical practical skills are lacking in the curriculum or have not received sufficient emphasis. This finding is in agreement with the findings of Ugwu and Etiubon (2009), and Ezeudu (2008) where similar skills were listed and teachers accented to their inclusion in the curriculum of secondary schools.

The chemistry teachers' low level on the six of the listed chemical skills is an indication that they are not sufficiently prepared for the chemical skills needed for the students learning. The three skills where the teachers indicated high competence are in high demand in the society, and the teachers may have acquired their knowledge through informal training.

For the strategies for effective instruction, of the skills, the result showed that all the teachers are in agreement with the strategies that were listed. There is need for all involved to put hands together to ensure that there is hill implementation.

Implication

The inclusion of these important chemical skills which has great industrial application and are of vast entrepreneurial demand in our society would not only help the recipients to become self-reliant, bridge the gap between theory and the practice of science, but would contribute towards building a sustainable national development.

Conclusion

The researcher has looked at the need for the inclusion of some chemical skills which have industrial and entrepreneur application into chemistry curriculum continents, so as to address issues of self-employment and competence in the industries. It is hoped that the educational system will give adequate attention to these ideas.

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Software as tool for Education Reformation through Multiple-Intelligence

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Abstract

With the arrival of twenty first century, development and application of knowledge in all professional discipline was given a new direction in order to contain the current challenges which include the gaps between what is available and what is needed to overcome those challenges. This paper intends to examine educational reforms through the periscope of multiple intelligences. The study however will explore the path and method of promoting education and teaching reform in the era of rapid software development that could be put in place to address the issues that bedeviled the educational reformation and teaching methodologies. Navigating through the process of solution procurement, the paper adequately explores the benefits associated with Artificial intelligence.

Keywords*:* Reformation, Educational Software, Multiple intelligence, Natural Language Processing, Computer Vision, Speech Recognition, Machine Learning.

Introduction

Education is the transmission of knowledge, skills, and character traits. There are many debates about its precise definition, for example, about which aims it tries to achieve. A further issue is whether part of the meaning of education is that the change in the student is an improvement. Some researchers stress the role of critical thinking to distinguish education from indoctrination. These disagreements affect how to identify, measure, and improve forms of education. The term can also refer to the mental states and qualities of educated people. Additionally, it can mean the academic field studying education. According to Cambridge.org (2023), education is the process of teaching or learning in a school, or the knowledge that you get from a high school/college.

The place of education in the scheme of things which covers the entire horizon that touches the all spheres of human endeavor, Education For All ((EFA), 2010) explained further the education counts because it helps eradicate poverty and hunger. Education gives people the knowledge and skills they need to live better lives. It can boost productivity and open doors to jobs and credit. Poverty is one of the main reasons children are being left out of school. The Education for All EFA movement is a global commitment to provide quality education for all children, youth and adults. It aims to achieve six key education goals by 2015, which relate to: early childhood care, primary

education, youth and adult learning, literacy, gender equality and education quality. Furthermore, it was put forward that education counts because it helps ensure environmental sustainability Education helps people make decisions that meet the needs of the present without compromising those of future generations. Education for sustainable development is fundamental to changing values, attitudes and behaviours EFA (2010).

State of Educational Decadence

The state of decadence is an act or process of falling into an inferior condition or state. Deterioration or decay could be attributed to the state of decadence. It is wisely said that "no country can develop more than the level of its education." This makes it imperative for every responsible government to take the development of education in the country seriously.

The success of a student is not the sole responsibility of an entity but a joint collaboration of some stakeholders; parents, government and teachers, who have a lot of responsibilities and roles to play in education to make it successful.

It is when these major stakeholders perform their roles effectively that the students can record unblemished success. If any of these aforementioned stakeholders fail in carrying out their responsibility, a lacuna has been created; hence, there is a problem BusinessDay, 2022).

If Nigeria educational system could be taken as a case study in this respect, the level of decadence in Education in Nigeria, especially primary and secondary education requires urgent attention which if not nipped in the board might degenerate to an unexpected level. Primary and secondary educations are the foundation stages of education that need to be concretized and taken with all seriousness. If the foundation is weak, the structure built on it cannot stand. It is discovered that most of these schools lack the basic facilities that are needed for the smooth running of an educational institution. There are no enough teachers to teach the students in primary and secondary schools. Corp members, who most of them are not trained to teach, are substituted for trained teachers across the country, especially in public secondary schools. How do we expect to get results here?

Most of the schools are not provided with furniture for the learners. The classrooms in some schools are dilapidated and not conducive for learning. The teachers who are expected to dress corporately to school do not sit in corporate offices. Teachers in our primary schools are not enough to teach the pupils in the schools effectively. These pupils are expected to write an external exam (common entrance) on the subjects and the topics they have never been taught. This would qualify them for secondary school education. This leads to malpractice even at that elementary level of education; the pupils would want to pass at all costs to go to secondary school. In Allison Academy (2021) article, claimed that UNICEF clarified that causes of educational decadence in developing countries as follows:

1. contemporary infrastructure/
2. indiscipline among stake holders; staff, students, guardians and government

3. decayed social values
4. impunity to existing laws and regulations
5. the lack of qualified teachers
6. inadequate teaching materials

According to Dakuku (2023) opinion in premium times newspaper, education is a critical priority for Nigeria, as it is for any nation serious about growth and development. Unfortunately, in the past ten years, we have not seen any focus on or dramatic improvement in education throughout the country. The best efforts the country can offer at addressing education have put us steps behind our peer nations in all key development indicators. Therefore, there is need to inadvertently signal to the world that we do not care about the future. Education is a fundamental human right that should be available to all citizens, regardless of socio-economic status or background. This is different in Nigeria. The country's literacy rate, put at 62% by Global Data, does not make Nigeria competitive among nations and it shows the dysfunctional state of Nigeria's education.

Need for Educational Reformation

Reformation means making changes to something with the intention of setting it back on the right path. It is an act or process of changing a religious, political, or societal institution for the better is called a reformation. Explain further, vocabulary.com (2022) defined reformation as an improvement in the existing form or condition of institutions or practices that is intended to make a striking change for the better in social or political or religious affairs. The intension is holistic and all-encompassing toward radical change for a new improve version. Scholars and or researchers being stake holders in education have widely discussed the issue of educational reformation and publications were made to develop the literature.

Education reform is the process of constantly renegotiating and restructuring the educational standards to reflect the ever-evolving contemporary ideals of social, economic, and political culture. Reforms can be based on bringing education into alignment with a society's core values. In this contextual discuss, Claudio-Rafael et al (2015) claimed that the objective of educational reform is to fulfill the world-wide commitments made on the subject of the education. When speaking of the educational reform, reference is often made to changes and transformations in the scholastic system in relation to such factors as educational philosophy, student policy, curriculum, pedagogy, didactics, organization, management, financing and links with national development in this century, the consensuses that the prime purpose of education is care for and improve holistic education in early childhood, especially for the most vulnerable and underprivileged children, and to guarantee access to free, compulsory and high quality education.

It was further maintained that within the field of education, reforms of education are undoubtedly one of the most complex and controversial subjects, because of the effects that they generate in the societies and countries where they take place. Nevertheless, this situation makes it possible to investigate the reasons why such reforms generate substantial changes in the school systems where

they are applied (Claudio-Rafael et al, 2015). The present study takes as its object the analysis of great educational reforms across the world in order to relate some of the main lines of development: when the curricular design is changed and the consequent curricula; when the system as a whole is modernized, imposing more agile and effective dynamic for institutional operation; when decentralizing the central bureaucracy; when an attempt is made to raise the general quality of education, in order to improve the academic yield of students and reduce school failure; when an attempt is made to adapt educational formation to the demands of the labour market.

Comfort and Joy-Telu (2013) were of the opinion that educational reform is the key to participation in the global economy of the 21st century, based on technological revolution in communication and transfer of information as well as major changes in production, distribution and the economic value of knowledge. Education as Achuonye and Ajoku (2003), Achuonye (2007) cited in Comfort and Joy-Telu (2013) is an agent for the maintenance of social status quo in the society through the transmission of modern ideas, modern strategies of doing things. In an effort to better meet the diverse needs of learners and ultimately of the society, there have been numerous curricular reforms and the introduction of a range of new approaches and strategies in the class room environment. Every child, youth and adult should be able to benefit from educational opportunities designed to meet their basic learning and personal needs (Achuonye, 2007). To be able to achieve the desired results of reforms in education, Obanya (2004) said such needs comprise both essential learning tools (such as literacy, numeracy, oral expression and problem solving) and the basic learning content (such as knowledge, skills, values and attitudes) required by human beings to be able to survive, to develop their full capacities, to live and work in dignity, to participate fully in development to improve the quality of their lives and to make informed decisions. He expressed that the basic learning needs of youths and adults are divers and should be met through a variety of educational reform programs. Husain (2004) cited and went further in Comfort and Joy-Telu (2013) to say that the learner and society need educational reform because it helps to build human potentials, builds upon responsibility, active participation, reflection and flexibility which creates competences that develop active citizens and further democratic behaviour. It gives quality learning that enables the learners to function in various roles as individuals as well as part of the work force which takes place in the school and outside. It is a driving force that helps individuals and society to move from the practice of educational mono culture to a system which recognizes that human beings have a wide range of variety of socially useful talents, all of which should be developed through educational reforms. Dike (1999) and Husain (2004) agreed that we are presently going through phase of transition where one tradition of teaching is giving way to another. They totally condemn the traditional method where the teacher is looked upon as a dispenser of information, a repository of knowledge and data bank, where the learner is only a passive receiver.

Educational Reforms through Multiple-Intelligence

The relationship between intelligence and education is one that scientists have been studying for years. A study done in Germany proved how education did affect the intelligence of students and proof of intelligence affecting education was seen in the military, where people with lesser intelligence were observed to have a slower learning speed and benefited less from education. According Wikipedia (2022), that there is substantial evidence to suggest that education influences intelligence. Wikipedia (2022) further claimed that longitudinal studies have shown a predictive interaction of intelligence on educational attainment. In the same vein, Nicholas (2022) explained further that Schooling, socioeconomic status, and genetics all impact intelligence. However, it is unclear to what extent their contributions are unique and if they interact. Schooling is an important environmental factor, having a large impact on intelligence in children. This has been shown in longitudinal studies controlling for prior intelligence and in studies evaluating the cognitive effects of policy changes regarding compulsory schooling. However, Nato (2002) supported these views explaining that when learners receive education then they are learning new things and thus they are improving the level of their intelligence. As a matter of fact, cognitive and developmental psychologists often state that a child's cognitive abilities hugely depend on the things they learn at school and the skills they gain as a result. For example, accepting the main points of Jean Piaget's theory, it could be concluded that education should be tailored to the individual's cognitive development to be most effective. A classical approach in the field of educational and developmental psychology, modern researchers have somewhat the same understanding of the link between intelligence and education. It turns out that the duration of education an individual receives and their scores on IQ tests are positively correlated.

Multiple intelligences theory in the classroom: The multiple intelligences theory is connected to multisensory learning, which teaches that children learn better with activities that involve more than one sense (Gardner, 1997). Teachers are encouraged to engage their students' visual, tactile, auditory, and other senses to reach more students (Waterford.org, 2019). Multiple intelligences refer to a theory describing the different ways students learn and acquire information. These multiple intelligences range from the use of words, numbers, pictures and music, to the importance of social interactions, introspection, physical movement and being in tune with nature. Accordingly, Waterford (2019) presented the list of Gardner's, multiple intelligences which endowed by individual learners to include the following:

- Linguistic intelligence
- Logical-mathematical intelligence
- Spatial intelligence
- Musical intelligence
- Naturalistic intelligence
- Interpersonal intelligence
- Intrapersonal intelligence

Each of these intelligences are relatively independent of one another. This means that a child can be highly proficient in one intelligence and struggle with another. An athlete, for example, could have strong bodily-kinesthetic and spatial intelligence but poor musical intelligence. That's why it's so important to use instructional strategies that involve a variety of these multiple intelligences so every child has the opportunity to learn in a way that works best for them. Waterford (2013) quoted Gardner saying that there is strong evidence that human beings have a range of intelligences and that strength (or weakness) in one intelligence does not predict strength (or weakness) in any other intelligences. Essentially, integrating educational theory and methods of instruction is a pragmatic approach to teaching. The theory of multiple intelligences is useful to educators who find a connection to a method for application such as the gradual release of responsibility. The big question is; what actually is necessarily needed to undergo reformation, educational policies or the classroom instructional methodology?

The answer is all of the scenarios need to undergo reforms in essence. Reformation of educational sector covers the following areas:

i. Policy Formulation Frameworks
ii. Legislation Formulation Frameworks
iii. Classroom Instruction Methodologies
iv. Availability of functional facilities
v. Constant Training and Retraining of Teachers
vi. Constant and Effective Monitoring and Supervision on all of Education Administrators, Teachers and Students
vii. Motivation and Disciplinary on Education Administrators, Teachers, and Students

Software Tools for Educational Reformation and Twenty first Century Skills

In a computer system, the software is basically a set of instructions or commands that tell a computer what to do. In other words, the software is a computer program that provides a set of instructions to execute a user's commands and tell the computer what to do. Britannica.com (2023) defined software as instructions that tell a computer what to do. Software comprises the entire set of programs, procedures, and routines associated with the operation of a computer system. Software tool readily refers to the system software tools. The system software tool provides the platform for running application or application software. It brings together the capabilities of the computer. Tasks that benefit end-users fall under the domain of application software. Subsequently the ICT became the buzz word and it happened that the computer is central to ICT.

Reformation of education is in other word institutional reforms, and it will affect all polities that govern education in every stratum. Institutional reform is the process of reviewing and restructuring state institutions so that they respect human rights, preserve the rule of law, and are

accountable to their constituents. To institutionalize reform in educational sector, the application of software tools is central achievement which in the long run will help toward realization of the twenty-first century skills as is being the trend worldwide. The practical frameworks toward realization of twenty first century skills, is practically possible by directing energy by exploring and exploiting the potentials of the Educational Software.

Kenneth (2023) explained educational software or computer applications developed for the purpose of teaching and learning, arrived with virtually the first desktop computers. Education professionals recognized this potential early, and many schools acquired computers long time ago before computers populated the homes. Educational applications then greatly increased. Educational software encompasses a variety of forms, costs, and purposes. Programs exist to teach individual preschoolers letter names, sounds, and grammar in English as well as other languages. Other programs introduce mathematical concepts for all grades, or are aimed at helping to develop good writing skills. Some programs, such as flight simulators, teach professionals the details of their jobs. Still other programs, called Learning Management Systems (LMSs), are designed for use by certain grades in entire school districts for teaching or evaluation purposes; these often include access to a software company's web site for comprehensive services.

At the college and university level, LMSs are powerful application management systems that offer courses via the internet for non-traditional students. These tools allow institutions to design entire online courses. The projects require a team, consisting of the subject-matter expert (usually a faculty member), a graphics artist, a curriculum designer, and a programmer, to put the complete package together.

