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EDITORIAL FOREWORD

It is a great pleasure to present to you the third edition of the Minna Journal of Science and Technology (MIJOST). I am most excited that the Journal is published at the most critical period when the contribution of science and technology is needed to solve rising global challenges. A period that requires experience sharing in our collective efforts to address the global challenges in education. It is also a period to demonstrate to the global community one of our core values of promoting academic excellence in the attainment of our goals especially in the areas of science and technology.

Now, you can explore the latest discoveries and advancements in the world of science and technology with the newly published Volume 3, Issue No. 1 of the Minna International Journal of Science and Technology (MIJOST). In this edition, you'll find a diverse range of research articles, insights, and thought-provoking discussions from leading scholars and experts. MIJOST continues to be your trusted source for staying up-to-date with the most exciting developments in science and technology in 2024.

Prof. Muhammad Yakubu
Editor-in-Chief

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DIAGNOSIS AND INSTRUCTIONAL INTERVENTIONS FOR JUNIOR SECONDARY STUDENTS WITH DYSGRAPHIA IN GEOMETRIC CONSTRUCTION TASK

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Abstract
The study was conducted to enhance the academic performance of junior secondary students with dysgraphia in the Bida local government area of Niger State. The intervention focused on diagnosing and remedying their learning difficulties. The study used a quasi-experimental design with two groups: control and experimental. The sample included 81 students (experimental: 38, control: 43). Dysgraphia was identified in two stages using the Diagnostic Dysgraphia Test (2DT) and General Cognitive Ability Test (GCAT), validated by three experts in mathematics education (reliability: r = 0.75). The experimental group received reciprocal peer-tutoring (RPT), while the control group followed conventional teaching methods (CTM). Descriptive statistics (mean, standard deviation, mean difference, mean gain) analyzed the data and answered research questions, while ANCOVA tested the null hypothesis. Results showed that RPT improved the academic performance of dysgraphia learners compared to CTM. Gender did not significantly affect dysgraphia performance. The recommendation is for mathematics teachers to incorporate RPT when teaching students with dysgraphia.
Keywords: Dysgraphia, Instructional Intervention, Diagnosis, Reciprocal Model, Conventional Model

Introduction

Mathematics is a fundamental academic subject that encompasses the study of numbers, patterns, space, quantity, and their applications in various fields. It plays a crucial role in science-based professions and fosters problem-solving, creativity, and critical thinking skills. Mathematics is considered a core subject for learners at all levels of education, from nursery to secondary school. In Nigeria, admission into tertiary institutions for both science and non-science courses requires a credit pass in mathematics in external examinations such as WAEC, SSSE, and NECO, making it a compulsory subject of high importance.Despite its significance, student performance in mathematics is generally poor, as reported by Ahmad & Zakariyya (2023). Several factors have been attributed to this underachievement, including the adherence to conventional teaching methods by many mathematics teachers (Wonu & Nwoko, 2022). Conventional Teaching Method (CTM) is teacher-centered and primarily relies on oral presentations. This method tends to favor academically advantaged learners while neglecting those who are educationally disadvantaged. Ahmad & Zakariyya (2022) emphasize that using appropriate learning strategies can enhance effective teaching and learning outcomes. They suggest that mathematics teachers should be open to innovative learning strategies that engage learners' experiences, since the conventional mode of instruction delivery has been found to be ineffective in producing desired learning outcomes. Therefore, it is crucial to incorporate innovative instructional strategies that promote improved outcomes and address Mathematics Learning Difficulties (MLD).

MLD, also known as a learning disorder, refers to various difficulties learners face when it comes to mathematics. It encompasses learning deficits and low academic performance in the subject. Individuals with MLD may struggle to learn in a traditional classroom setting and may face challenges in developing basic mathematical skills compared to their peers. MLD can be caused by factors such as genetics, psychological trauma, parental and neonatal risks, and physical trauma (Sufiyanu et al., 2019). Conditions like Dysgraphia, Dyslexia, and Dyscalculia

are examples of MLD identified by scholars such as Wonu & Zalman (2017), Sufiyanu et al. (2019), and Wonu & Nwoko (2022). These learners often have fundamental difficulties in understanding, representing, and manipulating mathematical problems. These challenges can become more significant as learners' progress to higher grades, given that mathematics curricula are cumulative and interconnected.

Dysgraphia is a writing disorder characterized by impaired letter formation and difficulties in writing (Mahesh, 2019). Communication plays a crucial role in learning, and it serves as an indicator of a learner's level of success. Writing, reading, listening, and speaking are components of communication that are interconnected and essential for acquiring and expressing knowledge. Learners with dysgraphia may struggle with tasks in mathematics that involve sketching, drawing, constructing place values, fractions, aligning numbers, organizing complex mathematical expressions, and equations. This learning disorder affects the student's ability to learn and apply mathematics skills, particularly in construction tasks, as dysgraphia is tied to visuo-spatial abilities, which are fundamental in mathematics (Sufiyanu et al., 2019).

Dysgraphia goes beyond difficulties in spatial awareness when writing or drawing. Many experts consider dysgraphia as a problem with a set of skills known as transcription, which includes drawing, handwriting, typing, and spelling (Sufiyanu et al., 2019). Learners with dysgraphia may struggle with the mechanics of writing or constructing, and some may have comorbidities with language, reading, and numeracy disorders, further affecting their ability to write or construct (Taruly, 2019).

Agraphia, on the other hand, refers to the loss of the ability to write or construct, usually resulting from brain insult or injury in specific areas. In terms of behavioral outcomes, however, the terms agraphia and dysgraphia are synonymous. Dysgraphia can manifest as difficulties in writing at any level, including illegible handwriting, slow writing speed, problems with syntax and composition, among others. Ukwueze (2015) also views dysgraphia as a problem with the set of skills related to transcription, including drawing, handwriting, typing, and spelling. Given that the writing process is complex and involves various skills related to brain functions and motor actions, dysgraphia can have several aspects that impact an individual's ability to write and construct effectively.

i. **Aphasic agraphia:** This refers to leaving out numbers, letters, and words in writing, as well as incomplete symbols, signs, and numerals when copying mathematics from a chalkboard or book.
ii. **Spatial agraphia:** Errors in spatial orientation, spatial organization, and the relative positions of objects in writing can be observed. Individuals with spatial agraphia may struggle to align numbers properly in addition and subtraction or place numbers in their correct positions in multi-digit operations. They may also have difficulty with drawing distorted geometrical figures, accurately representing relative sizes, and integrating figures, dimensions, and representations.
iii. **Apraxic agraphia:** Apraxic agraphia is associated with poor handwriting and is often caused by a condition called dysgraphia. Dysgraphia can be accompanied by Developmental Coordination Disorder (DCD), which affects motor skills and coordination. Learners with apraxic agraphia may struggle with writing symbols, drawing shapes, and accurately reproducing mathematical signs, numerals, and other elements when copying or constructing problems. They may find it challenging to perform calculations and accurately copy numbers, shapes, figures, diagrams, and equations from a chalkboard.
iv. **Aphasia:** Learners with aphasia may omit or substitute letters, symbols, numbers, and operational symbols when writing, copying, or communicating mathematical information.

v. **Acquired dysgraphia:** Some learners, due to poor instruction in handwriting, lack of practice, and a sense of helplessness or distaste for writing, may develop poor handwriting skills. As a result, they may avoid tasks that involve drawing, constructing, or writing (Mahesh, 2019).

These different aspects of dysgraphia can manifest in learners and impact their ability to effectively express mathematical ideas in writing, copying, and other related tasks.
Dysgraphia can manifest in learners and significantly impact their ability to express mathematical ideas effectively through writing, copying, and related tasks. However, despite its prevalence and impact on reading, language, and mathematics, dysgraphia has received limited attention from researchers, particularly in the context of writing in mathematics situations. The role of writing, drawing, sketching, and construction in mathematics, especially in geometric construction, is crucial. Learners with dysgraphia may face difficulties in understanding and performing in mathematics due to challenges in these areas.
Diagnosis plays a vital role in addressing learning difficulties such as dysgraphia. It involves recognizing and analyzing signs and symbols to determine the cause and nature of a problem.

Diagnosis is a systematic evaluation, analysis, and recognition of signs, symptoms, or patterns that leads to a valid conclusion. It is an essential step in the problem-solving and decision-making process, facilitating the development of treatment plans, educational interventions, and strategies to effectively address the identified issues. Diagnosis involves determining the nature and cause of a particular occurrence (Wonu & Nwoko, 2022). In the case of dysgraphia, the diagnosis focuses on identifying, recognizing, and understanding the status and exact causes of difficulties in understanding mathematics-related concepts, particularly in geometric construction.

To assess and evaluate the different disabilities affecting a learner's mathematics proficiency, various mathematics diagnostic tools can be employed. These tools are used in understanding the specific challenges faced by learners with dysgraphia. They include assessments of writing and copying, handwriting analysis, spatial awareness assessments, and math problem-solving tasks. Through the use of these diagnostic tools, educators and professionals can gather valuable insights that inform the development of appropriate interventions, support strategies, and educational plans to effectively address the needs of learners with dysgraphia.
Different mathematics diagnostic tool can be employed to assess and evaluate different disabilities of learner’s mathematics proficiency as opined by Nwuke and Anaekwe, (2023), include:

- **Previous evaluation:** This assessment is conducted at the beginning of a new task or instructional unit to determine learners' prior knowledge and understanding of relevant mathematical concepts and experiences. It helps instructors tailor instruction to meet learners' individual needs.
- **Monitoring evaluation:** This type of evaluation is carried out during or at the end of instruction to track learners' progress and identify areas of weakness. It allows instructors to make timely adjustments and provide additional support to ensure the achievement of learning goals.
- **Summative evaluation:** This evaluation is conducted at the end of a course or a defined period, such as a semester or academic year. It assesses learners' overall mathematical proficiency and provides a comprehensive summary of their performance.
- **Diagnostic examination:** This evaluation is specifically designed to pinpoint learners' areas of strength and weakness in mathematics. It helps identify specific areas where learners may require additional support or intervention.
- **Diagnostic misconception evaluation:** This evaluation is focused on identifying and resolving common misunderstandings or misconceptions that learners may have in

mathematics. It helps instructors address these misconceptions and promote accurate understanding of mathematical concepts.

- **Diagnostic procedure:** This involves determining learners' proficiency in using specific mathematics strategies or techniques. It assesses their ability to apply mathematical knowledge and problem-solving skills effectively. Mathematics teachers, mathematics educators, and researchers in mathematics education play a crucial role in understanding and applying diagnostic tools to address dysgraphia in learners and overcome their learning difficulties. This process is known as remediation, which involves interventions aimed at addressing and managing learners' specific disorders or difficulties. Remediation focuses on developing strategies to help learners cope with their challenges and improve their mathematical abilities. It encompasses assessment, planning, implementation, and continuous monitoring to ensure progress and improvement in learners.

The concept of remediation is applicable in various fields, including education, healthcare, environment, sanitation, and building structures. In the context of mathematics learning difficulties (MLD), remediation refers to the intervention or assistance provided to help learners overcome diagnosed difficulties in a particular topic or subject. Mathematics teachers should employ innovative teaching methods to address identified problems and ensure effective learning and remedial teaching. As a guide, the teacher should facilitate quality learning by actively involving learners in the learning process (Ukwueze, 2015; Wonu & Nwoko, 2022).

It is important to incorporate innovative instructional strategies that enhance students' performance in mathematics, particularly in the context of MLD. Innovative instructional strategies involve using diverse methods to translate complex or abstract theories into real-life experiences in the classroom, ensuring learners' understanding as submitted by (Ahmad & Zakariyya, 2022; Nwuke & Anaekwe, 2023). These strategies are also being found to promote academic performance and reduce boredom among students of all levels. They suggested that collaborative learning, problem-solving strategies, metacognitive strategies, guided discovery strategies, peer tutoring, and the use of technology has some innovative instructional strategies that can be employed to enhance the performance of students with learning difficulties. These strategies provide a structured framework to address MLD and help students develop understanding, confidence, and competence in mathematics (Nwuke & Anaekwe, 2023).

The research conducted by Wonu and Charles-ogan (2017) demonstrated that students with mathematics learning difficulties (MLD) who used metacognitive strategies showed improvements in problem-solving skills, learning outcomes and cognitive knowledge in everyday arithmetic.
Another study by Wonu and Nwoko (2022) focused on collaborative learning strategies for students with developmental dyscalculia (DD). The findings indicated that the collaborative learning model was more effective than the traditional model in enhancing the performance of students with DD in number and numeration. The study did not find significant differences in learning outcomes based on gender. Nwuke and Anaekwe (2023) conducted research on the diagnosis and remediation of math-phobia using Polya 's problem-solving model. The results showed that the model encouraged participation and collaboration among students, leading to improved performance.

Dysgraphia is a learning difficulty characterized by poor drawing, handwriting, spelling, and coordination of numerical figures due to inadequate psychomotor skills. The illegibility of handwriting, non-adherence to rubrics, and lack of skills in drawing shapes and maps have been identified as weaknesses among students by the West African Examination Council (WAEC, 2002). Ukwueze (2015) noted the lack of sufficient research on dysgraphia despite its contribution to academic difficulties.

The reciprocal peer tutoring model (RPT) can be an effective approach for diagnosing and remediating dysgraphia to improve students' construction, handwriting, and performance in mathematics. RPT involves two students working together in a one-to-one setting, where the tutor assists the target learner in practicing or reviewing an academic skill. The model has the potential to support students with MLD by providing peer learning and fostering a supportive learning environment. Working in peers can create a relaxed and supportive learning atmosphere where humor can be used to foster positive experiences. Ahmad and Zakariyya (2023) highlighted the benefits of the RPT model in inclusive classrooms, as peers can cater to a wide range of learning needs and disabilities. Cooperative learning in RPT can positively impact the learning outcomes of students with MLD. Additionally, RPT allows students to track their own progress, promoting a sense of feedback and ownership of their tasks. The RPT lesson model typically involves four steps: predicting, clarifying, solving, and summarizing. Each group member rotates through these roles, ensuring active participation. The teacher's role is to guide the learners and ensure that each learner effectively uses the strategies based on their abilities.

The research on gender differences in academic performance in mathematics has yielded inconclusive results. Different scholars have reported varying findings regarding the performance of boys and girls in mathematics. Nsofor and Nasiru (2013) found that boys outperformed girls in science subjects, while Gambari et al. (2014) reported that male students achieved better than female students in mathematics. On the other hand, Gimba (2013) reported that female students achieved better than male students in mathematics. Etsu and Manko (2019) conducted a study that revealed no significant difference in the academic performance of male and female students. Based on these studies, there is no consistent result indicating a clear gender difference in mathematics performance. The inconclusive findings highlight the need for continuous investigation into gender issues and academic performance in mathematics. Further research is necessary to gain a deeper understanding of the factors influencing gender differences, if any, and to develop strategies to promote equitable learning outcomes for all students.

Statement of Problem

The poor performance of students in examinations is attributed to some factors such as inadequate preparation, incomplete coverage of the mathematics curriculum, and students' difficulties in writing clearly, among others (Ukwueze ,2015; Etsu & Manko, 2019). They also often blame the parents and teachers for this situation. Taruly (2019) commented that many students struggle in school due to difficulties expressing their thoughts in written form, which they perceive as dysgraphia. This difficulty in writing has a negative impact on students' success in their subjects. The West African Examination Council (WAEC, 2002) also reported that students' weaknesses in examinations include illegible handwriting, failure to follow instructions, and lack of skills in constructing and drawing maps and diagrams.

Ukwueze (2015) expressed concern that dysgraphia is not a widely researched disorder, despite its contribution to school failure. As a result, there is limited available research on the topic. To the best of our knowledge, no research has specifically focused on diagnosing and remediating dysgraphia among junior secondary school students with dysgraphia in geometric construction. To address this gap, the present study aims to investigate the effectiveness of reciprocal peer tutoring (RPT) in enhancing the academic performance of junior secondary school students with dysgraphia in the Bida Local Government Area of Niger State.

Objectives of the Study

This study aims to provide instructional intervention to improve the academic performance of junior secondary school students with dysgraphia in the Bida Local Government Area of Niger State. Specifically, the objectives of the study are to:

1. Find out the difference in the academic performance of students with dysgraphia taught geometric construction using RPT and those taught using CTM.
2. Examine the difference in the academic performance of the male and female students with dysgraphia taught geometric construction.

Research Questions

The research questions were asked to guide this study; include:

1. What is the mean difference in the academic performance of students with dysgraphia taught geometric construction using RPT and those using CTM?
2. What is the mean difference in the academic performance of students with dysgraphia taught geometric construction using RPT?

Research Hypotheses

The following null hypotheses were test at 0.05 level of significance.

$H0_1$: There is no significant difference in academic performance of student with dysgraphia taught geometric construction using RPT and those taught using CTM.

$H0_2$: There is no significant difference in academic performance of male and female students with dysgraphia taught geometric construction using RPT.

Method and Materials

A quasi-experimental research design was utilized in this study. It involved a pre-test and post-test with both an experimental group and a control group. The research was conducted in two selected public schools. The target population for this study comprised all 3,530 J.S.S II students in the Bida Local Government Area of Niger State. Two junior secondary schools were chosen randomly from a total of fifteen schools using a balloting process. In the second stage of randomization, one intact class was selected from each of the selected schools, representing the total number of JSSII classes in each school. The sample size for the study consisted of 81 students. This sample size aligns with the central limit theorem, which suggests that a minimum of 30 samples is suitable for experimental research (Etsu & Manko, 2019). The experimental group consisted of 38 students, comprising 25 males and 13 females, while the control group consisted of 43 students, comprising 32 males and 11 females. The screening method outlined below was used to identify learners with dysgraphia:

Stage One: A diagnostic test titled "Diagnostic Dysgraphia Test" (2DT) was developed. The test comprised ten essay questions focused on simple construction and graph of straight lines. It was administered to JSSII students in each selected school. The maximum score on the 2DT was 100%. For this study, students who scored less than 40% were classified as students with dysgraphia, while those who scored 40% or higher were classified as non-dysgraphia students.

Stage Two: The 2DT was reshuffled and administered to all the identified students with dysgraphia in the selected schools. This step was taken to confirm the results obtained in Stage One.

Stage Three: Students who underperformed based on their results and fell outside the specified range were included in the study. This decision was supported by Wonu & Nwoko (2022) and Nwuke & Anaekwe (2023).

The research instruments used in this study were the 2DT and the Geometric Construction Achievement Test (GCAT). The GCAT consisted of 20 multiple-choice items with four options (A-D), covering topics such as bisecting line segments and angles, geometric constructions of shapes, and locus of points and circles in the JSSII mathematics syllabus. JSSII students were chosen for the study as it is a foundational class for the geometry course in the curriculum.

Both the 2DT and GCAT were validated by three independent experts who were senior lecturers in the Department of Science Education at Ibrahim Badamasi Babangida University (IBBUL) and Federal University of Technology (FUT) Minna. The reliability coefficients for the two

instruments, 2DT and GCAT, were achieved through the test-retest method using the product moment correlation (PPMC) and yielded values of 0.75 and 0.83, respectively.
The experimental group received instruction on geometric construction using the Reciprocal Peer Tutoring (RPT) lesson model, while the control group was taught using the Conventional Teaching Method (CTM). This instructional intervention lasted for five weeks. After the intervention, the GCAT was administered to both groups. The answer scripts were collected, marked, and scored out of 100%. The data were collected and analyzed using descriptive statistics such as mean and standard deviation to answer the research questions, while hypothesis testing was conducted using analysis of covariance (ANCOVA).

Results

Research Question One: What is the mean difference in the academic performance of students with dysgraphia taught geometric construction using RPT and those taught using CTM

Table 1: Descriptive Statistics on the Performance Experimental and Control group

Group	N	Pre-Test		Post-Test		Mean Difference
		$\bar{X}$	SD	$\bar{X}$	SD	
Experimental	38	19.73	11.9	44.77	7.76	26.04
Control	43	16.92	10.46	20.75	11.51	4.83
Mean gain		1.81		24.02		

The results presented in Table 1 indicate that the experimental group, which was taught geometric construction using RPT, had a pre-test mean score of 18.73 and a standard deviation of 11.90. In comparison, the control group, taught using CTM, had a pre-test mean score of 18.92 with a standard deviation of 10.46. The mean gain between the pre-test and post-test for both groups was 1.81. After the intervention, the post-test mean score for the experimental group was 44.77, with a standard deviation of 7.76. On the other hand, the control group had a post-test mean score of 20.75, with a standard deviation of 11.57. The mean gain in performance between the pre-test and post-test was 24.02 in favor of the experimental group.

Null Hypothesis One: There is no significant difference in the academic performance of students with dysgraphia taught geometric construction using RPT and those taught using CTM

Table2: Analysis of Covariance (ANCOVA) of mean achievement scores of Experimental and Control Groups

Sources of variance	Type III sum of squares	Df	Mean square	F-CAL	P-value	Decision
Corrected Model	27734.269[a]	2	13867.135	1217.605	.000	
Intercept	3209.868	1	3209.868	281.843	.000	
PRETEST	13.744	1	13.744	1.207	.274	
GROUP	25497.058	1	25497.058	223.667	.000	S
Error	1560.274	78	11.389			
Total	477114.000	81				
Corrected Total	29294.543	80				

a. R Squared = .605 (Adjusted R Squared = .576)

The result in Table 2 reveals a significant difference between the mean scores of students with dysgraphia who were taught geometric construction using RPT and those taught using CTM. The F-ratio was calculated to be 223.667, with an associated probability value of 0.00. Since the probability value (p-value) of 0.00 is less than the alpha level of 0.05, the null hypothesis is rejected. This indicates that there was a significant difference in the mean performance scores of students with dysgraphia who were taught geometric construction using RPT compared to those taught using CTM. These findings suggest that Reciprocal Peer-Tutoring (RPT) had a greater positive impact on the academic performance of learners with dysgraphia in geometric construction compared to the Conventional Teaching Method (CTM).

Research question Two: What is the mean difference in the academic performance of male and female students with dysgraphia taught Geometric Construction using RPT.
Null Hypothesis Two: There is no significant difference in the academic performance of male and female students with dysgraphia taught Geometric Construction using RPT.

Table 3: Descriptive Statistics of Performance of Gender in Experimental Group

Group	N	Pre-Test		Post-Test		Mean Difference
		$\bar{X}$	SD	$\bar{X}$	SD	
Male	25	18.40	10.88	53.85	6.16	34.45
Female	13	19.21	11.02	52.76	4.70	33.55
Mean Gain		9.19		1.09		

Table 3 presents the results for male and female students in the experimental group who were taught geometric construction using RPT. The male students had a pretest mean score ($\bar{X}$) of 18.40, with a standard deviation of 10.88, while the female students had a pretest mean score of 19.21, with a standard deviation of 11.02. After the intervention, the posttest mean score for the male students was 53.85, with a standard deviation of 6.16. On the other hand, the female students had a posttest mean score of 52.76, with a standard deviation of 4.70. The difference in the mean gain scores between the two groups was found to be 1.09.

Table4: Analysis of Covariance (ANCOVA) achievement scores male and female students in Experimental Group

Sources of variance	Type III sum of squares	Df	Mean square	F-Cal	P-value	Decision
Corrected Model	2768.059[a]	2	1384.030	7.148	.001	
Intercept	13016.035	1	13016.035	67.223	.000	
PRETEST	2707.487	1	2707.487	13.983	.000	
GROUP	530.849	1	530.849	51.431	.239	NS
Error	26526.483	36	193.624			
Total	477114.000	38				
Corrected Total	29294.543	37				

a. R Squared = .532 (Adjusted R Squared = .521)

The results in Table 4 indicate that there was no significant difference in the mean scores of male and female students with dysgraphia when taught geometric construction using RPT. An F-

ratio of 1.41 was recorded, with a corresponding probability value of 0.239. Since the probability value (p-value) of 0.239 is greater than the significance level of 0.05, the null hypothesis is upheld. This suggests that there is no significant difference in the mean scores of male and female students with dysgraphia when they are taught geometric construction using RPT. Thus, gender is not a significant factor in determining the performance of students with dysgraphia in geometric construction.

Discussion

The results in Table 1 provide evidence for the first research question, which examined the performance of students with dysgraphia taught geometric construction using RPT compared to those taught using CTM. The post-test mean score for the experimental group taught with RPT was 44.77, while the control group taught with CTM had a mean score of 20.75. This suggests that students with dysgraphia who were taught with RPT performed better than those taught with CTM, as indicated by their higher post-test mean score. Statistical analyses of the data confirmed a significant difference in the performance of students with dysgraphia taught using RPT compared to CTM. This finding aligns with previous studies by Ahmad and Zakariyya (2023) that highlight the positive impact of innovative teaching strategies, such as RPT, on students' learning outcomes. RPT caters to a wide range of learning needs and disabilities, and the collaborative and problem-solving nature of the approach contributes to better outcomes compared to CTM (Sufiyanu et al., 2019; Wonu & Nwoko, 2022).

Table 2 addresses the second research question, which explored the performance of male and female students with dysgraphia taught geometric construction using RPT. The post-test mean score for male students was 52.85, while female students had a mean score of 52.76. The mean gain between the pre-test and post-test scores for both genders was 1.09. The relatively close mean scores indicate that both genders performed at a similar level. Moreover, the statistical analysis confirmed that there was no significant difference in the academic performance of male and female students with dysgraphia when taught using RPT. This finding supports previous research by Etsu and Manko, which found no significant difference in the academic performance of male and female slow-learners in geometry concepts when using peer-tutoring. Additionally, the study by Wonu and Nwoko (2022) reported no discernible difference in the performance of junior secondary school students with developmental dyscalculia when taught with a collaborative strategy, irrespective of gender. The influence of gender on performance was found to be minimal, as indicated by the low partial Eta square value of 0.050, representing a 5% variation, as explained in Cohen's theory (Wonu & Nwoko, 2022).

Conclusion

The study provides strong evidence that reciprocal peer-tutoring (RPT) is an effective instructional remediation for students with dysgraphia in junior secondary school. The findings demonstrate that RPT significantly improves the academic performance of these students, irrespective of gender. This inclusive approach caters to a wide range of learning needs and encourages active participation, making it a valuable tool for enhancing learning outcomes. Implementing RPT as a teaching strategy can have a positive impact on the academic success of students with dysgraphia, fostering a supportive and inclusive learning environment.

Recommendation

The following recommendations are made based on the results of the study:

1. Mathematics teachers should be well-versed in effective RPT to enhance student learning outcomes.
2. Mathematics teachers should create a relaxed and supportive learning environment that encourages and motivates both male and female students to learn effectively.

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ASSESSMENT OF SILHOUETTE AND GESTURAL METAL SCULPTURES IN THE WORK OF PROF. KENNETH OKOLI: A HISTORICAL PERSPECTIVE

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Abstract
This historical review examines the evolution and significance of silhouette and gestural metal sculptures by Professor Kenneth Okoli, a prominent figure in contemporary African sculpture. Prof. Ken's innovative approach to sculpture, particularly his mastery in using metal to create dynamic, expressive forms, has positioned him as a transformative artist in the field. This study traces the development of his unique style, exploring the historical and artistic influences that shaped his works. It delves into how his sculptures embody a fusion of traditional African aesthetics and modern sculptural techniques, with a focus on the expressive potential of silhouette and gestural forms. By analyzing the use of metal as a medium, the review highlights Prof. Ken's exploration of movement, abstraction, and how these elements serve to convey deeper cultural narratives and personal expression. The paper also situates Prof. Ken's work within the broader context of African and global sculpture movements, examining his contribution to contemporary art and his lasting influence on future generation of artists.
Keywords: welded metal sculpture, silhouette and gestural sculpture, mixed media, exploration.

Introduction

Background to the Study

The contemporary era has seen significant experimentation in the execution of metal sculptures. Artists have developed new ideas, styles, and materials in exploring and creating metal sculptures. This evolution is reflected in the work of Sani (2019), who reported that the depiction of human figures in sculpture has given way to new subjects such as dreams, ideas, emotions, and explorations of form and space. Materials like plastic, chromium, and welded steel, as well as objects like boxes, broken automobile parts, and pieces of furniture, have been used in this new wave of sculpture. The 20th-century sculptor Auguste Rodin, whose work inspired a new generation of artists direct fresh-ideas in art forms that had previously relied on odd conventions. Although Rodin's successors, including contemporary artists such as Professor Ken whose stylistic of approach to metal sculpture is the focus of this paper, his works often deviates from realism to abstracts, with unique innovations.

Iron melting and forging technologies may have existed in West Africa among the Nok culture of Nigeria. According to Lamidi (2000), as early as the 6th century B.C., iron technology played a significant role in the development of powerful kingdoms in West Africa, particularly in the western Sudan and along the Guinea coast. Similarly, Fatunmbi (2016) reported that Ogun, the Yoruba god of iron, is a significant deity believed to have introduced iron technology. The author concluded that iron smelting occurred in various parts of Nigeria before the arrival of Europeans. Iron objects, including tools such as hoes, traps, knives, arrows, spearheads, and musical instruments, have been discovered as evidence of iron working traditions.

Statement of the Problem

Records from Danjuma (2010), Duniya (2014), Muhammad (2015), Lamidi (2015), and other art scholars substantiate the idea behind this research. Notably, Professor Kenneth Okoli has created a substantial body of metal sculptures exhibited in Nigeria and abroad. However, available records indicate that no comprehensive documentation analysis has been conducted on the

contextual forms of his silhouette and gestural metal sculptures, which is the focus of this study. While, the **Objectives of the Study** are to:

1. examine the educational background of Professor Kenneth Okoli as a sculptor.
2. identify the stylistic approaches in his silhouette and gestural metal sculptures.
3. analyze the aesthetic meanings and contextual forms of his artworks.

Research Questions

In line with these objectives, the study seeks to answer the following research questions:

1. Where did Professor Kenneth Okoli receive his training as a sculptor?
2. What makes his style unique compared to other sculptors?
3. How do aesthetic qualities influence the metal sculptures of Kenneth Okoli?

Review of Related Literature

The review of related literature includes works from scholars such as Pollitt (2000), Cole (2009), Eleanor (2012), Elkins (2013), and Sani (2022), among others. The study examines various individual and group styles in contemporary metal sculpture across the globe, with a focus on the stylistic approaches and techniques employed in Okoli's silhouette and gestural sculptures. This research identifies welding techniques and other methods used by Okoli, addressing the gap in the literature concerning his work.

Theoretical Framework

This study is guided by the Technology Acceptance Model (TAM), as proposed by Davis (1989) and referenced in Sani (2021). The model focuses on understanding how individuals accept and use technology, and it is applied here to understand how visual artists, like sculptors, adopt and utilize new materials and techniques. The Theory of Reasoned Action (TRA), as proposed by Martin Fishbein and Icek Ajzen in the late 1970s, was used to predict the impact of an artist's works. According to Haagger (2019), the theory is effective in predicting the actions of artists, which allow the holistic study of Prof Ken's silhouette and gestural metal works.

Research Methodology

A qualitative mode of inquiry was adopted for this research, utilizing historical and descriptive approaches, as outlined by Osuala (2002). These approaches were employed to describe and analyze observed phenomena. According to Sambo (2012), qualitative research helps to understand the effects of social events or phenomena on individuals, groups, societies, or cultures.

Findings

From the outcome of interviews and analysis carried out, the following are the major findings:

Professor Kenneth Okoli

In his curriculum vitae, Steven (2016) and Sani (2019) revealed that Prof. Kenneth Okoli, popularly known as "Ken Okoli," was born in Kano State on March 30, 1964, and hails from Awka, Anambra State. Kenneth Okoli attended Ezechima Primary School in Onitsha from 1971 to 1976, where he was exposed to art and engaged in numerous drawings and sketches for his peers. He began his secondary education at Uga Boys' Secondary School in Anambra State in 1977 and obtained the West African Examination Council (WAEC) certification in 1982. He

then proceeded to Pankshin, Jos, Plateau State, where he studied Fine Arts at the Federal College of Education, Pankshin, and earned the National Certificate in Education (NCE) between 1985 and 1988. Furthermore, Stephen (2016) reported that in 1991, Ken Okoli enrolled at the prestigious Ahmadu Bello University (ABU) in Zaria, where he pursued a Bachelor of Arts (B.A. Hons) in Fine Arts, specializing in sculpture, which he completed in 1994. Additionally, Samaila (2004) stated, "During his undergraduate years, Ken Okoli became the pioneer president of the Association of Fine Art Students (AFAS) following its split from the dual Association of Industrial Design and Fine Art Students (AIDFAS)." Ken Okoli later pursued a Master of Fine Arts (M.F.A.) in sculpture from 1996 to 1998 and further advanced his education in the field of Art History. He was awarded a Doctor of Philosophy (PhD) in 2007 from the same institution, Ahmadu Bello University, Zaria. He currently teaches sculpture in the Department of Fine Arts at Ahmadu Bello University, Zaria, and has held numerous solo exhibitions while also participating in several group exhibitions. According to the Exhibition Catalogue (2014), Ken has attended national and international workshops and conferences and is a Fellow of the Carnegie Corporation of New York.

Prof. Ken Okoli has also published in several prestigious national and international journals. He served as an art consultant for the states of Kaduna and Nasarawa for many years and has been awarded numerous sculptural commissions by various states in Nigeria, including Nasarawa, Kaduna, and Ebonyi states, to mention just a few. His academic career has earned him many notable positions, such as Head of Sculpture Section (HOS), Team Leader to the South African Automobile Competition with selected ABU, Zaria students, and was Head of the Department of Fine Arts (HOD), among others.

In a related development, Jari (2014) described Ken Okoli's metal sculptures and styles as follows: "His motifs are drawn from the northern Nigerian environment in which he has lived for much of his life. His mode of presentation evolved from the green environment within the northern context, presented in two-dimensional reliefs." Duniya (2014) added that Ken Okoli has been able to sculpturally articulate the physiology, characterization, and climatology of Zaria through his metal works. Further studies indicate that Okoli has expressed his years of critical observation, engagement, and experience through the use of materials such as mild steel rods, metal sheets, and copper wire, among others. Similarly, Jari (2014) noted, "Ken is known for his relief sculptures in metals, and in recent times, he has produced novel sculptural pieces in steel and copper wire." Furthermore, Danjuma (2014) observed that "Ken, as he is fondly called, is an Art Historian and Sculptor who is aware of world art trends; one can see this knowledge reflected in his sculptural style." Duniya (2014) further noted the influence of Okoli's experiences on his sculptures, stated thus Ken began landscape sculpture in 1996 and has since explored various aspects of the Northern landscape, particularly the Zaria landscape. This observation emphasizes how the artist's first experience in Zaria and his years of living there, both as a student and now as a teacher at his alma mater (Ahmadu Bello University, Zaria), are represented in his welded sculptures.

Supporting the above statement, Okoli (2014) said "Having lived in the north of Nigeria for about thirty years and watching the gradual disappearance of greenery, the role of the artist as a social commentator has become significant. My master's degree (MFA) research in 1998 focused on producing metal sculptures depicting the landscape of the Zaria environment. In conclusion, the artist said that most of baobab trees that inspired him to document in his landscape works have been cut down for firewood.

Analysis of Selected Silhouette and Gestural Metal Sculptures

The title of this work, *"Gidan Sarki"*, is a Hausa term literally means "Emir's Palace." The relief landscape was created in 1996 and measures 115cm width and 33cm height. *Gidan Sarki* in

Plate I depicts a palace set in the savannah, symbolizing the supremacy of the Hausa monarch. Regarding the technique used, the artist states, "The linear sculpture of the landscape was created directly with mild steel rods through the art of welding, representing an imaginary African monarch's palace" (Okoli, 1998). He further explained that the monumental size of the building towers over the tranquil landscape, emphasizing the supremacy of the African monarch.

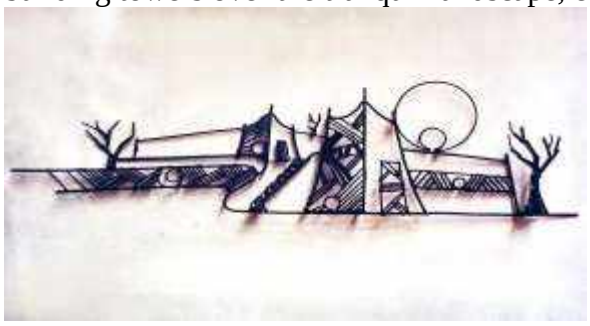

Plate I: "Gidan Sarki," Ken Okoli, Mild Steel, 115cm Width x 33cm Height, 1996, Collection of the Artist, Photography by the Researcher

The decorative elements incorporate northern motifs from traditional African architecture. The work can be viewed from different angles, offering an interesting perspective. The artist's long stay in the northern part of Nigeria, particularly in Samaru and Zaria, likely influenced the creation of this work. One consistent feature in Prof. Ken's landscape compositions is the presence of baobab trees. These trees appear in many of his sculptures, capturing their distinctive form and topography. Since his postgraduate days, the baobab has been both a subject matter and a central part of his artistic innovation. The rising sun is depicted with a single iron rod in a circular shape, while the interplay of light and shade adds vibrancy to the piece. A cress-cross technique represents the various building forms, and the systematic arrangement of elements reflects the artist's creativity and professionalism.