Recently, Tetfund engaged all stake holders in tertiary institutions through workshops to tape the potentials and benefits of the learning management systems (LMS), sooner or later the Tetfund will enforce the utilization of the LMS to address some of the problems that bedeviled the education sector. On the wider context, a researcher Yiqiang (2020) gives a broad-based opinion about reforming even the teaching method in this era of artificial intelligence is necessary. Yiqiang went further and explain the integration of AI digital contents in the arena of educational reforms and present it as follows:

Natural Language Processing

Natural language processing technology is composed of natural language understanding technology and natural language generation technology. The former enables the computer to understand the meaning of natural language text, and the latter enables the computer to express the given ideas and intentions in natural language text. The development goal of natural language processing technology is to avoid people spending a lot of time and energy to learn all kinds of obscure computer languages, let people use their most familiar and most used natural languages to operate computers, and realize natural language communication between human and computer.

Computer Vision

Computer vision technology aims to establish an artificial intelligence system that can obtain information from images or multi-dimensional data, and realize the function of using computers and cameras to replace human eyes to identify, track and measure targets. Through further processing of the captured images, it can generate images that are more suitable for human eyes to observe or instruments to test and detect.

Speech Recognition

Speech recognition is the most successful technology in the application of artificial intelligence, which includes feature extraction technology, pattern matching criteria and model training technology. Speech recognition technology solves the problem of making the machine understand the human speech content. It realizes the machine's recognition and understanding of the speech signals, and then transforms the content into the corresponding text or command.

Machine Learning

Machine learning is the core of artificial intelligence. This technology studies how to make machines have the same learning ability as human beings, how to simulate or realize human learning behaviour, so as to acquire new knowledge or skills and reorganize the existing knowledge structure to improve their own performance. Nowadays, to judge whether a system can be called "intelligence" is to see whether it has learning ability. At present, the research direction of machine learning is mainly divided into two categories: one is the study of traditional machine learning, which focuses on exploring the learning mechanism of simulated human; the other is to study how to effectively use information, and how to obtain hidden, effective and understandable knowledge from mass data in the big data environment.

Conclusion

Change appears to be the only thing that remains constant in the fluid context of contemporary education. Governments across the globe are re-examining and changing many aspects of education trying to find optimum ways to meet the present-day challenges. The bargain is how to reform education, make it up-to-date and modern. Modernization of education is commonly used as a synonym to improvement. Many notions are embedded into the discourse for educational reform and modernization: benchmarks, standards, standardized tests, comparative studies and analysis. However, the way forward to change the present narratives to new face values is by traversing through the adoption of twenty first century skills are as follows:

Suggestions

The following suggestions are presented to scale down the identified problems associated with present day educational system.

i. Curriculum Review to Attain the Twenty First Century Skills

ii. Policy Formulation Frameworks

iii. Legislation Formulation Frameworks

iv. Classroom Instruction Methodologies

v. Availability of functional facilities

vi. Constant Training and Retraining of Teachers

vii. Constant and Effective Monitoring and Supervision on all of Education Administrators, Teachers and Students

viii. Motivation and Disciplinary measures on Education Administrators, Teachers, and Students

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Relative Effects of Two Teaching Strategies on NCE Students' Performance and Interest in Balancing Redox Equations

By

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Abstract

This study set out to investigate the relative effects of cooperative learning and individualized instruction teaching strategies on NCE students' performance and interest in balancing redox equations. The study was guided by four research questions and four null hypotheses. The study adopted a quasi-experimental nonequivalent control group design. The sample consisted of eight hundred and thirty eight(838) NCE 1I Chemistry students, made up of five hundred and eighty seven (587) males and two hundred and fifty one (251) females in the six public colleges of Education in three states: Delta state (South-south zone), Kogi state (North central zone) and Yobe state (North - east zone) in Nigeria. In each college all the NCE 11 chemistry students were grouped into two experimental groups; group one was taught with cooperative teaching method while group two was taught using individualized instruction teaching method. Performance test and interest inventory in balancing of redox equations (PTBRQ) were developed by the researcher. The validity and reliability of the instruments were established. The coefficients of reliability of the instruments were 0.86 and 0.81 respectively. Mean and standard deviation were used to provide answers for the research questions while analysis of covariance (ANCOVA) was used to test the null hypotheses at 0.05 confidence level of significant. The result of the study, among others revealed that cooperative teaching strategy was found to enhance students' performance and interest in balancing redox equations than individualized method. The result of the study also showed that gender was not a significant factor in determining students' performance and interest in balancing redox equations when taught with cooperative learning and individualized instruction teaching strategies .Based on these findings, the researcher among others recommended that Chemistry teachers should endeavor to develop and adopt cooperative learning strategy as it would enhance overall performance and interest as well as help reduce gender gap in the subject.

Keywords : Cooperative learning, individualized instruction , teaching strategies, performance, interest, and redox equations

Introduction

In the dynamic field of chemistry education recent literature has emphasized the critical need for innovative instructional strategies to enhance learning outcomes and cultivate sustained interest among students. This study, titled "Relative Effects of Cooperative Learning and Individualized Instruction Strategies on NCE Chemistry Students' Performance and Interest in Balancing Redox Equations," aligns with contemporary discourse on optimizing pedagogical approaches.

Recent contributions by (Chen and Tang 2021) underscore the importance of tailoring teaching methods to address diverse learning styles and preferences. Additionally, the work of (Dhawan,2020) highlights the pivotal role of student engagement in fostering a deeper understanding of complex chemical concepts such as balancing of redox equations which pose difficulty to NCE students

The aspects of redox reactions that posed difficulty to NCE students as pointed out by Ekairia (2021) are: Writing out the half cells equations, balancing the equations with respect to atoms, charges, and electrons. The researcher further posited that a concept may be difficult for students to learn because the methods used by the teachers are inappropriate and do not promote better understanding of the concept

Despite these advancements, a noticeable gap exists in understanding how specific instructional strategies impact the performance and interest of NCE chemistry students, particularly in the context of balancing Redox equations. This gap forms the nucleus of this research problem, underscoring the necessity of this investigation.

Redox reactions involve the transfer of electrons between chemical species. The term "redox" is derived from the simultaneous occurrence of reduction (gain of electrons) and oxidation (loss of electrons). Key concepts include oxidation numbers, electron donors and acceptors, and the conservation of charge. Notable scholars . Erbil, (2020)) extensively discussed the principles of redox reactions. The researchers went ahead and further stated that understanding redox reactions is fundamental in chemistry, as they play a crucial role in various biological, industrial, and environmental processes. Mastery of redox reactions is essential for students pursuing chemistry education, providing a foundation for comprehending complex chemical phenomena.

The overarching problem addressed in this study revolves around the lack of clarity regarding the relative effectiveness of Cooperative Learning and Individualized Instruction in the realm of Redox equation balancing for NCE chemistry students. Identifying the most conducive approach is paramount in the ongoing efforts to refine pedagogical practices and elevate the quality of chemistry education.

There are several innovative methods pointed out in literature for effective teaching and learning of some complex chemical concepts as noted by Dhawan,(2020). The researcher further opined that cooperative learning is an innovative instructional strategy where students work together in small groups to achieve common goals. This method emphasizes positive interdependence, individual accountability, face-to-face interaction, and group processing.

Recent contributions by (Wang and Holcombe 2021), highlighted the social and cognitive benefits of cooperative learning, emphasizing its potential to enhance academic achievement, promote critical thinking, and improve interpersonal skills. The method fosters a collaborative learning environment, encouraging students to actively engage in the learning process and share responsibilities for their academic success. The researcher went ahead and further emphasized the

importance of recognizing individual differences in learning styles and abilities and advocated for individualized instruction method when the need arises.

Individualized instruction is an approach tailored to meet the unique needs and pace of each learner. It involves personalized learning plans, adaptive materials, and differentiated instruction.

Scholars like Hattie and Yates (2020) have emphasized the importance of recognizing individual differences in learning styles and abilities. Individualized instruction aims to maximize student success by allowing them to progress at their own pace, addressing specific learning needs. This method often utilizes technology and various instructional strategies to create a customized learning experience, fostering autonomy and self-directed learning.

The present research or exploration is rooted in contemporary literature, seeking to provide practical solutions to enhance both academic achievement and sustained interest in this critical facet of chemical education. Hence, this study aims to offer valuable contributions and insights to the scholarly dialogue on effective teaching methodologies in the realm of chemistry education.

Purpose of Study

The general purpose of the study is to determine the relative effects of two teaching strategies on students' performance and interest in balancing redox equations at NCE teacher education level. Specifically, the study intends to:

1. Ascertain effects of individualized instruction and cooperative learning teaching strategies on NCE students' performance in balancing redox equations
2. Ascertain effects of individualized instruction and cooperative learning teaching strategies on NCE students' interest in balancing redox equations
3. Ascertain the mean performance scores of male and female NCE students' in balancing redox equations.
4. Ascertain the mean interest scores of male and female NCE students' in balancing redox equations

Research Questions

The following research questions have been raised to guide the study:

1. What are the mean performance scores of NCE students in balancing redox equations when taught with Individualized Instruction and Cooperative learning teaching strategies?
2. What are the mean interest scores of NCE students in balancing redox equations when taught with Individualized Instruction and Cooperative learning teaching strategies?
3. What are the mean performance scores of male and female NCE students in balancing redox equations when taught with Individualized Instruction and Cooperative learning teaching strategies?
4. What are the mean interest scores of male and female NCE students in balancing redox equations when taught with Individualized Instruction and Cooperative learning teaching strategies?

Hypotheses

The following null hypotheses have been formulated for the study:

HO_1. There is no significant difference in the mean performance scores of students taught balancing redox equations using Cooperative learning and their counterparts taught with Individualized Instruction teaching strategy at NCE level

HO_2. There is no significant difference in the mean interest scores of students taught balancing of redox equations using Cooperative learning and their counterparts taught with Individualized Instruction teaching strategy at NCE level

$H0_3$. There is no significant difference in the mean performance scores of male and female NCE students in balancing redox equations when taught with Individualized Instruction and Cooperative learning teaching strategies

HO_4 There is no significant difference in the mean interest scores of male and female NCE students in balancing redox equations when taught with Individualized Instruction and Cooperative learning teaching strategies.

Method

A quasi-experimental design was used as intact classes from each school were randomly assigned to the two experimental conditions. Groups one and two were taught with Cooperative learning teaching strategy and Individualized Instruction learning teaching strategy respectively.

The sample consisted of eight hundred and thirty eight (838) NCE I1 Chemistry students, made up of five hundred and eighty seven (587) males and two hundred and fifty one (251) females in the six public Colleges of Education in three states in Nigeria. The choice of NCE 11 Chemistry students is due to the fact that NCE 11 Chemistry curriculum contains Redox equations.

Purposive sampling technique was used for the study. This involved sampling of three states where the study was carried out, on the condition that each state must have Federal and state Colleges of Education with well-equipped chemistry laboratories facilities and qualified chemistry teachers as stated in the new minimum standard. Following these conditions, two colleges of Education from each of the three states (Delta, Kogi and Yobe States) constituted the six public colleges of Education used for the investigation as shown below:
Federal College of Education (Technical) , Asaba, Delta State;
College of Education,Agbor, Delta State, Federal College of Education, Okene, Kogi State,
College of Education, Ankpa Kogi State, Federal College of Education (Technical), Potiskum, Yobe State and Umar Suleiman College of Education Gashua,,Yobe State.

The researcher developed two set of instruments - Performance test in redox equations (PTRQ) using the table of specification and the corresponding Marking scheme with lesson plans and interest inventory scales(IIRQ) for the two teaching strategies, and the PTRQ was subjected to face and content validation while the IIRQ was subjected to construct validity by experts in science Education and Measurement and Evaluation in University of Nigeria, Nsukka.
The instruments were trial tested on 48 students in college of Education Igueben, Edo state who are part of the target population of the study but not part of the sample.

Two trained chemistry teachers were used to administer the instruments in each school. Scores of students were used in determining the reliability of the instrument using the Kudder- Richardson (k-R 21) formula for the PTRQ, with a reliability coefficient of 0.81; and chronbach alpha expression for the IIRQ, with a reliability coefficient of 0.79.
The feedback was used to draft the final items on both instruments.

These lesson plans for the two teaching strategies were used in teaching the students in the two experimental conditions.

In each college all the NCE 1I chemistry students were grouped into two experimental conditions as follows: Group one was taught with cooperative teaching method (COP). While group two was taught with Individualized Instruction teaching method (ID). The students were taught by their regular teachers under the supervision of the researcher. The experiment lasted for six (6) weeks and it is expected that this period may be long enough as not to permit the pre-test to affect the post-test scores.

For each group, the treatment lasted for twenty-four hours. The pre-test was administered to the subjects by their various teachers in each school before the study began while the post test was administered to the subjects during the period immediately after the last period of teaching. The instruments were appropriately scored based on the validated marking scheme.

Two chemistry teachers from each of the sampled school attended the training workshop before the commencement of the experiment. The researcher trained the research assistants on the two teaching approaches for the study. Each research assistant was trained on the teaching strategy he/she implemented.

The research questions were answered using the mean and standard deviation. Analysis of covariance (ANCOVA) was used in testing the hypotheses. The pretest scores were used as covariate to the post test scores. The ANCOVA served as a controller of the initial differences across groups as well as increasing the precision due to the extraneous variables thus reducing error variance (Okiemhen, 2010).

Results

Research Question one

1. What are the mean performance scores of NCE students in balancing redox equations when taught with Individualized Instruction and Cooperative learning teaching strategies?

Table 1: Mean and Standard Deviation of performance scores of NCE Students taught balancing of redox equations with Individualized Instruction and Cooperative learning teaching strategies.

		Pre- test		Post- test		Mean gain
Teaching Strategies	N	$\bar{x}$	SD	$\bar{x}$	SD	
Individualized Method	430	3.34	2.49	10.09	4.24	6.75
Cooperative Method	408	3.37	2.80	10.61	3.36	7.24
Total	838					

The result presented in Table 1 shows that the students taught balancing of redox equations with cooperative method had a pre -performance mean score of 3.37 with a standard deviation of 2.80 and a post-performance mean score of 10.61 with a standard deviation of 3.36. The difference between the pre and post-performance mean for the collaborative group was 7.24. The Individualized group had a pre performance mean score of 3.34 with a standard deviation of 2.49 and a post-performance mean score of 10.09 with a standard deviation of 4.24. The difference between the pre and post-performance mean scores for the Individualized group was 6.75.

However, for each of the groups, the post-performance mean scores were greater than the pre-performance mean scores with cooperative group having the higher mean gain. This is an indication that cooperative learning strategy enhances students' performance more than the individualized instruction learning strategy in balancing redox equations.

Research Question two

What are the mean interest scores of NCE students in balancing redox equations when taught with Individualized Instruction and Cooperative learning teaching strategies?

Table 2: Mean and Standard Deviation of interest scores of NCE Students taught balancing of redox equations with Individualized Instruction and Cooperative learning teaching strategies

		Pre- test		Post- test		Mean gain
Teaching Strategies	N	$\bar{x}$	SD	$\bar{x}$	SD	
Individualized Method	430	3.00	2.50	15.09	4.50	12.09

Cooperative Method	408	3.35	2.48	18.61	4.51	15.26
Total	838					

The result presented in Table 2 shows that the students taught balancing of redox equations with cooperative method had a pre -interest mean score of 3.35 with a standard deviation of 2.48 and a post- interest mean score of 18.61 with a standard deviation of 4.51. The difference between the pre and post- interest mean for the collaborative group was 15.26. The Individualized group had a pre- interest mean score of 3.00 with a standard deviation of 2.50 and a post- interest mean score of 15.09 with a standard deviation of 4.50. The difference between the pre and post- interest mean scores for the Individualized group was 12.09.