The work titled *"Tudun Wada"* in Plate II, executed in mild steel and coated with oxide. The relief sculpture measures 58cm width and 19cm height and was done in 1997. *Tudun Wada* is a slightly hilly landscape that inspired the artist. The sculpture was constructed using a flat surface and arranged different metals and iron rods. The entire composition captured the traditional architectural buildings; arranged them side by side yet creating perspective and balance on the flat surface resulting in an asymmetrical composition.

Plate II: "Tudun Wada," Ken Okoli, Mild Steel, 58cm Width x 19cm Height, 1997, Collection of the Artist, Photography by the Researcher

The narrative of this piece demonstrates the need to create sculptures that reflect the immediate surroundings and environment. The sculpture communicates the settlement of Zaria and its environs, offering a glimpse into the past when *Tudun Wada* was a significant place. But for now, modern architecture design has overtaking the traditional structures. The artist deliberately omitted baobab trees from this piece, perhaps reflecting a studio experiment during his master's degree period. The piece successfully captures the essence of traditional African architecture using welding techniques, resulting in an elegant and sophisticated sculpture.

The relief sculpture is titled *"Whirlwind on Makarfi"* in Plate III; it was created with mild steel and coated with oxide to prevent corrosion. It was done in 1997 the size of work is 79cm width and 30cm height. Unity is achieved by the use of cursive lines that crisscross each other in harmonious pattern.

Plate III: "Whirlwind on Makarfi," Ken Okoli, Mild Steel, 79cm Width x 30cm Height, 1997, Collection of the Artist, Photography by the Researcher

The title *Makarfi* is a town along the new Kano road, which may have inspired Prof. Ken's work. As he explains thus, the work is reminiscent of a Sahara oasis, which acted as a source of inspiration. The artist modeled the trees to bend under the pressure of the whirlwind, while combining Hausa motifs with lines to enhance the composition. The piece features two baobab trees positioned proportionally within the composition. A close observation revealed that the two baobab trees are swaying to the strong Sahara wind. The moon-like shape is created using rods positioned behind the large baobab tree. The artist employs abstract African patterns, using a zig-zag motif to represent traditional mud buildings. Prof. Ken's landscape sculptures possess a narrative quality and sculptural eloquence, giving them painterly feels. The work demonstrates the artist's skill in manipulating iron-rods to create a dense yet sensuous landscape.

"Hayin Dogo at Sunset" in Plate IV was executed in mild steel and coated with oxide, the work measures 52cm width and 18cm height. It was completed in 1997. *Hayin Dogo* is a section of Samaru bordering the railway track leading to Gusau, the capital city of Zamfara State. In the past, trains carried cotton from Gusau to textile industries in the eastern and southern parts of Nigeria. The relief landscape sculpture captured a complete sunset going down the scene, behind the traditional African buildings, giving a vivid illustration of how architectural structures were, before, the advent of modern structures in Samaru. The sculptor emphasizes the fading presence of traditional buildings because of the impact of modernization.

Plate IV: "Hayin Dogo at Sunset," Ken Okoli, Mild Steel, 52cm Width x 18cm Height, 1997, Collection of the Artist, Photography by the Researcher

The omission of human figures and baobab trees in this composition was deliberate by the artist that highlights two principles. Firstly, from Islamic perspective and secondly it has to do with studio experimentation. Religion has played vital role in the life of Prof. Ken Okoli. On the other hand, studio practicing had shaped the practice of his experimentations. Prof. Ken used a cutting technique, rather than welding, to produce the work. Metal sheets were cut with iron cutters after series of sketches were made on the metal surface with white chalk. This method is similar to his

other works. One of such works is the *"Kofar Gaya"*, which share a common theme of traditional narrative of architectural design and the use of similar production techniques.

"Kofar Gaya" in Plate V, measuring 93cm width and 28cm height the simplicity of the work makes the onlooker to easily understand the artist's message about the remote areas in the Northern Nigeria, particularly the Samaru-Zaria region. Prof. Ken's exploration of elongation and stylization, which began in 1996, is evident in this work, where the buildings were elongated at the top. Through the use of mass and space, Ken's sculpture exemplifies the successful treatment of metal as a medium, making his work distinct from that of his contemporaries.

Plate V: "Kofar Gaya," Ken Okoli, Mild Steel, 93cm Width x 28cm Height, 1998, Collection of the Artist, Photography by the Researcher

This analysis underscores the artist's unique approach to metal sculpture, which blends abstraction with stories, creating works that resonate with the cultural and architectural history of Northern Nigeria.

Conclusion

Based on the foregoing, the study finds that sculptural exploration at the turn of the 20th and 21st centuries have shifted towards conceptual art. In this era, the artist's ideas have become the most significant aspect of artistic trends. Consequently, metal sculptures have become more popular than other forms of sculpture, which were traditionally rooted in modeling and casting, especially in materials like bronze and other related alloys. Sculptures made from stone, wood, plaster of Paris, and terra cotta are gradually being replaced by metal in terms of material use.
Prof. Ken uses the electric arc welder, which is the most powerful and economical option in this region compared to other contemporary welding methods like TIG (Tungsten Inert Gas), MIG (Metal Inert Gas) to mention just a few.
His works address significant issues like desertification through his relief landscape sculptures, serving as social commentary. Again, some of his works has been analyzed have a highly political content, socio-cultural background and spiritual issues.

Recommendations

The research works of Prof. Ken Okoli's silhouette and gestural metal sculptures, the study offers the following recommendations:

1. **Further Research**: Scholars are encouraged to explore other categories of Ken's work. This could be promoted within art history programs at Nigerian institutions of higher learning.
2. **Collaboration with Government Bodies**: Artists and scholars should work with relevant government agencies to facilitate more exhibitions and workshops that feature Prof. Ken as a metal sculptor. This will not only enhance his exposure but also provide a platform for emerging sculptors.

3. **Investigating Collaborative Works**: Further research into Prof. Kenneth Okoli's collaborative sculptures could reveal insights into the nature and implications of works produced in such collaborative efforts.

Contributions to Knowledge

This study has established that:

1. **Revealing Prof. Ken's Art**: The review highlights Prof. Ken Okoli's artwork, particularly his metal sculptures, and connects his work with the local environment. His creations serve as a valuable resource for younger artists.
2. **Modern and Conventional Techniques**: The study has found that the styles and techniques in Ken's metal sculptures incorporate both conventional and modern methods, making his work accessible and accepted in society. This research contributes to the existing literature on his contributions to sculpture.
3. **Contribution to Metal Sculpture**: Prof. Ken Okoli has significantly contributed to the documentation and development of metal sculpture, particularly in Northern Nigeria, and his influence extends globally.

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FACTORS AFFECTING THE CULTIVATION AND AVAILABILITY OF YAMS (*Dioscorea spp.),* IN NIGER STATE NORTH-CENTRAL NIGERIA

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Abstract
Yams (Dioscorea spp.) is one of the major food crops grown in Niger State. The crop is grown for its nutritive, economic and social benefits. In spite of all these importance, research on factors militating against its cultivation has been inadequate. Against this background, a survey was conducted on factors affecting it cultivation and availability of the crop in the state. This study was conducted to investigate factors affecting cultivation and availability of the tubers in major producing areas across the state. The study was conducted in Bossso, Minna metropolis, paikoro and Shiroro Local Government Areas. Thus population of eighty (80) peasant farmers and eighty (80), Yam marketers were randomly selected from markets across the Local Government areas under investigation. Four hypothesis were formulated to guide the research work and data collected were analyzed using Chi-Square. The result revealed high cost of Yam seedlings and insecurity are significant factors affecting cultivation of Yams at ($p<0.5$) in Niger State and this have rejected hypothesis 1 and 2.Consequently the findings showed that seasonal variation and insecurity are significant factors hindering the availability of the tubers in Niger State with value ($p<0.05$), thereby rejecting hypothesis 3 and 4. It is recommended among others that farmers should form cooperative society to enable them obtain subsidized loans for individual, group and government to purchase Yam seeds to boost production and subsequent availability in the State and country at large. In the same vein Government should reinforce robust security in production areas to counter the activities of criminals constituting insecurity.
Key words: Factors, Cultivation, Availability, Yams

Introduction

Yam according to Nahanga and Becvarova (2015) is a tuber crop of the family *Dioscorea specie* and accordingly there are more than 600 species, out of which six (6), are socially and economically important, International Institute of Tropical Agriculture (IITA,2009). It is cultivated in commercial quantities in several states of the middle belt of Nigeria (Benue, Edo, Niger, Nassarawa), and also eastern states of (Edo, Anambra) of Nigeria. It is also cultivated for subsistence in many other states of Nigeria. It could be eaten boiled, fried or pounded. It is special food in many cultures particularly the Gbagys of Niger and Nassarawa states of Nigeria and also the Igbo of Eastern Nigeria. It has a great potential for export and to serve as alternative cash crop revenue to fuel, especially now that oil revenues are dwindling and also due to the burdensome fuel subsidy regime, but its cultivation and availability in Niger State, is hampered by certain factors which will make it fail as revenue earner. This can be said to be the crux of this research.

Justification

Nigeria from time immemorial has been an agricultural/farming nation, with its vast arable land. Earnings from farm produce sustained its people at that time, and produce like Cocoa, timber, cotton come to foe, but with the advent of oil this once thriving sector was neglected, as Nigeria came to depend solely on oil, which came to constitute between 80-85% of its foreign exchange earnings. For us as a nation this narrative has to change, particularly due to the rapid decline of oil revenues coupled with the so-called subsidy regime and expanding population. This research will focus on one crop that has a great potential/prospect to earn the Niger state and Nigeria foreign exchange, i.e., Yam a tuber crop if cultivated in commercial quantities and the researchers shall dwell solely on factors that affects its cultivation and availability in Niger-State, North-Central Nigeria.

Brief History of Yam

Yam collectively is the most common name for Plant species in the genus ***Dioscorea*** (family: ***Dioscoreaceae***), which form edible tubers. Yams are perennial herbaceous vines that are cultivated for the consumption of their starchy tubers in Africa, Asia, Latin America, the Caribbean and Oceania. According to Fact-Sheet-Yam (USDA Wisconsin Department of Public Instruction), Yams are said to have originated from Africa, Asia, and the Carribean. Africans call yams nyami which is where we got the word yam from. Yams are cylindrical and vary in in size and shape. Some of the largest Yams have weighed 100 pounds and several feet long. Yams have a dense white purple or red flesh, and scaly brown skin with dark spots. Nutritionally yam is a major staple food consumption, providing food for millions of people in West Africa, and is eaten in different forms such as fufu, pounded yam, Amala in Nigeria, boiled and roasted (Aidoo 2009). In Africa. Yam is also said to have a shelf life of six months, but you will have a hard time finding a true yam on a shelf in an American grocery store.

Cultivars of Yam

According to IITA(,2009),Species and Varieties of Yam include the following, white yam, Yellow yam, water yam ,Chinese yam, wild bitter Yam, bitter Yam, cush-cash yam(www.teezab.com.ng)

In Africa many species of Yams abound, but the most cultivated species in Africa includes the following according to Christian and Olugbenga (2017), white yam (*D. rotundata*), Water yam (*D.alata*), Air potato (*D. bulbifera*), and Bitter yam (*D. dumetorum*)

Yam Production in Niger State

Nigeria and Niger State are part of the global community and there is a worrisome trend that indicates that the rising demand for food due to population and real income growth will definitely lead to increasing global food security and worsening hunger and malnutrition particularly in a developing country like ours (Nmadu, Coker,Adams(2017).According to the report of the Niger State Bureau of Statistics (2012),stated agriculture as the major occupation of its people, with about 85% of its population engaged in farming, The report also mentions Yams,Rice,Groundnuts,Maize amongst several others as crops grown. Yam as a staple food crop in Niger state, should not serve only as an integral vehicle for food security, but should also serve as a source of income (Nahanga and Becvarova 2015). According to Zinash and Yisa (2000), Niger state serves as one of the major Yam producing states in Nigeria and statistics show that the state produced over 2.3 metric tons of yams representing more than 10% of the total yam produced in Nigeria annually. The Yam producing local government areas include Shiroro, Rafi, Munya, Paikoro Bosso, Mariga, wushishi.

Research Hypothesis

For the purpose of research, the following hypothesis were formulated,

H_o1: High cost of seedlings is not a factor affecting the cultivation of Yams in Niger state.

H_o2: Insecurity is not a factor affecting the cultivation of Yams in Niger State.

H_o3: Season (climate) is not a factor affecting the availability of Yams in Niger State

H_o4: Insecurity is not a factor affecting the availability of Yams in Niger State.

Research Design

The method employed in this research is the survey method of collecting data.

Area of Study

The area of study is Minna metropolis and suburbs of Minna., Niger State, North-Central Nigeria. The markets surveyed in Minna includes the following, Yam markets in Bosso, Tungan-Goro , and Paiko(Paikoro) and Beji markets, all in suburbs of Minna, and Kuta market in Kuta (shiroro), a major yam growing town.

Population of Study
The population of the study comprises of Yam Marketers and Yam Farmers of BossoTungan-Goro markets located in Minna metropolis and Paiko and Beji markets located within suburbs of Minna, and Kuta market in Shiroro a major yam growing town.

Sample size/Method of sampling
The sample size comprises Eighty (80), Yam Marketers and Eighty (80), Yam Farmers in the aforementioned markets and all these were selected by random sampling.

Research Instrument
The main instrument used for data collection is a structured questionnaire, developed by the researchers. The instrument was validated by senior lecturers from School of Sciences College of Education, Minna. The questionnaire was divided into two sections. Section (A), provides information on the demographic data of the respondents, while section (B), provides answers to questions on the research.

Data Analysis
Chi-Square and Percentages were used in the Statistical Analysis

Table 1: Showing responses of respondents on factors affecting cultivation and availability of Yams in Bosso Market.

S/N	Questions	Yes	No	Total
1.	a. Availability of fertilizer affects the cultivation of Yams in Niger State	12 (60)	08 (40)	20
	b. season(climate) is a factor affecting the availability of yams in Niger State	13(65)	07 (35)	20
2.	a. Availability of Seedlings affects the cultivation of Yams in Niger State	12 (60)	08 (40)	20
	b. transportation is a factor affecting availability of Yams in Niger State	09(45)	11(55)	20
3.	a. Availability of improved seedlings affects the cultivation of Yams in Niger State	07 (35)	13 (65)	20
	b. Lack of proper storage is a factor affecting the availability of Yams in Niger State	10(50)	10(50)	20
4.	a.High costs of seedlings affect the cultivation of yams in Niger State	13 (65)	07 (35)	20
	b.Lack of processing into other forms is a factor affecting Yam availability in Niger State	11(55)	09(45)	20
5.	a. Diminishing soil value(nutrients'), affects cultivation of Yams in Niger State	10 (50)	10 (50)	20
	b. Insecurity is a factor affecting the availability of Yams in Niger State.	08(40)	12(60)	20
6.	a. Disease infestation affects the cultivation of Yams in Niger State	10 (50)	10 (50)	20
	b.Interference of middle men is a factor affecting availability of Yams in Niger state	10(50)	10(50)	

7.	a .Insecurity affects the cultivation of Yams in Niger State b. Varieties of Yams affects the availability of Yams In Niger State	08 (40) 10(50)	12 (60) 10(50)	20 20
8.	Labor cost affects cultivation of Yams in Niger State	12 (60)	08 (40)	20

Source: Field Data, 2023

Table 2: Showing responses of the respondents on factors affecting Yam cultivation and availability in Tungan-Goro market

S/N	Questions	Yes	No	TOTAL
1.	a. Availability of fertilizer affects the cultivation of Yams in Niger State b.Season(Climate) is a factor affecting the availability of Yams in Niger state	12 (60) 10(50)	08 (40) 10(50)	20 20
2.	a. Availability of Seedlings affects the cultivation of Yams in Niger State b. Transportation is a factor affecting availability of Yams in Niger State.	09 (45) 06(30)	11 (55) 14(70)	20 20
3.	a. Availability of improved seedlings affects the cultivation of Yams in Niger State b.Lack of proper storage is a factor affecting availability of Yams in Niger state	12 (60) 13(65)	08 (40) 07(35)	20 20
4.	a. High costs of seedlings affects the cultivation of yams in Niger State b. Lack of processing into other forms is a factor affecting availability of Yams in Niger State	17 (85) 06(30)	03 (15) 14(70)	20 20
5.	a. Diminishing soil value(nutrients), affects cultivation of Yams in Niger State b.Insecurity is a factor affecting availability of Yams in Niger State	14 (70) 14(70)	06 (30) 06(30)	20 20
6.	A Disease infestation affects the cultivation of Yams in Niger State b. interference of middle men is a factor affecting availability of Yams in Niger state.	11 (55) 07(35)	09 (45) 13(65)	20 20
7.	a. Insecurity affects the cultivation of Yams in Niger State b. varieties Yams affects the availability of yams in Niger State	14 (70) 11(55)	06 (30) 09(45)	20 20
8.	Labor cost affects cultivation of Yams in Niger State	11 (55)	09 (45)	20

Source: Field Data, 2023

Table 3: Showing responses of the respondents on factors affecting Yam cultivation and Availability in Paiko market

S/N	Questions	Yes	No	Total
1.	a. Availability of fertilizer affects the cultivation of Yams in Niger State	01 (10)	09 (90)	10
	b.Season(climate) is a factor affecting the availability of Yams in Niger State	10(100)	00(00)	10
2.	A. Availability of Seedlings affects the cultivation of Yams in Niger State	02 (20)	08 (80)	10
	b. Transportation is a factor affecting the availability of Yams in Niger State	10(100)	00(00)	10
3.	a. Availability of improved seedlings affects the cultivation of Yams in Niger State	04 (40)	06 (60)	10
	b. Lack of proper storage is factor affecting the availability of yams in Niger State	10(100)	00(00)	10
4.	a. High costs of seedlings affects the cultivation of yams in Niger State	10 (100)	00 (00)	10
	b.Lack of processing into other forms is a factor affecting the availability of Yams in Niger state	10(100)	00(00)	10
5.	a. Diminishing soil value(nutrients'), affects cultivation of Yams in Niger State	10 (100)	00 (00)	10
	b. Insecurity is a factor affecting the availability of Yams in Niger State	10(100)	00(00)	10
6.	a. Disease infestation affects the cultivation of Yams in Niger State	10 (100)	00 (00)	10
	b. Interference of middle men is a factor affecting the availability of Yams in Niger State	10(100)	00(00)	
7.	a. Insecurity affects the cultivation of Yams in Niger State	10 (100)	00 (00)	10
	b.Varieties of Yams affects its availability in Niger State	07(70)	03(30)	10
8.	Labor cost affects cultivation of Yams in Niger State	10 (100)	00 (00)	10

Source: Field Data, 2023

Table 4: Showing responses of respondents on Factors affecting Yam cultivation and Availability in Kuta market

S/N	Questions	Yes	No	TOTAL
1.	a. Availability of fertilizer affects the cultivation of Yams in Niger State	10 (100)	00 (00)	10
	b.Season(Climate) is a factor affecting the availability of Yams in Niger state	10(100)	00(00)	10

2.	a. Availability of Seedlings affects the cultivation of Yams in Niger State b. Transportation is a factor affecting availability of Yams in Niger State.	06 (60) 09(90)	04 (04) 01(10)	10 10
3.	a. Availability of improved seedlings affects the cultivation of Yams in Niger State b.Lack of proper storage is a factor affecting availability of Yams in Niger state	08 (80) 08(80)	02 (20) 02(20)	10 10
4.	a. High costs of seedlings affects the cultivation of yams in Niger State b. Lack of processing into other forms is a factor affecting availability of Yams in Niger State	10 (100) 08(80)	00 (00) 02(20)	10 10
5.	a. Diminishing soil value(nutrients), affects cultivation of Yams in Niger State b.Insecurity is a factor affecting availability of Yams in Niger State	10 (100) 10(100)	00 (00) 00(00)	10 10
6.	a. Disease infestation affects the cultivation of Yams in Niger State b. interference of middle men is a factor affecting availability of Yams in Niger state.	10 (100) 06(60)	00 (00) 04(40)	10 10
7.	a. Insecurity affects the cultivation of Yams in Niger State b. varieties Yams affects the availability of yams in Niger State	09(90) 10(100)	01(10) 00(00)	10 10
8.	Labor cost affects cultivation of Yams in Niger State	09(90)	01(10)	10

Source: Field Data 2023

Table 5: Showing responses of respondents on Factors affecting Yam cultivation and availability in Beji Market

S/N	Questions	Yes	No	TOTAL
1.	a. Availability of fertilizer affects the cultivation of Yams in Niger State b.Season(Climate) is a factor affecting the availability of Yams in Niger state	18 (90) 06(30)	02 (10) 14(70)	20 20
2.	a. Availability of Seedlings affects the cultivation of Yams in Niger State b. Transportation is a factor affecting availability of Yams in Niger State.	06 (30) 07(35)	14 (70) 13(65)	20 20
3.	a. Availability of improved seedlings affects the cultivation of Yams in Niger State b.Lack of proper storage is a factor affecting availability of Yams in Niger state	13 (65) 13(65)	07 (35) 07(35)	20 20

4.	a. High costs of seedlings affects the cultivation of yams in Niger State	06 (30)	14 (70)	20
	b. Lack of processing into other forms is a factor affecting availability of Yams in Niger State	08(40)	12(60)	20
5.	a. Diminishing soil value(nutrients), affects cultivation of Yams in Niger State	14 (70)	06 (30)	20
	b.Insecurity is a factor affecting availability of Yams in Niger State	06(13)	14(70)	20
6.	a. Disease infestation affects the cultivation of Yams in Niger State	07 (35)	13 (65)	20
	b. interference of middle men is a factor affecting availability of Yams in Niger state.	12(60)	08(40)	20
7.	a. Insecurity affects the cultivation of Yams in Niger State	11(55)	09(45)	20
	b. varieties Yams affects the availability of yams in Niger State	10(50)	10(50)	20
8.	Labor cost affects cultivation of Yams in Niger State	06(90)	14(10)	20

Source: Field Data 2023

Table 6: Showing responses of Respondents on Factors affecting Yam cultivation and Availability in Niger State

S/N	Questions	Yes	No	TOTAL
1.	a. Availability of fertilizer affects the cultivation of Yams in Niger State	53 (66.25)	27 (33.75)	80
	b .Season(Climate) is a factor affecting the availability of Yams in Niger state	59(73.75)	21(26.25)	80
2.	a. Availability of Seedlings affects the cultivation of Yams in Niger State	35 (43.75)	45 (56.25)	80
	b. Transportation is a factor affecting availability of Yams in Niger State.	41(51.25)	39(48.25)	80
3.	a. Availability of improved seedlings affects the cultivation of Yams in Niger State	34 (42.50)	46 (57.50)	80
	b.Lack of proper storage is a factor affecting availability of Yams in Niger state	54(67.50)	26(32.50)	80
4.	a. High costs of seedlings affects the cultivation of yams in Niger State	56 (70.00)	24 (30.00)	80
	b. Lack of processing into other forms is a factor affecting availability of Yams in Niger State	43(53.75)	37(46.25)	80
5.	a. Diminishing soil value(nutrients), affects cultivation of Yams in Niger State	58(72.50)	22 (27.50)	80
	b.Insecurity is a factor affecting availability of Yams in Niger State	58(72.50)	22(27.50)	80

6.	A. Disease infestation affects the cultivation of Yams in Niger State	48 (60.00)	32 (40.00)	80
	b. interference of middle men is a factor affecting availability of Yams in Niger state.	44(55.00)	36(45.00)	80
7.	a. Insecurity affects the cultivation of Yams in Niger State	52(65.00)	28(35.00)	80
	b. varieties Yams affects the availability of yams in Niger State	48(60.00)	32(40.00)	80
8.	Labor cost affects cultivation of Yams in Niger State	48(60.00)	32(40.00)	80

Source: Field Data, 2023

Analysis:

Table 7: Chi-square Analysis of Factors Affecting Cultivation of Yams in Niger state

S/N	Questions	Yes	No	Tot.	X^2	X^2Tab(2-1)df
1.	Availability of fertilizer affects the cultivation of Yams in Niger State	53	27	80	8.45^{*s}	3.841
2.	Availability of Seedlings affects cultivation of Yams in Niger State	35	45	80	1.45^{ns}	3.841
3.	Availability of improved seedlings affects cultivation of Yams in Niger State	34	46	80	1.80^{ns}	3.841
4.	High costs of seedlings affects the cultivation of Yams in Niger State	56	24	80	12.80^{*s}	3.841
5.	Diminishing soil value(nutrients),affects the cultivation of Yams in Niger State	58	22	80	16.20^{*s}	3.841
6.	Disease infestation affects the cultivation of Yams in Niger state	48	32	80	3.20^{ns}	3.841
7.	Insecurity affects the cultivation of Yams in Niger State	52	28	80	7.20^{*s}	3.841
8.	Labor costs affects cultivation of Yams in Niger state	48	32	80	3.20^{ns}	3.841

Table 7, high cost of Yam seedlings and insecurity are amongst factors affecting the cultivation of Yams in Niger state at ($p<0.05$), thereby rejecting hypothesis 1 and 2

Table 8: Chi-square Analysis of Factors Affecting Availability of Yams in Niger State

S/N	Questions	Yes	No	Tot.	X^2	X^2Tab(2-1)df
1.	Season (climate) is a factor affecting the availability of Yams in Niger state	59	21	80	18.05^{*s}	3.841
2.	Transportation is a factor affecting availability of Yams in Niger State	41	39	80	0.05^{ns}	3.841
3.	Lack of proper storage is a factor affecting availability of yams in Niger State	53	27	80	8.45^{*s}	3.841
4.	Lack of processing into other forms is a factor affecting yam availability in Niger State	43	37	80	0.45^{*ns}	3.841

5.	Insecurity is a factor affecting the availability of Yams in Niger state	58	22	80	16.20*^{s}	3.841
6.	Interference of middle men is a factor affecting availability of Yams in Niger State	44	36	80	0.80^{ns}	3.841
7.	Varieties of Yams affects availability of Yams in Niger state	48	32	80	3.20*^{ns}	3.841

Table 8, above shows that lack of storage facility and insecurity are vital factors affecting the availability of Yams in Niger state at ($p<0.05$), thereby rejecting hypothesis 3 and 4.

Discussion

The importance of Yams as a staple food not only Niger state but in Nigeria cannot be overemphasized. It has the potentials of been a foreign exchange earner for Niger state and also other yam growing belts if its cultivation and availability is enhanced. Its formulation i.e. processing into export forms can also boost our economy if its cultivation is given priority in Niger state. From the Table of results and analysis its worthy of note that several factors affect its cultivation and availability in Niger state and in extension other Yam growing belts of Nigeria.

Table 7 shows several factors that affects the cultivation of Yams in Niger state. The result shows that high cost of seedlings is a factor affecting its cultivation as the chi-square analysis showed a significant activity, there by rejecting hypothesis one which stated otherwise at ($P<0.05$) see (Table 7) and this is in agreement with (FAO, 2012) who reported decreasing yield and low annual growth rate of yam production in Nigeria due to high cost of seedlings. Verter et al, (2015) said that Yam production is one of the most expensive and labor intensive activity in Nigeria. Although not listed in our hypothesis (IITA, 2009) reported labor cost of Yam production in the forest areas from mounding to staking approximately accounts for 40% of production costs. The findings of this study (see Table 7 and 8)), chi-square analysis showed that insecurity is a factor affecting the cultivation and availability of yams in Niger state as the result showed a significant effect ($p<0.05$) thereby rejecting hypothesis two which stated otherwise and these agrees with the findings of (Muhammad,2015), who said that escalation of insurgency, banditry, herdsmen and farmers' clashes etc. affected Yam cultivation in Gombe, Nassarawa, Niger and other states in Northern Nigeria and has caused many farmers to abandon their farms for safety reasons.(Awodola and Oboshi(2015), stated that the farmers are no longer able to produce Yams in sufficient quantities to meet the demands of the people. Several factors have also been adduced to be responsible for the availability of yams in Niger state amongst (see Table 8) and one of such is season/climate, the Chi-square analysis showed that it is a significant factor ($p<0.05$), there by rejecting hypothesis three and this finding alludes to those of (King,2004),who reported that the world's most pressing issue is climate change and that it possess a greater threat than international terrorism, and this is because the potential permanent changes that that climate change has brought to our planets geological, biological and ecological systems suggests that over the next fifty (50), years climate change pose a greater threat and strains on our agricultural systems(IPCCC,2007) in building Nigerians response to climate change,2008).Table 8, also shows that lack of processing the Yams which are produced in excess when in season is a vital factor affecting its availability in Minna and in extension Niger state as it was a significant factor ($p<0.05$),therefore stake holders involved in the cultivation of Yams should look into ways of processing into other forms to ensure its availability when not in season.

Recommendations

1. Given the impact of high cost of seedlings on Yam cultivation, the government and relevant stakeholders should consider implementing subsidies or support programs to alleviate the financial burden on farmers.

2. To address the impact of insecurity on Yam cultivation and availability, there is the need to improve and increase security in Yam growing areas in Niger State. Collaborative efforts between local communities, law enforcement, and relevant stakeholders can contribute to a safer environment for farmers.
3. Yam farmers should be educated and encouraged to adapt climate resilient farming practices to mitigate the effects of seasonal variations. This may involve promoting the use of adaptable Yam varieties and implementing strategies to cope with climate-induced challenges.
4. To enhance Yam availability, investment in proper storage facilities and processing units is essential. This will help reduce post-harvest losses and ensure a steady supply of yams throughout the year.

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INTEGRATION OF INFORMATION AND COMMUNICATION TECHNOLOGY FOR EFFECTIVE TEACHING AND LEARNING IN BASIC AND SECONDARY SCHOOLS IN NIGER STATE

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Abstract
This paper investigates how the integration of ICT tools can enhance educational outcomes and addresses the challenges faced by educators and students in utilizing these technologies in Niger state focusing schools with ICT tools and non-ICT. Through the existing literatures, the benefits and challenges associated with integrating ICT into science education especially in basic and secondary schools were enumerated. Two research questions and hypotheses were formed which guided the investigation. One of these is whether the integration of ICT affects student engagement and academic performance in basic and secondary schools in Niger State? That, the integration of ICT tools in teaching significantly improves teachers' preparedness and performance in basic and secondary schools in Niger State. Mixed-methods of surveys, interviews, and classroom observations were adopted and data were garnered from 200 teachers, 500 students and 50 school administrators across various schools in the Niger state. Purposive, stratified and simple random samplings were adopted. The results were presented in Means and standard deviations, independent sample t-tests to compare the above stated variables against those who do not have at 0.05 significance level. The Mean aggregate in schools with ICT 3.8 against non-ICT schools 3.0 revealed that ICT significantly improves student engagement, understanding, and retention of information. The paper therefore, recommended for policy makers, educators, and stakeholders to invest in ICT infrastructure, provide comprehensive training programmes for teachers, and develop strategies to ensure equitable access to technology.
Keywords: ICT, Teaching and Learning, Effective Teaching and Basic and Secondary Schools.

Introduction

The integration of Information and Communication Technology ICT in education has transformed teaching and learning processes globally. In Niger State, a region in Nigeria, the adoption of ICT in basic and secondary schools aims to enhance educational outcomes and bridge the digital divide. Despite this, challenges such as limited infrastructure and inadequate training for educators persist. The integration of Information and Communication Technology ICT into education has become a global trend, transforming traditional teaching and learning environments (Agbo, Oyelere, Suhonen and Tukiainen, 2021). ICT encompasses a range of digital technologies, including computers, the internet, and multimedia tools, which can enhance educational practices by providing new ways to engage students, deliver content, and manage educational processes (Agustin, Hanesman, Efrizon and Hidayat, 2024)

In Nigeria, and specifically in Niger State, the adoption of ICT in schools is seen as a critical step towards modernizing education and improving educational outcomes. Niger State, located in central Nigeria, is characterized by a diverse demographic with a mix of urban and rural populations. This diversity poses unique challenges and opportunities for ICT implementation in education (Ogunyemi, 2021).

Niger State, being one of Nigeria's largest states in terms of land area, faces significant challenges in educational infrastructure and resource distribution. The state's educational system includes a wide range of schools, from well-resourced urban institutions to under-equipped rural schools. The disparity between urban and rural schools in terms of resources and access to

technology is a notable issue (Aderinoye *et al*. 2017). Urban schools in Niger State generally have better access to ICT resources compared to their rural counterparts. These schools are often equipped with computers, internet access, and multimedia tools, which support interactive and technology-enhanced learning. Conversely, many rural schools struggle with limited access to ICT infrastructure, which hampers their ability to integrate technology into the curriculum effectively (Afolabi, 2022).

The Nigerian government and various educational stakeholders have recognized the importance of ICT in improving educational quality and have initiated several programs aimed at integrating technology into the classroom. These initiatives include the provision of ICT facilities, training for teachers, and the development of digital educational content (Adedeji and Fashola, 2019).
Despite these efforts, the implementation of ICT in Niger State's schools remains uneven. Factors contributing to this disparity include insufficient funding, inadequate technical support, and a lack of comprehensive training programs for teachers (Ogunyemi, 2021). As a result, the potential benefits of ICT such as enhanced student engagement, personalized learning experiences, and improved academic performance are not fully realized. Several challenges hinder the effective integration of ICT in Niger State's educational institutions Johnson et al., 2016). Many schools lack the necessary hardware and software to implement ICT effectively. Rural schools, in particular, face significant infrastructure deficits, including unreliable electricity and poor internet connectivity. Teachers often lack adequate training to use ICT tools effectively (Koumpouros, 2024). Professional development programs are either limited or not sufficiently tailored to address the specific needs of educators in different regions. There is sometimes resistance to adopting new technologies among educators and administrators (Samala, Mhlanga Bojic, Howard and Coelho, 2024). This resistance can stem from a lack of familiarity with technology, fear of change, or skepticism about the benefits of ICT. The allocation of funds for ICT in education is often inadequate, and the resources that are available may not be evenly distributed across schools (Samala *et al*. 2024.

Significance of the study
The findings will help policymakers, educational administrators, and stakeholders understand the current state of ICT in education within Niger State. By addressing the challenges identified, the study aims to inform strategies to improve ICT integration, ultimately enhancing educational quality.

An overview
The integration of Information and Communication Technology ICT into the educational system is widely recognized as a potential catalyst for enhancing teaching and learning experiences. In Niger State, Nigeria, however, the implementation of ICT in schools faces a range of systemic and contextual challenges that impede its effectiveness (Ansori, Faiza, Thamrin and Efrizon, 2024). These challenges hinder the ability to fully leverage ICT's benefits, creating disparities in educational quality between different regions and types of schools (Arora and Bhatia, 2021).

Despite the potential benefits, ICT implementation in Niger State’s schools faces significant obstacles. These include insufficient resources, lack of technical support, and varying levels of teacher preparedness. This study investigates these issues to provide insights for improving ICT integration. The problem of ICT integration in Niger State’s schools is multifaceted, involving infrastructural, educational, financial, and policy-related challenges (Afolabi, 2022). Addressing these issues requires a coordinated approach that includes improving infrastructure, providing adequate teacher training, overcoming resistance to change, ensuring equitable resource distribution, and developing clear policies for ICT integration. Without addressing these challenges, the potential benefits of ICT in enhancing educational outcomes will remain unrealized, perpetuating disparities in educational quality and access.

Objectives of the study

1. To assess the effects ICT tools on student engagement and academic performance in basic and secondary schools in Niger State.
2. To evaluate teacher preparedness and their ability to effectively use ICT tools in basic and secondary schools in Niger State.

Research questions

1. What are the effect ICT tools on student engagement and academic performance in basic and secondary schools in Niger State?
2. What is the level of teachers' preparedness and their ability to effectively use ICT tools in basic and secondary schools in Niger State?