However, for each of the groups, the post- interest mean scores were greater than the pre- interest mean score with cooperative group having the higher mean gain. This is an indication that cooperative learning strategy enhances students' interest more than the individualized instruction learning strategy in balancing redox equations.

Research Question three

What are the mean performance scores of male and female NCE students in balancing redox equations when taught with Individualized Instruction and Cooperative learning teaching strategies?

Table 3: Mean and Standard Deviation of performance scores of male and female NCE Students in balancing redox equations

Gender	N	Pre- test		Post- test		Mean gain
		$\bar{x}$	SD	$\bar{x}$	SD	
Male	587	50.35	2.57	101.80	3.61	51.45
Female	251	50.34	2.77	71.75	3.38	21.41
Total	838					

The result presented in Table 3 shows that for the male students balancing redox equations had a pre-test performance mean score of 50.35 with a standard deviation of 2.57; and a post-performance mean score of 101.80 with a standard deviation of 3.61. The mean gain score for the male group was 51.45. For the females, the pre performance mean score was 50.34 with a standard deviation of 2.77 and a post -performance mean of 71.75 with a standard deviation of 3.38. The mean gain score was 21.41. This shows that the male students performed higher than their female counterparts in balancing redox equations. This result shows that gender has some effects on students' performance in balancing redox equations.

Research Question four

What are the mean interest scores of male and female NCE students in balancing redox equations when taught with Individualized Instruction and Cooperative learning teaching strategies?

Table 4: Mean and Standard Deviation of interest scores of male and female NCE Students in balancing redox equations

Gender	N	Pre- test		Post- test		Mean gain
		$\bar{x}$	SD	$\bar{x}$	SD	
Male	587	30.50	4.55	88.50	4.45	58.00
Female	251	30.40	4.37	71.75	4.50	41.35
Total	838					

The result presented in Table 4 shows that for the male students balancing redox equations had a pre-test interest mean score of 30.50 with a standard deviation of 4.55; and a post- interest mean score of 88.50 with a standard deviation of 4.45. The mean gain score for the male group was 58.00. For the females, the pre interest mean score was 30.40 with a standard deviation of 4.37 and a post - interest mean score of 71.75 with a standard deviation of 4.50. The mean gain score was 41.35. This shows that the male students have higher interest mean score than their female counterparts in balancing redox equations. This result shows that gender has some effects on students' interest in balancing redox equations.

Hypothesis One

There is no significant difference in mean performance scores of students taught balancing of redox equations using Cooperative learning and their counterparts taught with Individualized Instruction teaching strategy at NCE level

Table 5: Analysis of Covariance (ANCOVA) of the significant difference in mean performance scores of students taught balancing of redox equations using Cooperative learning and Individualized Instruction teaching strategies

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	13137.257[a]	4	3284.314	232.808	.000
Intercept	40267.231	1	40267.231	2854.339	.000
PRE PERFORMANCE	373.814	1	373.814	26.498	.000
METHOD	10505.520	1	10505.520	744.683	.000
GENDER	38.411	1	38.411	2.723	.109
PRE INTEREST	373.814	1	373.814	26.498	.000
METHOD	10505.520	1	10505.520	547.683	.010
GENDER	3.780	1	3.780	1.268	.105
Error	9832.840	697	14.107		
Total	167766.000	838			
Corrected Total	22970.097	837			

Hypothesis Two

There is no significant difference in mean interest scores of students taught balancing of redox equations using Cooperative learning and their counterparts taught with Individualized Instruction teaching strategy at NCE level

The result in Table 5 above shows there is significant difference in the mean interest scores of students taught balancing of redox equations with Cooperative

learning strategy and those taught with Individualized Instruction teaching strategy, as an F-ratio of 547.683 was obtained with associated probability value of 0.01. Since the associated probability value of 0.01 is less than 0.05 set as level of significance, the null hypothesis (H_{02}) which stated that there is no significant difference in mean interest scores of students taught balancing of redox equations using Cooperative learning and their counterparts taught with Individualized Instruction teaching strategy at NCE level is rejected in favor of the alternative hypothesis. Thus, inference drawn therefore is that there is significant difference in the mean interest scores of students taught balancing of redox equations using Cooperative learning and their counterparts taught with Individualized Instruction teaching strategy at NCE level. Students taught balancing of redox equations with cooperative learning teaching strategy having a higher mean gain. This shows that cooperative learning teaching strategy had more effect on students' interest in balancing of redox equations than Individualized Instruction teaching strategy.

Hypothesis Three

There is no significant difference in the mean performance scores of male and female students in balancing of redox equations at NCE level.

The result in Table 5 above shows there is no significant difference in the mean Performance scores of male and female students taught balancing of redox equations, as F-ratio of 2.723 was obtained with associated probability value of 0.109. Since the associated probability value of 0.109 was greater than 0.05 set as level of significance; the null hypothesis (H_{03}) which stated that there is no significant difference in the mean performance scores of male and female students in balancing of redox equations at NCE level is not rejected. Thus, inference drawn therefore is that there is no significant difference in the mean performance scores of male and female students in balancing redox equations at NCE level. This means that gender is not a significant factor in determining students' performance in balancing of redox equations.

Hypothesis Four

There is no significant difference in the mean interest scores of male and female students in balancing of redox equations at NCE level.

The result in Table 5 shows there is no significant different in the mean interest scores of male and female students taught balancing of redox equations, as F-ratio of 1.268 was obtained with associated probability value of 0.105. Since the associated probability value of 0.105 was greater than 0.05 set as level of significance; the null hypothesis (H_{04}) which stated that there is no significant difference in the mean interest scores of male and female students in balancing of redox equations at NCE level is not rejected. Thus, inference drawn therefore is that there is no significant difference in the mean interest scores of male and female students in balancing of redox equations at NCE level. This means that gender is not a significant factor in determining students' interest in balancing of redox equations.

Discussion of the Findings

The study revealed the post-test performance mean score for both cooperative learning and individualized instruction teaching strategies groups to be greater than the pre-test performance mean score with the students taught with cooperative learning strategy having the higher performance mean gain. Therefore, this result shows that cooperative learning strategy enhanced students' performance in balancing of redox equations than individualized instruction teaching strategy.

The findings of this study are in line with the view of Dhawan,(2020) and Ekairia, (2021) who noted that cooperative learning strategy leads to greater students' achievement as the teacher switches roles from presenter to facilitator to aid, guide students, integrate prior knowledge with novel learning, and stimulate cognitive achievement.

The study also revealed the post-test interest mean score for both cooperative learning and individualized instruction teaching strategies groups to be greater than the pre-test interest mean score with the students taught with cooperative learning strategy having the higher interest mean

gain. Therefore, this result shows that cooperative learning strategy enhanced students' interest in balancing of redox equations than individualized instruction teaching strategy.

The findings of this study are in line with the view of Dhawan,(2020) and Ekairia, (2021) who noted that cooperative learning strategy leads to higher students' interest as the teacher switches roles from presenter to facilitator to aid, guide students, integrate prior knowledge with novel learning, and stimulate cognitive achievement, retention and interest.

However, the Finding of the study showed no significant gender difference on performance and interest for both strategies.
This implies that gender is not a significant factor in determining Students' performance and interest in balancing redox equations. The observed difference therefore may have been a result of chance.

The result of this study is in agreement with the submission of Isa and Bukar (2023), who noted insignificant difference in the performance and interest of male and female students in volumetric analysis when taught with flipped classroom model.

Conclusion

Based on the findings of the study, the researcher drew the following conclusions.

1. The use of cooperative learning strategy results in students' higher performance and interest than the use of individualized instruction teaching strategy in balancing redox equations.
2. Gender was not a significant factor in determining students' performance and interest in balancing redox equations when taught with cooperative learning and individualized instruction teaching strategies.

Educational Implications of the Study

The study's findings underscore the effectiveness of Cooperative Learning in improving both academic performance and student interest in balancing Redox equations compared to

Individualized Instruction. Educators can leverage Cooperative Learning strategies to create collaborative learning environments that foster active engagement and peer interaction, thereby enhancing students' conceptual understanding and problem-solving skills in chemistry. By prioritizing Cooperative Learning approaches, educators can cultivate a classroom culture where students feel supported and motivated to explore complex chemical concepts together, ultimately leading to improved learning outcomes.

Additionally, the study highlights the importance of recognizing individual differences in learning styles and preferences, regardless of gender, when designing instructional strategies. While gender was not found to be a significant factor in determining students' performance and interest in Redox equation balancing, educators should continue to employ inclusive teaching practices that cater to the diverse needs of all students. By adopting a student-centered approach and providing opportunities for personalized learning experiences, educators can create equitable learning environments that empower every student to succeed in chemistry education.

Recommendations

Based on the study's findings, several recommendations can be made to inform future practice and research in chemistry education:

1. Promote the Use of Cooperative Learning: Encourage educators to incorporate Cooperative Learning strategies into their teaching practices to enhance students' performance and interest in balancing Redox equations. Provide professional development opportunities for teachers to learn and implement Cooperative Learning techniques effectively, fostering collaborative problem-solving and peer interaction in the classroom.

2. Tailor Instruction to Individual Learning Needs: While Cooperative Learning proved effective overall, recognize the importance of catering to individual learning styles and preferences. Encourage educators to incorporate elements of Individualized Instruction alongside Cooperative Learning strategies, allowing for personalized support and scaffolding to meet the diverse needs of NCE chemistry students.

3. Foster Inclusive Learning Environments: Emphasize the importance of creating inclusive learning environments that prioritize equity and diversity. While gender was not found to significantly impact students' performance and interest in Redox equation balancing, continue to promote inclusive teaching practices that accommodate the varied backgrounds and experiences of all students.

4. Further Investigation: Encourage further research to explore the underlying mechanisms driving the observed differences in performance and interest between Cooperative Learning and Individualized Instruction. Investigate additional variables that may influence the effectiveness of instructional strategies, such as prior knowledge, motivation, and classroom dynamics. By implementing these recommendations, educators and researchers can continue to advance the field of chemistry education, ultimately enhancing student learning outcomes and fostering a deeper interest in the subject among NCE chemistry students.

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Nigeria's Sustainable Economic Stability Strategies for Overcoming Draught and Desertification

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Abstract

Natural disasters, particularly desertification and drought, pose significant challenges to Nigeria's ecological and socio-economic landscape. As the country faces increasing threats from climate change, proactive measures for coping with these disasters are essential for sustainable development. This abstract explores the impacts of desertification and drought on Nigeria, the existing coping strategies, and potential approaches to enhance resilience. By addressing these challenges through a comprehensive and integrated framework, Nigeria can foster community-based initiatives, leverage technological advancements, and implement adaptive policies to mitigate the adverse effects of desertification and drought and ensure a more resilient future.

Key words: Drought, Desertification, Economic Stability.

Introduction

Geomorphology, Natural hazards and Natural disasters. The functioning of landscapes is the product of interaction between physical structures, which are the basis of natural processes, and human actions. Most natural disasters are the product of geomorphological processes. Geomorphology is the aspect of science that deals with landforms and the physical processes that shape them (Addy, 2017 in Nandy, 2019). Geophysical and hydro meteorological processes, such as earthquakes, volcanic eruptions, landslides and/or flooding, storms, drought, tsunamis, acid rain, etc are responsible for natural disasters in the tropics. All these processes threatened not only the human population but the prevailing flora and fauna. Natural disasters occur worldwide;

however, their impact is greater in developing countries such as ours (Beck, 2020). In most cases, the occurrence of natural disasters in developing countries is due to two main factors:

1. The relation between the geological location and geological-geomorphological settings

2. The historical development of developing countries. There include economics, social, political and cultural conditions, which are generally not good. These two factors combined to create high vulnerability to natural disasters in developing countries.

Natural hazard has been described as a physical event which makes an impact on human beings and their environment (Alexander, 2018) Natural hazards are threatening events, capable of producing damage to the physical and social space where they take place not only in the moment of their occurrence, but on a long-term basis due to their associated consequences. When these Consequences impact significantly on the infrastructure and/or society it is considered natural disaster.

Desertification and drought have brought about the expansion of desert areas in a typical region and the engulfing of farm lands, water bodies and settlement that in turn give rise desert-like characteristics in a previously known non-desert areas. Desertification occurs which when human activities disturb the balance of arid, semi-arid, and semi-humid ecologies, climatic fluctuation as a key dynamic factor [Lyu, 2020; UN 2020]. Without efficient measure desertification control, the externalization of degradation costs will persist, and desertification will result in acute sustainability issues for the coming generations (Lyu, 2020). desertification control can improve the well-being of local residents and promote sustainable development.

Over the last six decades, governments and researchers in Asia, Africa, Europe, America Australia, etc. have made great efforts to manage desertification (Lyu, 2020; UN 2020). However, in Northern Nigeria, Yobe state in particular, efforts on the management of desertification remains a difficult task to solve (Audu and Adie, 2018; UN 2020). Moreover, previous studies focused mainly on causes of desertification; while neglecting the most important components this include various ways of ameliorating desertification and the use of the right plants to control

Concept of Desertification

Desertification is derived from the term desert, and according to United Nations Economic Commission of Africa (UNECA) (2016) desert" is a barren area of landscape where little precipitation occurs, and consequently living condition are hostile for plant and animal life. Desertification therefore is defined according to preamble to the convection to combat desertification (CCD) (2018) as land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climate variations and human activities. There are two main components of desertification include vegetation degradation and soil degradation. These components0 are caused by over cultivation, overgrazing, reduction in tree cover, and poor irrigation management. Desertification is generally reversible until land is eventually turned into desert, and can occur anywhere in dry areas and not just on desert fringes (Grainger, 2022).

Desertification is a condition of human-induced land degradation that occurs in arid, semiarid and dry sub-humid regions (precipitation/potential evapotranspiration or P/ETP 0.05 to 0.65) and leads to a persistent decline in economic productivity > 15% of the potential) of useful biota related to a land use or a production system. Climatic variations intensify the decline in productivity, restorative management mitigates it. Drylands or territories susceptible to desertification occupy 39.7% (~5.2 billion ha) of the global terrestrial area (~ 13 billion ha). The highest concentration of drylands occurs in Africa, Asia and Australia. Two out of every three hectares of drylands suffer from land degradation of one kind or another. Barring 78 M ha which are irreversibly degraded, the remainder area - affected by desertification - is reclaimable at a price.

Desertification is a type of land degradation in which a relatively dry land region becomes increasingly arid, typically losing its bodies of water as well as vegetation and wildlife. It is caused by a variety of factors, such as climate change and human activities. Desertification is a significant global ecological and environmental problem (Seixas, 2017).