Hypotheses

1. There is no significant difference in academic engagement and performance between students in schools with adequate ICT infrastructure and those in schools with inadequate ICT infrastructure.

2. There is no significant difference in preparedness between teachers with more ICT training hours and those with fewer training hours.

Literature review

The study is grounded in the Technology Acceptance Model (TAM), which suggests that perceived ease of use and perceived usefulness significantly influence technology adoption (Davis, 1989). This model helps in understanding teachers' acceptance of ICT tools. Studies have shown that ICT can significantly improve learning outcomes by providing interactive and engaging learning experiences. However, the effectiveness of ICT is often contingent upon the quality of implementation and support. Global trends indicate that ICT enhances educational opportunities by facilitating access to information and enabling personalized learning (Higgins et al, 2012). However, in developing regions like Niger State, the benefits are often hampered by infrastructure limitations and training gaps (Aderinoye *et al*. 2017). Challenges include inadequate ICT infrastructure, lack of ongoing teacher training, and resistance to change (Venkatesh and Bala, 2018). Opportunities lie in leveraging ICT to support innovative teaching methods and improve student engagement (Johnson *et al.* 2016).

Challenges for the implementation ICT in schools

A major problem in Niger State is the inadequate infrastructure necessary for effective ICT integration. Many schools, especially in rural areas, lack essential ICT resources such as computers, reliable internet connections, and multimedia tools (Aderinoye *et al.* 2017). The scarcity of these resources limits the ability of schools to implement technology-driven teaching methods and hinders students' access to digital learning materials. Urban schools, although better equipped, still face challenges related to maintaining and upgrading their ICT infrastructure due to budget constraints and frequent technical issues (Afolabi, 2022). Another significant issue is the lack of adequate training and support for teachers.

Many educators in Niger State have limited experience with ICT tools and digital teaching methods. The existing training programs are often insufficiently comprehensive or not well-aligned with the teachers' actual needs and contexts (Adedeji and Fashola, 2019). Without proper training, teachers struggle to integrate ICT effectively into their teaching practices, leading to underutilization of available technologies and reduced impact on student learning outcomes. (Cabero-Almenara, Romero-Tena and Palacios-Rodríguez, 2020). Resistance to change is a common barrier to ICT integration in education. Some educators and school administrators are hesitant to adopt new technologies due to a lack of familiarity, fear of the unknown, or perceived inefficacy of ICT in improving educational outcomes. This resistance

can be exacerbated by a lack of ongoing technical support and maintenance, further discouraging the use of ICT tools in classrooms (Cabero-Almenara *et al.* 2020).

Insufficient funding is a pervasive problem that affects the implementation of ICT in education. Many schools struggle with budget constraints that limit their ability to purchase, maintain, and upgrade ICT resources. Moreover, the allocation of resources is often uneven, with disparities between urban and rural schools. Rural schools frequently receive less financial support, exacerbating the digital divide and perpetuating educational inequalities (Ogunyemi, 2021). The disparity in ICT access and usage between urban and rural schools in Niger State highlights an issue of inequity. While urban schools may have better access to technology and resources, rural schools are often left behind due to infrastructural and financial limitations (Aderinoye *et al.* 2017). This inequity results in a significant gap in educational opportunities, as students in rural areas have fewer chances to benefit from digital learning tools and resources. There is often a lack of clear policy and strategic planning for ICT integration in schools.

Effective ICT implementation requires a well-defined strategy that includes goals, resources, training, and support. However, many educational institutions in Niger State lack comprehensive policies and strategies to guide ICT adoption and integration (Olaniyan and Ojo, 2020). This absence of a strategic framework results in fragmented and inconsistent implementation efforts.

Methodology

The study employs a mixed-methods approach, combining quantitative and qualitative techniques to provide a comprehensive analysis of ICT integration in schools. The population consists of all basic and secondary schools in Niger State, with a focus on both urban and rural areas. Using stratified random sampling, schools are categorized into ICT and non-ICT groups, and samples are drawn proportionately from each category. Data is collected through surveys administered to 20 teachers (15) male (5) female, 500 students and 50 school administrators across 10 schools using Likert scales to assess the perceptions of ICT resources and training. Interviews provide qualitative insights into the challenges faced. Quantitative data is analyzed using statistical software to calculate means, standard deviations, and test hypotheses with thresholds of mean 2.5 and above as acceptable but low mean, 3 point and above as high mean score while below 2.5 as reject able mean score.

Results

Demographic Data

The sample includes a representative mix of schools from ICT and non-ICT, ensuring diversity in the data collected. Key demographic details include number of schools each, teacher experience, and access to ICT resources.

Table 1: Demographic Data of the respondents

Variable	Schools	Students (Male/Female	Teachers (Male/Female)	Computers	Internet access
ICT	5	150/100	15/5	100	80%
Non-ICT	5	120/100	5/5	05	10%
Total	10	470	30	105	90%

Source: Field survey, 2024

The table 1 provides a detailed overview of demographic and resource distribution across schools in Niger State. The table includes a total of 10 schools, split evenly between ICT and non-ICT settings, with 5 in each category. Schools with ICT tools, all 5 schools are equipped

with ICT tools. This indicates that ICT schools are fully equipped with technology, whereas non-ICT schools have limited access. This reflects a significant disparity in access to technology. There are 250 students in schools with ICT and 220 students in non-ICT schools. This shows that schools with ICT tools serve a larger student population.

In schools with ICT tools, there are 150 male students, while non ICT schools have 120 male students. Schools with ICT tools have a higher number of male students compared to non ICT schools. ICT schools have 100 female students, while non ICT schools have 100 female students. There are 20 teachers in ICT schools and 10 in non ICT schools. Schools with ICT tools have a higher number of teachers, which could contribute to better educational support. ICT schools have 15 male teachers, whereas non ICT schools have 5 male teachers. This shows that schools with ICT tools also have more male teachers. Urban schools employ 25 female teachers, while non ICT schools have 5 female teachers. Schools with ICT tools have 100 computers, whereas non ICT schools have 5. This large disparity indicates a significant difference in the availability of computers. All schools with ICT have internet access, while only 10% of non ICT schools do. This highlights the lack of internet connectivity in non ICT schools compared to others.

Descriptive Statistics

Means and standard deviations are computed for survey responses, providing an overview of teachers' and students' perceptions of ICT resources and their impact.

Table 2: Impact of ICT Infrastructure on students' Academic engagement and Performance

Question	**Mean ICT**	**Std**	**Mean non ICT**	**std**	**Remark**
1. The availability of computers in my school enhances my academic performance.	4.4	0.90	4.0	0.32	**Accepted**
2. Regular use of ICT tools improves my understanding of core subjects.	4.3	0.75	4.1	0.25	**Accepted**
3. Internet access in my school helps me perform better academically.	4.0	1.00	2.5	1.01	**Accepted**
4. The computer-student ratio in my school is adequate for effective learning.	3.2	1.15	2.3	1.13	**Accepted**
5. ICT tools are regularly used in teaching core subjects in my school.	3.8	0.85	1.6	0.82	**Rejected**
6. The ICT infrastructure in my school is well-maintained and functional.	3.6	1.05	2.5	1.01	**Accepted**
7. My school provides modern and up-to-date ICT equipment.	3.4	1.20	2.8	1.10	**Accepted**
8. ICT resources are equally accessible to all students in my school.	2.6	0.95	1.6	0.33	**Rejected**
Mean Aggregate	**3.8**		**3.0**		**Accepted**

Source: Field survey, 2024

On the table 2 above, the mean aggregate of 3.8 and 3.0 suggests that students generally perceive ICT infrastructure as having a positive impact on their academic performance. This is

consistent with the global understanding that ICT, when properly implemented, enhances educational outcomes. The highest mean scores are related to the belief that regular use of ICT tools improves understanding of core subjects 4.3 and that the availability of computers enhances academic performance. This highlights the critical role that ICT plays in improving educational quality, particularly in subjects like Mathematics, Science, and English. With a mean of 4.0 and 2.5, students believe that internet access contributes to better academic performance. This underscores the importance of reliable internet connectivity in schools, enabling students to access a wide range of resources and information that can support their studies.

The mean score for the computer-student ratio 3.2 and 2.3 are indicating concerns about the adequacy of ICT resources relative to the number of students. This suggests that overcrowding or limited resources may be hindering the effective use of ICT in some schools. The responses regarding the quality 3.6 and maintenance 2.5 of ICT infrastructure suggest that while students generally find the infrastructure functional, there may be issues with outdated or poorly maintained equipment. This could affect the overall effectiveness of ICT in supporting learning. The mean score of 2.7 and 1.6 for the equal accessibility of ICT resources indicates that most students particularly non-ICT schools feel they do not have fair access to ICT tools, though there is some room for improvement. Ensuring equitable access is crucial for maximizing the benefits of ICT across different student populations.

Table 3: Teacher Preparedness and ICT usage in schools

Question	**Mean ICT**	**Std**	**Mean non ICT**	**std**	**Remark**
1. I feel confident in using ICT tools to teach my students.	4.2	0.85	3.0	0.48	**Accepted**
2. My school provides adequate ICT resources for effective teaching.	3.5	1.10	2.5	1.00	Rejected
3. The ICT training I received was sufficient to integrate ICT into my teaching.	3.8	0.95	2.6	0.83	Accepted
4. I regularly use ICT tools in my lesson plans.	4.0	0.80	1.0	0.40	Rejected
5. ICT has positively impacted my students′ learning outcomes.	4.3	0.70	3.4	0.20	Accepted
6. I find it easy to troubleshoot basic ICT issues in the classroom.	3.2	1.20	1.4	1.10	Rejected
7. I need more training to effectively use ICT in my teaching.	3.9	1.05	4.7	1.02	Accepted
8. The technical support provided for ICT in my school is sufficient.	3.4	1.15	3.2	1.13	Accepted
Mean Aggregate	**3.8**		**2.9**		**Accepted**

Source: Field survey, 2024

On the above table 3 the mean aggregate of 3.8 and 2.9 indicates that, on average, teachers feel moderately prepared to use ICT in their teaching. This suggests a generally positive attitude towards ICT integration, though there is variability depending on school. With a mean of 4.2 and 3.0, teachers express strong confidence in their ability to use ICT tools in the classroom.

This confidence is likely a result of previous training and experience, as seen in the relatively high score 3.8 and 2.6 for the sufficiency of ICT training. The highest mean response 4.3 and 3.4 are for the statement that ICT has positively impacted students' learning outcomes. This reflects a belief among teachers that ICT is effective in enhancing educational results, which aligns with global trends in education. The mean score for the adequacy of ICT resources 3.5 and 2.5 and the sufficiency of technical support are moderate. This suggests that while resources are available, there may be gaps in availability or access that could affect how effectively teachers can integrate ICT into their lessons. The mean scores 3.2 and 1.4 relates to teachers' ease in troubleshooting ICT issues, indicating a potential area of weakness. The relatively high standard deviation 1.20 and 1.10 also suggests significant variability in teachers' confidence in handling technical problems, possibly reflecting differences in access to support or training.

The mean response of 3.9 and 4.7 for the need for additional training indicates that while teachers feel somewhat prepared, there is a recognized need for further professional development. This is critical for ensuring that teachers stay up-to-date with rapidly evolving ICT tools and methodologies.

Table 4: Hypothesis 1: Independent Samples t-test on student's academic performance based on ICT infrastructure

Group	Mean Academic Performance	Std	t-value	p-value	Decision
Adequate ICT Infrastructure	4.6	6.8	0.45	0.002	Reject
Inadequate ICT Infrastructure	2.4	7.5			

On the table 4 above, the mean academic performance for students in schools with adequate ICT infrastructure 4.6 is significantly higher than for those in schools with inadequate ICT infrastructure 2.4. The p-value of 0.002 is less than 0.05, so we reject the null hypothesis, concluding that ICT infrastructure has a significant impact on academic performance.

Table 5: Hypothesis 2: Independent Samples t-test on teachers' preparedness based on ICT training hours

Group	Mean Preparedness	Std	t-value	p-value	Decision
Training Hours ≥10 hours	4.8	1.2	0.85	0.006	Reject
Training Hours <10 hours	3.4	1.5			

On the table 5 above, the mean preparedness score for teachers with more training hours 4.8 is significantly higher than those with fewer training hours 3.4. The p-value of 0.006 is less than 0.05, so we reject the null hypothesis, concluding that more ICT training hours significantly enhance teachers' preparedness for inculcating knowledge.

Key Findings

1. More ICT training hours significantly enhance teachers' preparedness for inculcating knowledge.
2. ICT infrastructure has a significant impact on academic performance.
3. ICT Resource Distribution**:** some schools have fair access to ICT tools, while some schools have limited access, with a substantial number lacking essential technology. This results in a significant gap in technological resources and access to modern educational tools in the basic and secondary schools in Niger state.

These findings underscore the urgent need to address the resource gap between schools to ensure equitable access to educational technology in basic and secondary schools in Niger state.

Conclusion

The state of ICT in education across schools in Niger State is characterized by significant disparities in infrastructure, training, and the resultant impact on student engagement and academic performance. While some schools are leveraging ICT effectively, others are struggling due to inadequate resources and insufficient teacher preparedness. To bridge this gap, it is essential to focus on improving ICT infrastructure, enhancing teacher training, and addressing the specific challenges faced by under-resourced schools. Doing so, the potential of ICT to enhance teaching and learning can be fully realized across all schools in Niger State.

Recommendations

Based on the findings, the following recommendations are offered:

1. Expand ICT Infrastructure in Rural Schools: Allocate funds specifically for improving ICT infrastructure in rural schools. This includes providing computers and internet access.
2. Enhance Internet Connectivity: Invest in improving internet infrastructure in rural areas to ensure that schools have reliable and high-speed internet access. Implement community-based Wi-Fi solutions to extend internet access to schools.
3. Professional Development for Teachers: Develop and implement training programmes to help teachers particularly in rural schools effectively use ICT tools in their teaching practices.
4. Increase Educational Resources: Ensure equitable distribution of educational resources such as textbooks, digital content, and other learning materials across all schools. Support the integration of technology into the curriculum to enhance learning outcomes and prepare students for a digital future.

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EXPLORING THE APPLICATION OF ARTIFICIAL INTELLIGENCE IN STRENGTHENING THE INTEGRITY OF SCHOOL-BASED ASSESSMENTS IN INDUSTRIAL AND TECHNOLOGY EDUCATION PROGRAMMES

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Abstract
This study aimed to explore the application of Artificial Intelligence (AI) in strengthening the integrity of school-based assessments in Industrial and Technology Education (ITE) Programmes. It employed a cross-sectional descriptive survey design. North-Central Nigeria was selected as the study region due to its concentration of higher institutions offering ITE Programmes. The population comprised 600 individuals: 300 ITE lecturers, 200 EdTech professionals specializing in AI for education, and 100 IT support staff at universities offering ITE. Using stratified random sampling, a sample of 240 participants was selected, ensuring representation from all categories within the population. Data collection was conducted through a self-developed Likert scale questionnaire containing 20 items evenly distributed between the two research questions. The instrument was validated by three experts. Cronbach's Alpha confirmed the reliability of the instrument, yielding indices of .89 and .92 for the two sections, indicating high internal consistency. Data was collected electronically via Google Forms, with a 95% response rate. Descriptive statistical methods including mean, mode, and standard deviation were used to analyze the data. The findings revealed potential AI technologies such as AI-powered proctoring tools, machine learning algorithms, and AI-based plagiarism detection tools. Implementation strategies include regular teacher training, stakeholder collaboration, infrastructure investment, establishing feedback loops, pilot testing before full-scale implementation, curriculum integration, and strategies addressing resistance to AI. Based on these findings, the study recommended that curriculum developers of ITE programmes should tailor AI tools to specific student needs and integrate them into the curriculum as well as University administrators offering ITE programmes should enter into collaborations with AI tech firms or experts to deliver effective training for ITE lecturers in using AI technologies.
Keywords: Industrial and Technology Education, School-Based Assessment, Integrity, Artificial Intelligence

Introduction

In the context of Nigeria's Technical and Vocational Education and Training (TVET) system, Industrial and Technology Education (ITE) Programmes refer to structured educational initiatives aimed at equipping students with practical skills and theoretical knowledge in diverse industrial sectors and technological disciplines. These programmes play a pivotal role in Nigeria's TVET system by promoting technical and vocational skills development, fostering local industrial growth, and contributing to national socio-economic development (Bakare et al. 2020). They aim to equip students with practical skills and knowledge needed for various industrial sectors, thereby advancing self-reliance, stimulating local industries, and reducing unemployment (Pacher et al., 2024). However, challenges in implementing these programmes, particularly concerning school-based assessments, risk hindering their effectiveness and the attainment of their objectives.

School-based assessment is a continuous process where teachers evaluate students' understanding and progress throughout the academic year. The process is central to the successful implementation of ITE Programmes. These assessments support continuous learning, ensuring that students acquire necessary skills over time (Lund & Kirk, 2019). They also offer insights into students' strengths and weaknesses, allowing for individualized instructions to improve outcomes (Dejene & Chen, 2019). However, Cotton et al. (2023) disclosed that, issues

ranging from grading inconsistencies to subjectivity and potential academic dishonesty undermine the integrity of these assessments.

The integrity of school-based assessments entails conducting evaluations in a manner that is fair, accurate, and truly reflective of a student's competence. This integrity is crucial for maintaining the credibility of qualifications awarded under such programmes, ensuring equal learning opportunities, and upholding the overall value of education (Rosli et al., 2024). The absence of such integrity could lead to flawed evaluations of student abilities, diminishing trust in the education system, and ultimately impeding the effective delivery of ITE Programmes (Zia & Khan, 2023). It could also erode trust in the education system, slowing down progress, and obstructing the effective delivery and impact of these crucial programmes on national development. Hence, to avert these consequences, there is need for innovative solutions like Artificial Intelligence technologies.

Artificial Intelligence (AI) technologies may offer a solution to counteract this pressing issue. AI involves computer systems capable of executing tasks typically requiring human intelligence, such as decision-making, pattern recognition, and learning from experience (Duan et al., 2019). Within the educational context, AI holds substantial potential for enhancing various aspects, notably the integrity of school-based assessments. AI can automate grading processes to reduce subjectivity, provide personalized feedback, and detect instances of academic dishonesty, thereby fostering a more reliable and robust assessment environment (Trunk et al., 2020). According to Aloisi (2023), given the instrumental role of school-based assessments in ITE Programmes and the prevalent challenges, it is paramount to explore how AI technologies can enhance assessment integrity. Thus, this exploration has the potential to lead to more accurate evaluations of student abilities, improved programmes delivery, and ultimately, a stronger contribution of these programmes to Nigeria's national development.

Statement of the Research Problem

In an ideal scenario, school-based assessments in the ITE Programmes would be fair, consistent, and accurately reflective of students' abilities (Venatius et al., 2023). Such assessments would provide a valid basis for evaluating students' competencies, thereby promoting deeper learning and readiness for industry demands. However, the real situation seems to contrast starkly with this ideal. Numerous challenges currently undermine the school-based assessment system in Nigeria's ITE Programmes (Ebete et al., 2020). These issues encompass inconsistent grading practices, subjectivity in marking, susceptibility to academic dishonesty, and lack of standardized assessment procedures (Kubiszyn & Borich, 2024).

Efforts have been made to address these problems; for instance, implementing standardized grading rubrics, providing invigilator training, and enforcing stringent rules against academic misconduct (Tu et al., 2020). Despite such measures, the challenges persist, pointing to the need for innovative solutions that can more effectively uphold the integrity of school-based assessments. The persistence of these challenges has serious implications. It not only jeopardizes the credibility of the assessment system but also compromises students' learning progress, their readiness for the job market, and even the overall reputation of the ITE Programmes (Chisom et al., 2023). This situation, if unaddressed, could undermine national efforts aimed at fostering self-reliance and industrial growth through technical education.

This study seeks to address these enduring problems by exploring the potential of AI (AI) technologies. Yang (2020) stress that AI offers promising solutions, as it can automate grading, provide personalized feedback, and detect academic misconduct, potentially strengthening the integrity of school-based assessments. Thus, by investigating how AI can be utilized within the context of the ITE Programmes, this study sought to contribute to improving the integrity of school-based assessments. The goal is to narrow the gap between the current situation and the ideal, thereby enhancing educational quality, boosting student outcomes, and fostering a stronger Industrial and technology workforce in Nigeria.

Aim and Objectives of the Study

The study aimed to explore the application of AI in strengthening the integrity of school-based assessments in ITE Programmes. To achieve the aim, the study sought to achieve the following objectives:

1. To identify various AI technologies that could potentially enhance the integrity of school-based assessments in the ITE Programmes.
2. To investigate strategies for applying AI technologies to strengthen the overall integrity of school-based assessments within the ITE Programmes.

Research Questions

To achieve the aim of the study, the following research questions were raised and answered:

1. What are the various AI technologies that could potentially enhance the integrity of school-based assessments in the ITE Programmes?
2. What strategies can be employed in applying AI technologies to strengthen the overall integrity of school-based assessments within the ITE Programmes?

Literature Review

School-based assessment

School-based assessment refers to assessments conducted by teachers within the school environment to evaluate students' academic achievements and practical skills as part of the learning process (Tu et al., 2020). It involves various assessment methods such as quizzes, assignments, class projects, practical examinations, and presentations designed to complement formal exams. According to Firoozi et al. (2023), school-based assessment enables educators to provide immediate feedback, which enhances students' learning experiences and encourages the development of critical thinking and problem-solving skills. Dejene and Chen (2019) assert that school-based assessment supports active learning by allowing educators to design tasks that match real-world applications and student-centered learning approaches. The inclusive nature of school-based assessment makes it adaptable to the diverse needs of learners, fostering a more comprehensive assessment system (Rosli et al., 2024).

Despite its importance, several challenges threaten the integrity of school-based assessment. Bretag et al. (2018) emphasize that academic dishonesty, such as contract cheating, unauthorized assistance, and plagiarism, undermines the credibility of assessments. Additionally, the lack of standardized evaluation criteria creates inconsistencies in grading and can affect the comparability of student results across institutions (Aloisi, 2023). Tu et al. (2020) highlight that teacher biases, either intentional or unintentional, further jeopardize the reliability of school-based assessment outcomes. These challenges necessitate urgent measures to safeguard the integrity of school-based assessment and maintain its credibility as a valuable educational assessment tool.

Integrity of school-based assessment

The integrity of school-based assessment involves ensuring that assessments are conducted in a manner that upholds fairness, authenticity, and accuracy in evaluating students' knowledge and skills (Rosli et al., 2024). Maintaining integrity is essential for building trust among educators, students, and stakeholders, as well as ensuring that assessment outcomes are credible and reliable (Aloisi, 2023). According to Dejene and Chen (2019), the presence of integrity in school-based assessment motivates learners to put in their best efforts and fosters confidence in educational assessment systems. Furthermore, Aloisi (2023) asserts that assessments conducted with high integrity are more valid and defensible in high-stakes academic and professional settings.

Strengthening the integrity of school-based assessment requires the adoption of innovative technologies such as AI. Alam (2023) emphasizes that AI can automate assessment processes, enhancing objectivity and reducing errors associated with human bias. The implementation of

machine learning techniques for detecting patterns of academic dishonesty has proven effective in combating issues such as contract cheating and plagiarism (Alsabhan, 2023). Cotton et al. (2023) argue that AI-powered proctoring systems are essential for maintaining secure assessment environments and preventing dishonest practices during remote evaluations. Moreover, AI's ability to standardize assessment processes ensures consistency and fairness, thereby reinforcing the credibility of school-based assessment outcomes (Firoozi et al., 2023). The ethical adoption of AI technologies, as outlined by Ashok et al. (2022), is critical to sustaining trust and maintaining the integrity of school-based assessment.

Artificial Intelligence

Artificial Intelligence (AI) refers to the simulation of human intelligence processes by computer systems to perform tasks such as learning, reasoning, and decision-making (Duan et al., 2019). In the education sector, AI has emerged as a transformative tool for enhancing instructional delivery, assessment, and administrative operations (Alam, 2023). AI-powered systems are capable of providing personalized learning experiences by analyzing students' learning patterns and adapting instructional content to their individual needs (Ebadi & Amini, 2022). Furthermore, Luckin and Cukurova (2019) highlight the potential of AI in automating routine tasks for educators, such as grading and attendance management, thereby increasing teaching efficiency.

AI plays a critical role in strengthening the integrity of school-based assessment and addressing its associated challenges. Alam (2023) asserts that AI can enhance the objectivity and standardization of assessments, thereby reducing inconsistencies in grading. AI-powered plagiarism detection systems are effective in identifying and preventing academic dishonesty, ensuring the authenticity of student submissions (Alsabhan, 2023). Cotton et al. (2023) emphasize that intelligent proctoring systems powered by AI can monitor students during assessments, minimizing cheating opportunities and safeguarding assessment security. Moreover, Firoozi et al. (2023) argue that AI's ability to provide instant feedback and identify learning gaps contributes to the accuracy and reliability of assessments. Ethical considerations, as outlined by Ashok et al. (2022), are essential for guiding the responsible adoption of AI in educational settings to ensure transparency and trustworthiness in assessment practices.

Research Methodology

The study employed a cross-sectional descriptive survey research design. Cross-sectional designs collect data at a specific point in time from different groups, which allows for comparisons and conclusions to be drawn (Spector, 2019). This design was suitable because it allowed for an understanding of the assessment of AI technologies and implementation strategies for strengthening the integrity of assessment in ITE Programmes. North-Central, Nigeria was selected as the area of study. This region was identified due to its concentration of higher institutions offering ITE Programmes (Auta, 2017), making it an appropriate setting to explore AI use in school-based assessments. The population consisted of 600 individuals, divided among three groups: 300 ITE lecturers, 200 EdTech professionals specializing in AI for education, and 100 IT support staff at universities offering ITE Programmes. These groups were selected due to their direct involvement with AI technologies in educational contexts (Ebadi & Amini, 2022).

A stratified random sampling technique was used to select a sample of 240 participants, ensuring representation from all categories within the population (Obilor, 2023). The sample size was justified as it represented 40% of the population, which is within the acceptable range for such studies. A self-developed Likert scale questionnaire, consisting of 20 items divided equally between the two research questions, was used for data collection. The Likert scale is a useful tool for capturing attitudes or opinions and allows for straightforward analysis (Alabi & Jelili, 2023). The instrument was validated by three experts including an ITE lecturer, an EdTech

professional specializing in AI for education, and an IT support staff member. Their expert validation ensured content relevance, clarity, and comprehensiveness (Colquitt et al., 2019).

The reliability of the instrument was confirmed using Cronbach's Alpha, which yielded indices of .89 and .92 for the two sections. This method is widely accepted for evaluating internal consistency and these scores indicate high reliability (Izah et al., 2023). Data was collected electronically using Google Forms. This method was selected due to its proven efficiency, speed of data gathering, and relative ease in management of collected data (Hair Jr et al., 2019). However, 229 out of the 240 questionnaire was filled, indicating 95% response rate. Descriptive statistics (mean and standard deviation) were used to address the research questions. A mean score of 3.50 and above indicated agreement with the statement, while a mean below 3.50 signified disagreement (Weir & Vincent, 2020). These statistical methods allow for a detailed exploration and confirmation of variables (Weir & Vincent, 2020).

Results

Research Question 1: What are the various AI technologies that could potentially enhance the integrity of school-based assessments in the ITE Programmes? Results for answering research question one is contained in Table 1.

Table 1: Mean and standard deviation for the responses of respondents on the various AI technologies that could potentially enhance the integrity of school-based assessments in the ITE Programmes

S/N	AI Technologies	Mean	SD	Remark
1	AI-powered proctoring tools enhance the integrity of online assessments.	4.30	.78	Agreed
2	Machine Learning algorithms are effective in detecting cheating patterns in assessments.	4.32	.76	Agreed
3	AI-based plagiarism detection tools significantly reduce instances of academic dishonesty.	4.38	.80	Agreed
4	Natural Language Processing (NLP) tools accurately grade open-ended responses in assessments.	4.30	.78	Agreed
5	AI-protected databases securely store sensitive assessment information.	4.30	.79	Agreed
6	Automated scoring systems using AI provide reliable and timely results.	4.44	.80	Agreed
7	AI predictive analyses help identify areas of concern in assessments.	4.31	.75	Agreed
8	Intelligent tutoring systems provide personalized learning experiences, improving preparation for assessments.	4.40	.77	Agreed
9	AI speech recognition tools improve the accessibility and inclusivity of assessments.	4.22	.91	Agreed
10	AI adaptive learning systems effectively tailor content delivery, enhancing comprehension and performance in assessments.	4.37	.79	Agreed

Table 1 displays participant responses to various AI technologies that could potentially enhance the integrity of school-based assessments in the Industrial and Technology Education Programmes. The mean values range from 4.22 to 4.44, signifying high concurrence among respondents. Standard deviation ranges from 0.75 to 0.91, suggesting that responses were closely clustered around the means. Therefore, all listed AI technologies were agreed upon by respondents as beneficial in enhancing the integrity of assessments.

Research Question 2: What strategies can be employed in applying AI technologies to strengthen the overall integrity of school-based assessments within the ITE Programmes? Table 2 contains results for answering research question two.

Table 2: Mean and standard deviation for the responses of respondents on the strategies in applying AI technologies to strengthen the overall integrity of school-based assessments within the ITE Programmes

S/N	Strategies to Apply AI Technologies	Mean	SD	Remark
1	Regular training for teachers on AI usage in assessment is effective.	4.26	.85	Agreed
2	Collaborative efforts among stakeholders can successfully establish AI implementation guidelines.	4.33	.79	Agreed
3	Infrastructure investment in AI hardware and software is beneficial.	4.33	.87	Agreed
4	Addressing ethical considerations linked to AI use is crucial for successful implementation.	4.30	.86	Agreed
5	Establishing regular feedback loops involving teachers, students, and AI providers improves the system.	4.23	.84	Agreed
6	Partnerships with AI tech firms help keep the technology updated.	4.40	.84	Agreed
7	Resilience of AI systems is essential to guard against technical failures during assessments.	4.30	.78	Agreed
8	Pilot testing before full-scale AI implementation can identify potential issues.	4.43	.80	Agreed
9	Integrating AI usage into curriculum and teaching methodologies enhances learning outcomes.	4.20	.98	Agreed
10	Strategies addressing potential resistance from teachers or students towards AI implementation are necessary.	4.40	.88	Agreed

Table 2 presents respondents' views on various strategies that can be employed to apply AI technologies to strengthen the overall integrity of school-based assessments within the ITE Programmes. Mean scores range from 4.20 to 4.43, showing high consensus among respondents. Standard deviations range from 0.78 to 0.98, suggesting that respondent reactions were tightly grouped around the means. Thus, all listed strategies were agreed upon by respondents as effective approaches for implementing AI to enhance assessment integrity.

Findings

1. AI technologies such as AI-powered proctoring tools, machine learning algorithms for detecting cheating, plagiarism detection tools, and natural language processing for grading were found to be effective in enhancing the integrity of school-based assessments in the ITE Programmes. Other notable technologies included AI-protected databases, automated scoring systems, and intelligent tutoring systems, all contributing to improved assessment reliability and accessibility.
2. Strategies to apply AI to strengthen the integrity of assessments included regular training for teachers, collaborative efforts to establish AI guidelines, and infrastructure investments. Other strategies involved addressing ethical considerations, forming partnerships with AI firms, conducting pilot testing, and integrating AI into curricula to ensure smooth and effective implementation.

Discussion of Findings

The study's findings indicate the significant potential of various AI technologies including AI-powered proctoring tools, machine learning algorithms for detecting cheating, AI-based plagiarism detection tools, Natural Language Processing (NLP) tools for grading, AI-protected databases, automated scoring systems, AI predictive analyses, intelligent tutoring systems, AI speech recognition tools, and AI adaptive learning systems to enhance the integrity of school-based assessments in the ITE Programmes. In accordance with these findings, several studies have highlighted the role of AI technologies in improving assessment processes. For instance, intelligent proctoring tools have been recognized as effective mechanisms for preventing academic misconduct during online exams (Lee & Fanguy, 2022). Similarly, machine learning algorithms are increasingly being leveraged to detect anomalous patterns that may indicate cheating (Alsabhan, 2023).

Plagiarism detection has also been significantly enhanced by AI technologies, aligning with the findings of this study (Bretag et al., 2018). This study also echoes the growing body of research illustrating the effectiveness of NLP tools in accurately grading open-ended responses (Wilson et al., 2022), along with the use of automated scoring systems that provide reliable and timely results (Firoozi et al., 2023). Furthermore, the significance of AI predictive analyses, intelligent tutoring systems, AI speech recognition tools, and AI adaptive learning systems in enhancing educational outcomes is well-documented in literature (Alam, 2023). The implications of these findings are profound. They suggest there are numerous AI technologies that can be harnessed to improve the integrity and efficiency of school-based assessments. Yet, their successful implementation will require concerted effort in addressing related ethical, practical, and technical challenges.

Furthermore, the study also highlights a variety of strategies for enhancing the integrity of school-based assessments in the ITE Programmes through the implementation of AI (AI) technologies. First of these strategies is regular teacher training. This finding aligns with Fakhar et al.'s (2024) emphasis on the importance of continuous professional development for teachers to effectively use AI technologies. Another critical strategy is stakeholder collaboration. Luckin and Cukurova (2019) also identified this as a key component for successfully integrating AI into educational settings, as it involves the active participation of not only teachers, but also students, administrators, parents, and other community members. A third strategy is investing in infrastructure. Shwedeh's (2024) research underscores how important having robust infrastructure is for the successful implementation and use of AI technologies in an educational context.

Furthermore, addressing ethical considerations is another imperative strategy when implementing AI technologies. Ashok et al. (2022) has highlighted similar concerns, emphasizing the need to address issues related to data privacy and fairness. Next, the strategy of establishing feedback loops is crucial. Valencia's et al. (2023) research supports this, suggesting that mechanisms for regular feedback improve the integration and usefulness of AI technologies. Additionally, partnerships with AI tech firms can be beneficial. Fakhar et al. (2024) found that such collaborations provide invaluable resources and technical expertise, facilitating successful AI adoption. Ensuring system resilience is also essential. Ashok et al. (2022) stresses this point, explaining that robust systems provide protection against data breaches and ensure overall system stability.

Finally, the study reveals two additional strategies: pilot testing before full-scale implementation and addressing resistance to AI. These findings correspond with those of Luckin and Cukurova (2019) and Fakhar et al. (2024), respectively. Luckin and Cukurova suggests that running pilot tests can help identify potential challenges and make necessary adjustments before a full-scale deployment, while Fakhar et al. emphasizes the need to manage resistance to change for successful technology integration. These findings are significant as they provide a comprehensive plan for integrating AI into educational assessments, considering both technical requirements and human factors. This could lead to improved assessment integrity, more personalized learning, increased digital competency, and better handling of ethical challenges.

Conclusion

The study demonstrates that applying AI technologies can significantly strengthen the integrity of school-based assessments in the ITE Programmes. Several AI tools were identified as beneficial, including AI-powered proctoring tools, machine learning algorithms for detecting cheating, AI-based plagiarism detection tools, Natural Language Processing tools for grading, AI-protected databases, automated scoring systems, AI predictive analyses, intelligent tutoring systems, AI speech recognition tools, and AI adaptive learning systems. Moreover, the study outlined comprehensive strategies for effective implementation of these AI technologies. These include regular teacher training, stakeholder collaboration, infrastructure investment, addressing

ethical considerations, establishing feedback loops, partnerships with AI tech firms, ensuring system resilience, pilot testing, and curriculum integration. This comprehensive approach combining potent AI tools with strategic implementation offers a promising pathway toward enhancing assessment integrity in the ITE Programmes. It reveals the potential of AI in reshaping educational assessments while highlighting the importance of a mindful, deliberate, and inclusive approach towards its integration. In conclusion, the findings of this study open up new avenues for research and action, setting a valuable precedent for similar initiatives aiming to integrate AI in education.

Recommendations

Based on the findings from the study, the following recommendations were made:

1. Curriculum Developers of ITE Programmes should integrate AI tools into the curriculum, tailoring them to specific student needs.
2. The Administrators of Universities offering ITE Programmes should collaborate with AI tech firms or experts for training ITE lecturers in using AI technologies to leverage these tools effectively.