Component of Desertification

There are two main components of desertification, in which both are caused by over cultivation, Overgrazing. Reduction in tree cover (deforestation), poor land management, and poor

water management including poor irrigation management. These components are the Vegetation degradation and Soil degradation

Extent of Desertification

The United Nations Environmental Programme (UNEP) estimated that 35% of the land surface of earth is at risk, and the livelihoods of 850 million people are directly affected by desertification.75% of the world's drier lands - 45,000,000 km are affected by desertification, and every year 6,000,000 hectares of agricultural land are lost and become virtual desert. In all, more than 110 countries have dry lands that are potentially threatened by desertification. Africa, Asia and Latin America are the most threatened by desertification (Do Nascimento, 2023).

Desertification in Africa

About two-third of Africa is desert or dry lands and land degradation affects at least 485 million people or 65% of the entire African population. There are extensive agricultural dry lands, almost three quarters of which are already degraded to some degree. Most of the African countries adequate irrigation supplies determine the hydrology, land development, and vegetation of the area (UNCDD, 2014).

Sand Erosion and Deposition

Drifting sand and migrating sand dunes in severe wind erosion areas are a continuous threat to potential agricultural land, range plant life, settlements, highways and other areas. The main effect is due to sand deposition rather than erosion, although erosion and transport of sand are the primary factors. Sand accumulation will bury crops and destroy arable land. In China, 1.09 million km2 were affected by shifting sand dunes and drifting sand in many desert districts of which 59% is covered by sand dunes (UNCDD, 2014).

Reduction in Soil Moisture

The desert soils normally retain moisture for several weeks after precipitation, whereas ground dryness may cause a desert to persist (UNCDD, 2014; Lyu, 2020; Ikram, and Heribert, 2022).

Human Activities

Human activities leading to desertification are mainly related to agriculture. The intensification of human activities brings an increased greenhouse effect causing global warning. Drylands are likely to be especially vulnerable to rises of temperature during the 21st Century (Lyu, 2020), Ikram, and Herbert, 2022).

Unsustainable Agricultural Practices

Unsustainable agricultural practices include extensive and frequent cropping of agricultural areas. Excessive use of fertilizer and pesticides, and shifting cultivation without allowing adequate period of recovery (Lyu, 2020; Ikram, and Heribert, 2022).

Unsustainable Water Management Practices

Poor and inefficient irrigation practices and over abstraction of ground water, particularly in the coastal regions resulting in saline intrusion into aquifers are some of major unsustainable water management practices which has led to problems of desertification Over-abstraction of groundwater without compensatory recharge has led to depletion of groundwater table (UNCDD, 2014; L yu, 2020).

Overgrazing

Overgrazing by domestic animals feeding on grassland reduces the vegetation cover, damages the soil, and causes erosion and further compaction of top soils (Lyu 2020, Ikram, and Heribert, 2022). The effect of grassing in destroying the vegetation cover has also a negative impact on oil composition and the soil microbial communities involved in carbon and nutrient cycling Grassing land is estimated to cover about one-third of the land surface of world.

Deforestation and Drought.

The plant community in arid regions is generally patchy and scarce. Cutting wood for purposes and fires destroy the plant community in the desert. People living in an arid environ cut trees to feed animals and use them as a source of dry wood for sale to the rural people (K 2022).

The primary causes of deforestation especially in the tropical region are:

i Extreme poverty

ii. Population growth.

iii. Other humans' associated disturbances such as conversion of forests to alternative such as agricultural production, cattle ranching, commercial logging, and demand for fuel wood

The precise contribution of each of these activities to forest depletion is unknown, but one suggests that 64% of tropical forest depletion can be attributed to agricultural conversion, commercial logging, 10% to the actions of fuel gatherers, and 8% percent to cattle ranching. Significantly, tropical timber exports, either as logs or processed timber, account for only one percent of all trees felled in developing countries. Therefore, timber extraction itself accounts for a certain amount of forest depletion, it also fosters agricultural use by providing greater access (that is, logging roads) to the forest's interior.

Extreme poverty

The principal causes underlying tropical forest destruction are extreme poverty and population growth. In the last fifty years, the world's population has grown from two billion to five billion, and population experts predict that there will be 7.5 billion people worldwide by 2035. The overwhelming majority of this growth is occurring in the developing world, which leads to Malthusian predictions about land and natural resource scarcity. Likewise, poverty, malnutrition, disease, and early death can be expected to increase exponentially. Excluding China, approximately three billion people currently live in the world's tropics and subtropics, and 750 million of these people live in absolute poverty in the tropics (UNCDD, 2014; Ikram, and Heribert, 2022).

Unsustainable land use

The unsustainable utilization of land mainly driven by overpopulation, increasing urbanization, and a massive increase in food demand that, together, slowly degrade drylands and even more fertile lands into infertile deserts (Burrell et al, 2020). A key factor is a large-scale deforestation whenever range land is converted to cropland or paddy cultivation.

Global warming, overgrazing, salinization and urbanization

This has been reported to cause the loss of 12 million hectares of arable land, each year, an area larger than Portugal is turned into unproductive deserts. Over-irrigation of arable lands can also lead to the salinization of soils if the water is mostly evaporated through plants or directly from the ground. Globally, huge formerly arable areas have been lost to over salinization followed by desertification notably in Australia, Africa, and the Middle East. The fate of Lake Aral in Central Asia vividly demonstrates how over irrigation by Soviet agriculture to produce cotton not only drained what was the fourth largest lake on the planet, but also caused a massive environmental catastrophe by salinization of once fertile soils followed by desertification (Lyu, 2020).

Impact of desertification

Desertification has severe financial and societal consequences including direct economic losses, increased health and safety hazards, and decreased agricultural productivity.

Environmental Impacts

The direct physical consequences of desertification may include an increased frequency of sand and dust storms and increased flooding due to inadequate drainage or poor irrigation practices. This can contribute to the removal of topsoil and vital soil nutrients needed for food production, and bring about a loss of vegetation cover which would otherwise have assisted with the removal of carbon dioxide from the atmosphere for plant photosynthesis.

Desertification causes a drop in biological productivity of land which to a decline in economic productivity. It adversely affects the lives of wild species, domestic animals, agricultural crops and people. Desertification can also initiate regional shifts in climate which may enhance climate changes due to greenhouse gas emissions (Lyu, 2020).

Social Impacts (e.g. Poverty and Migration)

Desertification brings hunger and poverty. People living in areas threatened by desertification are forced to move elsewhere to find other means of livelihood. Mass migration is a major consequence of desertification. From 1997 to 2020, some 60 million people are expected to move from the decertified areas in Sub-Saharan Africa towards Northern Africa and Europe (UNCDD, 2014).

Control of Desertification and Drought.

Desertification is generally reversible until land is eventually turned into desert, and can occur anywhere in dry areas and not just on desert fringes (Grainger, 2022). Desertification reversal is accompanied by increase in the content of soil organic carbon, improvements in the physical and chemical properties of soil, stabilization of shifting sand, and restoration of the ecological balance (Cheng, et al. 2020). Desertification reversal exhibits self-regulating and self-organizing ability in semi-arid environment, but the effect differs among regions (Cui, 2019). The reversal process typically requires 3 to S years to take hold in regions with an annual rainfall of around 500nmm but in region with annual rainfall below 200mm. a much longer time could be required (Cui, 2019). The prevention or reversal of desertification requires massive investments at multiple levels, including societal and economic policies to change land use and agricultural practices. Such policies should be put in place at the first signs of desertification as it is much easier and cost- efficient to halt land degradation at an early stage than attempting to reclaim desert lands. Many strategies to restore desert lands have been tried and tested worldwide.

Reforestation by planting

Planting of trees for many kilometers (wide green walls of trees) consolidates the soil through the extensive root system and thereby generates fertile ground to grow other plants. According to UNCDD (2017), many reforestation become not sustainable because of a number of reasons including: The use of wrong trees increasing population growth and land use inappropriate farming practices the effects of climate change

Develop Sustainable Agricultural Practices

Sustainable agriculture refers to the ability of a farm to produce food indefinitely, without causing irreversible damage to ecosystem health. Dry lands are home to a large variety of species, which are also become important commercial products. Agriculture biodiversity must be preserved. Land overexploitation shall be stopped by leaving the soil 'breathe' during a certain-time period, with no cultivation, nor livestock grazing.

Reforestation

Trees help fix the soil, act as wind breakers, enhance soil fertility, and help absorb water during heavy rainfall. Because the burning of land and forests increases dangerous greenhouse gases, planting new trees can help reduce the negative impacts of resulting climate change. The reasons that make many reforestations unsustainable are because of the wrong selection of trees for reforestation. Learning from the failures, reforestation projects have shifted their approach from simple tree-planting projects to a network of locally sourced sustainable land management practices. One promising method for regreening the desert is termed "planting pits

also called Zai . Previous reviews posited that it originated in Burkina Faso and included digging holes in the soil before seeding, which improves water retention during dry periods, more efficient use of rainwater, and better uptake of nutrients. Yet, the most sustainable and promising solutions are emerging from the study of desert biomes: soils, microbiomes, and indigenous desert plants. Exploiting their particular properties should be instrumental to achieve more sustainable solutions than what has been tried and tested so far. Indeed, the use of native tree species in Nigeria and Northern Ethiopia helped to restore ecosystems by improving soil quality and reclaim land lost to desertification (Carey, 2020). This knowledge, combined with modern irrigation and monitoring technologies, will be used in the recently launched Middle East Green Initiative, the aim of which is to restore an area equivalent to 200 million hectares of degraded land across the Middle East by planting 50 billion trees (https://www.vision2030.gov sa/v2030/v2030-projects/middle-east-green initiative).

Desert plants to restore rangeland Desert plants in particular may well be the key factor for any reforestation project to have success. These desert survivors" have adapted their morphology,

architecture, and tissues to infertile soils with high salinity and p0or nutrients (Kirschner et al., 2021), which makes them ideal for restoring desert lands. Moreover, desert plants include a wide range of species from grasses to shrubs to trees that can be used not only for restoring lands but also for landscaping to substitute commonly used species that require constant irrigation.

Way Forward

Addressing these challenges through a comprehensive and integrated framework, Nigeria can foster community-based initiatives such as; land management practices, water conservation methods, the impacts of these disasters can be mitigated at the grassroots levels, leverage technological advancements and implements adaptive policies to mitigate the adverse effects of desertification and drought and ensure more resilient future.

Conclusion

The issues of desertification and drought in Nigeria demand urgent attention and concerted efforts from the government, civil society, and the global community. To safeguard the nation's environment and livelihoods, it is imperative to adopt sustainable practices, invest in climate resilience, and prioritize the well-being of vulnerable communities. Through collaborative action and increased awareness, Nigeria can strive to overcome the challenges posed by these natural disasters and build a more secure and sustainable future for all its citizens.

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Survey on Availability of Koha Open-Source Software by Academic Libraries in North East Colleges of Education

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Abstract

The was set out to explore how Open source has been the Centre of attention in the library world for the past several years. Koha and evergreen are examples of major open-source integrated library systems (ILSs), and they have continued to grow in maturity and popularity. Four purposes out four research questions have to guide the study. The questions remain as to how many libraries are aware of the advantage presented by this open-source development toward library management. Little has been written in the library literature to answer this question. The study was a survey design which involved college of educations in Northeast Nigeria. The population consist of 72 library staff and the sample consist 72 were randomly selected from colleges of Education. The questionnaire and checklist were used for data collection which was administered to COEs. The data was analyze using mean and standard deviation. Instrument was validated before use. This paper discusses the present status of Koha usage in north-east Nigeria, services automated use Koha, opinion about feature of Koha and advantage of the software over other commercially developed library management systems. The paper further highlights the strategy to be adopted in deploying the software, and outlines factors to be considered by librarians when developing automation process for their libraries. The research proposal is estimated at about one million nine hundred and fifty thousand naira only (#1,950,000)

Keywords: Availability, KOHA, Open, Source, and Software

Background of Study

A library is a room or building where books, films, records, videos etcetera are kept for study, reference, and reading or for lending Chamber 21st century Dictionary, (2013). The dictionary added that a library is a collection of films, records, videos etc for public or private use. Contemporary libraries maintain collections that include not only printed materials such as manuscripts, books, newspapers and magazines, but also art reproductions films, sound and video recordings, maps photographs, microfiches, CD-ROMs, computer software, online databases, and other media (Helsey and Richard 2017 et al). Library automation and other facilities made possible

by information and Communication Technology (ICT) have really made operation easy and the world as a global village. The concept of Koha is firmly rooted in developed countries of the world as most of the libraries in such countries are fully computerized (e-libraries) but the same cannot be said of developing like Nigeria as a result of the enormous challenges that tend to inhibit the establishment of Koha in the country (Adeyomoye, J. I 2018). The use of ICT in libraries has become inevitable in an era of information explosion and wide spread use of digital information resources. Effective application of ICT in libraries has helped in performing library operations and services most efficiently. The modernization of libraries and information centers enable information transfer and access, meeting objectives and there establishing a network of libraries and information centers. This initiative saw a major shift in resource development, resource sharing and their utilization at various levels. However there has been number of software available under proprietary and open source license for the purpose of library automation. Open source is one of such software that has gaining a good momentum during the last few years. Koha has been in the market for more than a decade now and is used by many libraries all over the world.

The Colleges of Education (COE) which were as one of the three pillars of tertiary education in Nigeria, is to train teachers who will be able to meet the requirements for the Nigerian certificates of education's minimum teaching qualification (NCE). In Nigeria, graduate with NCE can teach in junior secondary schools and technical institutions. The

NCE programme this takes three years to complete. The COEs were established to provide high-quality teacher training oriented toward addressing the issues plaguing the Nigerian educational system, particularly with regard to preparing teachers of science and Nigerian languages to teach in the fundamental foundational schools (Musa, 2020). Government at the state and federal levels, as well as private persons, owned and managed these COEs.

Open-Source Concept

Literally, "open source" refers to the open-source initiative of 2018, but for the purpose of this paper the term to encompass a broader array of allied movements: free culture, free software, open-source software, open access, open content, open archives, and open standards. All share principles of freedom of access and shared creation of resources for the common good. These

initiatives are defined by two features: free distribution and collaborative development (Fatoki, L 2019). Open- source resources are shared without cost, provided with the means to customize and enhance them, and are managed through a licensing process that protects the rights of the creators and their collaborators while allowing users broad access.

Features

Open source promotes software reliability and quality by supporting independent peer review and rapid evolution of source code," according to the Open- Source Initiative's FAQ. While "no cost" is often of first interest to users, the ability to modify the product, superior quality control and better security through peer review, and a rapid development cycle through collaboration are keys to the success of open source. Open-source software is distributed with source code-a licensing condition and users can alter the product to meet their needs and so contribute to its development. Open-source adopters become part of a community, blurring the distinction between users and developers (Paul, O. 2021).

Open-source features, such as low cost, rapid development, and high reliability, that motivate other users will also attract libraries. Some feature of particular interest for libraries, especially when contrasted with proprietary systems, include local control, customizability, interoperability, vendor independence, reliance on open standards, collaborative development, and flexible support options.

Other important open-source advantages are the service benefits we can deliver to our users, with the most profound enhancements emerging in the open access publication arena. As Peter Suber (2021) points out in "A very brief introduction to open access," the question is not whether scholarly literature can be made costless, but whether there are better ways to pay the bills than by changing readers and creating access barriers."

About Koha

According to the Koha software (2012), Koha is the first open-source integrated library systems in use worldwide; its development is steered by a growing community of libraries

collaborating to achieve their technology goals. Koha impressive feature set continues to evolve and expand to meet the needs of its user base. It includes modules for circulation, cataloging, acquisitions, serials, reserves, patron management, branch relationships, and more. Koha is the most successful of several open-source ILS projects. Katipo.com's Koha Library System page states that developers decided "to release Koha as Free Open Source as a risk management strategy, to ensure that they could get support and development work done." As Peart, (2011) point out, further advantage lies in users' ability "get their data out of Koha if they have to chance systems later on. Koha can be changed or written without breaking any agreements or license restrictions." According to the Koha wiki entry "Koha users around the world." Koha has 215 participating institutions though not yet a single ARL library. According to Paul, (2021) adopting Koha not only lowers the overall automation costs to your library but more importantly it empowers your organization to take control of your technology and drive the direction of your ILS rather than act as a passenger. http://Koha-community.org/

New trends in Librarianship and the use of Koha

Recently the Nigerian Library Association (NLA), Delta State Chapter, held its Annual Conference/AGM at the College of Education (COE), Agbor, with theme "Library automation: Myth or Reality". Speaking on the conference; Engr. Ofuafor, the managing Director of Rolof Computers. Warri, one of the key presenters noted that "Koha in Nigeria is reality despite the myth; the pace may be slow, but it has come to stay". He concluded that Librarians should try as much as possible to key into campaign for the revival of reading culture in the country just as he implored (librarians to wake up to the reality of Koha). Thus, as the information age matures into the knowledge age, it is imperative for librarians and other information professionals to acquire information literacy skills which include the ability to select appropriate search terminology, construct a logical search terminology, construct a logical search strategy, and evaluate information appropriately. Also, it entails ability to know when there is need for information, how and where to get the information and using such information effectively to a specific purpose.

An information literate individual is expected to possess some qualities as observed by Association of College and Research Libraries (Information Literacy Competency Standards 2006). These include individual ability to:-

a. Incorporate selected information into one's knowledge base.
b. Use information effectively to accomplish a specific purpose.
c. Understand the economic, legal and social issues surrounding the use of information and access and use information ethically and legally

Statement of the Problem/ Justification

Libraries, public and academic, in developing countries have always lacked a wealth of possibilities for library automation. Hardware and relevant software used to be expensive and relatively speaking is still expensive for developing countries (Alex, 2019). Another issue not often raised is the need for collaboration both within and between institutions to get library automation project off the ground and then maintain it. However, the use of open-source packages is increasing thereby providing various opportunities for addressing the issues of library automation in libraries across the world. This paper therefore is response to challenges faced by libraries in the choice of software requirement for library automation.

Objectives / Purpose of the Study

The main purpose of the study is to determine the availability of KOHA open- source software in the Academic Libraries in the Northeast Colleges of education. Specifically, the study sought to:

i. Assess the availability of KOHA open-source facilities for teaching practical skills.
ii. Assess if the librarians are exposed in using KOHA open-source facilities.
iii. Assess if the effectiveness of KOHA open-source facilities in the library.
iv. Find out the challenges facing the adoption of KOHA open source in the library.
v. Find out solution to the challenges of KOHA open source in the library

Research Questions

The study will answer. The following research questions.

a. How effective is the utilization of KOHA open -source facilities in the library?
b. What is the of exposure of librarians to KOHA open-source facilities?
c. To what extent are the KOHA open-source facilities available to teach practical skills?
d. What are the challenges of KOHA open source in teaching practical skills in library?
e. What are the solutions to the challenges of KOHA open source in teaching practical skills in library

Scope and Delimitation of Study

This study will cover COEs in Northeast academic libraries, comprising Federal College of Education (Technical) Potiskum, Federal College of Education (Technical) Gombe, Federal College of Education Yola, Umar Suleiman College of Education Gashua, College of Education Zine, Kashim Ibrahim College of Education Maiduguri, Aminu Saleh College of Education Azare, College of Education, Hong, College of Education, Billiri, College of Education, Bama, College of Education and Legal Studies Nafada and College of Education, Waka Biu.

Theoretical framework of the study

According to Agha (2016), library automation has been a subject of attention since the mid-1970s because of the spreading knowledge of Information Communication Technologies. Libraries in Nigeria are trying to automate their functions. However, there have been challenges and constraints facing library automation, which could be general. These challenges include, among others: erratic power supply inadequate professional librarians to execute the project, absence of maintenance and support agreement, poor ICT infrastructure, poor funding, and poor ICT skills among library staff. (Agha, 2016) Another major challenge of library automation in Nigeria has to do with choice of software to deploy. Just as Onohwakpor and Anre (2018) observed, software selection decision in libraries is basically based on report from other colleagues

through conferences on what they feel and heard the software could offer. They also note that some of the libraries do not do a thorough system analysis to certain what their library needs are Onohwakpor and Anre (2018) further noted that, dependence on software vendors has been of great disadvantages. This is true especially where the library staff input is inadequate in the acquisition and installation, with the library ending up with an inappropriate automated system. Despite these challenges Agha, (2016) while carry out a survey observed that Nigeria library workers are enthusiastic about and willing to use new technologies. In spite of this interest, findings on automated services in Nigeria universities and colleges of education by Sani and Tiamiyu (2017) revealed that the services were far from adequate and that out of about 49% were available and utilized.

In spite of the challenges automation brings, its benefits quite outweigh its disadvantages. It is a known fact that automation of library enables easy access to library materials, and allows staff to better serve the patrons and facilitate a multitude of tasks such as acquisition, circulation, reference and cataloguing, (Chandra 2015). Tamuno and Ojedokun (2019) observed that once a library is computerized there are some intangible benefits that staff and students gain such as computer literacy, introduction of new services such as internet searches, online database searches, CD-ROM searches, etc. Kadiri (2021) also asserted that automation of library will address the problem of manual processing of filling and typing errors, retrieval errors, time consumption and drudgery. Ehikhamenor, (2017) opined that automation of libraries activities becomes inevitable if the libraries were to fulfill their role in the realization of universities' mission or goals, summarized as preservation, transmission and advancement of knowledge. This is so because information explosion has brought with it huge problems of management and

control of not only the published sources of information but also less formally produced documents (Ifidon, 2018).

Availability of KOHA Software

According to Yang and Hofmann (2020) the library community welcomes open-source Integrated Library Systems (ILSs) with open arms, as evidenced by the increasing number of libraries and library consortia that have adopted or are considering open-source options, such as

Koha, evergreen, and the Open Library Environment project (OLE project). Librarians see an develop. Open source OPACs, especially with Koha, seem to be more innovative than their long-established proprietary counterparts. In few years software began to build up an information society which has crossed the geographical limitation and has provided facilities to access in global information system. As a result, nature of modern librarianship has changed considerable part of modern library information system development, organization, management and services. In the present age of information, software making tremendous impact on different aspects of the libraries especially in the area of quality services. In view of complex and multi-faceted user requirements, this results in specialization and flow of non-stop information, increasing comprehensive acquisition of documents for libraries, growing demand of information, increased number of users, etc. Software has been playing vital role in improving the capabilities of libraries towards attaining satisfaction of their users (Alex Koohang, 2019)

Sources of KOHA Software

Koha has been defined differently by experts. Iwe (2017) defines Koha as application of computers to perform traditional library housekeeping activities such as acquisition, circulation, cataloguing, reference and serial control. Macias-Chapula (2018) also describes Koha as a process which involves liking computers electronically within and outside the institution, entering library resources in a database to create an open access cataloguing, which allows users to access and retrieve information in a timely manner. While Fatoki (2019) viewed Koha as a use of computers to serve the need of library users. The operation of library services gets to a quantum jump with the introduction of computers. The computers help to provide fast and reliable access to resources available in the library. Allan et al, further emphasizes that Koha should always be used as a means to achieve overall better patrons' services.

There is current lack 0f KOHA skill possessed by librarians, staff and students to design and deliver the course in automation format. Many are not still ICT compliant and as such, are not interested about its use in education programmes.

The objective of practical skills is to prepare both librarians, staff and students' entry of employment in the field of specialization. The KOHA training centre course set by the Nigerian

government Apprenticeship training both Librarians, Staff and students. Through this programme which combines theory and practical exercise, Librarians, Staff and students will develop the ability to perform basic knowledge about KOHA tasks. Librarians, staff and students are encouraged to seek apprenticeship upon completion of this KOHA open-source software as a means of further their skills toward journey person level in the automation. KOHA training center will allow the all librarians, staff and students to become familiar with equipment in the academic libraries, and learn safety on and off the use site.

This KOHA programme aimed at developing the field of specialization taking by librarians, staff and students through the various work areas necessary to produce excellent work acceptable to the academic libraries. The KOHA covers all library activities, there is an introductory of basic KOHA open source that can be considered at all level. The portion includes equipment usage and identifications as well as a strong background of safety and awareness in the workshop and seminar.

Utilization of KOHA Software in Academic Library

The following features characterize Koha. Ratha (2017) identified the features of Koha

i. An electronic based activity which is carried out human being.
ii. Helps in providing library services
iii. Standardization in library work
iv. Accuracy in work
v. Speed communication of information
vi. Avoid duplication in library work
vii. Training staff
viii. Availability of information
ix. Time saving
x. User friendly
xi. Networking

Librarians know that merely placing computers and internet connections in the academic libraries is not by itself enough in bringing the gap. Staff and students need to learn how to

effectively use the new equipment for than just playing games and passively search the web for factbook, forbidden the pornographic videos and pictures. Librarians need to learn how to effectively incorporative the tools into their teaching. In a world overflowing with easily available information, there is the need to equip the popular with efficient skills to assess and judge the relevance, veracity and recency of any particular piece of information.

Utilization implies the degree or extent to which an item has put into effective use (Abubakar, 2017). In other words, it is extent of usage of KOHA equipment or items if the items or equipment is not used maximally, then it is referred to under utilizations, but if the equipment is optimally used then items is effectively used.

If their frequent need of the used of an item, it may lead to break-down of such equipment or item.

This concept demand careful planning, adequate insurance cover, utilization and maintenance as well as proper keeping and evaluation of facilities in KOHA training center (Abubakar, 2017). According to Thingam (2015), in order to make optimal of physical facilities such Librarians, lecturers, Staff and Students should have knowledge of KOHA open source the functioning of such facilities and the alternative use to which they can be put, without the knowledge such item will be under-utilized.

Maintenance culture is carried out for the following purposes:

1. To promote high degree of efficiency.
2. To maintain a safe working condition
3. For improved financial return
4. Improved productivity
5. Employment opportunity

Adequate and appropriate physical facilities are important in the education process. A part from that they lead to attainment of goal, it is required of the equipment to be effectively maintained (Nwachuku, 2020). There is nothing good as ensuring that the existing physical facilities are maximally utilized and longevity. Indeed, no academic libraries can be relevant

without adequate, effective and efficient instructional materials well put in place, maintained and utilized to actually inculcate the technical knowledge required or the society (Ezeji, 2020). He add that adequate maintenance culture in term of facilities will go a long way in promoting skills development in KOHA open source programmed

Since the introduction of ICT in education there were series of researches conducted by many researchers, yet researchers are carrying out in order to identify the rate of changes and development in COEs and provide an effective recommendation to ameliorate the particular educational field. Concerning the need of facilities Efiong. Mfon (2018) new technology seems to pose a threat to the survival of older ones. It is rare at such points to appreciate the complementary roles and constructive interplay that can result from the co-existence of old and new ways of doing things. The revolution in information and communication technology is threatening the very existence of a number of highly regarded institutions such as publishing, scientific societies, and academic libraries. In the same vein, as print media faces challenges digital and online services such as the internet, MP3 players, cell phones and online versions of newspapers have led news consumers to rely increasingly on information from online and digital sources.

Academic libraries in Nigeria are realizing the need to move from their isolated past into integrated systems and networked operations. As Khalid (2017) observes, networked and integrated functions draw on the experiences of the evolution of libraries in developed countries. Academic libraries in Nigeria are trying their best to catch up with their counterparts in the developed world. University library automation KOHA in Nigeria which started in the late 1980s are at various stages of KOHA library services.

Inwang (2015) stated that problem of poor funding to the COEs libraries to establish

KOHA, lack of professional librarians, lack of KOHA facilities, this are the definitely affects output from COEs.

This chapter covered the library automation system, the conversion of manual routine to digitalization. Libraries has assumed additional roles because of changing demands and new trends in technology. As the use of Koha libraries continue to soar, users and Librarians are expected to develop Koha skills in order to make efficient and effective use of information

resources. Thus, the researcher is obliging to make attempt to assessing a survey of availability and use of Koha open-source software by academic libraries in Nigeria (The Casa Study of College of Education Northeast Nigeria) with a view to finding empirical evidences on the issues at stake.

Methodology

The following procedures were used to carry out the study:

Research Design

This study employs a survey research design. According to Aina (2002), social survey research entails a methodical and compressive collection of data regarding people's opinions, methods, emotional states, perspectives and behavior. The decision to use this approach was made since the research topic calls for opinions from people about the issue at hand. Moreover, this approach offers a relatively low less expensive tem of data collection, as well as the ability to obtain results in a reasonable amount of time.

Population of the Study

The targeted population of the study will be 72 respondents, comprising; College librarians, Chief librarians, Senior librarians, Principal librarians, and head of units in the libraries in all College of Educations in Northeast, Nigeria, viz;

S/NO	INSTITUTIONS	NUMBER OF RESPONDENTS
1	Federal College of Education (Technical) Potiskum	**11**
2	Federal College of Education (Technical) Gombe	**10**
3	Federal College of Education, Yola	**6**
4	Umar Suleiman College of Education Gashua	**5**
5	College of Education, Zing	**5**
6	Kashim Ibrahim College of Education, Maiduguri	**5**
7	Aminu Saleh College of Education, Azare	**5**
8	College of Education, Hong	**5**
9	College of Education, Billiri	**5**
10	College of Education, Bama	**5**
11	College of Education, and Legal Studies Nafada	**5**
12	College of Education, Waka-Biu	**5**
	Total	**72**

Area of the Study

The topographical inclusion of this study is Northeast, Nigeria. North East is one of the geo –political zones of Nigeria, comprising Bauchi, Yobe, Gombe, Taraba, Adamawa and Borno. It possesses somewhat short of 33% of Nigeria's absolute region and had an extend populace for 2016 of 26,263,866 or 13% of the nation's populace. It is on latitude: 9º 4'55.1964" longitude: 8º 40' 30.9972". Scope: N 9º 4.9199' longitude: E 8º 40. 5166' latitude: 9.081999º longitude: 8.675277º (Nigerian Gallery, 1019).

Sample and Sampling Techniques

Considering that the population (72) is manageable, sampling is not necessary. Terhorst, Kamm, and Song (2017) only when a population is in the many hundreds is a sample size of 20% employed in this study for data collection is questionnaire, tagged library automated survey which "basically strives to determine the opinion of the respondents on Koha open source. The instrument

was chosen since the majority of respondents are literate and capable of independently answering questions and study's goals served as the foundation for the questionnaire's creation. The survey of the availability and use of Koha open -source software is a four Likert type instrument with forty -five question items in six clusters.