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Exploring Identity and Sustainability: Yinka Shonibare's Art as a Catalyst for Promoting Contemporary Art in Nigeria

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Abstract
This study investigates the sculptural artworks of Yinka Shonibare, a British-Nigerian artist known for his exploration of themes related to colonialism, race, identity, and the complexities of cultural hybridity. The research also seeks to examine and deepen our understandings of his sculptural works, particularly those involving clothing. Some of his outstanding works were taken and analyzed for better understanding. Some artists, authors and scholars whose works or writings could serve as useful references for researching Shonibare's arts were consulted. These artists and scholars have aided this study by providing firsthand information with a range of theoretical, historical, and cultural frameworks that help the research to explore the depth and complexity of Yinka Shonibare's artworks, particularly in relation to post-colonialism, identity, and cultural hybridity. For more on specific exploration of the artist works, Nigerian and African scholars, art critics, and curators, are additional authors who have directly or indirectly engaged with Yinka Shonibare's artwork or whose work connects to the themes they explore, such as post-colonialism, identity, and the African diaspora. These scholars from Nigeria and Africa at large bring critical perspectives on African art, colonialism, and identity that resonate with the themes in Yinka Shonibare's artworks. Their literatures and curatorial contributions help to contextualize Shonibare use of African and diaspora symbols, his engagement with post-colonial histories, make his works to be historic and famous.
Keywords: Exploration, Identity, Sustainability, Colonial, Contextual

Introduction

Background of the Study

In Nigeria, the visual art scene has seen a notable transition from the use of conventional sculptural materials, such as wood, clay, and metal, to more unconventional and innovative materials, including textiles, plastics, and recycled objects. To buttress the above statement, in an interview with Saliu in (2023) said that "this trend reflects the global shift towards sustainability, as well as the increasing importance of mixed media and the creative reuse of discarded materials". Similarly, Muhammad (2023) concluded that "…artists continue to experiment with new materials as they create works that are not only addressing traditional tastes, but also reflects on contemporary issues, such as environmental degradation, cultural identity, and global interconnectedness.

Yinka Shonibare, a Nigerian-born artist in the diaspora, stands as one of the most prominent figures who blends traditional Nigerian heritage with global artistic influences. In Vanguard (2011), reported that "Shonibare is renowned for using brightly patterned Dutch wax fabrics in his sculptures, installations, and performances". This fabric, though associated with African culture, actually has its origins in colonial trade, symbolizing the complex intersection of African identity, history, and globalization. Similarly, The Daily Telegraph (2015) has it that Shonibare's work critically explores issues of colonialism, race, and identity while embracing the possibilities offered by contemporary materials and mixed media.

In another development, Sani (2010) opined that the use of textile fabric as a medium in Shonibare's sculptures marks a significant development in Nigerian contemporary art. The artist's choice of textile materials not only reflects Nigerian heritage but also opens up new

possibilities for artistic expression within the context of global art movements. Shonibare's works challenge traditional notions of sculpture, inviting viewers to reconsider the relationship between culture, history, and materiality (Wilson, 2003). Shonibare's innovates within the medium of sculpture, creating complex, thought-provoking works that invite discussions about identity, culture, and the role of the artist in a globalized world is worth for examining.

This study aims to explore the use of textile fabric materials in Shonibare's sculptures, focusing on how such materials contribute to the conceptual depth and formal aesthetics of his work. By investigating Shonibare's use of mixed media, this research highlights the intersection of Nigerian heritage and global influences in contemporary art.

Statement of the Problem

One significant aspect of Nigerian modern art is the use of innovative materials in sculpture, with the incorporation of unconventional materials. The practice of using improvisation in sculpture can be traced back to the early stages of contemporary Nigerian art, yet this approach has received limited documentation and critical examination. There is a gap in the academic and artistic literature concerning the use of unconventional materials in Nigerian sculptures.

The use of fabrics in sculptures has not been comprehensively explored or documented in existing scholarship. Hence, this study seeks to address this gap by examining how textile fabric is been utilized in Shonibare's sculptures.

Objective of the study

The primary objective of this study is to explore the use of textile fabric in the sculptures of Yinka Shonibare. While, the specific objectives are to:

1. identify the types of textiles used, the methods of incorporating these materials, and its role in the overall composition of his works.
2. analyze the cultural and symbolic meanings of textile fabric in Shonibare's sculptures. It will expose how Shonibare use fabric to convey identity, globalization, and post-colonialism.
3. expose the creativeness and skills of manipulating textiles in Shonibare's sculptures.

Literature Review

Comprehensive literature review was conducted to contextualize the study within existing research on Shonibare. The review is also on the use of textiles in Nigerian contemporary art, especially in relation to the post-colonial era, culture, and globalization.

All consulted scholars and materials that positioning Shonibare's work within a larger context of Nigerian and global art were acknowledged. Among them, are Mensah (2011), Charlie (2014), Saliu (2023), Duniya (2023), and Sani (2024).

Conceptual Framework

The conceptual framework for this study, grounded on the intersection of materiality, identity and post-colonial discourse within the context of contemporary art. As propound by Ocvirk, Bone, Stinson, & Wigg (1998), their frameworks guided the researcher on how to interrogate the artist's sculptural works.

The use of textiles, specifically African wax prints, in Shonibare's sculptures challenge conventional views of sculpture and materiality, which traditionally focused on solid, hard materials like metal, wood, and stone. Gordon (2013) argued that materials in modern art carry significant meanings, often reflecting the social, political, and cultural forces of the time.

Methodology

This study has employed qualitative research of approach focusing on investigation of Yinka Shonibare's sculptures incorporate with textile fabrics. This approach is appropriate due to the nature of the research, which aims to explore the symbolic, cultural, and material implications of

his cladded works. The study has employed several interconnected methods, such as art analysis, literature review, interviews, and case studies. These methods will provide a comprehensive understanding of the use of textile materials in Shonibare's sculptures and their broader implications for Nigerian art.

The analysis has guided by the framework of material culture theory, Gordon (2013), which examines the relationship between physical objects and the cultural meanings. Through art analysis, the study aims to understand how textiles in Shonibare's work function for both aesthetic and symbols of socio-political narratives.

Interviews and Expert Insights

The study sought to get first-hand information, although, it was difficult to directly interview Shonibare, therefore, secondary interviews were conducted to establish comprehensive data. Again, scholars who have studied used unconventional materials, provide an insight into the use of textiles. Such as Prof. Jari Jat Jacob and Prof. Lasisi Lamidi are both artists who have used textile materials in their efforts.

Oral tradition was conducted to the following art connoisseurs in the field of visual art, Professor of Art History; Prof. Emeritus Ahmed Rufai Saliu, and a Professor of Art and Cultural Critics; Prof. Gambo Gilis Duniya and a Professor of Art History; Prof. Muhammad Aliyu. From the Department of Fine Art, Ahmadu Bello University, Zaria.

Findings:

A brief historical background of the Artist:

The Artist, Yinka Shonibare Member of British Empire **(MBE)** is a British-Nigerian contemporary artist known for his sculptural installations that explore issues of Post-colonialism. Gayford (2010) reported that Yinka Shonibare was born on 10th February, 1962 in London, United Kingdom. He grew up in Lagos, Nigeria, but returned to England throughout his childhood. He artist attended Byam Shaw College of Art in London, and later received his Master of Fine Art (MFA) degree from Goldsmiths in 1991.

Robert (2023) reported that in 2005, he was honoured with a Member of the Order of the British Empire (MBE), a moniker continues to officially attach to his name. In another development, he was awarded and decorated with the Commander of the Order of the British Empire (CBE) in 2019. In another development, Gayford (2010) stated that Yinka Shonibare received the Whitechapel Gallery Art Icon Award in March 2021 he is the 8th recipient of such award. The award celebrates artists who have made significant contributions to a particular medium. Disability Arts Online (2012) recounted that at the age of 17 years Shonibare came down with transverse myelitis a disorder caused by inflammation of spinal cord. The illness resulted in a long-term physical disability where one side of his body was paralyzed that made him to be on a wheel chair. Despite of his disability, he still produces sculpture pieces with the help of his assistance.

The Artist: Yinka Shonibare Member of British Empire (MBE)

Photography: David Lindsay, 2003.
According to Graford (2010) in 2015, Shonibare's work was the subject of the inaugural contemporary exhibition program at the Driehaus Museum in Chicago, United States of America (USA). Shonibare continues to live and work in London, United Kingdom. Today, his works are held in the collections of the National Gallery of Art in Washington, D.C., the Victoria and Albert Museum in London, and the Walker Art Centre in Minneapolis, among others.

Some of exhibitions he held are his first solo exhibition in 1989 at Byam Shaw Gallery, London. During 2008–09, he was the subject of a major mid-career survey in both Australia. Another, one was in September, 2008 at the Museum of Contemporary Art Australia (MCA), Sydney, and toured to the Brooklyn Museum, New York, in June 2009. He staged another at the Museum of African Art at the Smithsonian Institution, Washington DC, in October 2009. For the 2009 Brooklyn Museum exhibition, he created a site-specific installation titled "Mother and Father Worked Hard So I Can Play," which was on view in several museum displayed rooms. One of the group exhibitions was at the Centennial commission, which was simultaneously on view at the Newark Museum in Newark, New Jersey, from 1 July 2009, to 3 January 2010, in the dining-room of the museum's Ballantine House. Some of his installation works exhibited are; "Party Time", "Re-Imagine America" among others.

The Analysis of Some Selected Yinka Shonibare's Artworks
Shonibare's artwork is marked by his use of vibrant textiles, which play a crucial role in conveying messages about colonialism, identity, and post-colonial narratives. Five (5) of his artworks were chosen for the purpose for analysis.
The first work to be analyzed is titled "Justice for All" is a standing female figure dressed in full regalia. The head of the figure is suggested by a round object, which is embellished with a world map, symbolizing that justice should be universal. The figure holds a knife pointing skyward in her right hand and a scale in her left hand, representing the formal nature of justice, the work was done in 2019. This piece of work was created using Shonibare's signature approach, employing mannequins dressed in brightly colored Ankara fabric. The figure's hands and neck are painted ultramarine blue, emphasizing the strength and power of justice. The gown, dominated by pink hues with yellow ochre flowers, black lines, and a flowing design, covers the figure's feet. These vibrant patterns represent Shonibare's creative ingenuity in using textile fabric materials. The artwork addresses themes of injustice, colonialism, and political and economic struggles, as it explores the complex interrelationship between Africa and Europe, particularly their historical and economic histories.

Plate I: "Justice for All", Size: 2400cm x 2000cm, Year: 2019.
Source: Stephen Friedman Gallery, London.

The researcher observed as reported by Kaiser (2003) that Shonibare's primary material is batik, which he started using in 1994. Furthermore, the author stressed that the artist chooses bright

colours of "African fabric" led the artist to later incorporate Dutch wax-printed cotton, which he source from Brixton market in London.
The next work to be analyzed is titled "Headless Man" is a life-size sculpture of a male figure dressed in a combination of African and European styles. The fabric made of coat is a pure African fabric (Ankara), which give the viewers the feelings of appropriateness of the giant work. The figure is headless, symbolizing the loss of identity and the removal of African leaders during the colonial era. The headless mannequins figure with Batik or Ankara textiles, instead of European fabrics which, represent the double faces played by the Europeans. Another opinion by (Stamberg, 2009) said, alternatively, the artist uses this fabric when depicting European art and fashion to portray a 'culture clash' and a theme of cultural interaction within post-colonialism.

Plate II: Title: "Headless Man Trying to Drink" Size: Life-size, Year: 2005
Source: National Museum of African Art.

The figure's body is draped in African Ankara cloth designed in a Western style, as a commentary on the cultural and political imbalances imposed during the colonial period which within the ambit of the Europeans. Yinka Shonibare has created headless figures, examples of such works are "Mr. and Mrs. Andrews" in 1998, "Reverend on Ice" produced in 2005, also was a piece titled "Reverend Robert Walker," on roller-skating at Duddingston Loch.

This sculpture presents an incongruous situation of a man who is headless trying to drink from a water fountain. The absurdity of this scenario is reinforced by the patterning of the man's costume, which features the doubled motif of an abundantly flowing tap and water glass. His elegantly tailored late Victorian costume suggests he is gentleman of colourful taste. Jaunty red trousers and green bows on his patent leather shoes lend a foppish note to the figure.
The use of army green colour fabric on the figure's coat and shoes, and the green colour on the supporting stand, possibly signifies the dominance and exploitation of African resources by European collaborators and powers. The "Headless Man" serves as a visual representation of colonialism's dehumanizing effects.

The next work is titled "Untitled", done in 2010 and the figure is holding the umbrella with both hands, positioned as if shielding the blowing wind from the environment. The figure's head is represented by a round object, symbolizing that the world is economically and socially in trouble.

Plate III: Name: "Untitled," Size: Life-Size Year: 2010
Source: National Museum of African Art.

The figure is dressed in a vibrant orange and purple cultured pattern jacket, and the trousers are a combination of light-green, purple, and chocolate shades colours. The boots on its legs made of synthetic maroon colour leather, shining and the reflection suggest the high quality of the boots. Also on the main ground it gives the feeling of a wet ground that symbolizes the effects of climate change on the entire environment. As the figure remain in a straggling position.
The use of textiles in this piece, like the other works, highlights Shonibare's exploration of post-colonialism and globalism. The hybrid identity embodied in the figure's attire speaks to the cultural intersections and displacements experienced in a modern world influenced by both Western and African legacies.
The work to be analysed is a 14 seated figures were made out of fiberglass, clothed with African and Dutch made Ankara. The mannequin figures captured the scene the Europeans deliberating on strategies on Africa. The title is "Scramble for Africa" it was executed in 2003. It was a pivotal work for Shonibare in its exploration of late Victorian England and its territorial expansion into Africa during the 1880s. The "scramble" for Africa by leading European and world powers resulted in the carving up of the continent, an act that was formalized at the Berlin Conference of 1884-85 as suggested by (Sheila, 2012). Shonibare's work depicts this historic gathering, showing various statesmen huddled around a table with a large map of Africa, eagerly staking their claims.

Plate IV: Title: "Scramble for Africa" Size: Life-size, Year: 2003
Source: The Pinnell Collection, Dallas, USA.

"Scramble for Africa" is presented upon a raised platform that is lit from underneath, giving it a heightened sense of visual drama. Like actors upon a stage, the headless leaders gesticulate to one another as they scramble for the riches of the continent. Shonibare said the theatricality is

certainly a device in my work, it is a way of setting the stage; it is also a fiction a hyper-real, theatrical device that enables you to re-imagine events from history.
Shonibare's installation art has a unique ability to provoke conversation around race, identity, and the lingering effects of colonialism. His work encourages a re-examination of historical narratives and their impact on contemporary society.

Yinka Shonibare's installation arts are in series, he titled them "Wind Sculptures" and most of them are nearly 20 feet high, the sculpture captures the movement of a billowing bolt of fabric. The design was inspired by the sails of ships whose patterns derived from Dutch wax fabrics. The artist chooses these iconic fabrics to exemplify how signs of national or ethnic identity are culturally constructed, this famous and beautiful work was executed in 2014.

Plate V: Name: "Wind Sculpture," Size: 610 × 80 cm, Year: 2014
Source: Nathan Keay, MCA Chicago

Yinka Shonibare's installations serve as rich, multi-layered critiques of history, identity, and power, using vibrant aesthetics to convey complex messages. His works engage with global themes, transforming how viewers think about history, race, and the ways in which cultures interact.

Conclusion
Conclusively, Shonibare's works demonstrate the artist's innovative approach to blending textile fabrics with sculptural forms, creating a compelling visual dialogue about colonialism, identity, and power. The research emphasizes the importance of recycling in art, elevating unwanted materials to new heights of creative and artistic expression. Shonibare's use of fabric in his sculptures provides a critical commentary on historical injustices while simultaneously offering a platform for artistic development in Nigeria's contemporary art scene.

Recommendations
Based on the findings, the following recommendations were proffered:

- Institutions should organize workshops to showcase his works through slides shows.
- Shonibare's other works; painting, photography, and film should be researched upon.
- Government institutions to create centers for younger artists to be trained his skills in art.

Contributions to Knowledge:
This study contributes significantly to the body of knowledge in the followings:

- It has exposed a British-Nigerian sculptor, into the space of contemporary Nigerian art.
- It has showed that the use of fabric off-cuts is easily accessible and inexpensive.
- Recycling is an innovation and experimentation, allowing artist(s) to develop new ideas.

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PERCEPTION OF STUDENTS AND LECTURERS ON THE ROLE OF INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) IN THE TEACHING AND LEANING OF ECONOMICS IN NIGER STATE COLLEGE OF EDUCATION, MINNA.

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Abstract
This paper examined Perception of Students and Lecturers on the Role of ICT in the Teaching and Leaning of Economics in College of Education, Minna: A Roadmap for Sustainable Development. A cross-sectional survey design was adopted. This study was guided byone research question with corresponding objective and hypothesis. The instrument for data collection was a researcher-developed questionnaire titled "Students' Perception of the Role of ICT in Teaching and Learning Economics Questionnaire (SPRTLEQ)." A simple random technique was employed to select 354 samples from the targeted population of 733. The instruments underwent content and criterion validity checks by two experts from the Economics and English Departments at the College of Education, Minna. Their suggestions were used in selecting the items. The test-retest method was used, and the reliability index of the instrument was 0.76, calculated using Cronbach's alpha. The collected data were analysed using the Pearson Correlation Coefficient approach for the null hypothesis at a 0.75 level of significance. The findings signify that the use of ICT enhances students' academic performance in teaching and learning of economics. Based on the findings, recommendations include incorporating ICT into tertiary education syllabi by curriculum designers to prepare students for the digital age.
Keywords: Students, Lecturers, Information and Communication Technology (ICT), teaching and Learning.

Introduction

The concept of Information and Communication Technology (ICT) encompasses a broad range of technologies, including hardware, software, networks, and media, all aimed at storing, retrieving, manipulating, transmitting, and receiving information in digital form (World Bank, 2002). According to UNESCO, ICT is defined as a discipline that utilizes scientific and management techniques in information handling, employing various technologies for efficient information processing, communication, and task performance (Ratheeswari, 2018; Pedagoo, 2020). The integration of ICT in education has brought about transformative changes, offering benefits such as enhanced engagement, access to educational resources, collaborative learning experiences, personalized learning platforms, streamlined assessments, and preparation for the digital workforce (Johnson et al., 2016; Anderson & Ronnkvist, 2019; Westera et al., 2018; Gulbahar and Madran, 2009; Voogt et al., 2013).

The ICT revolution in education has led to explicit changes in instructional methods and research, accelerating and extending educational reforms (Davis & Tearle,1999). The influence of ICT on teaching and learning is profound, motivating and engaging learners, supporting schools in understanding financial and operational practices, and preparing students for the increasingly technology-reliant real world (Ashley, 2016; Smith and Anderson, 2021). The types of ICTs used in education range from traditional tools like radio and television to modern approaches such as e-learning and blended learning, combining traditional methods with online resources (Hughes, 2005; Ismail, 2015; Bello et al., 2017). The impact of ICTs on student learning and academic achievements is significant, with potential benefits ranging from a shift towards student-cantered approaches to improved achievement in specific subjects like economics through methods like Computer-Aided Instruction (CAI) and integrative computer-

assisted learning (Mukama and Anderson, 2008; Hockly, 2013). The successful incorporation of ICT tools in education requires thoughtful alignment with pedagogical strategies to enhance learning outcomes, emphasizing active student participation and knowledge construction (Bates, 2015; Voogt et al., 2013).

The integration of Information and Communication Technology (ICT) in education offers numerous benefits, enhancing students' cognitive abilities, expanding access, and improving learning quality. However, successful implementation in teaching Economics at Nigerian tertiary institutions faces challenges such as inadequate ICT infrastructure and lecturers' competence. Despite government efforts, the effectiveness of policies remains a challenge. This study aims to evaluate the impact of ICT in teaching and learning at Niger State College of Education, Minna, from the perspectives of lecturers and students.

Objective of the Study

The study sought to:

1. Examine lecturers' and students' perceptions of ICT utilization for teaching and learning in Niger State College of Education, Minna.

Research Question

The following research question guides the study:

1. What are lecturers' and students' perceptions of the extent of ICT utilization for teaching and learning in Niger State College of Education, Minna?

Research Hypothesis

The study was guided by the following null hypothesis:

1. H_{01}: There is no significant difference between lecturers' and students' perceptions of ICT utilization for teaching and learning in Niger State College of Education, Minna.

Scope of Study

The study aims to determine the perceptions of lecturers and students in Niger State College of Education, Minna, regarding the impact of ICT usage in the teaching and learning of economics. Due to the paucity of funds and time constraints, the study is limited to students and lecturers in the Department of Economics, School of Arts and Social Sciences and does not cover other departments and schools within the college.

Significance of the Study

The study's findings will benefit the Department of Economics, administrators, government officials, ICT experts, and students, offering insights into the utilization of ICT in teaching and addressing its challenges and barriers. Additionally, the findings will encourage stakeholders to embrace ICT-based teaching in tertiary education, aiding policy and investment decisions.

Literature Review

Conceptual Clarification

Concept of ICT

Gwani (2024) ICT stands for Information and Communication Technology. It refers to the broad range of technologies and tools used to handle, store, transmit, and process information digitally. ICT encompasses both hardware and software components, as well as the networks and systems that enable the flow of information. It includes technologies such as computers, smartphones, tablets, the internet, telecommunications, software applications, digital media, and more. Virmani (2024) ICT (Information and Communications Technology) encompasses tools and services that handle and communicate information, ranging from mobile phones to interactive whiteboards. Information and communication technology, or ICT , is defined as the combination of informatics technology with other, related technologies, specifically communication technology.

Concept of ICT in Education

ICT in education refers to the use of various technology tools and resources to aid and enhance the teaching and learning process. According to Brown (2023), ICT covers computers, laptops, tablets, interactive whiteboards, instructional software, online platforms, internet access, and multimedia content, all of which optimize learning experiences for students and improve the efficiency of teaching methods. ICT plays a key role in obtaining, processing, storing, and displaying data while facilitating cooperation and communication among learners and educators. It involves digital tools that promote information interchange, including computers, digital TV, email, and robotics. ICT also integrates informatics with communication technologies to promote digital engagement and increase knowledge dissemination. The value of ICT in education extends beyond convenience—it promotes access to substantial instructional materials, engages many senses for successful learning, and adds variation in pedagogical approaches to alleviate monotony (Prabhu, 2020). Furthermore, UNESCO (2021) highlights that ICT aids inclusive education by bridging the digital gap and providing flexible learning options, particularly for underprivileged populations and students in remote places. Similarly, Anderson and Dexter (2019) believe that ICT stimulates critical thinking, problem-solving, and creativity by enabling interactive and student-cantered learning settings. Moreover, ICT supports in evaluation and feedback systems, allowing educators to track students' progress effectively and tailor educational tactics (Al-Fadhli, 2022). With the increasing acceptance of ICT in classrooms globally, it is obvious that digital technology serves as a catalyst for revolutionizing education, making it more dynamic, accessible, and effective

Concept of Teaching

Teaching is the process of facilitating learning by imparting knowledge, skills, and values to students through various methods, such as instruction, guidance, and demonstration. It involves a teacher or instructor who creates an environment conducive to learning and helps students achieve specific educational goals (Ornstein & Hunkins, 2018). Teaching is aimed not only at transferring knowledge but also at encouraging critical thinking, problem-solving, and personal development in learners (Shulman, 2004).

Concept of Learning

Learning is the process of gaining information, abilities, values, or attitudes by study, instruction, or experience. It entails both internalizing new information and changing preexisting actions or knowledge. Learning is an active process in which people link new information to what they already know in order to make sense of the world around them. This process frequently results in changes in behaviour, understanding, or thought patterns (Bransford, Brown, & Cocking, 2000). It can happen in formal contexts, such as classrooms, or informally, through ordinary experiences (Kolb, 1984).

Roles of ICT in Education

In education, ICT plays a crucial role by integrating digital tools into the learning environment, enhancing the teaching and learning experience. Whether it’s multimedia presentations, educational apps, or digital textbooks, ICT in education means leveraging technology to improve the delivery and effectiveness of education Virmani (2024).

Recent studies continue to underscore the pivotal role of Information and Communication Technology (ICT) in enhancing educational outcomes. Adewoye and Salau (2023) revealed the positive relationship between ICT adoption and improved educational experiences. However, factors such as personal characteristics, organizational capacity, support, and availability significantly influence ICT adoption in Nigerian universities. Efedi and Moemeke (2010) emphasize the crucial functions of ICT in curriculum implementation, encompassing storage, dissemination, analysis, stimulation, engagement, communication, audience reach, overcoming physical constraints, enhancing productivity, and facilitating personalized education. These

positions enhance instructional quality and, if well-utilized, improve student performance. This aligns with the objectives of the National Policy on ICT in Education (2019), which aims to integrate ICT into teaching, learning, and administration to foster problem-solving, critical thinking, and creativity while ensuring access to ICT tools and infrastructure at all educational levels. By addressing traditional teaching obstacles, the policy encourages a more engaging learning environment and enhances student achievement Federal Ministry of Education (2019).

Opportunities of ICT Use in Teaching and Learning in Higher Education

ICTs in educational institutions offer significant chances to increase learning by boosting students' performance in core courses such as reading, writing, mathematics, and sciences, especially when employed under optimal conditions (UNESCO, 2021). These tools stimulate motivation, independent learning, and the development of skills required for the current, knowledge-based economy (Anderson & Dexter, 2019). Network technologies enhance active learning, innovative teaching, and change educators and students into active researchers (Al-Fadhli, 2022). ICT also alleviates lecturers' responsibilities by reducing administrative tasks like lesson preparation, grading, and communication, thereby boosting efficiency (Granados, 2011). It fosters professional development through online materials, workshops, and collaborative platforms, such as UNESCO's ICTs in Education (Anderson, 2004). Moreover,

ICT allows a change from teacher-centered to student-centered learning, encouraging students to take an active role in knowledge generation and collaboration, while lecturers act as facilitators (Prabhu, 2020). The multimedia capabilities of ICT ensure inclusive learning for everybody, including students with disabilities and those in remote regions (Cradler & Bridgforth, 2004). It also develops problem-solving, cooperation, and vocational skills (Brown, 2023). The internet's removal of geographical obstacles offers flexible access to resources, supporting varied learning demands (UNESCO, 2021). Teleconferencing bridges distance learning barriers and encourages effective use of ICT in education, leading to a flexible, interactive, and globally connected learning environment.

Theoretical Framework

The Theory of Diffusion of Innovation (DOI) by Everett Rogers, developed in 1961, is a foundational framework for comprehending the adoption and dissemination of new ideas, practices, or technologies within a social system. In the context of integrating Information and Communication Technology (ICT) in education, the DOI theory helps to understand the process of introducing innovations like ICT in teaching economics. The theory outlines key components such as the nature of innovations, communication channels used to convey information about the innovation, the time it takes for adoption, the social system within which the innovation is introduced, and the decision-making processes related to innovation adoption. The DOI theory also identifies stages through which individuals progress when adopting an innovation, starting from awareness and ending with ongoing utilization. Applying this theory to the study of ICT integration provides valuable insights into how students and lecturers of department of economics perceive and accept ICT, shedding light on the factors influencing their willingness to utilize ICT for teaching and learning purposes**.**

Methodology

This study adopted a descriptive survey research design. The population consisted of 721 final-year (300 level) students from the 2023/2024 academic session and 12 lecturers from the Department of Economics, Niger State College of Education, Minna, bringing the total population to 733.A sample size of 260 was determined using Yamane's (1967) formula at a 0.05 level of significance. The data was collected through a structured questionnaire, utilizing a simple random sampling technique. To ensure the instrument's validity, it underwent content and criterion validation by two senior lecturers in the Department of Economics, whose feedback

guided the final revision. The instrument's reliability was assessed through a pilot study, applying the Pearson Product-Moment Correlation Coefficient (PPMC) at a 0.05 significance level. The reliability index was approximately 0.8, indicating a high level of internal consistency. For data analysis, both descriptive and inferential statistics were employed. Descriptive statistics (mean and standard deviation) were used to address the research questions, while inferential statistics, specifically Pearson Product-Moment Correlation Coefficient (PPMC) and Chi-Square (χ^2) test, was applied to test the null hypotheses.

Data Presentation and Analysis

Table 4.1: Classification of Respondents by Category

Category	**Freq.**	**Percentage**
Students	248	95.38%
Lecturers	12	4.62%
Total	**260**	**100.00**

Source: Field survey 2023

Category of respondents shows that the highest response students with 248 representing 95.38%, while lecturers were 12 representing 4.62% of the returned instruments

Research Question 1: What are lecturers and students' perception on the extent of ICT utilization for teaching and learning of Economics in Niger State College of Education, Minna?

Table 4.2: Lecturers and Students Perception on ICT utilization

Statement	**SA**	**A**	**D**	**SD**	$\bar{x}$	**SDEV.**	**Decision**
1.The use of ICT in the presentation of curriculum content in Economics	143	107	6	4	6.5	59.5	Agreed
2. The use of ICT in Teaching and learning deductive analysis in Economics	172	78	3	6	5.3	41.1	Agreed
3.The use of ICT in Enhancing teaching and learning inductive reasoning in Economics students	189	69	0	2	65	70.4	Agreed
4.Use of ICT in teaching and learning special Economics skills	190	65	5	0	65	58.2	Agreed

Source: Field survey 2023. **Decision mean** = 2.5

In Table 4.2, it is observed that respondents unanimously agreed on items 1 to 6. These items include the use of Information and Communication Technology (ICT) in presenting curriculum contents in Economics, employing ICT for teaching and learning deductive analysis in Economics, leveraging ICT to enhance teaching and learning in inductive reasoning, and utilizing ICT for teaching and learning special Economics skills to improve students' comprehension, deep reasoning, and memory retention. The mean scores for these aspects were found to be 6.5, 5.3, 65, and 65 respectively, with a minimum standard deviation of 4.1.

Table 4.2: PPMC (Chi-square x^2) Correlation Coefficient of Lecturers and Students' Perceptions on the Utilization of ICT in Teaching and Learning at Niger State College of Education, Minna.

Variable	N	Mean	Df	Sd	t-val	p-val	remark
Lecturers and students´ perception	260	8.14	1	0.813	3.00	0.00	**
Utilization of ICT on the Teaching and Learning Economics	260	8.14	1	0.813	3.00	0.00	**

Source: Field Survey, 2023

Table 4.2. displayed the Chi-square (x^2) PPMC correlation coefficient of lecturers and students' perceptions regarding the utilization of ICT in teaching and learning at Niger State College of Education, Minna. The results demonstrate a significant correlation between lecturers and students' views on the application of ICT in teaching Economics. The table indicates a correlation value of 3.00 on a 2-tail test, denoting (r=8.14, n=260, df=1, t-val=3.00) at a 0.01 level of significance. Consequently, the findings suggest the rejection of the null hypothesis and the acceptance of the alternative hypothesis, signifying that the use of ICT enhances students' academic performance in learning Economics.

Summary of Findings

The findings indicate a robust agreement among instructors and students regarding the beneficial effects of ICT on the teaching and learning of Economics at Niger State College of Education, Minna. A predominant percentage of respondents (95.38% students and 4.62% lecturers) concurred that ICT augments curricular content delivery, promotes logical and inductive reasoning, and aids in the acquisition of specialized Economics abilities. Statistical study employing the Chi-square (x^2) correlation coefficient established a significant association (r=8.14, t-val=3.00, $p<0.01$) between ICT consumption and enhanced academic achievement, resulting in the rejection of the null hypothesis. This emphasizes the critical importance of ICT in enhancing understanding, reasoning, and memory recall in students, underscoring its significance for effective Economics instruction.

Discussion of Findings

In the study exploring students' and lecturers' perceptions of ICT in learning and teaching economics, the findings are in line with previous research. Agrahari and Singh (2013) demonstrated positive effects of ICT on secondary-level chemistry scores. Similarly, Ziden, Ismail, Spian, and Kumutha (2011) found enhanced achievement in science subjects with ICT use. Safdar, Yousuf, Parveen, and Behlol (2011) supported the positive impact of ICT on student achievement. Furthermore, Okoro and Ekpo (2016) found that ICT usage improved data processing, understanding, and memory. Avinash and Shailja (2013) highlighted ICT programs' effectiveness in chemistry education. However, conflicting views exist. Cener, Acun, and Mbaeze, Ukwandu, and Anudu (2010) found no significant link between ICT and academic performance. Furthermore, (Jones & Lee, 2022) opined that the integration of ICT has transformed instructional methodologies, making learning more personalized and adaptive. Educators now have access to a plethora of digital resources and online platforms that cater to diverse learning styles and abilities. Adaptive learning software, for instance, tailors educational content based on individual student progress, providing targeted support and challenges to optimize learning experiences (Brown et al., 2023).

Conclusion

The study at Niger State College of Education, Minna, investigated the perception of students and lecturers on the role of Information and Communication Technology (ICT) in teaching

Economics education. It highlighted positive perceptions among lecturers and students regarding ICT's potential in enhancing teaching and learning experiences. However, the research identified barriers such as inadequate training, lack of essential ICT resources, and limited technical support. Accessible ICT tools, including computers and projectors, were deemed crucial, but challenges like workload demands and teachers' proficiency hindered effective implementation. The study emphasized the importance of embracing ICT in education for easier dissemination of educational information to students, aligning with previous research in East African countries.

Recommendations

Based on the findings of this study the following recommendations was made:

1. Curriculum designers should incorporate ICT into tertiary syllabi to prepare students for the digital age.
2. Educational authority should Make internet access more affordable for students to enhance educational achievements through online learning and research.
3. Educational authority should provide diverse ICT tools like computers, projectors, and radios to promote ICT deployment and self-directed learning.

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ASSESSMENT OF THE IMPLEMENTATION OF THE CURRICULUM OF MOTOR VEHICLE MECHANICS' WORK AT TECHNICAL COLLEGES LEVEL IN NIGER STATE, NIGERIA.

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Abstract
The study assessed the implementation of the curriculum of Motor Vehicle Mechanics' Work at technical college levels in Niger State. The descriptive survey research design was adopted for the study. Two research questions guided the study. The population for the study consists of 21 administrators of technical colleges and 28 motor vehicle mechanics work (MVMW) teachers in all the technical colleges in Niger State. A structured questionnaire was used for data collection. The reliability coefficient of the instrument was found to be 0.75.The data collected were analyzed using mean, standard deviation for the research questions. The findings of this study revealed that the objectives of motor vehicle mechanics work curriculum (MVMWC) were adequate in producing competent and enterprising motor vehicle mechanics; but instructions in technical colleges today remained more of theory than practical. Hence, it was recommended that both the teachers of MVMW and instructors should employ teaching strategies that engage students in high-level cognitive activities which stimulate thought, and practical work during curriculum implementation. Finally, it was also recommended that the curriculum of motor vehicle maintenance work should be revised and updated by National Board for Technical Education regularly.
Keywords: Objectives, Teaching Strategies, Technical Colleges, Self-reliance, Curriculum.

Introduction

Technical Education is a type of education designed to equip individuals with competencies in an occupational trade for the technological and economic development of Nigeria. According to Federal Republic of Nigeria (FRN, 2014), Technical education is described as a comprehensive term referring to those aspects of the educational process involving, in addition to general education, the study of technologies and related sciences, and the acquisition of practical skills, attitudes, understanding and knowledge relating to occupations in various sectors of economic and social life.

The objectives of technical education according to FRN (2014) include: providing training for manpower development in applied sciences, technology and business particularly at craft, advanced craft and technical levels; providing technical knowledge and vocational skills necessary for agricultural, commercial and economic development; acquire technical and vocational skills, and give training and impact the necessary skills to individual who shall be self-reliant economically. The technical colleges according to FRN (2014) is to offer training and impact the essential competences leading to the production of craftsmen and other categories of skills personal who will be enterprising and self-reliant upon graduation in various trade areas such as bricklaying, block laying and concreting, electrical installation and maintenance work, fabrication and welding, carpentry and joinery, painting and decorating, and motor vehicle mechanics work trade among others.
The objectives of Motor Vehicle Mechanic's Work (MVM), according to United Nations Educational Scientific and Cultural Organization (UNESCO) 2020) is to enable the craftsmen to

diagnose and repair faults, maintain and service vehicles, improve vehicle performance, endure safety and reliability, promote entrepreneurship, support economic growth among others. The following teaching strategies are used in the implementation of the contents of motor vehicle mechanics work curriculum, hands on training, demonstration method, project based learning, mentorship, simulation based learning, group work field trips, case studies and assessment and feedback (UNESCO, 2020).

Motor Vehicle Mechanic's Work in technical Colleges is a vocational trade aimed at producing competent vehicle mechanics with sound practical skills, knowledge and ability to diagnose and carryout repairs and/or maintenance of different types of motor vehicles. Motor vehicle graduates upon completion of one or more employability modules have the opportunity to set up independent automobile enterprises to become self-employed and be able to employ others (NBTE, 2014). With advancement in technology, automobiles that are manufactured, imported or assembled in Nigeria are controlled primarily by computers, electronic components and controls that require a higher degree of sophistication for testing and servicing, as well as special diagnostic tools and instruments which are among the curriculum components of motor vehicle mechanics work.

These Curriculum components include: contents, teaching strategies, instructional facilities, and method of evaluation. The aim of the curriculum is to give insight and equip the students with knowledge, attitude and skills in automobile work that can enable them to be gainfully employed after graduation (Nigerian Educational Research and Development Council, NERDC, 2014). The general objectives of the course as embedded in the MVWC are for the learner to develop familiarity with the automobile, and the various changes in technologies that are applicable to the automobile, perform simple fault diagnosis and to effect simple routine automobile repairs (NERDC, 2014). Curriculum contents refer to the subject matter, and various topics (including skill, knowledge, attitude, among others), that help in achieving the objectives of programmes.

The contents of the MVMWC are designed and organized in modules for training of MVM students using appropriate teaching strategies on the following topics in MVMW: safety and maintenance, engine system, fuel system, cooling system, transmission and braking system, electrical systems (lighting system, ignition system), charging system, exhaust system, heating and ventilation system, steering and suspension system, lubrication system, and auto-air conditioning system (NERDC, 2014). Nwiyi and Okorie, (2014) stated that the MVMWC is very practical in nature and should ideally be taught through methods that maximize the active participation of the learner. This, according to Kumazhege and Egunsola, (2014) also result to students graduating with inadequate or complete lack of practical skills in the MVMW trade area. The term curriculum implementation has been defined in different ways by different scholars. In this study, curriculum implementation is the process of putting the planned MVMWC document into practice in the classroom/workshop; through the combined effort of the teachers/instructors, students, administrators and parents towards the realization of the set objectives.

However, administrators and MVMW teachers in these institutions play a vital role in the implementation of the motor vehicle mechanics work curriculum in technical colleges. Their responsibilities includes; curriculum development, resource allocation, instructor support, assessment and evaluation, industry partnerships, budgeting and funding, police implementation, and programme promotion (UNESCO, 2019).

The National Policy on Education was well structured and the contents were adequately defined but the implementation calls for question (Ayeni, 2016). Furthermore, several studies have revealed that despite the curriculum was well structured, products of the programmes still lacked the basic skills needed for gainful employment and self-sustenance in today's automobile

industry. Ayeni, (2016) stated that a poorly implemented curriculum will produce half-baked graduates. The preceding researches depict the situation experienced by graduates of technical colleges in Nigeria and revealed that there is an important link between the quality of MVMWC implementation and the graduates' sense of being effective and self- sustainable after school. Nyapson, (2015) observed that the MVMWC in Nigeria prepares graduates of technical colleges to have irrelevant and inadequate skills in MVMW, which has rendered most of them jobless and not able to contribute to the national economy, neither to set up their own workshops nor being employed by automobile industries in Nigeria. Hence, this situation calls for a critical assessment of the objectives of the MVMWC and strategies for the implementation of the curriculum at technical college level in Niger State.

Statement of the Problem

Motor Vehicle Mechanic's Work in technical colleges is a vocational trade aimed at producing competent vehicle mechanics with sound practical skills, knowledge and ability to diagnose and carryout repairs and/or maintenance on all types of motor vehicles. Motor vehicle graduates upon completion of one or more employability modules have the opportunity to set up independent automobile enterprises become self-employed and be able to employ others (National Board for Technical Education NBTE, 2014). With advancement in technology, automobiles that are manufactured presently are controlled primarily by computers, electronic components and controls that require a higher degree of sophistication for testing and servicing, as well as special diagnostic tools and instruments.

Consequently, vehicle technology and maintenance processes have adversely affected transportation system in Nigeria and advanced the problems facing motor vehicle mechanic graduates in the course of discharging their duties in the country (NBTE, 2014).. Therefore, availability of adequately skilled graduates to service the ever growing automobile population is seen as a critical area where there is a gap between curriculum content, and the quality of training received by graduates of MVMW in technical colleges.

This situation could be attributed to the deficiency of training facilities and equipments on modern automobile technology skills which has equally restricted MVMW graduates of technical colleges in skillfulness, efficiency, proficiency and productivity (Abuda, 2015). Based on this insight, the study assessed the objectives of the MVMW and curriculum implementation at technical college level in Niger State.

Purpose of the Study

The main purpose of this study was to assess the implementation of the curriculum of MVMW at the technical college level in Niger State. Specifically the objectives were to:

1. Examine the appropriateness of the objectives of MVMW in producing motor vehicle mechanics work craftsmen for gainful employment and self reliance.
2. Identify the teaching strategies used in the implementation of the contents of MVMWC in technical colleges in Niger state.

Research Questions

1. How appropriate are the objectives of the MVMW in producing motor vehicle mechanics work craftsmen for gainful employment and self reliance?
2. What are the teaching strategies used in implementation of the contents of MVMWC in technical colleges in Niger state?

Methodology

The study adopted the descriptive survey research design. The study was carried out in Niger State Government Technical Colleges and one Federal Science and Technical College: comprising of: Government Technical College Eyagi Bida, Government Technical College

Minna, Suleiman Barau Science and Technical College Suleja, Government Technical College Kotakora, Government Technical College New Bussa, Mamman Kontagora Technical College Pandogari and Federal Science and Technical College Shiroro, Kuta. The population for this study consisted of 21 administrators of technical colleges, 28 MVMW teachers in all the technical colleges in Niger State, making a total population of 49 respondents.

The study utilized quantitative techniques. A structured Questionnaire was used for data collection. The questionnaire answered the two Research Questions (RQs) of the study. The questionnaire was divided into three sections (A, B & C). Section A solicited information on demographic data of the respondents. Section (B) contains 8 items designed to elicit information on the objectives of the Motor Vehicle Mechanics' Work in producing motor vehicle mechanics students for self reliance after graduation. Section C contained 17 items, which were used to find out the teaching strategies adopted in implementing the curriculum contents of the MVMW. All the 25 items of the questionnaire were rated on a five-point Likert scale of strongly agree (5), agree (4), undecided (3), disagree (2), and strongly disagree (1). Cronbach Alpha (α) reliability Statistics was used to establish internal consistency of the instrument. The reliability coefficient for the instrument was 0.75. Meaning that a reliability coefficient is generally considered acceptable

Results

Research Question 1: How appropriate are the objectives of the MVMW in producing MVM Craftsmen for gainful employment and self reliance?

The data for answering this research question are provided in Table 1.

Table 1: Mean Responses of the Respondents on the Appropriateness of the objectives of the MVMW in producing MVMW Craftsmen for gainful employment and self reliance.

S/No.	Objectives of MVMW	$\bar{x}_1$	$\bar{x}_2$	$\bar{x}_3$	Remarks
1	Give technical college graduating students insight into the knowledge, attitude and skill in automobile work that can enable them be self-reliance	4.47	3.67	4.07	Agree
2	Equip technical college graduating students with knowledge, attitude and skill in automobile work that can enable them be enterprising and self-reliant	4.62	4.60	4.61	Strongly agree
3	Enable Students to familiarizes with the automobile components	4.48	3.90	4.19	Agree
4	Enable Students develop proper attitude towards automobile use	4.66	4.88	4.77	Strongly agree
5	Helps Students to appreciate the various development in technologies that are applicable to the automobile	4.42	3.99	4.36	Agree
6	Helps Students perform simple fault diagnosis	4.41	4.30	4.35	Agree
7	Makes Students effect simple routine automobile maintenance	4.44	4.10	4.27	Agree
8	Enables Students perform minor automobile repairs	4.47	4.33	4.00	Agree

Key:-

$\bar{x}_1$ = Means of the MVMW Teachers

$\bar{x}_2$ = Means of Administrators

$\bar{x}_3$ = Average Means

Analysis of mean responses of the respondents from Table 1 revealed that 2 items were strongly agree with their mean from 4.62 to 4.72, while 6 items were agree with their mean ranged from 4.42 to 4.48. This shows that the respondents agreed that the objectives of the MVMWC are appropriate in producing motor vehicle mechanics craftsmen for self-reliance after graduation.

Research Question 2: What are the teaching strategies used in implementation of the contents of the MVMW in technical colleges in Niger State?
The data for answering this research question are provided in Table 2.

Table 2: Mean Responses of Respondents on the Teaching Strategies used in implementing the Curriculum Contents of MVMWC in Technical Colleges in Niger state.

S/No.	Teaching Strategies used	$\bar{x}_1$	$\bar{x}_2$	$\bar{x}_3$	Remarks
1	Lecture Method	4.60	4.70	4.65	Strongly agree
2	Simulation	1.60	1.32	1.46	Disagree
3	Tutorial	1.82	1.90	1.86	Disagree
4	Group discussion	4.23	4.30	4.26	Agree
5	Discovery or inquiry	2.00	2.11	2.05	Disagree
6	Use of brainstorming	1.80	1.77	1.79	Disagree
7	Fieldtrips/excursions	2.40	2.35	2.37	Disagree
8	Practical activity based approach	2.47	2.28	2.38	Disagree
9	Problem based learning	3.60	3.55	3.58	Agree
10	Demonstration	4.21	4.33	4.27	Agree
11	Use of prototype models for teaching practical lessons	2.45	2.43	2.44	Disagree
12	Using case studies	1.61	1.50	1.56	Disagree
13	Use of Computer Assisted Instructions	1.80	1.76	1.78	Disagree
14	Debates	2.00	1.99	1.99	Disagree
15	Cooperative Learning: The Jigsaw strategy	1.44	1.45	1.45	Strongly disagree
16	Employment of experts to teach some specialized areas	1.85	1.88	1.87	Disagree
17	Project method	2.20	2.11	2.15	Disagree

Key:-
$\bar{x}_1$ = Means of MVMW Teachers
$\bar{x}_2$ = Means of Administrators
$\bar{x}_3$ = Average Means

The data presented in Table 2 above revealed that three (3) teaching strategies (lecture method, group discussion, and demonstration) were strongly agreed upon as being used in implementing the curriculum contents of the MVMWC in technical colleges in Niger state with their mean ranging from 4.60, 4.23, 4.21 and 3.60. Fourteen others with their mean ranging from 1.44 to 2.47 were disagreed upon by the respondents. This showed that respondents generally disagreed with the teaching strategies adopted in the implementation of the MVMW curriculum. It is worth noting that, the teaching strategies that were disagreed and strongly disagreed upon are

actually those that engage the students in high level cognitive activities which stimulate thought, practical work, analysis, and reflection during curriculum implementation; while those that were agreed upon were predominantly theoretical.

Discussion of the Findings

The findings of the study showed that the aims and objectives of the motor vehicle work curriculum are appropriate in producing competent and enterprising motor vehicle mechanics for self-employment. The findings are in line with the view of Udogu, (2015) who posited that, MVM curriculum in Nigeria technical colleges is designed to produce competent motor vehicle craftsmen for Nigeria's technological and industrial development. Therefore, the aim and objectives of the curriculum are in cognizant of the nature and structure of modern motor vehicle mechanic work programme. It was also revealed that instructions in technical colleges are more of theory than practical, and predominantly the lecture method. Therefore, the above result revealed that teaching strategies by teachers and instructors are more of theory than practical. Hence, the strategies are not good enough for the implementation of the curriculum and acquisition of practical skills in technical colleges. This finding is in line with the views of (Kumazhege & Egunsola, 2014) who observed that, instructions in technical colleges today have remained essentially devoid of practical skills in the different trades.

Instructions are more of theory (Lecture) than practical (demonstration). Idris (2012) posited that, the lecture method being predominantly used in teaching automobile technology is based on the behavioral learning theories; which emphasized knowledge transmission from the teacher to passive students and encourage rote memorization of facts. More work needs to be done to let go of the outdated modes of knowledge accumulation, and adopt methods that engage the students in high-level cognitive activities which stimulate thought, practical work, analysis and reflection during curriculum implementation (Bandele & Faremi, 2012). In another development, Federal Republic of Nigeria, (2014) maintained that Technical Colleges are saddled with the task of providing, imparting or teaching practical skills, attitudes, understanding and knowledge relating to occupations in various sectors of economy and social life. As such, it should provide training on the acquisition of relevant and needed skills to meet the demand of modern commerce, technologies, related sciences and industries.

Conclusion

Motor Vehicle Mechanic Work (MVMW) is designed to produce competent automobile craftsmen for the technological and industrial development of Nigeria. The study revealed that the respondents agreed that the teaching methods employed in the teaching of motor vehicle mechanic programme at technical college level. The study concludes that the acquisition of emerging technological skills which will enable MVMW graduates to become self reliant, self-employed and employers of labour. These skills will also enable MVMW graduates to acquire new competencies for servicing and repair of modern vehicles in order to remain relevant in the automobile industry.

Recommendations

Based on the findings of the study, it was recommended that;

1. Teachers and instructors should employ teaching strategies that engage students in high-level cognitive activities which would stimulate thought, practical work, during curriculum implementation.
2. Government through the NBTE and institutions should organized periodic seminars and conferences for MVMW teachers to update their knowledge in modern methods of teaching.

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ADOPTING PROBLEM-BASED LEARNING FOR BUILDING TECHNOLOGY PROGRAMS IN HIGHER EDUCATIONAL INSTITUTIONS OF DEVELOPING COUNTRIES

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Abstract
Problem-based learning has been effectively adopted in many developed countries. In developing countries, however, there are still restraints and challenges to adopting this student-centered instructional approach for Building Technology (BT) programs in many Higher Educational Institutions (HEIs) despite the skill gap. PBL is a student-centered approach that inspires students to study independently and apply their skills in solving real-world problems in an appropriate and realistic context. Few literatures have explored the adoption of PBL in HEIs in developing countries. Therefore, this paper provides an overview of PBL currently in HEIs of developing countries and convincing evidence for its effectiveness in instruction. The paper offers the basis for adopting PBL in BT instruction in HEIs of developing countries. The paper also describes a potential model of implementation, identifies some challenges facilitators may encounter during the application, and provides strategies for effective adoption, including the integration of real-world problems, collaborative group work, and the training of facilitators to guide students appropriately. Additionally, it provides specific recommendations for enhancing the adoption of PBL in HEIs of developing countries. As educational paradigms shift to embrace modern, student-driven methodologies, this analysis highlights the urgent need for HEIs in developing countries to adopt PBL strategies, which can significantly enhance both teaching and learning outcomes, prepare students for complex problem-solving, and ultimately, better equip them to meet societal and labor market demands.
Keywords: Adoption, Problem-Based Learning, Building Technology and Higher Educational Institutions

Introduction

Higher educational institutions (HEIs) in developing countries are immeasurable intellectual organizations. They impart in-depth knowledge and understanding to develop the students' opportunities for lifelong learning, new frontiers of knowledge, and upgrading their knowledge and skills from time to time but based on societal needs (Ogunode et al., 2025). HEIs comprise universities and colleges and various professional institutions that provide teaching and learning, human resource management, financial management, research, and innovation (Adedoyin et al., 2024).

The 4th industrial revolution (4IR) is driving the global economy and associated development including HEIs, which have evolved into technological centers through the delivery of lifelong skills for the future. HEIs invariably affect the understanding, capability, and potential of the educated person (Ogunode et al., 2025). Therefore, the system of delivery at HEIs ought to be modified to deliver services that are 4IR savvy, more importantly; the processes must be 4IR compliance to deliver lifelong skills to building technology undergraduates. The presence of student-centered learning in teaching and learning results in robust collaborative self-directed learning, and learner involvement in learning and content creation results from the influence of student-centered learning in education (Ogunode et al., 2025).

The transformation in teaching and learning now entails teachers leaving traditional approaches and embracing principles of skills-based, guided inquiry learning, and this involves teaching useful and employable skills using their professionalism for the students to implement the skills upon their graduation (Solissa et al., 2024).
PBL has been widely adopted due to its ability to impact students, ' solving, decision-making, and group collaboration skills (Baniyah et al., 2024). PBL stimulates students' interest due to independent learning adopted by the students in deciding and finding solutions to the problem at hand (Pratami et al., 2024).

Furthermore, the independent nature of PBL made it relevant to the different abilities of Building Technology (BT) undergraduates to come up with their thoughts and individual approaches in providing solutions to the given problem through engaging in real-life activities (Baniyah et al., 2024). PBL emphasizes solving real-world problems (Pratami et al., 2024), which is crucial in BT. This approach enables students to apply theoretical knowledge to practical scenarios, making learning more meaningful and relevant to their future careers. PBL develops critical skills (Siswanto et al., 2025), and BT often requires critical thinking, problem-solving, and decision-making skills. PBL fosters these skills by challenging students to analyze complex situations, collaborate with peers, and develop innovative solutions (Solissa et al., 2024). The construction industry relies heavily on teamwork and collaboration among various professionals (Habeeb & Eyupoglu, 2024). PBL encourages group work, allowing students to learn how to communicate effectively and work together to address challenges, skills that are vital in the workplace. Moreover, the PBL helps learners solve complex problems independently within the classes with the help of a lecturer who serves as a facilitator.

Therefore, PBL is anticipated to offer clarifications that will change teaching and learning in HEIs of developing countries.
In developing countries, PBL may be relatively a new actor in the teaching and learning process for HEIs but it plays an important function in developing improved learning and understanding between facilitators and learners via group collaboration within the HEI environment (Habeeb & Eyupoglu, 2024). The focus now is more on a student-centered approach to bringing improvement to learners in a class.

PBL in the Changing Terrain of HEIs
The concept of learning through problem management is not new but the emergence of PBL as an approach started from the works of Barrows, who found out in his research in medical instruction that medical students did not seem to think at all for the most part (Oktaviani & Abdjul, 2024). There has been growing anxiety about HEIs to re-assess and make clear their aims (Habeeb & Eyupoglu, 2024). The move towards a model of HEIs which is receptive to industry demand in the world of work, has increased for greater vocational relevance and this move has brought a closer bond between HEIs and industry (Nwosu et al., 2023). This has fostered changes in curricula generally, in precise the growth of personal skills and potentials for life and work through the development of key skills in HEIs (Lozano et al., 2022). A more distinct student population compared to former years necessitates a broader range of approaches, that will take into cognizance the diversity of student learning requirements and study patterns (Rodriguez-Sanchez et al., 2024). Such demands have made HEIs in developing countries like Nigeria consider PBL to take care of students' requirements (Ogunode et al., 2025).

The adoption of PBL arises from its innovative means of managing curricula problems or initiating improvement to teaching and learning in HEIs for building technology undergraduates (Tan, 2021) on the other hand, it may have been adopted because it offers prospects for life skill development and the call for the end of teacher-student boundaries in terms of knowledge development (Tan, 2021). There seem to be several reasons for the increasing popularity of PBL

while at the same time, there is obvious disdain for it as a stimulus for prompt transition in people's lives. From the foregoing, the adoption of PBL is yet to be realized from the viewpoint of HEIs in developing countries.

PBL is a significant approach to learning, which must be fundamentally placed in HEI curricula compared to what it is presently. Nevertheless, PBL has been misjudged in different ways, which signifies that it has not been accepted as a fundamental approach within the HEIs because, it is an approach that is often misconstrued and this tends to result in wrong views about the prospects for its adoption (Siswanto et al., 2025), and this misunderstanding has resulted in the sarcasm of its significant in terms of preparing students for an intricate and changing skillful life that can be acquired from it to develop student learning pattern (Solano et al., 2023). Learning should be seen as a recurring procedure in which students make modifications from which they acquire an understanding of themselves, and the methods and settings in which they can learn effectively.

Adopting PBL in BT Programs

PBL is in support of every development in the HEIs environment; of most prominent is the teaching and learning. In developing countries like Nigeria, the National Policy on Education necessitates the education sector to develop and standardize quality and obtainable education, training, and research (Nigeria, 2014). However, research has shown that PBL adoption in HEIs in BT programs is still in the early stages in developing countries with literature showing a gap in the adoption of PBL (Solissa et al., 2024). Therefore, there is a need, as a necessity for Nigerian HEIs to adopt PBL to develop desired life-long skills in building technology undergraduates. The educational system in most developing countries has been transformed but innovative requirements are necessary to create a more robust instructional approach for success within their structures and the boundaries that may be required (Ibrahim, 2023).

The current mode of teaching and learning in HEIs in Nigeria often does not facilitate collaborative learning, and students may find it challenging to translate academic knowledge or the theory aspect learned into practical skills required in the workforce (Siswanto et al., 2025). There is a pressing need to adopt Problem-Based Learning (PBL) in these programs, as it shifts the focus to a student-centered approach that encourages independent research, collaboration, and practical problem-solving (Anggraeni et al., 2023). PBL can enhance students' engagement and readiness for the complexities of the construction industry, ultimately bridging the skills gap and aligning education outcomes with labor market demands (Owolabi et al., 2023). Integrating PBL not only promotes deeper understanding but also fosters adaptability and innovation among students.

PBL is essential in allowing transformation from a traditional teaching and learning approach to a more problem-solving learning approach. Learners can study effectively in PBL, and facilitators can also do their job easily. They will have access to all relevant materials that will aid in solving the problem at hand and most essentially, PBL can deliver acceptable instruction for future generations. Building Technology (BT) provides individuals with the necessary skills needed for successful employment or for graduates to become self-employed (Owolabi et al., 2023). However, most BT graduates are found with abstract knowledge, which contributes very little in preparing them for realistic abilities they will meet in their employment industry.

However, the employment requirement of workers has changed drastically because of the changes being witnessed in this 21st century of technology and Artificial Intelligence. To meet these needs, a substitute to the traditional instruction approach should be introduced to BT graduates in developing countries, where teaching and learning delivery is aligned with the workplace and practices in the employment industries (Kissi et al., 2023). Moreover, teacher-centered approaches deprive students of learning because, the features of the 21st-century youths

necessitate action learning, interactivity, and teamwork and are not in line with the traditional base approach (Muhammad, 2021). The need for a shift from the traditional approach to more activity-based approaches is paramount. Consequently, the desire for Nigeria to become among the best-developed nations in the globe and the vision of eliminating poverty and hunger cannot be achieved without a critical development in manpower. Furthermore, one of the challenges in the education sector, most especially in building technology programs, is the desire to go along with the changing needs of the economy and employers, in terms of employability competencies and skills (Datta et al., 2023).

Some gains can be harnessed if PBL is to be adopted in various institutions of developing countries are shown in Table 1.

Table 1: Implication for the Adoption of PBL in the BT Program of HEIs

SN	Theme	Inferences
1	Enhanced Problem-Solving Skills	PBL fosters critical thinking and problem-solving abilities among students. They learn to identify, analyze, and solve real-world problems encountered in building technology
2	Integration of Theory and Practice	PBL facilitates the integration of theoretical knowledge with practical applications. Students engage in hands-on activities, simulations, and real-world projects, bridging the gap between classroom learning and professional practice
3	Promotion of Collaborative Learning	Students work in teams to solve complex problems. This promotes communication skills, teamwork, and the ability to exchange ideas, mirroring real-world collaborative environments in the building technology industry.
4	Student-Centered Learning Environment	PBL shifts the focus from the instructor to the students, empowering them to take ownership of their learning process. They become active participants in their education, driving their inquiry and exploration in building technology concepts
5	Preparation for Professional Practice	By engaging in authentic problem-solving scenarios, students develop skills and competencies directly applicable to their future careers in building technology.
6	Cultivation of Lifelong Learning Skills	Through PBL, students develop a mindset of lifelong learning, as they become adept at seeking information, analyzing problems, and adapting to changing circumstances within the dynamic field of building technology

In this	7	Interdisciplinary Learning Opportunities	Building technology encompasses architecture, construction management, and sustainability. PBL encourages interdisciplinary collaboration, allowing students to explore the connection between different fields and gain holistic perspectives

regard, introducing an active teaching and learning approach like PBL, which is student-centered, becomes vital because of the role PBL plays in aiding student study behavior and effective skills acquisition. A transitional adjustment for many PBL students has been documented in terms of feeling overwhelmed with the outcome of the PBL instructional approach (Jiang et al., 2022). Though a little difficult for an undergraduate who is already used to traditional instruction the students drastically not only improve their study habits by being taught what to do but to actively take charge of determining what needs to be studied (Miliou et al., 2022).

From the foregoing, there is a need for a complete instructional approach of BT undergraduates to a more robust and active student self-directed learning approach like the PBL, which allows students to explore their talents. Moreover, PBL aids in developing students' problem-solving skills, collaborative skills, communication skills, creativity, and critical thinking skills.

Challenges

Collaboration is significant in the PBL curriculum, BT undergraduates will learn best when they interact with their peers compared to working alone but forming a collaborative classroom of PBL is tasking (Hidayati et al., 2023). This must be done to provide a conducive environment for BT undergraduates to interact and express their views.

There is also the problem of adjusting roles, in a collaborative PBL, the lecturer acts as a facilitator and he is responsible for changing or introducing the real-world problem to the groups for a proper solution (Anggraeni et al., 2023). Successful implementation of PBL hangs on the ability of the facilitator to change the way they introduce the real-world problem and manage the class.

Another major challenge is identifying the real-world problem, knowing fully well that PBL classes revolve around authentic problems. To implement PBL class effectively, both the facilitator and students must identify good driving problems that are relevant to students' careers thereby allowing them to develop their investigations.

The last and final challenge is the development of assessment methods and instruments. It is essential to design suitable learning assessment techniques that will tackle both individual and group accountability (Herrera-Pavo, 2021). Herrera-Pavo (2021) asserts that skillful PBL facilitators often develop guidelines in partnership with their students so that students can foster an understanding of their group work and establish standards for quality outcomes.

Strategies for Effective Adoption of PBL in BT

The effective adoption of PBL in BT programs requires thoughtful strategies tailored to the unique challenges faced by HEIs in Nigeria. However, emphasis on training and development for educators can give room for effective implementation (Olugbade, 2025). In this regard, academic staff should be adequately trained in PBL methodologies, and this can be through professional development workshops on how to devise real-world problems relevant to the building technology field. This can enhance the understanding of PBL principles and equip academic staff with the skills necessary to create and facilitate PBL environments. There is also the issue of curriculum integration (Fred).

The existing curriculum should be reviewed and redesigned to incorporate PBL effectively. This can involve identifying key areas where PBL can reinforce theoretical knowledge through practical application. Collaborative efforts in the academic environment can lead to a more cohesive curriculum that emphasizes problem-solving skills.

Another strategy is more resource allocation, this means that adequate resources, including materials and tools, must be provided to support PBL activities. HEIs should ensure access to construction sites, laboratories, and simulation software, which can help in simulating realistic problems that students might face in the building industry. Educators should create an atmosphere where experimentation and innovation are rewarded. This mindset will help students feel more comfortable tackling complex problems and taking ownership of their learning thereby, promoting a growth mindset in the students.

Creating a collaborative learning environment can establish a culture of collaboration among BT students (Owolabi et al., 2023), which is essential for PBL's success. Group projects and peer-led discussions can foster teamwork and enhance collective problem-solving abilities (Fajimi et al., 2024). Encouraging diverse groups facilitates the sharing of varied perspectives, which surely enriches the learning experience. A good implementation of ongoing assessment will ensure that both students and facilitators track progress and address difficulties promptly. Constructive feedback on projects can guide students in refining their approaches and enhance critical thinking skills.

Conclusion

This paper attempts to introduce the adoption of PBL in Building technology programs for more advanced skill acquisition and employable skills. In Building Technology, PBL can offer many advantages over the traditional teaching and learning methods used in HEIs of developing countries. In PBL, students use real-world problems, which serve as motivation during the learning process, identify the basis of the problem, and decisively proffer proper solutions to the problem.

With PBL, students can improve their intellectual ability to think and see the relevant factors related to the problem at hand and discuss and offer meaningful solutions. Students also learn the ability to decide and learn independently, the materials they need, and how to convey their solutions. Finally, employing PBL in the classroom is still tasking for facilitators; it is also essential to empirically assess the efficacy of PBL in Building Technology Programs in HEIs of developing countries.

Recommendations

HEIs should incorporate real-world challenges specific to the building technology field into the curriculum. This will help students understand the practical applications of their knowledge and develop the ability to propose viable solutions to industry-relevant issues.

Encourage collaborative learning by forming diverse student groups for projects. This approach will enhance teamwork skills, expose students to different perspectives, and promote collective problem-solving, which is essential in the construction industry.

Provision of comprehensive training programs for instructors and facilitators on the principles and practices of PBL. This training should equip them with the necessary skills to guide and support students throughout the learning process effectively. A robust system for continuous assessment that incorporates feedback mechanisms should be established. This will help in evaluating students' understanding and progress while also allowing for adjustments in teaching and learning strategies to meet learning objectives better.

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EFFECTS OF SCAFFOLDING AND CONVENTIONAL INSTRUCTIONAL METHODS ON FEMALE STUDENTS' ACADEMIC ACHIEVEMENT AND MATHEMATICS ANXIETY IN GEOMETRY IN AGAIE LOCAL GOVERNMENT, NIGER STATE.

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Abstract
This study aimed to assess the effect of scaffolding and conventional instructional methods on female student's academic achievement and mathematics anxiety in geometry. The study employed a quasi-experimental design of pre-test and post-test control design. The population of the study consisted of 443 SSII female students' distribution over 8 public schools in Agaie Local Government Area of Niger State, Nigeria. 130 SSII students selected from two schools using multistage sampling formed the sample of the study. Data were collected through four instruments: Scaffolding lesson model for the experimental group, Conventional lesson model for control group, Geometry Achievement Test (GAT) and Mathematics Anxiety Questionnaire (MAQ). The instruments were validated by three experts from IBBUL and FUT Minna. The reliability index of (GAT) and (MAQ) are 0.76 and 0.86 respectively. Research questions were answered through mean, standard deviation and mean difference, while t-test at 0.05 level of significance was used to analyse the null hypotheses. The findings revealed that female students exposed to scaffolding instruction method have higher mean score than those exposed to conventional instructional method. Based on the results, it is recommended among others, the teaching of mathematics especially geometry incorporate scaffolding instruction. Similarly, this method should be incorporated in the methodology and micro- teaching courses of pre-service teachers.
Keywords: Anxiety, Conventional, Geometry, Mathematics, Scaffolding,

Introduction

The mathematics knowledge and competency proved to be vital vehicle to train the minds of the students to think logically, objectively and reasonable in solving daily problems. Mathematics as a science subject taught at the post primary level in Nigeria is divided into seven segments, which includes: number and numeration, Algebra, Mensuration, Geometry, Trigonometry, Statistics and Probability (Zakariyya &Ahmad, 2021). Geometry is a concept of mathematics which deals with study of different shapes, either plane or solid shape. It is vital area that forms the building block of engineering and technical graphics. But many learners in secondary schools have not been demonstrating strong conceptual knowledge, and they were not adequately prepared for geometry concept (Ahmad, 2016). Several research evidences have showed that students complained that some topics in mathematics are too difficult to understand and consequently cause mathematics anxiety and poor performance in the final examinations among students (Juman et al, 2022 &, Odor et al, 2024). Such difficult topics as observed by mathematics educators include bearings, latitude and longitude, areas and volume of shapes, word problems and geometry constructions (Salma, 2018).

These are attributed to some factors, which include instructional method use by mathematics teachers in our schools, large class size, and inadequate learning materials for teaching the subject. Teachers of mathematics have been criticized for adopting conventional method in teaching of large classes, with intention of covering large contents. However, the method is deficient in meeting the needs of majority of students. It has also been described as teacher centre and didactics with students simply listening, copying notes, doing homework and allowed

easy handling of large classes without stress (Ahmad & Zakariyya, 2021). The conventional method most often is found to favour the educational advantaged learners at detriment of the educational disadvantaged ones. This method has not been successful in promoting learners' anxiety in learning mathematics, which would enhance their high achievement in geometry (Zakariyya & Ahmad, 2021).
Furthermore, the instructional method does not tend to foster creative and logical thinking, and collaborative problem solving. Therefore, it has become very necessary to search for method that ensure and enhance better academic achievement of the students in mathematics especially geometry concepts, example of scaffolding.

Scaffolding is an instructional strategy where by a teacher or more knowledgeable peer assists a learner, modifying the learning task so the learner can solve problems or accomplish tasks that would otherwise be out of reach. It can also be regarded as a powerful instructional tool to help learners extend their level of understanding and complete tasks successfully (Yong, 2021). Ogundele (2020) see it as an instructional method in which learners are offered constructive support until when they can apply new skill and strategies individually. Scaffolding instructional strategy was based on the conceptual framework of Vygotsky's (1978) construct of the Zone of Proximal Development (ZPD) (Vygotsky, 1978).
It is an instructional method designed to promote a deeper level of learning. It is the support given during the leaning process, which is tailored to the needs of the students with the intention of assisting the learners achieved their learning objectives (Ahmad, 2016). The instructional scaffolding provides for supportive learning environment in which students are free to ask questions, provide feedback, and support their peers. Septi el at. (2024) submitted that when you incorporate scaffolding in the classroom, you become more of a mentor and facilitator of knowledge rather the dominant content expert. This instructional method provides the incentives for learners to take more active roles in their learning. Leaners share responsibility of teaching and learning through scaffolds that require them to move beyond their current skill and knowledge levels. Through these interaction students are enable to take ownership of the learning. According to Ukwueze el at. (2020) that scaffolding is a kind of support which learners receive in their interaction with parents, teachers, peers and mentors as they move to new tasks/skills, concepts or levels of understanding. It assists to portray the temporary, but essential nature of the teachers' assistance as the student advance in knowledge and understanding. The learners are well guided in the learning process, pushing them to think deeply, and model the kinds of questions that they need to be asking them; forming a cognitive apprenticeship. This method is not limited to the cognitive domain only but it also relates to affective and emotive factors. During the process the teacher might need to manage and control frustration, fear and loss of interest that could be experienced by the learners. It encourages learners to take a more active role in the learning process by fully participations and engaging in problem-solving activities (Ahmad el at, 2022). Also, Olubunmi and Ese (2018) conducted a study using scaffolding in Chemistry and reported that it improved students' achievement in Chemistry. To them, scaffolding instructional method assists learners to achieve significant success in tasks that would be too difficult to achieve by themselves and also build confident in learners. Furthermore, the method assists learners reach higher levels of comprehension and skill acquisition that they would not be able attain with assistance. Therefore, this study will into whether scaffolding instructional method can have improved students' achievement in Geometry in mathematics. Again students' poor achievement in Geometry has also been levied to gender.

Gender has been a controversial issue in many studies of mathematics education studies. Gender differences in mathematics performance and female underrepresentation in mathematics and STEM (Science, Technology, Engineering and Mathematics) disciplines has been documented. According to the National Science Foundation (2018), women outnumber men in earning Bachelor's degrees in biological and agricultural sciences, psychology, and the social sciences. However, in the more mathematics intensive areas of study, men outnumber women. Similarly,

Campbell (2020) in her study of gender differences at the highest levels of mathematics achievement showed that the percentage the gap between the percentage of male and female students scoring in the top quartile grew wider in higher score bands. In most studies male out performed female in mathematics tests. For example, Oluyemo, et al., (2022) study revealed that male students excel in mathematics more than their female counterparts. However, Efa and Frimpong (2023) study showed that there was a significant gender difference in students' performance in mathematics in favour of females. Since there is no general acceptable result on gender differences in geometry and mathematics, there is need to investigate whether the use of scaffolding instructional in teaching geometry could bridge the gap.

Mathematics anxiety which can refers to the fear, tension, and apprehension individuals experience when facing mathematics problem (McCullagh et al., 2024) is one of the psychological variable that has been found to have negatively influence on performance and acquisition of mathematics skills. Studies of Barroso et al., (2021) and Caviola et al. (2022) have shown that mathematics anxiety is strongly related to mathematical performance. Mathematics anxiety affects student's confidence in the subject (Ahmad & Babawacikio, 2021). Many learners of mathematics especially geometry suffer from mathematics anxiety and have little confidence in their ability to master the subject and this in turn bring low performance in the subject (Jerry, el at, 2019). Psychologists viewed mathematics anxiety to be positive sometime, if it helps you deal with a tensed situation to study harder for exams handle a new task, or stay focused on an important task.