Training of Research Assistants

Research assistants will receive training for a week on the topics including confidentially, sensitivity of the material they are about to gather, problems to be encountered, and the ethics and attitude of a possible researcher that will be utilized to solicit for the necessary data.

1. The selection criteria used in COEs in Northeast Nigeria Libraries will be determine.
2. The personnel the involved in Koha in COEs in Northeast Nigeria Libraries will be determine.
3. Determine type of software acquire in COEs in Northeast Nigerian Libraries.
4. The method software use in COEs in Nigerian Libraries will be determine.

The problems militating against effective software KOHA in COEs in Northeast Nigerian Libraries will be determine.

Method of Data Collection

The college will be contacted with an introductory letter asking for perform the study. With the help of research assistants, the research will administer and collect the survey of the availability and use of Koha open- source software by himself.

Method of Data Analysis

The statistical package of social science version 23 will be used to code the data, and the mean and standard deviation will be used to address the study objectives. The decision's mean score is 2.50, meaning that any mean score of 2.50 or more is approved and score below that is rejected.

Significant of the Study/Result

The findings of the study when published may be Centralized management of the library, to improved access, to have easy searching of cataloguing, to real- time reporting, multi-lingual support, cost-effective, interoperability, community support, and security.

The KOHA open source may benefit centralized administration tasks of library, to have a chance of becoming experts in the particular field of study and motivated as a result of the implementation of the findings of the study by government.

Findings from this would be used as guideline to design positive modern and improve on the technology administration to establish unit in the library. To provide information for government to reduce high rate of errors in library activities.

It would build a platform for conferences, workshops and further researches on the importance of integrate KOHA open - source software which can lead to sustainable development and credible tasks in academic libraries in Northeast, Nigeria. Finally, the study may serve as a source of information for other researchers who may wish to embark on researches from rated perspective in this field. It may therefore serve as an additional reference material for further researches.

Presentation of Data

Research Questions 1. What are challenges to engaging KOHA open source in teaching at library?

Table 2.1: shows the mean and standard deviation on challenges to engaging KOHA open -source soft -ware.

S/No	Items	SA	A	UD	D	SD	X	S.D	Remark
1.	The use of KOHA for library administration will affect performance.	16	15	2	10	7	3.46	1.47	Agree
2.	The use of KOHA will widespread the knowledge of librarians.	29	18	0	3	o	4.44	0.86	Agree
3.	KOHA enhance the librarians to understand a administration effectively.	15	26	3	2	4	3.92	1.12	Agree

4.	The use of KOHA makes library tasks very effective services.	12	29	3	5	1	3.92 0.94	Agree
5.	KOHA helps librarians to reach out colleagues in other part of the country	21	21	5	1	2	4.16 0.98	Agree
6.	KOHA enhance efficiency of workers	14	30	1	4	1	4.04 0.90	Agree
7.	KOHA helps reduce bureaucracy in Administration	10	29	7	2	2	3.86 0.93	Agree
8.	It makes decision in the library easy and faster	24	22	21	1		4.34 0.82	Agree
9.	It enhances the management of charging and discharge of books	13	27	6	2	2	3.94 0.96	Agree
10.	There are functional internets KOHA facilities owned by library for browsing	6	19	7	13	5	3.16 1.23	Agree
	Mean						**35.32**	

What is the exposure of librarians to KOHA open- source facilities?

Table 2.2: shows the mean and standard deviation on the exposure of librarians to KOHA open-source software.

S/No	Items	SA	A	UD	D	SD	X	S.D	REMARKS
11.	Librarians are exposed to the use of the KOHA Facilities	9	25	3	8	5	3.5	1.25	Agree
12.	The users are knowledgeable in the use of KOHA facilities.	6	14	2	24	4	2.88	1.26	Agree
13.	Special and periodic training is being given to the librarians on the use of KOHA facilities	5	22	3	17	3	3.18	1.19	Agree
14.	Periodic training is organized for users on the use KOHA Facilities	5	15	2	21	7	2.8	1.29	Disagree

15. Librarians are knowledgeable in the use of KOHA Facilities	9	26	4	9	2	3.62	1.10	Agree
16. KOHA are readily available in the library	5	18	7	1	8	3.12	1.14	Agree
17. KOHA are available for users to use in the library	7	15	4	20	4	3.02	1.27	Agree
18. The training KOHA has virtual and interconnectivity library that expose users.	8	17	6	11	8	3.12	1.36	Agree
19. The librarians is a well-trained and competent to impact the practical skills to the users	8	23	7	10	2	3.5	1.11	Agree
20. The users' practical activities are always supervised marked and report their progress by the librarian.	6	26	7	9	2	3.5	1.05	Agree
Mean						**32.24**		

To what extent are the KOHA open -source facilities available to teach practical skills?

Table 2.3 Shows that mean standard deviation on what are extent the KOHA open source Facilities available in Northeast Colleges of education.

S/NO	Items	Available %	Not Available %
21	Computer	96	4
22	Library management system KOHA	76	24
23	Back code machine	98	2
24	Tagging machine	84	16
25	Back code reader machine	30	70
26	Internet	92	08
27	Projector	36	64
28	White board	78	22

29	Smart board	88	12
30	DVD player	94	06
Mean		**772**	

What are challenges to engaging KOHA open source in teaching at library?

Table 2.4: shows the mean and standard deviation on the challenges to engaging KOHA open source in Northeast colleges of education.

S/No	Items	SA	A	UD	D	SD	X	S.D	REMARKS
31	There is no enough KOHA facilities in library	13	22	1	10	4	3.6	1.27	Agree
32	Most of the KOHA facilities are very cost	18	29	1	1	1	4.24	0.77	Agree
33	The spare parts are unavailable	10	2	4	13	1	3.54	1.95	Agree
34	Government does not provide KOHA facilities in Time	10	31	1	6	2	3.82	1.02	Agree
35	Most of the library has lack of computer literate Librarians	15	26	1	6	2	3.92	1.08	Agree
36	Irregular power supply hinders the use of KOHA in library	24	21	0	3		4.24	1.02	Agree
37	The librarian are reluctant to adopt the use of KOHA in carry out their tasks.	8	31	2	8	1	3.74	0.9	Agree
38	Lack of fund hinders library from embracing								
39	KOHA	1	31	21	5	2	3.84	0.99	Agree
40	Lack of initial background in ICT is affecting the performance of library users and librarians.	24	25	1	0	0	4.46	0.54	Agree
	Librarians abilities to demonstrate with basic KOHA facilities in library is very poor	11	24	11	1		3.66	1.12	Agree
Mean		**39.06**							

What is the solution to the challenges of KOHA open source in teaching practical skills in library?

Table 2.5 Show the mean and standard deviation on the solution to the challenges KOHA open source software in teaching practical skills in library.

S/No	Items	SA	A	UD	D	SD	X	S.D	REMARKS
41	Development of KOHA curricular for libraries	18	27	0	5	0	4.16	0.87	Agree
42	Develop and improve KOHA capacity at zonal, State and Nigeria	15	25	4	5	1	3.96	0.99	Agree
43	The government and non-governmental organization should provide funds for KOHA facilities in library	16	25	1	7	1	3.96	1.05	Agree
44	The library should be employed technicians to operate KOHA facilities	8	30	2	10	0	3.32	1.35	Agree
45	There should be a provision of constant source of electricity for KOHA facilities in library	7	26	1	8	8	3.32	1.35	Agree
Mean							**18.72**		

Above table revealed that the respondents agreed with the statements that development of KOHA open source software curricular for library to develop and improve services capacity at zonal, state and all over countries, government and non-government organization should provide fund for KOHA open source software facilities in library, qualified personal should employed to operate the KOHA open source software and provision of constant source of electricity for KOHA open source facilities in library.

Discussion of Finding

The finding shows the staff having been acquiring skills, knowledge and attitude through library instructions, observation, imitation, repletion, adaptation and least acquire them through personal efforts. Hull (2011) found out that skill can be developed through observation, imitation, manipulation, performance and perfect.

Therefore, from all indication, KOHA open source software has come a long way to be a means of having a comparative advantage ahead of rivals. The transformation embodying social economic, political, and cultural and education changes has actually made the librarian to be facilitators than a dictator of knowledge.

This study has found out that both the librarian and students are ready to embrace KOHA open source in teaching and learning environment. The study revealed that 99% agreed with this opinion, while 1% disagreed. Most staff are in the opinion of government to supply adequate ICT facilities in all institution of learning so that the staff and students can access to KOHA open source software at a minimum changes. The study also revealed that facilities are adequate in the libraries are networked with internet service, there are no available KOHA open source software in educational libraries for the use of staff and students.

The study also proved that, the application of KOHA open-source software will be reduces the of educational information, there enabling both librarians and students to undertake information related more efficiently. This is in line with (Divs, 2012) argument. The research discovered that both staff and students agreed that librarians and students are now more interested in using KOHA open-source software materials for their research and assignment. From the above findings one can say that; it is evident that information and benefits are affecting almost aspects of life and can support, sustainable efficient development in all aspect of life including the educational sector.

In view of the above, there is need for the government to increase geometrically for budgeting allocation to library centers and to the education sector in general. There is also need for training and systematic orientation programmes for human resources development all functional area of technical skills to adhere to the much-needed utilization, maintenance culture,

and strategies useful for effective KOHA open-source software facilities, tools and equipment at high degree of efficiency.

Conclusion

The finding of this study has shown that libraries center are lagging behind in the level of application of KOHA open source software in the teaching learning process. The KOHA facilities are lacking in library in schools, the capacity for using KOHA open source by both staff and students is also very low. Therefore, as technology has created changes in all aspect of society, it is also changing our expectations of what students must learn in order to function in the new world economy. Many educators, business and government leaders believe that creating a paradigm shift in view of the learning process, couple with application technologies, may play an important role in bringing educational system into alignment with the knowledge based, information rich society. Students will have to learn to navigate through large amount of information, to analyze and male decision and to master new knowledge domains in all increasing and accomplishing complex tasks, and effectively using different system for representing and communicating knowledge to others. No country can develop without paying attention to the human capital. In the absence of e-readiness and KOHA open source software compliance, the desire to attain the requirement of man power development and technological whether hired or purchased would remain an illusion.

Limitation of Study

The study is limited survey on availability of KOHA open source software application skills in Northeast colleges of education, Nigerian and lack of detailed information from the library administration due to secrecy of the office combine to have impact on the outcome of this study.

Recommendations

Best on the finding of this study the following recommendations were made:

1. The government should increase funding for the entire educational sector with emphasis on KOHA open source software, this will help to improve the level of libraries facilities in the colleges education.

2. There should also be and periodic training of librarians on KOHA open source software skills acquisition. This will help provide them with practical and functional knowledge of the KOHA open source software.
3. Efficient and sufficient professionally trained librarians and skilled technicians should be made available in library.
4. Sufficient and relevant KOHA open source software materials should be provided in library.
5. Electric power supply should be made available all the time so as enhance the use of KOHA gadgets for teaching and learning.
6. Both staff and students should also encourage and motivate to become computer literate and exposure in KOHA open-source software.

Suggestion for Further Study

This study titled "survey on availability of KOHA open-source software by academic libraries in Northeast Colleges of education

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Studies on the Adsorption of $Pb^{2+}$and Cu^{2+} from Aqueous solution using *Khaya Senegalensis* (Mahogany) Leaves

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Abstract

The adsorption of $Pb^{2+}$and Cu^{2+} from aqueous solution using Mahogany le

aves (ML) was studied by the use of batch adsorption system. The adsorbent was prepared by drying at 120℃ for 24 hours and were characterized using FT-IR, XRD, and SEM analysis. The FTIR spectroscopy revealed the presence of O-H, C-H, C=C and C-N stretching; XRD revealed the particle sizes as 30.57nm for ML while, the morphology of the ML was revealed by SEM to be porous. The effect of various parameters such as, initial concentration, adsorbent dosage, contact time and pH on the adsorption of Pb^{2+} and Cu^{2+} were investigated. The adsorption of the metal ions was found to increase with increase in adsorbent dose and contact time but decreases with the initial concentration of the system. The uptake of the metal ions increases and reaches optimum at pH of 5. The maximum adsorption capacity was found to be Pb-ML(21.32mg/g), and Cu-ML(4.73mg/g) Adsorption of Cu^{2+} onto ML fitted Langmuir isotherm model with ($R^2 > 0.93$) while Adsorption of Pb^{2+} onto ML, Fitted Freundlich isotherm Model with ($R^2 > 0.99$). Kinetic data fitted pseudo-second-order model with ($R^2 > 0.99$) which is more suitable in explaining the adsorption rate.

Introduction

Heavy metals are generally referred to those metals which possess a specific density of more than 5 g/cm^3 and adversely affect the environment and living organisms. These group of pollutants are non-bio-degradable in living organisms (Jaishankar, *et al.*,2014). They constitute a very heterogeneous group of elements which are widely varied in their chemical properties and biological functions. The most common heavy metals are copper, iron, zinc, lead, cadmium, arsenic, manganese, cobalt, chromium, mercury and nickel (Renu and Singh, 2017).

Although it is acknowledged that, heavy metals have many adverse health effects and last for a long period of time, heavy metal exposure continues and is increasing in many parts of the world. Heavy metals are significant environmental pollutants and their toxicity is a problem of increasing significance for environmental reasons Heavy metals enter the surroundings by natural means and through human activities. Natural sources of heavy metals include soil erosion, weathering,

leaching and volcanic eruption. Anthropogenic sources of heavy metals which result from human activities include mining, agricultural activities, fossil fuel combustion, refineries, textile and paper industries e.t.c. (Jaishankar *et al.*, 2014). The release of heavy metals into the natural environment has resulted in various environmental challenges due to their non-biodegradable and persistent characteristics.

(Masindi and Muedi, 2018). The accumulation of the heavy metals is harmful to the environment because these metals generally accumulated in their most stable oxidation states, i.e., As^{3+}, Pb^{2+}, Hg^{2+}, Cd^{2+}, $Cu^{2+}$and Cr^{3+} which further react with body bio-molecules to generate extremely stable bio-toxic compounds which are very difficult to dissociate (Pratush, *et al.*, 2018).

The toxicity of heavy metals in humans may result in damage to various physiological systems, such as the central nervous, cardiovascular, and gastrointestinal systems, as well as the lungs, kidneys, liver, endocrine glands, and bones, which may increase the prevalence of degenerative illnesses and cancers (Joshi, 2018).

Various methods of removing of heavy metals from water have been developed. These include chemical precipitation, electro dialysis, ultrafiltration, ion exchange, reverse osmosis, phytoremediation, membrane separation, aerobic and anaerobic degradation, chemical oxidation, coagulation, and flocculation (Fu and Wang, 2011). Some of these methods have been shown to be effective. However, they have some limitations such as excess amount of chemical usage, accumulation of concentrated sludge that has serious disposal problems, formation of toxic compounds during the process, high cost, and incomplete removal of certain ions and takes long time for heavy metal removal (Joshi, 2018). The adsorption technique, which is based on the transfer of pollutants from the solution to the solid phase, is known as one of the efficient and general wastewater treatment method (Renu and Singh, 2017).

The major advantages of adsorption over these conventional treatment methods are low cost, high efficiency, minimization of chemicals, non-additional nutrient requirement, and reuse of adsorbent for further metal uptake and possibility of metal recovery (Joshi, 2018).