Several studies examining gender differences in mathematics anxiety have found that female report higher levels of mathematics anxiety than male (Hart & Ganley, 2020; Szczygieł, 2020; Delage, et al., 2022 & Anbar et al., 2022. However, several studies have also shown that instructional strategies that are student-centre and activity based are effective in reducing gender differences in mathematics performance and anxiety. Similarly, Nwoke, et al., (2018) recommended that teachers should use innovative strategies in teaching mathematics to get both male and female students involved in classroom activities. However, when mathematics anxiety becomes excessive, doesn't fit the situation, or last for a long time, it can get interfere on students' performance on the task (Ahmad & Auwal, 2021).

Innovative strategies such as computer-assisted assessment model Nasution et al. (2019), cooperative learning Zavareh et al. (2022) and problem-based learning method as Ajai, and Imoko (2015) has been explored. This study therefore explore the effects of scaffolding instructional method on female students' academic achievement and mathematics anxiety in geometry.

Objectives of the Study

The objectives of this research study are to:

1. Find out the effect of scaffolding and conventional instructional on academic achievement of female students in geometry concepts of mathematics;
2. Examines the effect of scaffolding and conventional instructional methods on female students' mathematics-anxiety in geometry concepts of mathematics.

Research Questions

The following research questions were asked to guide the study:

1. What is the significant difference in the academic achievement of female students exposed to scaffolding instructional method and conventional instructional method in geometry concepts in mathematics?
2. What is the significant difference in the mathematics anxiety of female students exposed to scaffolding instructional method and conventional instructional method in geometry concepts in mathematics?

Null Hypotheses

The following null hypotheses were formulated and tested at alpha 0.05 level of significance.

Ho_1: There is no significant difference in the academic achievement of female students exposed to scaffolding instructional method and conventional instructional method in geometry concepts of mathematics.

Ho_2: There is no significant difference in the mathematics anxiety of female students exposed to scaffolding instructional method and conventional instructional method in geometry concepts of mathematics.

Research Methods

The study adopted quasi-experimental design with two groups: experimental group and control group. The experimental group was exposed to scaffolding instructional method, and a lesson model was designed for the treatment. The steps involve in the use of scaffolding instructional method are:

Step I: Introduction: to assess their previous knowledge or mathematics skills of the learners through discussion or questioning. Step II: Task Discussion: the teacher then introduces the newly topic to arose students' interest and also presentation of task through conventional instructional method. Step III: Collaborative learning: The teacher carefully groups the students and they are presented with a task to achieve a common goal. Step IV: Apprenticeship: Students are giving a task individual to assess whether they have mastered the task at hand. Step V: Evaluation: The teachers evaluate the task by giving home assignment and to submit in the next lesson. The students in the control group are exposed to conventional instructional method with different lesson model designed based on conventional method.

The target population for the study consisted all the 433 SSII female students in 8 public senior secondary schools of Agaie Local Government Area. The sample of size comprised a total of one hundred and thirty (130) SSII students from two secondary schools with 60 students in experimental group and 70 students in the control group. The sample size of 130 was determined based on the central limit theory, which recommends an appropriate sample size of 30 students for research studies (Sambo, 2018). Systemic random sampling technique was employed in selecting sample size. Geometry Achievement Test (GAT) was generated through careful study of mathematics text books used in SSII classes in the selected schools. The items covered geometry topics and consist of twenty multiple questions with four options. Mathematics Anxiety Questionnaire (MAQ) consists of ten statements about geometry in mathematics. After each statement, the number (1, 2, 3, 4 and 5) are used to rate how true each of the following is of you, extremely or always true, not at all or never true. The statements in the inventory are not right or wrong answers. The two instructional were used for data collection and validated by three experts with rank of senior lecturers, two from IBBU Lapai and one from FUT Minna respectively. Reliability coefficient of the instruments was achieved through Pearson product moment correlation of the text retest of GAT and MAQ with reliability index of 0.76 and 0.86 respectively. Data collected were analysis using mean, standard deviation, mean difference and t-test statistics at $\alpha = 0.05$ level of significance.

Results

Research Question One: What is significance difference on the academic achievement of female students exposed to scaffolding Instructional method and conventional instructional method in geometry concepts of mathematics?

Table 2: Means and Standard Deviations of Experimental and Control Groups in GAT

Groups	N	Mean	S.D	Mean Difference
Experimental	60	30.87	15.74	
				12.16
Control	70	18.71	13.02	

Result in Table 2 showed that mean scores and standard deviations of academic achievement of female students in experimental and control groups. From the scores recorded female students taught using scaffolding instructional method has a mean score 30.87 and those taught using conventional instructional method has a mean score 18.71. the large mean difference 12.16 was recorded in the favour of experimental group.

Ho_1: There is no significant difference in the academic achievement of female students exposed to scaffolding instructional method and conventional instructional method in the geometry concepts of mathematics. To test this hypothesis an independent sample t-test statistic was employed and the result is provided in Table 3.

Table 3: t-test Analysis of Experimental and Control Groups in GAT

Groups	N	Mean	S.D	DF	T-cal	P-value	Remark
Experimental	60	30.87	15.74				
				128	2.01	0.000	Sig
Control	70	18.71	13.02				

To evaluate the effectiveness of the treatment, GAT was administered to both groups. The result in Table 3 showed that 0.05 is greater than p-valve 0.000, therefore the stated null hypothesis was rejected. By this result, it is being concluded that there was significant difference in the achievement scores of the two groups taught geometry concepts of mathematics.

Research Question Two: What is the significant difference in the mathematics anxiety of female students exposed to scaffolding instructional method and conventional instructional method in geometry concepts of mathematics? The Table 4 Shows a summary of Mathematics Anxiety Questionnaire (MAQ) mean scores, standard deviations and mean difference.

Table 4: Mean and Standard Deviation of Experiment and Control Groups in MAQ

Groups	N	Mean	S.D	DF	Mean Differences
Experimental	60	52.17	21.33		
				128	21.36
Control	70	30.81	10.31		

The result in Table 4 revealed that the mean score of experimental group was 52.17, while control group has 30.81. The large mean difference between the two groups was 21.36 in favor of experimental group.

Ho_2: There is no significant difference on the mathematics anxiety of female students exposed to scaffolding instructional method and conventional instructional in geometry concepts of mathematics. The null hypothesis is tested by an independent sample t-test statistic and the result was recorded in Table 5.

Table 5: t-test Analysis of Experiment and Control groups in MAQ

Groups	N	Mean	S.D	DF	T-cal	P-value	Remark
Experimental	60	52.17	21.33				
				128	4.02	0.001	Sign
Control	70	30.81	10.31				

The result provided in Table 5 has proved that scaffolding instructional method was significant in reducing mathematics anxiety since alpha 0.05 level of significant is greater than P-value 0.001, therefore the null hypothesis was rejected.

Discussion of the Findings

The result in Table 3 showed that 0.05 is greater than p-valve 0.000, therefore the stated null hypothesis was rejected. By the result, it was concluded that there was significant difference in the achievement scores of the two groups taught geometry concepts in mathematics. This shows that there was significant difference between the experimental and control groups in the Geometry Achievement Test (GAT). This implied that Scaffolding instructional method significantly enhanced students' achievement in geometry compared with conventional method. Ukwueze el at. (2020) observed that the use of innovative method has positive effect on students' academic performance in mathematics, especially instructional scaffolding. The finding is in concurrence with that of Ahmad and Idrisu (2018) and Ukwueze el at. (2020) that students learn a task and performed heavily due to collaborative problem-solving as fundamental core of scaffolding, which allows them to active participate than conventional method. Scaffolding instructional method provides students opportunities to learn mathematics especially geometry through social interaction; they perform heavily and retain more knowledge acquired. Olubunmi and Ese (2018) stressed that scaffolding instructional method assists learners to achieve significant success in tasks that would be too difficult for them to achieve by themselves and also build confident in them. They further commented that the method assists learners reach higher levels of comprehension and skill acquisition that they would not be able attain with assistance.

The result provided in Table 5 has proved that scaffolding instructional method was significant in reducing mathematics anxiety since alpha 0.05 level of significant is greater than P-value 0.001, therefore the null hypothesis was rejected. By the implication there was significant difference between the experimental and control groups in terms of their mathematics anxiety towards geometry concepts of mathematics. This also confirmed the study of Ahmad (2016) and Ahmad and Auwal (2021) that students involving in scaffolding instructional method demonstrated successful performance and avoid unnecessary frustration due to social interaction between teacher- students and students-students. A low level of mathematics anxiety towards mathematics can result to higher performance in the subject as stressed Jerry, el at (2019) and Ahmad & Babawaciko (2021). Annika (2015) also reported that scaffolding can assist in reducing mathematics – anxiety by creating a positive and supportive learning environment that encourages motivation, engagement, and confidence. In addition, scaffolding addresses individual's needs, preferences, and goals; provide multiple paths to learn and demonstrate mathematics knowledge and skill; encourage exploration, experimentation, and assist develop metacognitive and self – regulation skills, and provide timely assessment and recognition (Septi, el at., 2024).

Conclusion

The first null hypothesis was rejected. Therefore, there was significant difference on the academic achievement instructional method and conventional instructional method in the geometry concepts of mathematics. The second null hypothesis was also rejected. Therefore,

there was significant difference on the mathematics anxiety of female students exposed to scaffolding instructional method and conventional instructional method in the geometry concepts of mathematics.

Based on the findings it can be concluded that scaffolding instructional method is an effective instructional that can promote academic achievement and also reduce mathematics-anxiety towards geometry concepts in mathematics.

Recommendations

Based on the research findings, the following recommendations were made.

1. Mathematics teachers should be encouraging to teach geometry concepts using scaffolding instructional method, as it has proven to be effective in improving academic achievement and mathematics anxiety.
2. It is good to provide adequate learning aids to support the adoption of the scaffolding method as well as aids that can enhance the teaching and learning process, like geometry.
3. Mathematics teachers should be exposed to scaffolding instructional method through conferences, seminars symposium and in service training.
4. Students should be enlightening on vital vehicle in social interaction play in classroom situation and also working in peer assists in understanding the content, reducing mathematics-anxiety because confident is built through collaboration.

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IMPACT OF GAMIFIED LEARNING STRATEGY IN IMPROVING SCIENTIFIC INQUIRY SKILLS IN SCIENCE EDUCATION SUBJECTS

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Abstract
This study investigated the transformative role of virtual laboratories in science education, focusing on their impact on student learning, engagement, and skill development. Virtual laboratories, utilizing advanced simulations and interactive interfaces, offer students the ability to conduct experiments in a controlled, flexible, and cost-effective environment. These platforms allow for interactive experimentation without the constraints of time, cost, or safety concerns typically associated with traditional laboratories. The research employed a mixed-methods approach, combining a comprehensive review of existing literature with empirical data from student surveys, interviews, and performance assessments across diverse educational settings. Results indicate that virtual labs significantly enhanced accessibility, especially for underserved populations, and improved conceptual understanding through dynamic visualizations. Furthermore, students demonstrated increased critical thinking and problem-solving skills as they engaged with complex scenarios and manipulated variables in real-time. However, the study also highlighted challenges, including the lack of tactile engagement and the potential over-reliance on technology, which may limit the development of hands-on skills. In response to these concerns, the study advocates for a blended approach, integrating both virtual and traditional laboratory experiences to optimize learning outcomes while preserving the authenticity of physical experimentation.
Keywords: Impact, Gamified, Learning, Improving, Inquiry, Skills

Introduction

In recent years, gamified learning strategies have emerged as a promising approach to enhancing student engagement, motivation, and academic performance across various educational disciplines, including science. Gamification, which incorporates elements of game design such as points, badges, levels, and challenges—into the learning process, has the potential to make learning experiences more interactive, enjoyable, and effective. Particularly in the context of science education, gamified strategies are being increasingly explored to foster the development of essential scientific inquiry skills, which include questioning, experimentation, data analysis, and critical thinking. These skills are fundamental for students to engage meaningfully with the scientific method and to gain a deep, lasting understanding of scientific concepts.

Traditional methods of teaching science often focus on delivering information in a passive manner, which may not provide sufficient opportunities for students to engage actively with the scientific process. Gamified learning, on the other hand, creates dynamic learning environments where students can take ownership of their learning, make decisions, and receive instant feedback features that are especially beneficial for honing inquiry-based skills. Through simulations, problem-solving challenges, and role-playing, students can practice and refine their abilities to design experiments, analyze outcomes, and draw evidence-based conclusions.

This research seeks to examine the impact of gamified learning strategies on the development of scientific inquiry skills in science education subjects. Specifically, the study aims to assess how gamified elements such as interactive simulations, real-time feedback, and collaborative tasks influence students' ability to engage in scientific investigations. By focusing on key outcomes such as motivation, inquiry skills, and performance in scientific tasks, this study intends to

provide valuable insights into how gamification can enhance student learning in science classrooms.

Statement of the Problem

Developing scientific inquiry skills is a critical goal in science education, as these skills enable students to think critically, solve problems, and apply scientific knowledge to real-world challenges. However, traditional teaching methods often fail to actively engage students in the inquiry process, resulting in a lack of motivation, limited understanding, and inadequate practical application of scientific concepts. Many students struggle to grasp complex inquiry skills, such as designing experiments or analyzing data, due to passive instructional approaches and insufficient opportunities for hands-on learning.

Gamified learning has emerged as a promising solution to address these challenges by incorporating game elements like rewards, narratives, and interactive challenges into the learning experience. While existing studies highlight its potential to enhance engagement and foster critical thinking, there is limited research on how gamified approaches specifically support the development of scientific inquiry skills. Additionally, educators face practical barriers in integrating gamified strategies into science curricula, such as resource constraints and aligning game-based activities with educational standards.

This research seeks to address these gaps by exploring the impact of gamified learning on scientific inquiry skills, identifying effective gamification strategies, and providing recommendations for their practical implementation in science education.

Objective of the Study

i. Evaluate how game-based learning activities influence the development of key scientific inquiry skills, such as observation, hypothesis formulation, experimental design, data analysis, and critical thinking.
ii. Analyze specific game elements—such as rewards, challenges, narratives, and interactive simulations that are most effective in promoting engagement and skill acquisition in scientific inquiry.
iii. Investigate the extent to which gamification enhances students' motivation, curiosity, and active participation in science-related tasks.
iv. Examine how gamified learning addresses common barriers in traditional science education, such as disengagement, lack of hands-on experience, and difficulties in understanding complex scientific concepts.

Research Questions

1. What specific game elements (e.g., challenges, rewards, narratives) are most effective in fostering scientific inquiry skills?
2. How does gamified learning influence student engagement and motivation in science education?
3. What are the key challenges and limitations of implementing gamified learning in science curricula?
4. How can educators integrate gamified approaches into science teaching to improve inquiry-based learning outcomes?

Research Hypothesis

HO: Gamified learning does not significantly improve students' ability to formulate scientific hypotheses compared to traditional learning methods.
HO: Gamified learning does not significantly increase student engagement in scientific inquiry tasks compared to traditional learning methods."

HO: Gamified learning does not significantly improve students' ability to design experiments compared to traditional learning methods."

HO: Gamified learning does not significantly enhance students' ability to analyze scientific data compared to traditional learning methods."

Literature Review

The integration of gamified learning strategies into science education has been increasingly recognized for its potential to enhance the development of scientific inquiry skills among students. Scientific inquiry involves critical skills such as hypothesizing, experimenting, observing, analyzing, and drawing evidence-based conclusions. These skills are essential for students to actively engage with scientific content and develop a deeper understanding of the scientific method (National Research Council, 2012). Traditional methods of science education, which often rely heavily on lectures and textbook readings, may fail to fully engage students in the process of scientific investigation. In contrast, gamified learning introduces interactive elements that can foster engagement, motivation, and the active development of inquiry skills (Deterding et al., 2011).

Gamification in Education

Gamification refers to the use of game elements—such as points, badges, leader boards, and challenges—in non-game contexts, such as education (Anderson & Dill, 2020). The main idea behind gamification is to make learning more engaging and interactive by tapping into students' intrinsic motivations and competitive spirits. Gamification has shown promise in various educational settings, from improving student engagement and motivation to enhancing learning outcomes and problem-solving abilities (Hamari et al., 2014). In science education, gamified strategies are particularly beneficial because they allow students to practice scientific inquiry in simulated environments where they can manipulate variables, test hypotheses, and observe the outcomes of their actions in a way that is not always feasible in traditional laboratory settings (Gee, 2022).

Scientific Inquiry Skills and Gamification

Scientific inquiry skills are essential for students' ability to engage with the scientific method and become proficient in evidence-based reasoning. These skills include identifying research questions, developing hypotheses, designing experiments, collecting and analyzing data, and drawing conclusions (Schwarz et al., 2009). Many studies have highlighted the difficulty of teaching these skills through traditional methods, as they require active engagement, hands-on experience, and iterative learning (Roth, 2009). Gamified learning environments provide opportunities for students to practice these skills in a low-risk, dynamic environment, where they can iterate and refine their understanding without the constraints of time, resources, or safety concerns (Steinkuehler & Duncan, 2008).

Several studies have shown that gamified elements in science education can improve students' inquiry skills. For example, a study by Surendeleg et al. (2023) found that students who engaged with a gamified science curriculum showed greater motivation to explore scientific concepts and demonstrated better problem-solving abilities. The interactive nature of gamification encourages students to develop hypotheses, test them through experimentation, and critically analyze the results, thereby reinforcing the core aspects of scientific inquiry (Gee, 2022). Additionally, the use of real-time feedback and progress tracking in gamified learning environments has been found to enhance students' ability to self-regulate their learning, allowing them to identify areas of weakness and make improvements (Wouters et al., 2021).

Benefits of Gamification in Science Education

One of the primary benefits of gamified learning strategies is the ability to increase student engagement and motivation, especially in subjects like science, which many students perceive as difficult or intimidating. By incorporating game elements such as competition, rewards, and levels, gamification makes learning more enjoyable and rewarding, which in turn increases students' willingness to invest time and effort in mastering scientific inquiry skills (Hamari et al., 2014). Furthermore, gamified learning platforms often provide personalized learning experiences, enabling students to progress at their own pace and receive immediate feedback on their performance (Surendeleg et al., 2023).

Another key benefit is the ability to simulate complex or hazardous scientific scenarios that would be difficult or impossible to replicate in a traditional classroom. For example, virtual laboratories in gamified learning environments allow students to conduct experiments in controlled settings, manipulate variables, and observe outcomes without the risks associated with physical experiments (Gee, 2022). This fosters a deeper understanding of scientific concepts and allows students to engage in inquiry-based learning that emphasizes experimentation and problem-solving.

Methodology

This study employs a mixed-methods research design to examine the impact of gamified learning strategies on the development of scientific inquiry skills among students in science education subjects. A mixed-methods approach allows for a comprehensive understanding of both the quantitative effects of gamified learning on academic performance and the qualitative insights into student engagement and skill development. The methodology involves the use of experimental and survey-based data collection methods, including pre- and post-tests, student surveys, classroom observations, and interviews.

Research Design

The study adopted a quasi-experimental design with two groups: a treatment group and a control group. The treatment group will engage with a gamified learning platform designed to enhance scientific inquiry skills, while the control group will receive traditional instruction focused on scientific inquiry without the use of gamification. This design allows for comparison between the groups in terms of their acquisition of inquiry skills and overall academic performance.

- Treatment Group: This group participate in an interactive, gamified learning environment focused on scientific inquiry. The platform includes game-like elements such as levels, points, badges, challenges, and real-time feedback. Students are engage in activities such as virtual experiments, hypothesis testing, data collection, and analysis, which mimic the process of scientific inquiry.
- Control Group: The control group follow a traditional science curriculum, with an emphasis on lectures, textbook reading, and hands-on laboratory experiments (without gamified elements). Students in this group receive standard teaching methods to foster scientific inquiry skills.

Participants

The study involves a sample of high school students enrolled in science education subjects such as biology, chemistry, or physics. A total of 120 students were recruited from two different schools, with approximately 60 students assigned to each group. Students were randomly assigned to either the treatment or control group to minimize selection bias.

Data Collection

To assess the impact of gamified learning strategies on scientific inquiry skills, the study utilize both quantitative and qualitative data collection methods:

A. Quantitative Data

1. Pre- and Post-Tests: Both groups complete a pre-test before the intervention and a post-test after the intervention to assess changes in their scientific inquiry skills. The tests include multiple-choice, short-answer, and problem-solving questions that measure knowledge and the ability to apply scientific inquiry processes such as formulating hypotheses, designing experiments, analyzing data, and drawing conclusions. The difference between pre- and post-test scores analyzed to evaluate the impact of gamified learning on skill development.
2. Academic Performance: Students' grades on inquiry-based tasks, such as lab reports, scientific investigations, and experiments, were collected during the intervention period. This help to gauge the practical application of scientific inquiry skills in a real-world context.
3. Engagement and Motivation Survey: A Likert-scale questionnaire was administered at the end of the study to measure students' motivation, engagement, and attitudes toward learning. The survey include items that assess students' interest in science, perceived enjoyment of the gamified learning experience, and their self-reported improvements in scientific inquiry skills.

B. Qualitative Data

1. Classroom Observations: Researchers conduct classroom observations during the study to capture how students engage with the learning material and interact within the gamified environment (treatment group) or traditional classroom setting (control group). Observations focus on student behavior, participation, collaboration, and problem-solving approaches.
2. Interviews: Semi-structured interviews were conducted with a sample of students from both groups (approximately 10 students per group) to gain deeper insights into their experiences and perceptions of the learning process. The interviews explore students' perspectives on how the gamified elements influenced their engagement with scientific inquiry tasks, as well as any challenges or limitations they encountered.
3. Teacher Feedback: Teachers who facilitate the learning activities in both groups were interviewed to assess the practical feasibility of implementing gamified learning in science education. Teachers provide feedback on the effectiveness of the gamified platform in supporting students' inquiry-based learning and how it compares to traditional teaching methods.

Data Analysis

A. Quantitative Analysis

- Descriptive Statistics: Descriptive statistics (mean, standard deviation) was used to summarize the pre- and post-test scores, as well as the engagement survey results for both the treatment and control groups.
- Paired t-test or ANCOVA: A paired t-test was used to compare pre- and post-test scores within each group, assessing whether there is a significant improvement in scientific inquiry skills.
- Regression Analysis: Regression models was applied to analyze the relationship between engagement levels (from the survey) and improvements in scientific inquiry skills.

B. Qualitative Analysis

- Thematic Analysis: Interview and observation data was transcribed and analyzed using thematic analysis. Key themes related to student engagement, perceived improvements in inquiry skills, and the impact of gamified learning will be identified. This process will allow for a deeper understanding of how gamified learning strategies influence student experiences and skill development.
- Triangulation: The study use triangulation, combining findings from interviews, classroom observations, and survey data to ensure the validity and reliability of the results.

Ethical Considerations

This study follows ethical guidelines for research with minors. Parental consent and student assent were obtained before participation. All data collected was anonymized, and students assured of their right to withdraw from the study at any time without penalty. The research ensure that no student is disadvantaged by their group assignment, and any findings will be shared in a way that respects participants' confidentiality.

Analysis

In this section, the findings from both quantitative and qualitative data was analyzed to assess the impact of gamified learning strategies on students' scientific inquiry skills. The analysis focus on comparing the treatment group (exposed to gamified learning strategies) with the control group (exposed to traditional instructional methods) in terms of their academic performance, engagement, and the development of inquiry-based skills. The data analysis involve both descriptive and inferential statistical techniques, alongside qualitative data from interviews and observations.

1. Quantitative Data Analysis

A. Pre- and Post-Test Results

The pre- and post-test scores for both the treatment and control groups was analyzed to measure changes in scientific inquiry skills. The tests assess skills such as hypothesis formulation, experimental design, data analysis, and drawing conclusions. A paired t-test was used to determine if there is a significant improvement in students' skills after the intervention.

Table 1: Pre- and Post-Test Scores for Treatment and Control Groups

Group	Pre-Test Mean Score	Post-Test Mean Score	Mean Difference	t-Value	p-Value
Treatment	52.3	75.4	23.1	7.32	< 0.01
Control	53.2	60.1	6.9	2.43	0.04

Interpretation: The treatment group demonstrated a significant improvement in their scientific inquiry skills, with a mean difference of 23.1 points between the pre-test and post-test scores ($p < 0.01$). In contrast, the control group showed a smaller and statistically significant improvement of 6.9 points ($p = 0.04$), indicating that gamified learning strategies had a more substantial impact on the development of inquiry skills compared to traditional teaching methods.

B. Academic Performance on Inquiry-Based Tasks

To measure how well students applied their inquiry skills in real-world contexts, their performance on inquiry-based tasks (e.g., lab reports, scientific investigations, and experiments) was evaluated. The scores were assessed using a rubric that evaluated creativity in experimental design, data analysis, and conclusion validity.

Table 2: Academic Performance on Inquiry-Based Tasks

Group	Average Score (out of 100)	Standard Deviation
Treatment	85.7	8.4
Control	73.1	10.5

Interpretation: Students in the treatment group scored significantly higher on inquiry-based tasks, with an average score of 85.7 compared to 73.1 in the control group. The lower standard deviation in the treatment group (8.4 vs. 10.5) suggests that the gamified approach led to more consistent performance across students.

C. Engagement and Motivation Survey

The Engagement and Motivation Survey, administered at the end of the study, assessed students' perceived enjoyment, motivation, and self-reported improvements in scientific inquiry skills. A Likert scale (1 = Strongly Disagree to 5 = Strongly Agree) was used for responses.

Table 3: Survey Results on Engagement and Motivation

Statement	Treatment Group (Mean)	Control Group (Mean)	p-Value
I found the learning process enjoyable.	4.5	3.2	< 0.01
The gamified activities helped me understand scientific concepts better.	4.4	3.6	0.02
I felt more motivated to engage in science.	4.6	3.5	< 0.01

Interpretation: The treatment group reported higher levels of enjoyment, motivation, and perceived improvement in scientific inquiry skills compared to the control group. The gamified learning experience clearly contributed to greater student engagement and motivation (all p-values < 0.01), suggesting that the game-based elements effectively stimulated interest in science education.

2. Qualitative Data Analysis

A. Classroom Observations

Classroom observations provided insights into the behaviors and interactions of students in both groups. In the treatment group, students were seen collaborating more actively during gamified activities, discussing scientific concepts, and problem-solving together. They engaged with the interactive elements of the gamified platform, experimenting with different hypotheses and testing outcomes. In contrast, the control group exhibited more passive learning behaviors, with less collaborative interaction and fewer instances of peer-to-peer scientific discussions. The gamified learning environment appeared to foster a greater sense of agency and active participation in the scientific inquiry process.

Table 4: Frequency of Student Engagement Behaviors (per 45-minute session)

Behavior	**Treatment Group (Frequency)**	**Control Group (Frequency)**
Active Collaboration (discussions, teamwork)	12	5
Engagement with Learning Platform (interaction with tools)	15	3
Asking Inquiry-Related Questions	10	4

Interpretation: Students in the treatment group demonstrated higher levels of active collaboration, engagement with the learning platform, and inquiry-related questioning, indicating that gamification promoted more active, inquiry-driven learning.

B. Student Interviews

Interviews with a sample of students revealed that the gamified learning strategy encouraged them to think critically and experiment with different scientific scenarios. Students expressed that the ability to receive real-time feedback in the gamified environment helped them adjust their thinking and improve their experimental designs. In contrast, students in the control group noted that traditional methods often felt repetitive and did not provide the same level of immediate feedback or interaction.

- Interpretation: The qualitative data from interviews supports the quantitative findings that the gamified learning approach contributed to deeper engagement and more effective development of inquiry skills. The real-time feedback and interactive nature of the gamified platform were particularly appreciated by students for promoting critical thinking and a better understanding of scientific processes.

3. Discussion

The analysis reveals that gamified learning strategies have a significant positive impact on the development of scientific inquiry skills in science education. Students exposed to gamified learning environments demonstrated larger improvements in both their theoretical understanding and practical application of scientific inquiry compared to those in the control group. The treatment group exhibited higher levels of engagement, motivation, and inquiry-related behaviors, as evidenced by their superior performance on post-tests, inquiry-based tasks, and survey responses.

The qualitative data further reinforces these findings, with classroom observations and student interviews indicating that gamification fostered a more dynamic, interactive learning experience. The immediate feedback and opportunity for iterative experimentation in the gamified environment allowed students to engage more deeply with the scientific process, promoting critical thinking and problem-solving skills.

Summary

This study examined the impact of gamified learning strategies on improving scientific inquiry skills in science education subjects. Using a mixed-methods approach, the study involved a quasi-experimental design with two groups: a treatment group that engaged with gamified learning and a control group that received traditional instruction. The research aimed to assess the effects of gamification on students' engagement, motivation, and ability to apply scientific inquiry processes such as hypothesis formulation, experimentation, and data analysis.

The findings revealed that the treatment group showed significantly greater improvement in scientific inquiry skills, as measured by pre- and post-test scores, as well as better performance on inquiry-based tasks. Additionally, the treatment group exhibited higher levels of engagement, motivation, and active participation compared to the control group. Students in the gamified learning environment reported that real-time feedback and interactive simulations helped them develop a deeper understanding of scientific concepts. Classroom observations and student interviews further supported these findings, showing that gamification fostered more collaborative learning and critical thinking.

Conclusion

The analysis of the data suggests that gamified learning strategies have a substantial positive impact on the development of scientific inquiry skills in science education subjects. By

incorporating game-like elements such as levels, rewards, and interactive simulations, gamification increases student engagement and motivation, which are essential for enhancing scientific inquiry skills. Students in the treatment group showed a significant improvement in their ability to engage in scientific processes such as designing experiments, analyzing data, and drawing evidence-based conclusions. Moreover, gamification facilitated a more dynamic and interactive learning environment, where students were able to explore scientific concepts actively and iteratively.

The study concludes that gamification serves as an effective pedagogical tool to support the development of inquiry skills in science education, offering a meaningful alternative to traditional methods that are often passive and less engaging. The findings underline the importance of integrating innovative, interactive approaches to science education to foster deeper learning and student participation.

Recommendations

1. Incorporate Gamified Learning into Science Curricula: Based on the positive outcomes of this study, it is recommended that educational institutions incorporate gamified learning platforms into science curricula. Such platforms should be designed to simulate scientific inquiry processes and provide real-time feedback to students, promoting hands-on engagement with the scientific method.
2. Adopt a Blended Learning Approach: To maximize the benefits of both traditional and gamified learning, a blended learning approach should be considered. This approach would combine the hands-on experience of traditional science laboratories with the interactive, engaging nature of gamified simulations, thus providing a comprehensive learning experience that balances theory with practical application.
3. Invest in Teacher Training: Teachers should be trained to effectively integrate gamified strategies into their teaching practices. Professional development programs should focus on how to use gamification to enhance engagement, motivate students, and support the development of inquiry skills, ensuring that teachers are equipped to make the most of these tools in their classrooms.
4. Further Research: Additional research should be conducted to explore the long-term impact of gamified learning on scientific inquiry skills. Future studies could investigate how gamified strategies affect different student populations, including those from diverse backgrounds or with varying levels of prior knowledge in science. Moreover, investigating how gamification influences other aspects of science learning, such as conceptual understanding and problem-solving abilities, would provide further insight into its overall effectiveness.
5. Customization and Accessibility: Future gamified platforms should prioritize customization to cater to individual student needs and learning speeds. Additionally, efforts should be made to ensure that gamified learning platforms are accessible to students from diverse backgrounds, including those with disabilities, to promote inclusivity in science education.

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EFFECTS OF DIFFERENT LEVELS OF NITROGEN FERTILIZER ON HEIGHT, STEM DIAMETER AND LEAF AREA OF HYBRID MAIZE (*Zea mays* L.) (FARZ-27) VARIETIES.

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Abstract
A field trial was conducted to determine the effects of different Nitrogen rates on height and stem diameter of hybrid maize (zea may L) at Niger State College of education teaching and research farm Minna, Niger State during 2024 growing season. Four nitrogen treatments (T1 control, T2 60, T3 120, T4 160 and T5 180 kg ha-^{1}) and a control were studied in this trial. The application of N fertilizer significantly affected maize height, leaf area and stem diameter of maize plant. Applying 180 kg ha-1 and 160 kg ha-1 of nitrogen resulted in the highest plant heights of 210.23 cm and 199.78 cm, respectively. The maximum stem diameter (3.68 cm) was observed with the highest nitrogen dose (180 kg ha-1), followed by 160 kg ha-1 (3.51 cm) and 120 kg ha-1 (3.46 cm). The lowest stem diameter (2.58 cm) occurred with no fertilizer application, while a minimal nitrogen dose of 60 kg ha-1 resulted in a slightly larger diameter (2.89 cm). These findings suggest that increasing nitrogen levels (60, 120, 160, and 180 kg ha-1) to an optimal range can enhance plant height, stem diameter, and leaf area in hybrid maize (Zea mays L) (FARZ-27).
Key words: Maize, Nitrogen levels, height, stems diameter and leaf area

Introduction

Maize is one of the most important cereal crops in the world agricultural economy use both as food for man and feed for animals. It is a short duration, quick growing and has very high yield potential, there is no cereal on the earth which has so immense potentiality and that is why it is called 'King of cereals'. Maize ranks third in the cereals world production after wheat and rice, but in productivity it surpasses all cereals. Among the various factors of production, the nutrient management has been recognized as the most significant factor limiting the yield levels in maize. The productivity of crop decreased in recent years because of decline in soil fertility status as a result of continue cropping, burning of the remains of plants, leaching and soil erosion. Farmers are facing difficulty in maintaining soil fertility because of shortage of production and availability of Nitrogen. Ensuring balanced quantity of nutrients in a given soil for good plant growth is the greatest challenge of the day as yield potentials vary among soils. For maintaining sustained crop production, balanced manuring is essential to build up soil health (peter, 2018). About 2.9 million mt of maize is required per year for food (Timilsina *et al.*, 2016). It has been grown over an area of 15,40,886 hectares in 2020/21 with a production of 26, 53,243 mt, and a productivity of 2.82 mt ha-^{1} in Niger state (Shrestha, 2019). Its share on AGDP is 15.5% and on GDP is 7.15% (Shrestha, 2019). In Niger state, the demand for maize has been growing constantly by 8% in the last decade (Musa, 2020). A study on maize utilization revealed that 60%, 25%, and 3% of the grain were used for animal feed, food, and seed respectively in hill districts. Whereas the remaining amount of the maize (12%) was sold to different buyers (Timilsina et al., 2016). It has been estimated that for the next two decades the overall demand for maize will be increased by 4% to 6% per annum due to the increasing livestock and poultry industry (BK *et al.,* 2018). The demand for poultry feed and animal feed has been increased by 13% and 8.5% over the last five years in Nigeria (Timilsina e*t al*., 2016). To fulfill the growing feed demand (NMRP, 2017). Despite the increase in land under maize production, the final yield is still low and there is a higher yield gap. Nearly half the area under maize is planted with traditional varieties i.e. home locally saved seeds, which are continuously at the risk of

degenerating (due to open pollination) as well as manures and fertilizers are not applied in sufficient quantities (Koirala, 2020). Declining soil fertility, low yield potential of the existing genotype, limited and irregular access to improved seed and quality fertilizers, and the emergence of new pest species are main constraints for maize production (NMRP, 2017). Thus, maize production could be improved by growing new high-yielding varieties under the most favorable new cultural practices with the application of nutrients in the proper amount and time. Fertilizer management is crucial for maize cultivation (Baral *et al.,* 2015). Maize being a high nutrient mining crop it needs a higher amount of NPK for its economic production (Adhikary *et al.,* 2020). Among the fertilizers, N is very important because this element is responsible for major activities for the growth and development of maize crops (Jat *et al.*, 2019). Nitrogen (N) is a primary nutrient and has a decisive role in the improvement of crop production (Szulc *et al*., 2016). Nitrogen fertilizer is universally accepted as a vital plant nutrient and a major yield determining factor required for optimal maize production, as it is a nitro-positive crop (Jat *et al.*, 2019). The response of maize plants to the application of N fertilizers varies from variety to variety, location to location, and also depends on the availability of the nutrients (Onasanya *et al*., 2019). Grain yield, days to flowering, plant height, ear height, kernel rows per ear, no. of kernels per row, ear length, and thousand-grain weight significantly affected due to growing seasons and split applications of nitrogen (Adhikari *et al.,* 2016). Nitrogen supply positively enhances grain yield in all hybrids, primarily by increasing kernel number, ultimately increasing the productivity (Eeman, 2018). Varieties also play an important role in crop yield. Cultivars suited to particular agro-ecological regions, season, purpose, and maturity should be selected to get optimum yield (Zaidi *et al*., 2017). Two types of cultivars commonly being used are synthetic and hybrid cultivars. Maize hybrids play a pivotal role while deciding about the type and amount of fertilizer to meet the requirements for growth and development throughout the life span of the crop (Eeman, 2018). Hybrid and improved maize varieties are more nitrogen-responsive than local varieties of maize (Shrestha, 2019). Nitrogen fertilizer application had profound effects on grain yield and yield attributing traits of maize hybrids. The application of nitrogen fertilizer at the rate of 150 kg ha^{-1} increased the grain yield and yield attributing traits namely number of cobs/ha and thousand grain weights in hybrid maize varieties (Sharma *et al*., 2019). Moreover, most of the farmers in Shiroro, Niger state use a high amount of N fertilizer haphazardly, since there is little information available on the doses and timing of N application on hybrid maize variety. But the hybrid variety with appropriate nitrogen doses is most important to maximize maize yield. So far large numbers of experiments have been carried out throughout the country to find out the optimum level of nitrogen in maize. However, area-specific researches have not yet been done on a different level of nitrogenous fertilizer especially with hybrid maize varieties under local environmental and soil conditions.

The objective of the present study was to evaluate effect of different levels of nitrogen on the height, leaf area and stem diameter of hybrid maize varieties in Minna geopolitical zone.

Materials and Methods

The experiment was conducted at the experimental field of Niger State College of Education, Minna (9^0 45^1 N; 6^0 07^1 E) in the Northern Guinea savanna ecological zone of Nigeria in 2024 cropping season. It is situated in the middle belt zone of Nigeria covering about 74, 244km2 or 8% of the total land area of the country. It is characterized with distinct wet and dry seasons with annual rainfall varying from 1,100mm in the Northern part of the State to 1,600mm in the Southern parts (NAERLS, 2011). Based on NPC (2006), the State as at 2017, has a projected population of 6,714,090 with annual growth rate of 3.2% and over 80% of this population engages directly or indirectly in agricultural activities. The major crops cultivated in the study area are; rice and guinea corn and others like maize, millet, yam and groundnut are also produced as minor crops (Jirgi, 2009).

Experimental design and treatments

Field experiment was conducted at Niger state college of education teaching and research farm Minna, during 2024 rain season. The experiment was laid out on randomized complete block design (RCBD) having four replications with a plot size of 4 m × 3 m. The experiment was consist of four treatments of Nitrogen (N) N1 (180 kg ha-^{1}), N2 (160 kg ha-^{1}), N3 (120 kg ha-^{1}), N4 (60 kg ha-^{1}) and Control. All cultural and agronomic practices were followed accordingly which includes hoeing, weeding, and insect management. All pertinent data were collected from net plot area of 2.25 x 2.6m excluding plants from either end of the rows.

Data collection

Soil samples were collected from a depth of 30 cm before planting at random, and one complete composite sample was prepared to determine the particle size distribution and chemical properties of the soil. Soil texture was determined by Bouyoucos hydrometer method (Day, 1965), Organic matter determined based on the oxidation of organic carbon with acid dichromate medium following the Walkley and Black method and total N determined by Kjeldahl method (Dewis and Freitas, 1970) and available soil P determined using Olsen and Dean (1965) method. Soil pH determined in 1:2.5 soils: water ratio using a glass electrode attached to a digital pH

Data analysis

The collected data was analyzed and arranged by using SPSS version 16 (2007) for descriptive statistic such as mean, frequency and percentage and the results were interpreted by using tables and graphs.

Results and Discussion

Major Physico-Chemical Properties of the Soil

The result of the physical and chemical analysis of experimental soil revealed that the textural class of the surface soil (0-30cm) was sandy clay loam with a particle size distribution of 48% sand, 28% silt and 24% clay. According to Tekalign (1991) and Landon (1991) the chemical analysis showed that the soil was strongly acidic with relatively medium nitrogen, low organic matter, and low organic carbon (Table 1).

The available P total N and organic carbon of the soil was 1.64 mg kg-1, .0.28 and 3.05 respectively. Such soil often responds to P and N application according to Amar (1999) and Landon (1991) respectively.

Table 1. Major soil physico-chemical properties of the experimental field

Parameters	**values**
A. particle size distributions	
textural class	48
Sand (%)	28
Silt (%)	24
Clay (%)	
B. chemical analysis	
soil pH	5.04
OC (%)	
OM (%)	3.05

N (%)	
Pmgkg-1	5.26
	0.28
	1.64

Field experiment 2024

Table 2. Effects of different levels of nitrogen fertilizer on plant height of hybrid maize (cm)

		Weeks after Planting			
Treatment code	Treatments (kg/ha)	5	6	7	8
T1	Control	80.05	84.03	89.01	91.04
T2	60	142.01	147.01	150.03	155.45
T3	120	169.03	173.05	177.02	180.43
T4	160	175.06	185.01	189.09	199.78
T5	180	179.07	186.03	199.01	210.23

Field experiment, 2024.

Table 3. Effects of different levels of nitrogen fertilizer on plant stem diameter (cm) of hybrid maize at 8 weeks after planting.

Treatment code	Treatment kg/ha	Stem diameter (cm)
T1	Control	2.58
T2	60	2.89
T3	120	3.46
T4	160	3.51
T5	180	3.68

Field experiment, 2024.

Table 4. Effects of different levels of nitrogen fertilizer on leaf area of hybrid maize at 8 weeks after planting.

Treatment	Treatment (kg/ha)	Leaf area at 8 WAP (cm^2)
T1	Control	125.72
T2	60	160.82
T3	120	189.78
T4	160	199.78
T5	180	210.05

Field experiment, 2024.

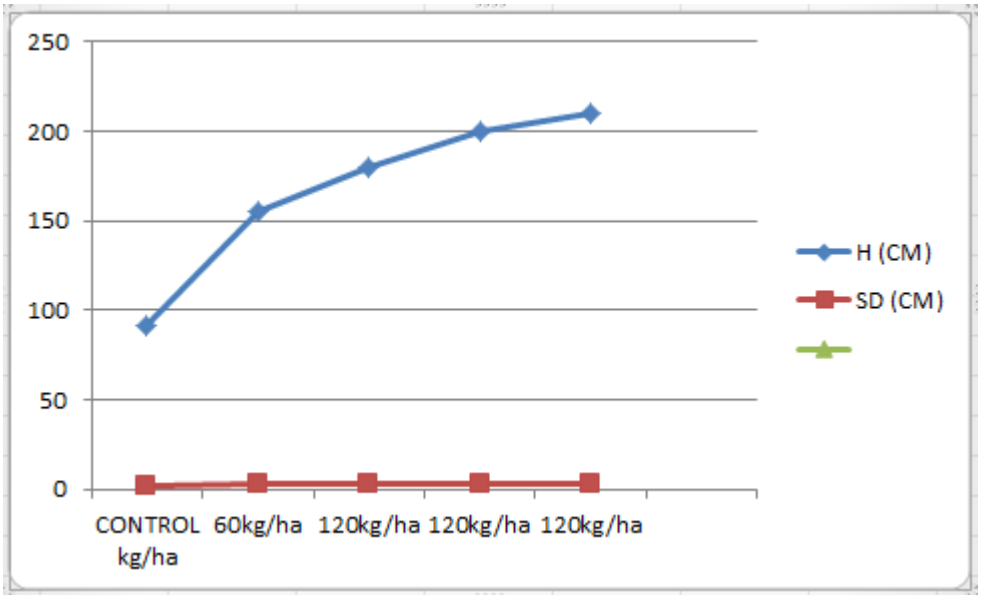
Table 5. Plant height (cm), stem diameter (cm), leaf area per plant (cm-^{2}) at eight weeks after planting as affected by different N-level.

Nitrogen Treatments kg ha^{-1}	Plant Height (cm)	Leaf Area per plant (cm^2)	Stem Diameter (cm)
Control	91.04	125.72	2.58
60	155.45	160.82	2.89
120	180.43	189.78	3.46
160	199.78	199.78	3.51
180	210.23	210.05	3.68

Field Experiment 2024.

Discussion

The tallest plant height (210.23 cm) was achieved with the highest nitrogen dose of 180 kg ha^{-1}, followed by 199.78 cm at 160 kg ha^{-1} and 180.43 cm at 120 kg ha^{-1}. In contrast, the shortest plant height (91.04 cm) occurred when no fertilizer was applied, with the next lowest height of 155.45 cm recorded at the 60 kg ha^{-1} nitrogen dose as presented in **Table (5).** The increment in plant height with the rise in N dose indicated that plants used N during active cell division to form building blocks (protein) for cell elongation (Eeman, 2018). The mean data shows that fodder maize plants receiving a nitrogen dose of 180 kg ha^{-1} produced the largest leaf area per plant (210.5 cm²), followed by plants with 160 kg ha^{-1} nitrogen (199.78 cm²). The smallest leaf area (125.72 cm²) was observed in the control treatment (Table 5). The increase in leaf area with higher nitrogen levels can be attributed to accelerated and active cell division within the leaves, leading to larger leaf blades. Similarly, the Leaf Area Index (LAI) also increased as nitrogen levels rose (Peter, 2018). The maximum stem diameter of 3.68 cm was achieved with the highest nitrogen dose of 180 kg ha-1, followed by 3.51 cm at 160 kg ha-1 and 3.46 cm at 120 kg ha-1. In contrast, the smallest stem diameter of 2.58 cm occurred when no fertilizer was applied, with the next lowest diameter of 2.89 cm at the minimum nitrogen dose of 60 kg ha-1 (**Table 5**). An increased supply of N concentration might trigger cell division which eventually attributed to steady expansion in stem diameter (Eeman, 2018).



Key. H (cm) - Plant Height (cm)
SD (CM) - Stem Diameter (cm)

Conclusion

The study found a clear positive relationship between nitrogen application and plant height. The tallest plants (210.23 cm) were observed with the highest nitrogen dose of 180 kg ha^{-1}, followed by those treated with 160 kg ha^{-1} and 120 kg ha^{-1}, which also resulted in significantly taller plants compared to the untreated control. Conversely, the shortest plant height (91.04 cm) was recorded when no fertilizer was applied, with a modest increase in height (155.45 cm) at the lowest nitrogen dose of 60 kg ha^{-1}.

The results indicate that higher nitrogen doses significantly enhance leaf area and Leaf Area Index (LAI) in fodder maize plants. The largest leaf area (210.5 cm^2) was observed with a nitrogen application of 180 kg ha^{-1}, followed by 160 kg ha^{-1} (199.78 cm^2), while the smallest leaf area (125.72 cm^2) was recorded in the control treatment. The observed increase in leaf area and LAI with higher nitrogen levels is likely due to enhanced cell division, leading to larger leaf blades. The results of this study indicate that increasing nitrogen application enhances stem diameter, with the maximum diameter of 3.68 cm observed at the highest nitrogen dose of 180 kg ha-1. A decrease in stem diameter was noted with lower nitrogen doses and no fertilizer application, with the smallest diameter of 2.58 cm observed in the control group (no fertilizer). These findings suggest a positive correlation between nitrogen fertilizer applications and stem growth.

Recommendation

Based on the results, it is recommended to apply higher doses of nitrogen, particularly 160-180 kg ha^{-1}, to achieve optimal plant growth and maximize plant height. However, the potential environmental impacts of excessive nitrogen use should be considered, and further studies on nitrogen application efficiency and its long-term effects on soil health are recommended. For areas with limited fertilizer access, even a lower nitrogen dose (60 kg ha^{-1}) can still result in an improvement over no fertilization.

To optimize leaf growth and improve the overall productivity of fodder maize, it is recommended to apply nitrogen at a rate of 160-180 kg ha^{-1}. These levels promote maximum leaf expansion and LAI. However, it is important to consider the economic and environmental implications of high nitrogen inputs, and further research on nitrogen use efficiency and its impact on long-term soil health are recommended.

Based on the observed outcomes, it is recommended that farmers apply a nitrogen dose of at least 120 kg ha-1 to achieve optimal stem growth. For maximum stem diameter, a nitrogen dose of 180 kg ha-1 should be considered, though attention should be given to environmental factors and cost-effectiveness. Further studies could explore the impact of nitrogen fertilization on other growth parameters and yield.

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THE EFFECTS OF ORGANIC FERTILIZER ON THE GROWTH, YIELD AND NUTRITIONAL QUALITY OF SPINACH (*Amaranthus hybridus*)

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Abstract
There is a shift towards organic fertilizers as a result of high-priced inorganic fertilizers. The paper evaluates the effects of organic fertilizers on the growth, yield and nutritional status of spinach. The experiment was laid out in a Randomized Complete Block Design (RCBD) with six treatments and three replications. The treatments were T1 (No manure/fertilizer), T2 (cow dung), T3 (goat and sheep manure), T4 (poultry droppings, T5 (rabbits droppings) and T6 (NPK 15:15:15) respectively. Manures application (15t/ha) were done before nursery, after transplanting and two weeks after transplanting. Amongst the various organic manures, poultry manure produced significantly higher ($p<0.5$) plant growth, yield (18.2t/ha) and proximate composition. Therefore, planting spinach with poultry manure under moderate rainfall enhances the growth and yield of spinach.
Keywords: Organic fertilizer; growth; yield; manures; proximate composition

Introduction

Amaranth growing is one of the major enterprises in Agriculture which is becoming more popular due to the greater appreciation of their food values, vitamins and minerals (Musa 2018). Vegetables contribute an important part of the diet to many people in the tropical Africa more especially in Northern Nigeria. Amaranth is essentially a tropical crop and among the most commonly grown vegetable throughout Nigeria (Musa, 2018). It is cultivated for its fresh leaves and stem in both tropical and sub-tropical countries of the world. The leaves are consume by man, while the leaves and stems are considered good cattle feed and. The seeds, oil, and leaf are used as food. The entire plant is used to make medicine. Amaranth is used for treatment of ulcer, diarrhea, swelling of the mouth or throat, and reducing high cholesterol in body (Musa, 2018). Amaranth cultivation requires nutrients such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sodium (Na) and Sulphur (S) for fertility maintenance and crop production. These nutrients are specific in function and must be supplied to plants at the right time and at the right quantity. Lack of sufficient amounts of these nutrients result in poor performance of the amaranth with growth been affected resulting to low yield (Abubakar, 2018).

Amaranth production in the Northern Nigeria is high yielding. The high yielding experience has been attributed to good soil fertility and high organic matter contents of the soil which are properly mixed with important mineral nutrients (Abubakar, 2018). This fertilizer has become a scarce commodity, even when available, is beyond the reach of the poor resource farmers due to its high costs. For example over 70 % of vegetable farmers in Niger State, have no access to mineral fertilizer due to high cost and scarcity. Hence Animal wastes that result to animal manures is better alternative and a necessary option (Peter, 2019). According to Olatunji *et al*. (2006), the application of organic manure had been found to have higher comparative economic advantage over the use of inorganic fertilizer.

A study conducted by Nwajiuba and Akinsanmi (2017) in Southeastern Nigeria, showed that returns per ha were higher in organic farms though outputs were slightly less in inorganic farms. Asiegbu and Carol (2000) reported that the application of poultry manure is the best way of improving the yield of amaranth and that amaranth requires soil with high organic content and such soils favored the production of leaf numbers which is highly consumed. According to Colling Wood, *et al*, (1988), proper poultry manure is required for optimum growth and

development of vegetable since excessive nitrogen increases their susceptibility to fungal disease and deterioration of keeping quality. Hence there is need for poultry manure application in cropping system to maximize nutrient recycling and to minimize losses.

Similar results were obtained by Olaniyi, *et al*., (2008) who reported increased Amaranth plant height at higher organic manure application rate. Olufolaji (2007) reported that Amaranth plants require high nitrogen content for their vegetative growth and poultry manure have high nitrogen than all others. Also, the increase in number of leaves with urea confirmed the role of nitrogen in promoting vigorous vegetative growth in leafy vegetables as reported by Myers, (1998) and Olaniyi, (2007). The higher stem length observed with urea treatment is also supported by Alonge, *et al.*, (2007) who reported that nitrogen caused increase in plant height. The finding also agrees with Pospisil, *et al.*, (2006) who reported that higher levels of nitrogen contents in poultry dropping application produced significantly taller and broader Amaranth plants compare to cow dung, goat and sheep and follow by rabbit manure.

Research Question

The research question guiding this study is: What is the effect of different organic fertilizers (NPK 15:15:15, poultry droppings, rabbits droppings, goat and sheep droppings, and cow dung) on plant growth and development?

Hypothesis: Based on the research question, the following hypothesis is formulated:

Null Hypothesis (H0): There is no significant difference in the effects of different organic fertilizers (NPK 15:15:15, poultry droppings, rabbits droppings, goat and sheep droppings, and cow dung) on plant growth and development.

Alternative Hypothesis (H1): There is a significant difference in the effects of different organic fertilizers (NPK 15:15:15, poultry droppings, rabbits droppings, goat and sheep droppings, and cow dung) on plant growth and development.

Rationale for Hypothesis: The alternative hypothesis is based on the assumption that different organic fertilizers have varying levels of nutrients and other beneficial compounds that can impact plant growth and development. NPK 15:15:15 fertilizer, for example, is a balanced fertilizer that contains equal amounts of nitrogen, phosphorus, and potassium, making it a popular choice for plant growth. On the other hand, organic fertilizers like poultry droppings and rabbits droppings are high in nutrients but may have varying levels of other beneficial compounds.

Materials and Method

Area of the study: The research was conducted at the teaching and research farm of Niger State College of Education Minna, 2022 cropping season. Minna is located in the Southern Guinea Savanna. It lies between latitude 9^0 37 North and Longitude 6^0 32 East (Smith. M. B. 1992). .

Sampling and data collection: The *Amaranthus hybridus* seeds and NPK (15:15:15) were bought from Vegetable Market popularly known as Tunga Goro Minna, Niger State. Cow dung, goat and sheep manure, poultry droppings and rabbit manure was collected from COE Minna Teaching and Research farm.

Following the clearance of the field, the soil was tilled using hoe. A measuring tape and a hoe were used to measure a gross plot of 12 by 12 metres square. The gross plot was further divided into twelve equal net plots and each net plot was measured 3 by 2 metres square. The distance between the net plots and the treatments is 0.5m. The five treatments were identified randomly as T1, T2, T3, T4, T5 and T6 for zero fertilizer, cow dung, goat and sheep manure, poultry droppings, rabbit manure, NPK and control respectively.

Sowing of the Seeds: The seeds rate of 0.075kg mixed with 5ml of triazine (insecticide) and sand. The seed was planted by broadcasting. After germination, the seedlings were transplanted

at a space of 0-18cm and a distance of 0.5m between the net plots and the treatments. Application of Fertilizers: All fertilizers used for the study (cow dung, goat and sheep manures, poultry droppings, rabbit manure and NPK) were quantified at 0.3kg (300g) were used for each net plot. Both cow dung, goat and sheep manures, poultry droppings and rabbit manure were thoroughly spread and mixed with the soil before broadcasting the seeds because they gradually incorporate into the soil compared to NPK which takes only 2-4 days, while NPK was applied a week after germination. NPK contains nitrogen, phosphorus and potassium; if applied before planting or less than 6 days after seeds germination, it may burn the seedlings or suppress their growth thereby leading to the death of the plants (Sanchez, 2011).

Watering and Weeding: After sowing the seeds, the experiment was carried out during the raining season. The A. *hybridus* plants neither require too much moisture nor dryness (Onyanga, 2010). According to Onyanga (2010) A. *hybdridus* should be watered with sufficient water, water shortage causes early flowering which reduces the yield and the market quality. Onyanga, (2010) also reported that too much of water washes the seeds away from the plots due to their lightness and high dryness also makes the plants to sprout and wilt, thereby causing them to become yellow in colour and finally die off. Normally, *Amaranthus hybridus* seeds have variability in germination. For this reason, some seeds started germinating on the second day after planting while others on the third and fourth days. The weeding was done when the need arise using hands (selective weeding) for the weeds on the beds and hoe for the weeds found in-between the rows/net plots, according to FAO (2008) and known herbicide is reported due to the variability in the seeds germination, the poultry manure and rabbit droppings) and NPK 15: 15: 15 inorganic fertilizer were applied to the soils at the rate equivalent to 5 ton/ha of the organic manure and 60 kg/ha of NPK fertilizer for the plots to be planted with vegetable. The rates amounted to 5 kg and 3.59 g per plot of organic manure and NPK fertilizer respectively. The plots were arranged in a completely randomized design with three replicates. The manures were incorporated into the soils two weeks before broadcasting while the NPK fertilizer was applied at weeks after broadcasting. The control plots were broadcasted without any treatment application.

Table 1: Measurement of the Stem Length

Weeks after transplanting	Stem Length (cm)					
	T1	T2	T3	T4	T5	T6
2 WAT	6.4	14.4	15.2	30.3	29.4	35.4
3 WAT	8.4	16.4	16.8	33.3	28.2	45.4
5 WAT	16.7	31.0	32.6	44.5	39.6	64.2

KEY: T1 –No manure/fertilizer; T2- Cow dung; T3- goat and sheep manure; T4- Poultry dropping; T5- rabbits dropping; T6- NPK 15:15:15

Table 2: Measurement of the Stem Width

Weeks after transplanting	Stem Width (cm)					
	T1	T2	T3	T4	T5	T6
2 WAT	2.1	3.6	3.6	5.0	4.8	6.4
3 WAT	2.5	3.8	3.9	5.0	4.8	7.0
5 WAT	3.0	4.4	4.5	5.2	5.0	8.1

KEY: T1 –No manure/fertilizer; T2- Cow dung; T3- goat and sheep manure; T4- Poultry dropping; T5- rabbits dropping; T6- NPK 15:15:15

Table 3: Measurement of the Leaf Length

Weeks after transplanting	Leaf Length (cm)					
	T1	T2	T3	T4	T5	T6
2 WAT	6.3	7.1	7.5	9.3	8.0	12.0
3 WAT	9.0	9.1	9.3	13.0	12.2	16.0
5 WAT	9.2	16.1	16.5	17.1	17.1	19.3

KEY: T1 –No manure/fertilizer; T2- Cow dung; T3- goat and sheep manure; T4- Poultry dropping; T5- rabbits dropping; T6- NPK 15:15:15

Table 4: Measurement of the Leaf Width

Weeks after transplanting	Leaf Width (cm)					
	T1	T2	T3	T4	T5	T6
2 WAT	3.0	5.0	5.5	7.0	6.0	11.2
3 WAT	5.0	5.1	5.8	8.0	6.5	12.4
5 WAT	5.5	8.0	8.4	9.1	8.8	14.2

KEY: T1 –No manure/fertilizer; T2- Cow dung; T3- goat and sheep manure; T4- Poultry dropping; T5- rabbits dropping; T6- NPK 15:15:15

Table 5: Number of Leaves per Plant

Weeks after transplanting	Number of Leaves per Plant					
	T1	T2	T3	T4	T5	T6
2 WAT	10	12	13	14	13	23
3 WAT	13	14	15	18	16	34
5 WAT	13	24	25	30	28	34

KEY: T1 –No manure/fertilizer; T2- Cow dung; T3- goat and sheep manure; T4- Poultry dropping; T5- rabbits dropping; T6- NPK 15:15:15

Figure: 1. Total yield in t/ha.

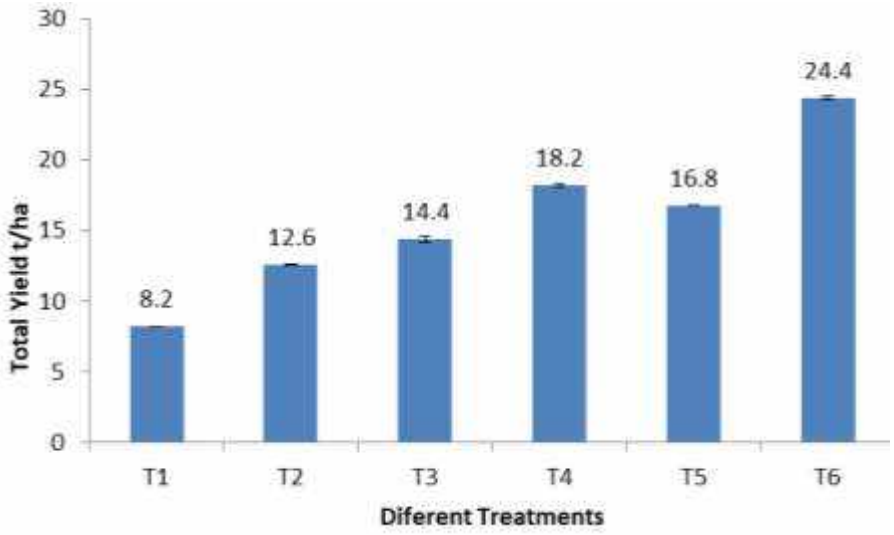

Table 6: Nutritional Quality of spinach

	Treatments		
Nutritional parameters	Control	Poultry droppings	NPK
Starch (g/100g FW)	3.00	3.53	4.00
Protein(g/100g FW)	2.00	2.35	2.50
Fat(g/100g FW)	0.00	0.00	0.00
Fibre (g/100g FW)	2.00	2.35	2.62
β-Carotene (mg/100g FW)	0.20	30.40	32.00
Vitamin C(mg/100g FW)	24.00	28.20	30.00
Flavonoids(QE/g)	7.82	9.86	10.20
Total phenols (GAE/g)	160.00	180.20	182.5

Discussion

There were (6) six treatments; zero manure/fertilizer, cow dung, goat and sheep manure, poultry droppings, rabbits dropping and NPK 15:15:15 which were randomly identified as Tl, T2, T3, T4, T5 and T6 respectively. The parameters observed and measured were the stem length, stem width, leaf length, leaf width, number of leaves per plant, total yield and nutritional quality. The data were collected three times; at the second, third and fifth after transplanting.

Measurement of the Stem Length: Table 1 shows the results obtained from the measurement of the stem length. The table indicates NPK 15:15:15 treatment as having the longest stem throughout the weeks with a maximum length of 64.2cm at the fifth week, followed by poultry droppings, rabbit's droppings, goat and sheep manure, cow dung and zero manure/fertilizer having a maximum length of 44.5cm, 39.6cm, 32.6cm, 31.0cm and 16.7cm respectively.

Measurement of the Stem Width: The results obtained from the measurement of the stem width are shown in Table 2. Plants treated with NPK 15:15:15 are found to have the thickest stem throughout the weeks with a maximum width of 8.1cm at the fifth week, followed by those treated with poultry droppings (5.2cm), rabbit dropping (5.0cm), goat and sheep manure (4.5cm), cow dung (4.4cm), and zero manure/fertilizer (3.0cm).

Measurement of the Leaf Length: Table 3 shows the results obtained from the measurement of the leaf length. NPK 15:15:15 treatment has the highest length throughout the period of the study with a maximum value of 19.3cm, followed by poultry droppings, rabbit droppings, goat and sheep manure, cow dung, and zero manure/fertilizer with a maximum height of 17.5cm, 17.1cm, 16.5cm, 16.1cm and 9.2cm respectively.

Measurement of Leaf Width: Table 4 shows NPK 15:15:15 treatment is the treatment which has the highest leaf width throughout the period with a maximum value of 14.2cm, followed by poultry droppings, rabbit droppings, goat and sheep manure, cow dung and zero manure/fertilizer with 9.1cm, 8.8cm, 8.4cm, 8.0cm and 5.5cm as at the seventh week respectively.

Number of Leaves per Plant: The results obtained for the number of leaves per plant are shown in Table 5. Based on the data collected, NPK 15:15:15 treatment have the highest number of leaves with 34 leaves, followed by poultry droppings 30, rabbit droppings 28, goat and sheep manure 25, cow dung 24 and zero manure/fertilizer 13 leaves as at the seventh week of the study respectively.

Total yield in t/ha: NPK 15:15:15 have the highest yield of 24 t/ha follow by poultry droppings l18.2 t/ha, rabbit droppings 16.8 t/ha, goat and sheep manure 14.4 t/ha, cow dung 12.6 t/ha and no manure/fertilizer 8.2 t/ha respectively as shown in figure 1 above.

The data gathered were subjected to Statistical Analysis and were analyzed using One-way Analysis of Variance (ANOVA) and the results were expressed as percentage differences, the differences between the mean values were determined at 95% confidence. NPK 15:15:15 treatment was found to have a significant difference at ($p< 0.05$) on the vegetative growth of *Amaranthus hybridus* when compared with the other organic manures. From this research, NPK 15:15:15 treatment is found to produce plant with the highest height of 64.2cm, followed by poultry droppings, rabbit dropping, goat and sheep manure, cow dung and zero manure/fertilizer with 44.5cm, 39.6cm, 32.6cm, 31.0cm and 16.7cm respectively. Similar results were obtained by Paul, *et al.,* (2018) who reported increased Amaranthus plant height at higher nitrogen application rate. The research is also in agreement with the report of Olufolaji (2020) who reported that Amaranthus plants require high nitrogen content for their vegetative growth.

Conclusion

The study investigated the effects of different organic fertilizers on plant growth and development. The results showed that NPK 15:15:15 fertilizer recorded the highest parameter observed, followed by poultry droppings, rabbits droppings, goat and sheep droppings, and cow dung. This indicates that NPK 15:15:15 fertilizer is the most effective in promoting plant growth, but the use of organic fertilizers such as poultry droppings and rabbits droppings can be a suitable alternative.

Recommendation

But it would be highly recommended for farmers to use the organic fertilizers despite their lesser effect because this research was conducted within a short period of time which would not allow the full effects of the organic fertilizers to manifest as their incorporation to the soil takes much time than the inorganic which takes only 2-4 days. It is also less hazardous to the soil quality and health of the consumers.

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

1. Farmers and gardeners should consider using NPK 15:15:15 fertilizer for optimal plant growth and development.

2. Organic fertilizers such as poultry droppings and rabbits droppings can be used as a suitable alternative to inorganic fertilizers.
3. Further research should be conducted to investigate the long-term effects of using organic fertilizers on plant growth and development.
4. The use of organic fertilizers should be promoted through extension services and education to reduce the environmental pollution associated with the use of inorganic fertilizers.

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CHARACTERIZATION AND CLASSIFICATION OF HYDROMORPHIC SOILS AT MAKUSIDI IN NIGER STATE, NIGERIA

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Abstract
This study was carried out to characterize and classify the hydromorphic soils at Makusidi in Wushishi Local Government Area of Niger State. Two pedons were dug representing upper and lower slopes of the field which were designated as MKS1 and MKS2 respectively. The pedons were described following the FAO guidelines for soil description. Soil samples were collected from each identified natural horizon and taken to the laboratory for analysis. Results revealed that MKS1 had very dark grayish brown (10YR3/2) at the topmost horizon and a very dark gray (10YR 5/1) at the subsoil. MKS2 had light brownish gray (10YR 6/2) overlying grayish brown (10YR 5/2) at the subsurface. Sand content ranged from 580 to 740 g/kg in MKS1and 430 to 920 g/kg in MKS2 silt ranged from 30 - 160 g/kg in MKS1 and 10- 160 g/kg in MKS2. Clay ranged from 170 to 270 g/kg in MKS1 and 70 to 410 g/kg in MKS2. The two pedons were slightly acidic with low organic carbon and available phosphorus contents and total nitrogen was irregularly distributed from low to medium down the two profiles, but exchangeable Ca, Mg, K and Na were found to be high at both study sites. The soils were classified under the USDA Soil Taxonomy as Typic Endoaqualfs (MKS1) and Arenic Epiaqualfs (MKS2) and correlated with WRB system as Stagnic Lixisols (Clayic) and Stagnic Lixisols (Arenic) respectively.
Keywords: Characterization, Classification, Hydromorphic soil, Makusidi, Niger State

Introduction

Hydromorphic soils of Africa's tropical and subtropical regions, such as the wetlands of West Africa (e.g., Fadama near River Niger), are vital for food production. However, effective exploitation requires a full understanding of soil resources and land features. To enhance crop output, dependable soil management approaches based on extensive knowledge of soil potentials, limits, and distribution are necessary (Nwaloka et.al., 2019). Soil results from both destructive activities (weathering of rock, microbial degradation of organic wastes) and creative processes (creation of new minerals like clays and organic compounds) (Brady and Weil, 2010). This synthesis leads to the production of horizontal strata called soil horizons, a distinctive property separating soil from deeper regolith minerals (Brady and Weil, 2010). Early Soil Science saw various ideas of soil across disciplines. Chemists considered it as a chemical storage, whereas geologists saw it as decomposed rock combined with biological materials. The agronomic concept describes soil as the natural substrate for plant growth, regardless of recognizable soil strata (Olushola, 2009). Soil is highly varied, comprising unique soils with various features and behaviors. It is a dynamic natural body made of mineral, organic components, and living organisms where plants thrive (Olushola, 2009; Clinton and Chinago, 2020). However, soil resources in the state are inadequately surveyed and identified, with limited surveys for specific development projects. This research intends to identify, characterize, classify the soils of the study region, and establish their potentials for rice production.

Materials and Methods

Study Area

The study site was a fadama plain at Makusidi which lies between Latitudes 9.57538° or 9° 34' 31" N and Longitudes 6.14659° or 6° 8' 48" E in Wushishi Local Government Area of Niger State situated at an elevation of 125 m above sea level. Niger State is characterized by

sub-humid tropical climate having distinct rainy and dry seasons (Animashauna *et al.,* 2020). It receives annual rainfall from the range of 1200 mm in the north to about 1600 mm in the south spread between the months of May and October. Mean annual temperature is high throughout, about 32 °C with peaks in the months of March to June (Animashauna *et al.,* 2020). The State has 110,000 ha of hydromorphic (fadama) soils equivalent to about 3.5 % of its total land area (Lawal *et al*., 2012a). The natural vegetation in Niger state follows the rainfall pattern and other climatic elements. The vegetation of the State is broadly classified as Northern Guinea savanna with a dense population of grasses, shrubs and trees (Animashauna *et al.,* 2020).

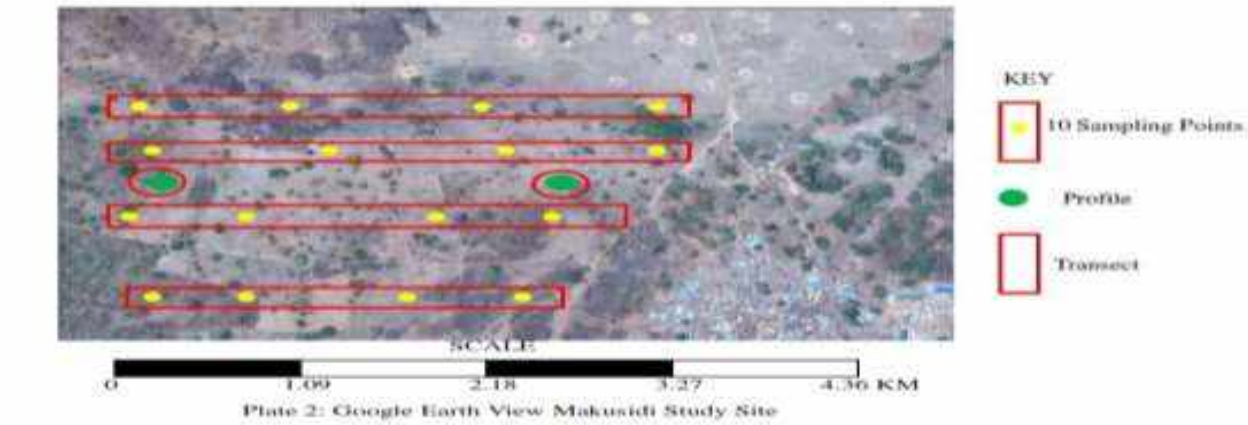

Plate 2: Google Earth View Makusidi Study Site

Figure 1: Showing Sampling Points in Makusidi

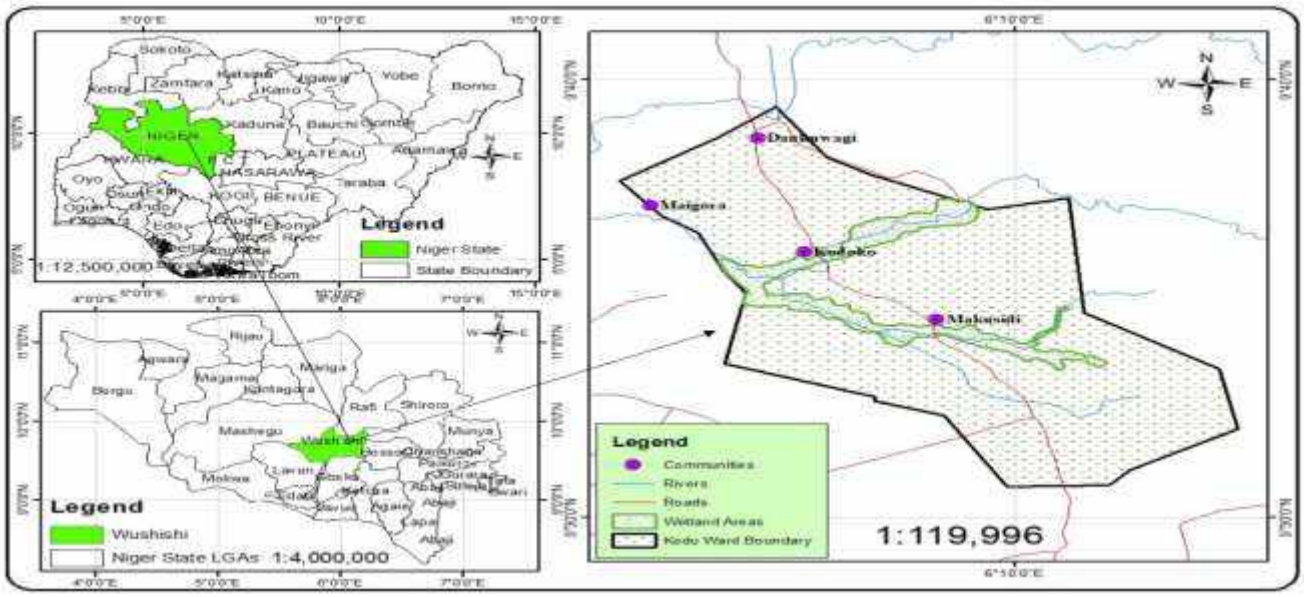

Figure 2: Map of the Study Area
Source: Niger State Geographic Information System (2023).