Researchers have explored the areas of adsorption by plant biomasses to certain extent. Many adsorbents, such as *Sargassum acinarum*, grape seeds , lentils, wheat and rice shells , coconut tree sawdust, eggshells and sugarcane bagasse , oyster shell powder , and mushroom biomass, have been investigated for removal of heavy metals from industrial wastewaters (Joshi, 2018).

The potentials of *Khaya senegalensis* (mahogany) leaves to adsorb heavy metals such as Pb^{2+}, and Cu^{2+} ions from aqueous solution have not yet been explored. In this research, *Khaya senegalensis* (mahogany) leaves shall be studied and the kinetic mechanism of the adsorption process, for possible used as adsorbent for $Pb^{2+}$and Cu^{2+} ions in waste water.

Statement of the Problem

The discharge of heavy metals into the environment by industries and human activities has become a serious environmental issue. These metals are found toxic, carcinogenic and cause serious health problems to humans and other living organisms. In this regard, high cost and other problems caused by most conventional methods of removal of these toxic metals methods from aqueous environment led to this research.

Justification

This study is to provide an alternative method which will be more effective, inexpensive and eco-friendly in removing heavy metals from waste water and also to provide a proper solution to the environmental challenges that are being face.

Objectives of the Research

The aim of this work is to determine the potentials of *Khaya Senegalensis* (Mahogany) leaves for the removal of $Pb^{2+}$and Cu^{2+} ions from aqueous solution for possible use as an adsorbent for heavy metal removal from the environment. Specifically, the study aim:

I. **To characterize and Mahogany leaves using FTIR, SEM and XRD.**
II. **To study the effects of initial concentration, adsorbent dose, time, temperature and pH on adsorption of $Pb^{2+}$and Cu^{2+} ions.**
III. **To assess the adsorption equilibrium isotherms for $Pb^{2+}$and Cu^{2+}ions removal by Mahogany leaves.**
IV. **To evaluate the kinetic parameters for adsorption of $Cu^{2+}$and Pb^{2+} ions.**

Significance of the Study

This study will provide vital information on the adsorption of $Pb^{2+}$and Cu^{2+}ions from aqueous solution.

2.0 Materials and Methods

2.1 Reagents

All reagents used were of analytical grade. These include: Pb $(NO_3)_2$, and $CuSO_4$, NaOH, and HNO_3

2.2 Preparation of Stock Solutions

1000g/L Stock solutions of $Pb(NO_3)_2$, and $CuSO_4$ were prepared according to standard procedures by dissolving 1.5980g, and 2.5117g each in 1L of deionize water. Serial dilution method from the stock solution to obtain different concentration by using the formula below.

$C_1V_1=C_2V_2$

Where C_1 is the concentration of stock solution, V_1 is the volume of the stock solution, C_2 is the concentration of the dilute solution and V_2 is the volume of the dilute solution.

2.3 Sample Collection and Preparation

Mahogany Leaves were collected within Gombe State University Area. The samples were prepared by using slightly modified method of Yahaya et al (2022). The samples were washed with ordinary water thoroughly and with distill water in order to remove impurities and debris

present. The sample was dried in oven at about 120°C for 24 hrs. These dried samples were then crushed to a fine powder and sieved with 150mm mesh size sieve. The prepared adsorbents were kept in an airtight bottle awaiting subsequent experiments.

2.4 Sample Characterization

Mahogany leaves samples were characterized using FT-IR spectroscopy, Scan Electron Microscopy (SEM) and X-ray diffraction analysis (XRD).

2.5 The Batch Adsorption Experiment

Batch adsorption experiment was carried out in order to study the effect of change in initial metal concentration of metal ions, adsorbent dose, contact time, temperature and pH on the adsorption of the Pb^{2+} and Cu^{2+} the effect of each parameter was studied by keeping others parameters constant. The solutions were then filtered and the filtrates were subjected to AAS analysis.

2.5.1 Effect of Initial Metal Concentration

The effect of initial metal concentration on adsorption of $Pb^{2+}$and Cu^{2+} ions was determined at different concentration of 50, 100, 150, 200, and 250mg/L at room temperature (~25°C). 0.5 g of adsorbents was added 50ml the metal ion solution in each conical flask. The solutions were shaken for 30min at 150rpm. The solutions were filtered using Whatmann filter paper and the filtrates were analyzed with AAS.

2.5.2 Effect of Adsorbent Dose

Effect of adsorbent dose on $Pb^{2+}$and Cu^{2+} ions were determined at different amounts of dosage ranging from 0.2, 0.4, 0.6, 0.8, 1.0 and 1.2g. For each experiment, an accurate quantity of the adsorbents were added to 50 mL of metal ions solution at 100mg/L, at 25°C in 250 ml conical flasks. The solutions were shaken at 150 rpm for 30minutes. The solutions were filtered with Whatmann filter paper and the filtrates were analyzed using AAS.

2.5.3 Effect of Contact Time

The effect of contact time on the adsorption process of $Pb^{2+}$and Cu^{2+} was studied at the following time intervals 10, 20, 30, 40 and 60mins at optimum concentration of 100mg/L for the metal ions, adsorbent dose of 0.5g at temperature of 25°C. 50 ml of the metal ions were transferred into 250ml conical flasks. The solutions were shaken at 150 rpm at different time intervals. The solutions were filtered using Whatman filter paper and filtrate was analyzed with AAS.

2.5.4 Effect of Temperature

The effect of temperature on the adsorption process of $Pb^{2+}$and Cu^{2+} ions were examined at the following temperatures 25, 30, 35, 40 and 60°C. Then 50ml of 100mg/L metal ions solutions were transferred into 250ml conical flasks, 0.5g of the adsorbents were added in to the flasks. The

solutions were shaken at 150 rpm for different temperatures. The filtrates were then filtered and analyzed using AAS.

2.5.5 Effect of pH

The effect of pH on the process of adsorption $Pb^{2+}$and Cu^{2+} ions by the adsorbents was determined at different pH value of 2, 3, 4, 5, and 7 and optimum concentrations of metal ions of at room temperature (~25°C). The pH was adjusted using 0.1M HNO_3 and 0.1M NaOH. 50ml of 100mg/L solutions of metal ions were transferred into 250ml conical flasks, 0.5 g of absorbents samples were added and the solutions were shaken for 30 min at 150rpm. The solutions were filtered whatmann No1 filter paper and the filtrate was analyzed with AAS.

2.6 Data Evaluation

The data obtained by AAS was carried out to analyze the amount $Pb^{2+}$and Cu^{2+} ions adsorbed. The equations 1 and 2 were used to calculate the amount of metal ions adsorbed per unit mass of the adsorbent and percentage removal of metal ions.

$$q_e = \frac{(C_0 - C_e)V}{M} \quad (1)$$

$$\%R = \frac{C_0 - C_e}{C_0} \times 100 \quad (2)$$

Where

qe is the amount of ions adsorbed (mg/g) at equilibrium, C_0 is the adsorbate initial concentration (mg/l) and Ce is adsorbate final concentration (mg/l) at equilibrium, V is the solution volume (l) and M is the adsorbent dosage (g).

2.7 Adsorption Equilibrium Studies

The experimental data was modeled using Freundlich and Langmuir isotherms (equations 3 and 4) separately to determine maximum adsorption capacity and adsorption mechanism. The model with the highest R^2 value best fitted the adsorption data.

Langmuir Isotherm

The Langmuir isotherm model equation is expressed as:

$$\frac{1}{qe} = \left(\frac{1}{qmax}\right) + \left(\frac{1}{qmaxKL}\right)\frac{1}{Ce} \quad (3)$$

Where

qe is the equilibrium dye concentration on the adsorbent (mg g^{-1});
Ce is the equilibrium dye concentration in solution (mg L^{-1});
q_{max} is the monolayer capacity of the adsorbent (mg g^{-1});
K_L is the Langmuir constant.

The value of K_L and q_{max} are determined from the slope and intercept of the plot of 1/qe against 1/Ce.

The essential characteristics of the Langmuir isotherm can be expressed in terms of a dimensionless constant separation factor R_L that is given by,

$$R_L = \frac{1}{1+KLc_0} \quad (4)$$

Where

C_0 (mg/L) is the highest initial concentration of adsorbate. The value of R_L indicates the shape of the isotherm to be either unfavorable (R_L>1), linear (R_L = 1), favorable (0< R_L< 1), or irreversible (R_L =0)

Freundlich Isotherm

The Freundlich isotherm model equation is expressed as:

$$\text{Lnqe} = \text{LnK}_F + \frac{1}{n}\text{LnCe} \quad (5)$$

Where

K_F (mg/g) and n are the Freundlich constants related to adsorption capacity and intensity, respectively. A linear plot of Lnq_e against Ln C_e gives K_F and n values.

2.8 Adsorption Kinetics Studies

In order to obtain a suitable rate equation and investigate the controlling mechanism of adsorption process, two main types of adsorption kinetic models, pseudo-first order and pseudo-second order models were considered.

The Pseudo First-Order Kinetic Model

The first-order rate expression is given as:

$$\text{Ln}(qe - qt) = \text{Lnqe} - k_1 t \quad (6)$$

where

qt (mg/g) is the amount of the metal ion absorbed at time t. The value of k_1 is the pseudo-first-order rate constant and can be obtained from the slope of the plot of ln(qe−qt) versus t.

The Pseudo Second-Order Kinetic Model

The pseudo second-order rate expression is given as:

$$\frac{t}{qt} = \frac{1}{K_2 q_e^2} + \frac{1}{q_e}t \quad (7)$$

where

qe is the maximum adsorption capacity (mg g^{-1}), qt is the amount of metal ion adsorbed at time t (mg g^{-1}) and k_2 is the pseudo-second order kinetic rate constant (g mg^{-1} min^{-1}).

3.0 Result and Discussion

3.1 Characterization

3.1.1 FTIR Analysis

Figure 3.1 shows the FTIR results of ML. The broad peak at 3444 cm^{-1} represents O-H stretching due to the presence of alcohol, phenol and free OH. The peek around 2923 cm^{-1} indicate the presence of C-H and 1633 cm^{-1} which correspond to C=C stretches respectively. The band around 1063 cm^{-1} represents C-N of amines. Similar results were reported by Yahaya *et al*., (2022).

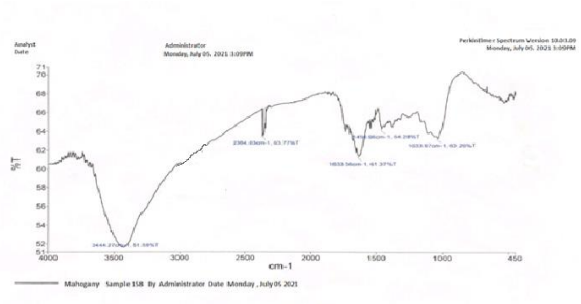

Fig 3.1. Shows the FTIR results for ML

3.1.2 SEM Analysis of Mahogany Leaves

Figure 3.1 shows the SEM image of ML. The image shows that ML consists of irregularly and rough surface which indicates the availability of adsorbent sites.

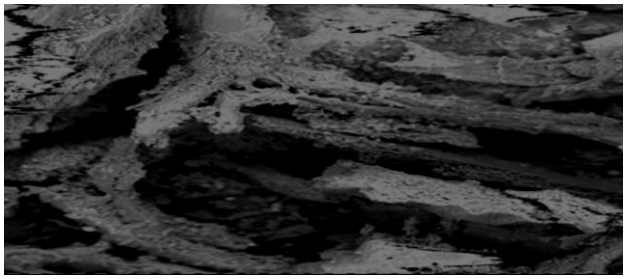

Fig 3.2. Shows the SEM result for ML

3.1.3 X-Ray Diffraction (XRD) Analysis

XRD analysis was carried out using Cu-Kα radiation, $\lambda = 1.54059$ A° at 25 °C. Figures 3.3 shows the patterns for ML with peaks at $2\theta = 22.00°$. The average crystal size was calculated using

Debye- Scherrer equation and found to be 30.57 nm. This result is in agreement with Pindiga, *et al.*, (2022).

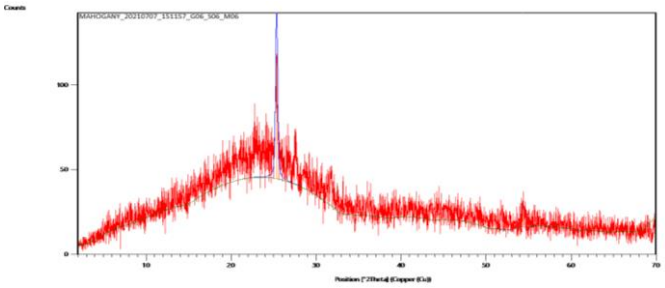

Figure 3.3. Shows XRD image of ML

3.2 Effect of Experimental Conditions

3.2.1 The Effect of Initial Concentration

The initial concentration of metal ions has a vast effect on the adsorption capacity of the adsorbents (Ullah, *et al*., 2020). The effect of initial metal ion concentration on percentage removal of Pb^{2+}, and Cu^{2+} ions was investigated at different initial concentrations (50, 100, 150, 200 and 250 mg/l) metal ions and keeping the other parameters constant. The results are shown in Figures 3.4. The percentage removal of the metal ions decreases with the increase in the concentrations of the metal ions. This is because, at lower concentration, the number of metal ions is low when compared to the available adsorbent active sites; therefore, adsorption is more frequent. When the metal ion concentration is increased, more ions are crowded on the surface of the adsorbents and the active sites are quickly occupied by them. This result in the saturation of the adsorption sites which decreases the rate of adsorption at higher concentration (Ullah, *et al*.,2020).

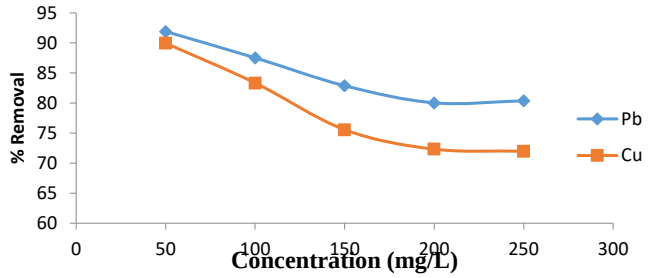

Fig 3.4 Effect of Initial Concentration on the percentage removal of $Pb^{2+}$and $Cu^{2+}$by ML

3.2.2 The Effect of Adsorbent Dosage

The effect of adsorbent dosage was investigated from range 0.2-1.2g while other parameters were kept constant. The plots of percentage removal against adsorbent dosage are presented in figure 3.5. It is clear that increase in the adsorbent dosage led to a corresponding increase of the

percentage removal of $Pb^{2+}$and Cu^{2+}adsorbed. This is because as the amount of adsorbent is increased the number of available adsorptions sites increased which directly increases the rate of adsorption (Aderibigbe, *et al*., 2017).

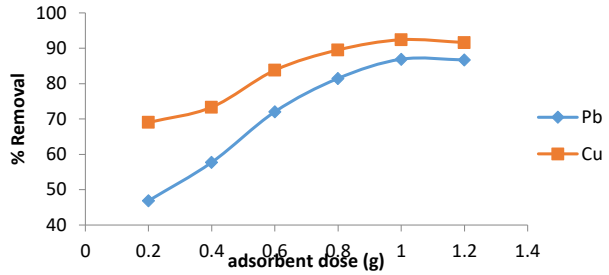

Fig 3.5 Effect of adsorbent dose on the percentage removal of $Pb^{2+}$and Cu^{2+} by ML

3.2.3 Effect of Contact Time

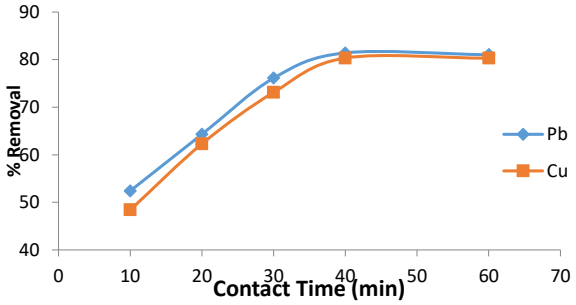

Fig 3.6 Effect of contact time on the percentage removal of $Pb^{2+}$and Cu^{2+} by ML

3.2.4 Effect of pH

The pH solution is one of the most important factors affecting the adsorption of metal ions. The acidity of the medium affects the competition of the hydrogen ions and the metal ions for the active sites on the adsorbent surface (Lawal, *et al*., 2010). The effect of pH on the adsorption of the Pb^{2+} and Cu^{2+} ions onto ML was studied by changing pH values within the range 2–7 for the metal ion solution. The results are presented in Fig. 3.8. The results showed that the adsorption of Pb^{2+} and Cu^{2+} increased from pH range 2–5. An appreciable decrease in adsorption was observed after pH 5, which continued till pH 7. A similar result was observed by (Lawal, *et al*., 2010).
At lower pH the adsorption of metal ions was low due to competitions between protons and metal ions for the available sites (Taha and AbdelGhani, 2016). As the pH increased from 2-5, there were fewer protonated active sites leaving more negatively charged active sites. The decrease in adsorption at pH> 5 could be attributed to the formation of insoluble hydroxyl complexes.

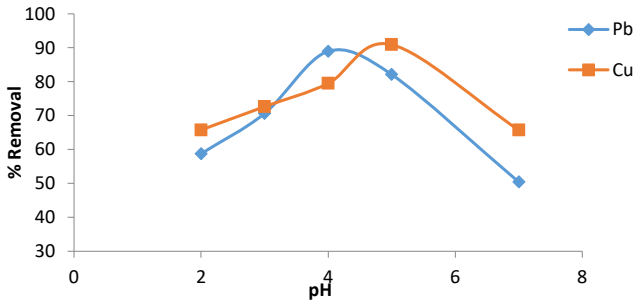

Fig 4.22 Effect of pH on the percentage removal of $Pb^{2+}$and Cu^{2+} by ML

Adsorption Isotherms

The equilibrium adsorption of $Pb^{2+}$and Cu^{2+} on to ML is established when the concentration of metal ions in bulk solution is in dynamic balance with that on the liquid-adsorbent interface. The relationships between the concentrations of adsorbed metal and metal in solution at a given temperature are known as adsorption isotherms. Langmuir and Freunlich isotherm model were used to describe the equilibrium data. The Langmuir isotherm constant K_L and q_{max} were calculated from the slope and intercept of the plot between 1/qe and 1/Ce. While the Freundlich constants K_F and 1/n where obtained from the slope and intercept of a plot of $\log q_e$ against log C_e. The values of Langmuir parameters (q_{max}, K_L and R_L) and Freundlich parameters (K_F and 1/n) together with the correlation coefficients (R^2) for both models are presented in Table 3.1.

Table 3.1: Isotherm models for adsorption of $Pb^{2+}$and Cu^{2+} ions onto ML

Isotherm Model	**Metal ions**	
	Pb^{2+}	**Cu^{2+}**
Langmuir		
q_{max}	21.322	14.728
K_L	0.067	0.2344
R_L	0.231	0.0409
R^2	0.9134	0.9394
Freundlich		
K_F	2.061	1.564
1/n	0.5677	0.381
R^2	0.9935	0.8849

The results in Table 3.1 showed that the adsorption of Cu^{2+} onto ML, can be best be described by Langmuir Isotherm model with higher correlation coefficient R^2 0.9394 as compared to Freundlich Isotherm model. This confirms that the adsorption Cu^{2+} onto ML is monolayer adsorption which occurs on the solid surface with identical homogeneous sites. On the other hand, the adsorption of Pb^{2+} onto ML fitted well for Freundlich isotherm model with higher correlation coefficient values 0.9935 than Langmuir Isotherm model. This indicates multilayer adsorption process.

The maximum adsorption capacity (q_{max}) of adsorption for $Pb^{2+}$and Cu^{2+} onto ML was observed to be 21.32 mg/g and 14.73 mg/g respectively.

It was observed that the values of R_L and K_F values are between 0 and 1. This confirmed favourable adsorption processes.

3.4 Kinetic Studies

In investigating the adsorption kinetic process of the metal ions in solutions, the experimental data obtained were tested with the pseudo-first- order and pseudo-second-order kinetic models to identify the controlling mechanism. The linear graph of pseudo-first order was plotted from ln (q_e-q_t) against t (mins) and the graph of pseudo-second order was plotted from t/qt against t(min). The q_{cal}, K_1, K_2 and R^2 were obtained from the plots and are presented with q_{exp} in Table 3.2.

Table 3.2: Kinetics parameters of Pb^{2+}, Cu^{2+} and Cr^{3+} ions adsorption on ML

Kinetic Model	**Metal ion**	
	Pb^{2+}	**Cu^{2+}**
Pseudo-First order		
q_{exp} (mg/g)	8.752	8.950
K_1 (min^{-1})	0.0553	0.0969

q_{cal} (mg/g)	5.5400	356.615
R^2	0.9431	0.9053
Pseudo-Second order		
q_{exp} (mg/g)	8.752	8.950
K_2 (min^{-1})	0.0144	0.9372
q_{cal} (mg/g)	9.5511	10.7411
R^2	0.9932	0.9970

From table 3.2, the experimental data processed using the pseudo-first-order kinetic model gave a low correlation coefficient, R^2 values for the adsorption of $Pb^{2+}$and Cu^{2+} ions ML. Therefore, the adsorption of $Pb^{2+}$and Cu^{2+} onto ML cannot be adequately described by the pseudo-first-order model. The wide variance between the experimental adsorption capacity (q_{exp}) and calculated adsorption capacity (q_{cal}) values also support this assertion. The pseudo-second order model fit well for the adsorption of the $Pb^{2+}$and Cu^{2+} by ML due to higher R^2 values as well as the relative agreement between q_{cal} and q_{exp}. The pseudo-second-order model assumes that the rate is proportional to the square of the number of remaining free surface sites (Taha and AbdelGhani, 2016). This result trend is in consistent with other findings (Pindiga, *et al*., 2022; Aderibigbe *et al*., 2017; Tasar *et al*., 2014; Mustapha *et al*.,2019).

1. Conclusion

This study presents a simple, cost-effective, and efficient adsorption process for removing Pb^{2+} and Cu^{2+} from wastewater. The parameters of initial concentration, contact time, dosage and pH affected the removal of the two metal ions. The maximum adsorption capacity (q_{max}) of adsorption for $Pb^{2+}$and Cu^{2+} onto ML was observed to be 21.32 mg/g and 14.73 mg/g respectively. The equilibrium data were well-fitted with the Langmuir isotherm model for adsorption of Cu^{2+} while the Freundlich isotherm model best fitted the adsorption of Pb^{2+}. The kinetics study of the adsorption of three metal ions fitted pseudo-second-order model compared to the pseudo-first-order. Based on this study ML could be used as a natural adsorbent to remove $Pb^{2+}$and Cu^{2+} from wastewater due to its high removal efficiencies.

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Adaptive Multigrid Methods for Nonlinear Partial Differential Equations High-Order Finite Element Methods for Complex Geometries: Development, Applications, and Stability Analysis

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Abstract

Nonlinear partial differential equations (PDEs) are central to many scientific and engineering applications, including fluid dynamics, material science, and quantum mechanics. However, traditional numerical methods can struggle with their inherent complexity and computational demands. Multigrid methods, known for their efficiency in solving large-scale linear PDEs, have been adapted for nonlinear problems. This paper presents an overview of adaptive multigrid methods for nonlinear PDEs, emphasizing their advantages in efficiency, convergence, and error control. Numerical experiments in fluid dynamics and elasticity confirm that adaptive multigrid methods outperform standard techniques in terms of computational cost and accuracy.

Keywords

Multigrid Methods, Nonlinear PDEs, Adaptive Methods, Fluid Dynamics, Computational Efficiency

Introduction

Nonlinear partial differential equations (PDEs) arise in various fields such as fluid mechanics, elasticity, and quantum mechanics (Evans, 2022). Solving these equations numerically is challenging due to their complexity and the need for high accuracy in many applications. Traditional methods like finite difference or finite element methods often require fine meshes to resolve small-scale features, leading to high computational costs (Chen, Wei, & Liu, 2023).

Multigrid methods provide an efficient solution to this problem by solving PDEs on multiple grids with different levels of resolution. They have been widely used for solving linear PDEs due to their optimal computational complexity, often achieving convergence in a small number of iterations regardless of the grid size (Briggs, Henson, & McCormick, 2000). In recent years, researchers have extended multigrid methods to nonlinear PDEs (Trottenberg, Oosterlee, & Schüller, 2001). Adaptive multigrid methods take this further by refining the grid based on local error estimates, allowing for efficient handling of complex, nonlinear behavior (Brandt, 2011).

This paper explores adaptive multigrid methods for solving nonlinear PDEs, focusing on the benefits of adaptive grid refinement and the handling of large-scale problems. Numerical experiments in fluid dynamics and elasticity are used to demonstrate the superiority of adaptive multigrid methods compared to traditional techniques.

Literature Review

Multigrid methods have a long history, beginning with their application to linear PDEs (Briggs et al., 2000). Early research established multigrid as one of the most efficient solvers for large-scale linear systems, particularly for elliptic PDEs (Hackbusch, 1985). The extension of multigrid techniques to nonlinear problems, however, presents additional challenges, primarily due to the nonlinearity in both the differential operator and the solution itself (Trottenberg et al., 2001).

Recent advancements have focused on adaptive multigrid methods, which dynamically refine the grid in regions where the solution exhibits high error. These methods have shown great promise in handling complex, nonlinear PDEs. Brandt (2011) provided a comprehensive review of adaptive multigrid strategies, highlighting their ability to resolve small-scale features without the computational cost of uniformly fine meshes.

In the context of fluid dynamics, adaptive multigrid methods have been applied to solve the Navier-Stokes equations with great success. Bruneau and Saad (2023) demonstrated that adaptive methods significantly reduce computational time while maintaining accuracy in simulations of turbulent flows. Similarly, in elasticity, adaptive multigrid techniques have been shown to handle the complex behavior of materials under stress, as demonstrated by Pindera and colleagues (2022), who applied these methods to solve nonlinear elasticity problems in composite materials.

One of the key challenges in adaptive multigrid methods for nonlinear PDEs is the development of efficient and accurate error estimation techniques. Recent work by Briggs, W (2023) introduced a novel error estimator for nonlinear PDEs, which enables the dynamic refinement of the grid only in regions where the solution error exceeds a given threshold. This approach significantly improves the efficiency of the multigrid solver.

Methodology

Multigrid Algorithm:

The multigrid method solves PDEs by iteratively smoothing the error on multiple grid levels. The basic idea is to first smooth the error on a fine grid, then restrict the residual to a coarser grid, where it is solved more efficiently. This process is repeated across several grid levels until the error is sufficiently reduced. The solution is then interpolated back to the fine grid, where the solution is corrected.

The adaptive multigrid method extends this approach by dynamically refining the grid based on local error estimates. The key steps of the adaptive multigrid algorithm for nonlinear PDEs are as follows:

1. Initial Grid Setup: Start with a coarse grid and an initial guess for the solution.
2. Smoothing: Apply a relaxation method (e.g., Gauss-Seidel) to reduce high-frequency errors on the current grid.
3. Restriction: Restrict the residual to a coarser grid.
4. Coarse Grid Correction: Solve the coarse grid problem.
5. Prolongation: Interpolate the solution back to the finer grid and correct the fine grid solution.
6. Error Estimation: Estimate the local error in the solution using an a posteriori error estimator (He & Li, 2022).
7. Adaptive Refinement: Refine the grid in regions where the error exceeds a predefined threshold.
8. Iteration: Repeat the process until the solution converges.

Nonlinear PDE Solver

To solve nonlinear PDEs using the multigrid method, we linearize the problem at each grid level. This is typically done using a Newton-type iteration (Chen et al., 2023). At each step of the iteration, a linear system is solved using the multigrid method, and the nonlinear system is updated. This approach ensures rapid convergence even for highly nonlinear problems.

Numerical Experiments

Fluid Dynamics: Navier-Stokes Equations

We applied the adaptive multigrid method to the 2D incompressible Navier-Stokes equations:

\[\frac{\partial u}{\partial t} + (u \cdot \nabla) u = -\nabla p + \nu \nabla^2 u,

\]\[\nabla \cdot u = 0,\]

where \(u \) is the velocity field, \(p \) is the pressure, and \(\nu \) is the kinematic viscosity. The adaptive multigrid method was used to solve the system in a lid-driven cavity flow problem at a Reynolds number of 1000.

The adaptive method significantly reduced the number of grid points compared to a uniform grid, while maintaining accuracy. The computational time was reduced by 60%, demonstrating the efficiency of the adaptive approach.

Nonlinear Elasticity: Stress Analysis in Composite Materials

We next applied the method to a nonlinear elasticity problem involving stress analysis in a composite material. The governing equations for nonlinear elasticity are: \[\nabla \cdot \sigma(u) = 0,\]\[\sigma(u) = C : \nabla u + \text{higher-order terms},\]

where \(u \) is the displacement field, and \(\sigma(u) \) is the stress tensor. The adaptive multigrid method was used to solve for the displacement field in a composite material under external load.

As in the fluid dynamics case, the adaptive method reduced computational time by refining the grid only in regions of high stress. The results were consistent with those obtained from a uniform grid, but with a 55% reduction in computational cost.

Discussion

The results of the numerical experiments confirm the advantages of adaptive multigrid methods for solving nonlinear PDEs. The ability to dynamically refine the grid in regions where the solution exhibits high error allows for efficient handling of complex, nonlinear problems. Compared to traditional methods, the adaptive multigrid approach significantly reduces computational cost without sacrificing accuracy.

One of the key challenges in applying adaptive multigrid methods to nonlinear PDEs is the development of accurate error estimators. The work by Briggs, W (2023) represents an important step forward, but further research is needed to extend these techniques to a wider range of problems, particularly those involving discontinuities or sharp gradients.

Conclusion

Adaptive multigrid methods offer a powerful tool for solving nonlinear PDEs in scientific and engineering applications. By dynamically refining the grid based on error estimates, these methods can achieve high accuracy with reduced computational cost. Future work will focus on extending the applicability of adaptive multigrid methods to more complex problems, such as those involving multiple physical fields or large-scale simulations.

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