Sampling Techniques

Twenty (20) hectares of paddy field was studied. Auger points (0-15cm; 15-30cm) were established to identify the different soil bodies. Two soil bodies were stationed in the upper-slope and lower-slope. Two profiles each over these landscapes were dug and described. The profiles described were designated MKS1 and MKS2 from the upper-slope and lower-slope respectively. Soil colour was determined using Munsell Soil Colour Chart (Munsell Color Chart, 2000). Soil samples were collected from each identified genetic horizon and sent to the laboratory for routine analysis.

Analytical Procedures

The soil samples were air-dried, gently crushed using a mortar and pestle, and passed through a 2mm-sieve to obtain a fine earth separates. Soil analyses were carried out in the laboratory

following the procedures outlined by the International Soil Reference and Information Centre and Food and Agriculture Organization (ISRIC/FAO 2002). Particle size analysis was determined using Bouyocous hydrometer method. The soil pH in H_2O 1:1 soil/water suspensions was measured with pH meter and also in $CaCl_2$ 1:2. Organic carbon was determined following Walkley-Black method; Total nitrogen (TN) was determined by Kjeldahl digestion procedure. Exchangeable bases, (Ca^{2+}, Mg^{2+}, K^+ and Na^+) were extracted with 1N NH_4OAC solution. Calcium and magnesium (Ca^{2+} and Mg^{2+}) in the extract were determined using Atomic Absorption Spectrophotometry; while potassium and sodium (K^+ and Na^+) were determined by flame photometry. Exchange acidity was determined by titration with standard NaOH. Cation Exchange Capacity (CEC) was determined by the neutral 1 N NH_4OAC saturation method. Percentage base saturation was computed by dividing the summation of exchangeable bases (Ca^{2+}, Mg^{2+}, K^+ and Na^+) by CEC and then multiplied by 100.

Results and Discussion

Morphological Properties and particle size Distribution of the Soils

The results of morphological properties and particle size distribution of the soils are presented in Table 1. The surface colour of MKS1 was very dark grayish brown (10YR 3/2) overlaying various shades of grey (10YR5/1), (10YR 6/1) amd (10YR7/1) colour in the subsoil. The subsoil was characterized with dark brown (7.5YR3/4) and yellowish brown (10YR5/8) mottle. The structure was crumb at the surface and graded to subangular, angular blocky and massive at the subsoil. MKS2 was characterized with a light brownish gray (10YR 6/2) colour overlying grayish brown (10YR5/2) to very dark gray (10YR 3/1) at subsurface. The structure was crumb at soil surface, subangular to massive at subsoil.

In (Table 1) sand values ranged from 580 to 740 g/kg and 430 to 920 g/kg for MKS1 and MKS2 respectively. Sand fraction was irregularly distributed in MKS1 and it decreased in a regular trend in MKS2. According to Ojanuga (2006), the floodplain soils of Nigeria are of alluvial origin and differed widely in their properties. It could therefore be explained that the dominance and variations in pattern of sand distribution between the profiles may be attributed to parent material rich in quartz mineral (Brady and Weil, 2010) and frequent cycles of alluvial deposition and sorting of soil materials as a result of geological processes involving clay migration through eluviation and illuviation, or surface erosion/ deposition by runoff, or by biological activities, or their combinations (Malgwi *et al*., 2000; Akintola *et al.*, 2009).

Silt content range very widely from 30 to 160 g/kg and 10 to 160 g/kg for MKS1 and MKS2 respectively. Variation in silt content of the soils may also be attributed to reasons explained for the sand. Except in the MKS2 where the pattern of distribution increased down the profile, in other pedon, silt was irregularly distributed.

Table 1: Morphological and Physical Properties of the Study Areas

Horizon	Depth (cm)	Munsell Colour		Structure	Consistence	Root	Boundary	Textural Class	Sand	Silt	Clay	Silt/ Clay Ratio
		Matrix	Mottle						(gkg^{-1})			
MKS1					**(Typic Endoaqualfs)**							
Ap	0-27	10YR 3/2	_____	2cr	nstk .nplst (wet)	f.md. v.gd	d.s	SL	700	130	170	0.76
Btg1	27-59	10YR 3/1	7.5Y R3/4	2sbk	sstk.splst (wet)	f.gd	c.w	SCL	580	160	260	0.62

Btg2	59-120	10YR 5/1	10YR5/8	3abk	sstk.splst (wet)	f.bd	c.s	SCL	630	100	270	0.37
Btg3	120-162	10YR 6/1	10YR4/6	M	sstk.splst (wet)	-	g.s	SCL	650	80	270	0.30
BC	162-200	10YR 7/1	10YR5/8	M	sstk.splst (wet)	-	-	SCL	740	30	230	0.13
MKS2					**(Arenic Epiaqualfs)**							
Ap	0-13	10YR 6/2	____ __	1cr	nstk.nplst (wet)	f.md. v.gd	g.w	S	920	10	70	0.14
AB	13-45	10YR 5/2	____ __	1sbk	nstk.nplst (wet)	f.md. gd	c.w	LS	850	60	90	0.66
Bt	45+	10YR 3/1	____ __	2m	stk.plst (wet)	f.gd	-	C	430	160	410	0.40

Determined at wet and moist, **Note**: symbols or codes according to FAO (2006)
Texture: c = clay, s = sandy, sl = sandy loam, ls = loamy sand, scl = sandy clay loam, **Structure:** 1 =weak, 2 = moderate, 3 =strong, sg=single grain, cr=crumb, gr=granular sbk = subangular blocky, abk = angular blocky, m=massive; **Consistence:** nstk=non sticky,, sstk=slightly sticky, s=sticky, nplst =non plastic, splst = slightly plastic, vplst =plastic, lo=loose, sft=soft, fr=friable, firm, frm =vfrm=very firm, shrd = slightly hard, hrd = hard, hrd =hard; **Root**: f=fine, f.m-fine and many, md.b = medium and big bd = bad, gd = good, v.gd=very good. **Boundary**: a= abrupt, c= clear, g= gradual, = smooth, w =wavy d=diffuse.

Clay content ranged from 170 to 270 g/kg and 70 to 410 g/kg for MKS1 and MKS2 respectively. The two pedons showed a regular increase and subsequent accumulation in the pattern of clay down the successive soil horizons with an approximate value of 1.53 and 4.56 times higher, in clay content between surface and subsurface horizons in profiles of the MKS1 and MKS2. This may be due to the development of argillic horizon in the pedons. Schaetzl and Anderson (2005) associated the increase of clay down the soil profile with three pedogenic processes, namely, eluviation and illuviation of clay particles, neo-formation and transformation of primary minerals in the subsurface horizons. Consequently, the afore-mentioned processes facilitate the formation of an argillic horizon in soil (Esu, 2010; Soil Survey Staff, 1999, 2010). The ratios for MKS1 and MKS2 were 0.13 to 0.76 and 0.14 to 0.66. The trend followed the distribution pattern of silt in the profiles examined. Silt/clay ratios had been used to describe age and/ stage or weathering patterns in the soil. According to Ashaye (1969), a low silt/clay ratio of < 1 could mean that the soil had undergone ferralitic pedogenesis.

Chemical Properties of the Profiles

The chemical properties the soils profiles studied are presented in Table 2. Data interpretation was according to guidelines for rating of Nigerian soils by Esu (1991) and Chude *et al*. (2011). Generally, soil reaction (pH) measured in $CaCl_2$ was lower than that measured in H_2O. The observed differences may be attributed to significant displacement and subsequent hydrolysis of exchangeable aluminum and hydrogen ions complexed on the exchange sites of the soils extracted by salts (Esu, 2010). Soil reaction (pH) values MKS1 ranged from 5.4 to 7.0 and were rated as strongly acidic to slightly acidic while the pH values for MKS2 ranged from 5.7 to 6.0 and were rated moderately acidic. The acid condition of the soils at pedons 2 and 4 may be partly attributed to extensive seasonal aquic moisture characteristics of the soils which probably caused the leaching of basic salts out of the horizons sampled for the study. Lawal *et al*. (2012a) reported similar pH values for some hydromorphic soils developed on basement complex rocks and sedimentary rock formations in Niger State, Nigeria. In all the pedons, the pH values had showed an irregular trend down the soil profiles, a characteristic peculiar to hydromorphic soils (Ojanuga, 2006). Differences in pH values, especially among the horizons, may be associated in part, with the aluminosilicate clay minerals releasing aluminum and/ or

hydrogen ions into the soil solution through isomorphous substitution (Tisdale *et al*., 1985), or maybe as a result of the effect of nutrient bio-cycling (Ogunwale *et al*., 2002).

Organic C content in the soil profiles ranged from 0.90 to 7.40 g/kg and 0.12 to 1.76 g/kg respectively for MKS1 and MKS2 eventually and was rated low except at the Bt-horizon of the bottomland where its concentration was rated marginally medium. The relatively higher organic C in the subsurface horizon, from a depth of 40 cm in MKS2, may be as a result of differences in organic matter contents of alluvial materials deposited during seasonal flooding (Ojanuga, 2006). Results obtained from the study corroborated the findings of Lawal *et al*. (2012b) which also reported low organic C content from studies in various hydromorphic soils underlined by Nupe sandstones within the same agroecological zone the current work was undertaken.

The total N content range at MKS1 had relatively low total N content which ranged from 0.04 g/kg to 0.12g/kg and was irregularly distributed while the MKS2 values ranged from 0.10 g/kg to 0.18 g/kg and had medium rating while pedon was rated low to medium according to Esu (1991). Brady and Weil (2010) reported that nitrogen has been a limiting factor in plant nutrient in tropical soils. Mustapha *et al*. (2003) and A.A. Panti *et al.,* (2023) also reported low nitrogen rates obtained from fadama soils in Bauchi State and fadama soils in Baddeggi, Niger State.

The result indicates that the soils are rated low to medium; the lower value of N content could be a result of losses of N through various sources. Nitrogen being a very mobile nutrient is very prone to losses through leaching and percolation under flooded situations, and volatilization once the flood water recedes. Nelson and Terry (1996) in their study observed a significant loss of soil total nitrogen after flooding.

The distribution pattern of available phosphorus (P) within the profiles was irregular and its values ranged from 3 to 5 mg/kg and 4 to 6 mg/kg in MKS1 and MKS2 respectively. According to Esu (1991), available soil P level of < 10 mg/kg is rated as low, 10 to 20 mg/kg as medium and > 20 mg/kg is rated high. Hence, the P status of the soils investigated falls under low soil fertility classification. These would confirm that soils of the Nigerian Savanna have inherently poor fertility status (Odunze *et al.*, 2004). Exchangeable calcium (Ca) of the soils of the entire pedons was within the range of moderate to high value (2 to 5 cmol/kg), but its distribution was irregular with an increase in soil depth. At the study site values ranged from 3.92 to 6.28 cmol/kg in MKS1, which was irregularly distributed down the profile too and in the bottomland, the values ranged from 2.80 to 5.12 cmol/kg, and Ca which increased down the profile. Adegbite and Ogunwale (1994) also found Ca to be the dominant cation in the soils of River Niger in nearby Kogi State which fall within the same ecological zone as Niger State, where this work was carried out. Mg concentration in MKS1 and MKS2 ranged from 2.42 to 3.52 cmol/kg and 1.36 to 2.00 cmol/kg respectively.

Table 2: Chemical Properties of Profiles of the Study Areas

								Exchangeable Bases						
Pedon No	**Horizon**	**Depth cm**	**H_2O**	**pH CaCl₂**	**Org. C g/kg**	**TN**	**Av. P**	**Ca**	**Mg**	**K**	**Na**	**CEC**	**Exchange Acidity**	**%Base Saturation**
							mg/kg	**cmol/kg**						
MKS1 (Typic Endoaqualfs)														
	Ap	0-27	5.4	4.2	7.40	0.04	4.0	3.92	2.42	0.47	0.09	11.37	0.05	60.69

Btg1	27-59	6.3	5.5	4.71	0.12	3.0	5.68	2.92	0.60	0.16	16.77	0.05	55.81
Btg2	59-120	6.7	5.8	4.71	0.08	3.0	4.84	3.52	1.08	0.24	18.77	0.05	51.57
Btg3	120-162	7.0	5.9	1.57	0.12	5.0	5.48	2.76	0.41	0.44	15.03	0.03	67.13
BC	162-200	7.0	5.8	0.90	0.11	3.0	6.28	2.60	1.08	0.44	15.98	0.05	65.08
MKS2 (Arenic Epiaqualfs)													
Ap	0-13	6.0	4.6	0.12	0.11	5.0	2.80	2.00	0.26	0.18	6.91	0.04	75.83
AB	13-45	5.7	4.0	1.79	0.10	4.0	3.12	1.72	0.13	0.20	7.68	0.07	67.32
Bt	45+	5.8	4.3	1.76	0.18	6.0	5.12	1.36	0.09	0.25	11.37	0.06	66.80

Source: A.A. Panti 2015

According to Esu (1991), the value of Mg in all the soils is rated high. The trend of distribution of Mg and Ca in the soils investigated was similar to the findings of Adegbite and Ogunwale (1994) and Lawal *et al*. (2012b) who also reported Ca as the dominant cation in the fadama soils of Abugi along the bank of River Niger under the same sub-humid central Niger-Benue trough agroecological zone of Nigeria. In Table 2, the K concentration was irregularly distributed in the profiles, the Ap-horizon and subsoil were rated medium, for the two pedons. In MKS1 ranged from 0.41 to 1.08 cmol/kg and in MKS2 values ranged from 0.09 to 0.26 cmol/kg and decreased progressively to a depth of 45 cm. According to Esu (1991) rating, MKS1 was rated high and MKS2 low to medium respectively. The surface horizons were medium to high in rating. Table 2 also presents the result of the exchangeable Na^+ and the values obtained at the study site, the values ranged from 0.09 to 0.44 cmol/kg and 0.18 to 0.25 cmol/kg in MKS1 and MKS2. The distribution of Na showed an increasing pattern down the profiles. Cation exchange capacity (CEC) the values obtained were in the range of 11.37 to 18.77 cmol/kg and 6.91 to 11.37 cmol/kg in MKS1 and MKS2. The cation exchange capacity of the soil was relatively high showing the capacity of the soils to retain nutrient elements. The exchange acidity of the study sites, had values ranging from 0.03 to 0.05 cmol/kg and 0.04 to 0.07 cmol/kg in MKS1 and MKS2. Percent base saturation of soils of the study site, had values obtained in the following order of 51.57 to 67.13 % and 66.80 to 75.83 % in MKS1 and MKS2 respectively.

Taxonomic classification of the Soils

The two pedons studied revealed evidence of clay accumulation in the subsurface. For the MKS1, there was 1.53 times clay in the subsurface (Btg1) than the surface (Ap) horizon. Similarly, MKS2 had 4.56 times more clay at Bt than AB horizon. Soil Survey Staff (2010) established a benchmark of 1.2 times clay between eluvial and illuvial horizons. Based on clay accumulation and base saturation > 50 %, both pedons were classified at Soil Order level as Alfisols. The pedons were further classified at Sub-order level as Aqualfs due to aquic moisture characteristic which do prevail for some time in normal years as evidenced by the presence of mottles in the subsurface horizons in MKS1 and saturated condition of the MKS2.

MKS1 at the Great-group level, MKS2 fall under Endoaqualfs because the subsurface horizons experiences water saturation over a period of time in normal years. Absence of further diagnostic features made this pedon to be placed under Typic Endoaqualfs at Sub-group level which correlated with WRB's Stagnic Lixisols Clayic.

MKS2 **a**t Great-group level was classified as Epiaqualfs because the surface horizon was saturated over a period of time in normal years. Sandy nature of the topmost horizon (Ap) extending to the top of an argillic horizon at a depth of 45cm below the mineral soil surface

placed the pedon under Arenic Epiaqualfs at Subgroup level which correlated as Stagnic Lixisols Arenic.

Conclusion

Based on their properties the soils investigated fall under Alfisols with aquic moisture conditions favourable for paddy rice. It has a moderately to slightly acid status and may not require any amendment to make them conducive for the cultivation of rice. Low to medium fertility in terms of N, P and K would require amendment through application of appropriate compound fertilizer to make the soils profitable for rice production. Low organic carbon may require management practices that will encourage recycling of crop residues to enhance organic matter content of the soils.

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CREATING OPPORTUNITIES FOR PERSONS WITH DISABILITIES IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS (STEM)

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Abstract
The inclusion and empowerment of persons with disabilities in the field of Science, Technology, Engineering, and Mathematics (STEM) are crucial for fostering innovation and creating a diverse and equitable society. Against this background this paper highlighted opportunities for persons with disabilities in STEM. The paper discussed the importance of creating equitable environments and providing appropriate resources to empower individuals with disabilities to thrive in these key disciplines. While recognizing/identifying some challenges that persons with disabilities might face in pursuing careers in STEM, the author emphasized the need for collaborative efforts between educational institutions, employers of labour, and policymakers. Furthermore, the author recommended implementing inclusive educational practices, starting from early childhood education to higher institutions. This approach involves providing accessible learning materials, leveraging assistive technologies, and adapting teaching methods to accommodate diverse learning styles. It also emphasized promoting STEM education as an inclusive and accessible field for individuals with disabilities, eliminating the stigma often associated with disabilities in STEM.
Keywords: Disabilities, Engineering, Inclusive Practices, Mathematics, Opportunities, Science, Technology

Introduction

There has been a growing global recognition that persons with disabilities alternatively referred to as PWD have the potentials to contribute significantly to various fields of human endeavour especially in the areas of Science, Technology, Engineering and Mathematics (STEM). However, in developing countries like Nigeria, the potential of PWDs to contribute to the advancement of STEM fields remains largely untapped, primarily due to systemic challenges that limit their access to education, employment, and opportunities for advancement. Perhaps, it is in support of this assertion that Obasanjo and Adedayo (2023) highlighted that despite the concerted efforts to promote inclusive policies for PWDs globally, in Nigeria, they still face multifaceted barriers that impede their active participation in the field of education in general and STEM in particular. These barriers range from inaccessible infrastructure and discriminatory practices to limited access to quality education and specialized resources.

Consequently, PWDs are disproportionately underrepresented in STEM-related disciplines, perpetuating a cycle of exclusion and hindering the nation's overall scientific and technological progress. Regrettably, the report of Oyeniyi (2023) contends that Nigeria still practiced a segregative system of education, with the establishment of special needs schools where PWDs learned separately from their non-disabled peers. According to this report, segregative system of education especially in the field of STEM does not promote inclusiveness and equality in pursue of knowledge and skills. Above all it does not also facilitate PWDs' active participation in the society. Accordingly, Obasanjo, and Adedayo (2023) affirmed that despite the enactment of several statutes for the prohibition of discrimination against PWDs, yet discrimination against the PWDs still persists especially in

terms of access to quality education in the field of STEM as majority of schools in Nigeria lack the resources and trained personnel to support students with disabilities, leading to exclusion from the education system.

It is against these numerous challenges when it comes to creating opportunities for PWDs in the field of STEM that this paper attempts to shed light on the importance of fostering inclusivity and equal opportunities in STEM for persons with disabilities in Nigeria, as well as identify key strategies to overcome the existing barriers.

The importance of fostering inclusivity and equal opportunities in STEM for PWD in Nigeria

Persons with disabilities (PWD) face significant barriers in accessing both educational opportunities and career advancement in the field of Science, Technology, Engineering, and Mathematics (STEM) in most developing countries, Nigeria inclusive. This view was corroborated by Wahab et al., (2022) who asserted that a significant portion of talent remains untapped due to barriers faced by PWD in Nigeria. However, fostering inclusivity and providing equal opportunities for PWD in STEM is a matter of social justice and crucial for driving innovation, economic growth, and societal development.

Thus, the importance of fostering inclusivity and equal opportunities in STEM for PWD in Nigeria as well as strategies to promote their participation and success are highlighted below:

1. Creating Accessible Technologies: By considering the needs of PWD from the outset, engineers and designers can create products and services that are more user-friendly, intuitive, and inclusive. Perhaps, it is in this regard that the World Health Organization (2020) hinted that Inclusive design practices in STEM can lead to the development of accessible technologies that benefit not only PWD but also the broader population.
2. Diverse Perspectives: According to the report of the National Science Foundation (2020) Inclusivity in STEM promotes diversity of thought and perspective which is essential for fostering creativity, innovation, critical- thinking and problem-solving techniques. By including individuals with diverse backgrounds and experiences, including PWD, STEM fields can benefit from a broader range of ideas and solutions.
3. Addressing Societal Challenges: Many of the societal challenges facing Nigeria, such as healthcare, infrastructure, and environmental sustainability, require interdisciplinary approaches and technological innovations (United Nations Development Programme, 2021). Thus, by engaging PWD in STEM, Nigeria can tap into their unique insights and expertise to address these challenges more effectively.
4. Tapping into Untapped Talent: By providing equal opportunities, Nigeria can tap into a pool of untapped talent. According to United Nations Development Programme, (2021) some of the PWD possess valuable skills and capabilities that can significantly contribute to the advancement of STEM fields.
5. Diverse Perspectives: Inclusivity in STEM ensures a diverse range of perspectives and approaches to problem-solving. PWD bring unique insights and experiences, contributing to creative solutions and innovations (National Science Foundation, 2020)
6. Enhanced Problem-Solving: It has been asserted that Inclusive STEM environments foster collaboration among individuals with diverse backgrounds, leading to more effective and innovative problem-solving. The report of the World Health Organization (2020) reveals that PWD often approach challenges with unique problem-solving skills, enriching the overall STEM landscape.

However, despite the growing global recognition for PWD in driving economic growth, innovation, and social development through STEM education, yet in developing countries like Nigeria, the PWD are still exposed to several barriers in accessing STEM education and pursuing careers in STEM fields.

Barriers Faced by Persons with Disabilities in STEM:

Although the national policy on education indicates that Nigerians (irrespective of their physical conditions, i.e whether physically able or disabled) have the right to an inclusive education and that schools should provide conditions which lead to successful education of all, however, investigations revealed that PWD are not only the most marginalized and excluded groups in the pursuit of education but they are also facing a myriad of challenges in realizing their right to quality education especially in the field of STEM. This assertion is in consonant with the findings of Obasanjo and Adedayo (2023).

Thus, PWD are still faced with numerous barriers that hinder their access to and participation in STEM education and employment. Some of the most prominent challenges prevalent includes:

1. Limited Access to Education:

One of the major challenges confronting PWD in Nigeria is that most of the educational institutions either have limited or in most instances, lacks the necessary infrastructure and accommodations to make STEM education accessible to PWD. This includes inaccessible buildings, lack of assistive technologies, and inadequate resources for specialized support services. Perhaps, it is in support of this observation that Jones (2019) revealed that majority of persons with disabilities in Nigeria face significant barriers to accessing quality education due to the absence of inclusive environments as well as lack of accessibility tools and resources which makes it difficult for them to make any meaningful contribution in the field of STEM.

2. Social Stigma and Discrimination: People with disabilities often face social stigma as a result of societal misconceptions, stereotypes, and discrimination towards persons with disabilities. This leads to isolation and self-esteem thus contributing to their exclusion from STEM career opportunities in Nigeria. Consequently, these negative attitudes hinder their inclusion in mainstream educational institutions and workplaces, where they can make substantial contributions. Thus, this hinders their full participation in society. According to Abdulraheem, (2021) even in the present 21st century, the negative attitudes and stereotypes of individuals toward PWD persist in most parts of Nigeria, consequently this leads to social exclusion and discrimination against PWD. This stigma often discourages PWD from pursuing education and careers in STEM fields.

3. Limited Representation and Role Models: The lack of visible representation of successful persons with disabilities in STEM fields creates a lack of role models and discourages aspiring students from pursuing STEM subjects or careers due to limited external inspiration. Reports by Ahmed et al., (2020) revealed that the underrepresentation of PWD in STEM professions is capable of discouraging the PWD from venturing into the field of STEM education or related careers as the struggle to find relevant role models becomes not only a mirage but virtually unattainable.

4. Lack of awareness and training on disabilities: Many STEM educators and professionals lack awareness and education about disabilities, which can hinder the inclusion and support of PWD in STEM fields. According to Abdulraheem (2021) lack of relevant training and awareness on the part of the teachers is a major barrier to STEM education by PWD because most of the Educators lack the necessary training and awareness to support PWD effectively in STEM education, hence leading to their exclusion and marginalization in STEM-related career.

Consequently, most STEM professionals and educators lack awareness and education about disabilities, which can lead to barriers in supporting PWD in STEM education and careers.

5. Inadequate facilities and Assistive Technology: Insufficient infrastructure, including inaccessible public facilities and inaccessible information and communication technology (ICT), inhibit the full participation of persons with disabilities in STEM-related activities.

Lack of affordable and appropriate assistive technology worsens this issue. In support of this assertion Oluwole and Ojo (2018) observed that in the few institutions where STEM facilities are available, they still lack adequate infrastructure for PWD, making it difficult for them to access laboratories, workshops, and other learning spaces.

6. Lack of Inclusive Curriculum: The curriculum of STEM education is not designed to be adapted to accommodate diverse learning needs thus hindering the participation of PWD. According to Oyeniyi (2023) the absence of inclusive curriculum development processes leads to a lack of appropriate learning materials and methodologies for PWD in STEM subjects. This also translates to lack of inclusive educational environments. Consequently, the PWD face challenges in finding inclusive educational environments in STEM fields which is not only capable of hindering their success but also participation in STEM. Thus, PWD often face barriers in accessing inclusive and accessible STEM education environments, which limits their ability to fully participate and succeed in stem-related careers and education.

7. Limited job opportunities and career advancement: Although the issue of unemployment is a global phenomenon, it is also one of the major issues confronting Nigeria as a nation. The problem is also not only peculiar to persons who are physically okay but even PWD face severe challenges in accessing job opportunities and advancing in their STEM careers. A report by the National Science Foundation found that many PWD struggle to find job opportunities in STEM fields, and face barriers to advancing in their careers due to discrimination and lack of support (National Science Foundation, 2020).

8. Limited networking and mentorship opportunities: PWD often face challenges in accessing networking and mentorship opportunities in the field of STEM, consequently this can limit their ability to advance in their careers. To buttress this assertion, Abdulraheem (2021) discovered that PWD have limited access to mentorship and networking opportunities, which hinders their career development and advancement.

Strategies to overcome barriers and Create Opportunities for PWD in STEM

1. To overcome the problem of limited access to education among the PWD, there is an urgent need for both government and non- governmental organizations to invest heavily in infrastructure modifications to make institutions of learning and workplaces more accessible to PWD. According to Frueh (2023) this can be achieved through construction of ramps, elevators, accessible restrooms, modifying classrooms with adjustable desks and ensuring that buildings comply with global accessibility standards for the PWD. Additionally, providing transportation services tailored to meet the needs of PWD's can improve access to quality education in general and STEM in particular. Thus, providing accessible learning environments, assistive technologies, and reasonable accommodations to support the diverse learning needs of PWD will ensure equal access to quality education which is fundamental for empowering PWD to pursue careers in STEM.

2. The social stigma and discrimination against PWD occasioned by the negative attitudes of the society towards disability which hinders their participation in STEM can be overcome through extensive awareness campaigns to challenge stereotypes and promote inclusivity. Teachers and peers can be educated on the capabilities of PWD which can foster a more supportive environment. Additionally, enacting and enforcing government policies that promotes inclusivity and equal opportunities for PWD in STEM, including reasonable accommodations and anti-discrimination measures is capable of eradicating the social stigma and discrimination against PWD in the field of STEM (Jones, 2019). Consequently, initiating training programs, educational awareness campaigns, and public outreach initiatives can help dispel myths and stereotypes about PWD and promote a culture of inclusion in STEM.

3. Another strategy to allow for full participation of PWD in STEM involves creating STEM outreach and mentorship programs. Initiating STEM outreach and mentorship programs plays

a crucial role in inspiring and supporting PWD to pursue careers in STEM. Accordingly, these programs are not only capable of providing opportunities for PWD to connect with renowned role models, but they can also allow them to gain hands-on experience, and thus develop essential skills for success in STEM fields (Frueh, 2023). Consequently, the initiative can promote the visibility of successful PWD in STEM fields through outreach activities, media campaigns and mentorship programs. Above all, highlighting the achievements of role models among PWD can inspire aspiring students and professionals and challenge stereotypes.

4. Most teachers lack adequate training to effectively teach STEM to PWD (Oluwole & Ojo, 2018). This is another major factor contributing to non-participation of PWD in STEM education and career pursuit. Therefore, it is paramount to provide training and awareness programs for STEM educators and professionals on and inclusive teaching practices for disabilities. This measure should include implementing inclusive education training programs, workshops and professional development opportunities for the educators. Consequently, it is also essential to seek for collaboration with non-governmental organizations especially disability organizations and experts can also provide valuable insights. This can also help them better support PWD in STEM education and careers. Thus, workshops, seminars and online resources can be utilized.

5. To address the challenge of lack of assistive technology as a barrier to accessing STEM education, there is a need for the government to invest in the development of accessible ICT infrastructure, adaptive tools, and assistive technology to ensure barrier-free learning for all students. The development and subsequent provision of these critical learning resources, such as Braille textbooks, screen readers, online learning platforms and other related assistive technologies can facilitate the participation of PWD in STEM education. According to Ahmed et al. (2020) these resources can help to overcome barriers to learning and thus enable PWD to effectively participate in STEM activities.

6. Encouraging the development of inclusive curriculum materials and methodologies that cater to diverse learning needs is another strategy that can be adopted to overcome the problem associated with lack of inclusive Curriculum and adaptations to accommodate diverse learning needs which is peculiar to STEM curricula (Oluwole & Ojo, 2018). Thus, the development of inclusive teaching materials which incorporates universal design principles into lesson planning, and offering personalized learning plans for PWD is a strategy that can ensure full participation of the PWD in STEM coursework. Additionally, the Involvement of PWD in the curriculum development process which shall make provisions for alternative teaching methods, flexible assessment strategies, and fostering a supportive and inclusive culture within educational institutions can ensure that their perspectives and needs are adequately represented.

7. Creating job opportunities and advancement in STEM career by PWD is possible if the government and other employers of labour can be encouraged through diversity and inclusion initiatives, mentorship programs, and partnerships with disability advocacy organizations. Additionally, advocating for policy changes at the government level to promote the rights and inclusion of PWD in STEM-related careers and employment. According to Obasanjo and Adedayo (2023) this may involve lobbying for legislation that mandates accessibility standards, anti-discrimination policies, and incentives for inclusive practices. This measure is capable of encouraging employers to create more job opportunities for PWD in STEM fields and to provide support for their career advancement.

Conclusion

Creating opportunities for persons with disabilities in STEM fields is essential for not only enhancing inclusivity but also harnessing their skills and potential to drive innovation and socio-economic progress. The paper dwells on the need to prioritize educational reforms,

inclusive policies and infrastructure development to ensure equal access and participation for persons with disabilities in STEM. By addressing the barriers and implementing the strategies discussed in this paper, Nigeria can unlock the untapped potential of its disabled population and foster a more inclusive, diverse, and prosperous society. Thus, the inclusion of PWDs in STEM fields is not just a matter of social justice but an essential requirement for sustainable development and global competitiveness of the nation. Consequently, the paper asserted that by harnessing the talents and potential of PWD Nigeria can attain new pathways to innovation, economic growth, and social progress. Through concerted efforts to remove barriers and create inclusive opportunities, Nigeria can pave the way for a more equitable and prosperous future for all.

Recommendations

The following recommendations are proffered to enhance opportunities for PWD in STEM field:

1. There is an urgent need to invest in accessible Infrastructure and resources. To this end, educational institutions, government and NGOs should invest in modifying infrastructure and providing necessary accommodations to make STEM learning environments accessible to PWD. This includes constructing ramps, elevators, accessible restrooms, and ensuring classrooms comply with global accessibility standards.
2. Establish STEM Outreach and Mentorship Programs. These programs can provide opportunities for PWD to connect with role models, gain hands-on experience, and develop essential skills for success in STEM fields. Highlighting the achievements of successful PWD in STEM through media campaigns and mentorship initiatives can challenge stereotypes and inspire aspiring students and professionals.
3. Training programs, workshops, and professional development opportunities should be provided for STEM educators and professionals on inclusive teaching practices for disabilities. Collaboration with disability organizations and experts can offer valuable insights to better support PWD in STEM education and careers.
4. There is the need to create extensive awareness campaigns to challenge societal misconceptions, stereotypes, and discrimination towards PWD. Educating teachers, peers, and the general public about the capabilities of PWD can foster a more supportive and inclusive environment in STEM fields. Government policies promoting inclusivity and anti-discrimination measures should be enacted and enforced to eradicate social stigma and discrimination against PWD in STEM.

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THE IMPACT OF COVID-19 LOCKDOWN ON PHYSICAL ACTIVITY AND WELL-BEING AMONG ACTIVE ADULTS IN NIGERIA

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Abstract
Measures aiming at containing the Corona-virus disease (Covid-19), include isolation, social distancing, and quarantine. Quarantine and other lockdown instruments were aimed at reducing the number of Covid-19 infections and deaths. It is reasonable to assume that lockdown leads to reduced levels of physical activity in the general population. Potential detrimental health effects of lockdown, such as psychological distress and physical inactivity induced maladaptation must be addressed. The aim of this paper was to review harmful effects of limited physical activity on mental and physical health due to social distancing and quarantine. Harmful effects of limited physical activity on mental and physical health due to social distancing and quarantine and to highlight the effects of simple physical activity regimes, with a special emphasis on acute effects. The paper provide recommendations for evidence based physical activities that are feasible even in lockdown situations, and that hold position to help patients cope with the situation and which build the base for physical activity counseling in Covid-19 lockdown times.
Keywords: Covid-19, well-being, lockdown and SARS-Cov-2

Introduction

The Covid-19 also known as Severe Acute Respiratory Syndrome Corona-virus 2 (SARS-CoV-2) outbreaks hold public health concerns. The stay at home increases sedentary behavior, with unintended adverse outcomes since organized recreation and sports facilities were closed. The corona-virus disease 2019 (Covid-19) has an impact on Physical Activity behaviors worldwide (Antunes, and Frontini, 2021). People around the world stayed at home self-isolated due to the lockdown policy. Although the lockdown is essential and is the best recommendation for preventing the spread of the disease, it may create a new challenge (Yomoda, and Kurita, 2021). Staying at home for a prolonged period can lead to disturbing consequences such as weight gain, social isolation may also cause a reduction in Physical Activity levels (Cypryańska, Nezlek, 2020). The decrease in Physical Activity level may be especially apparent among active individuals habitually practicing sports (Klaperski, and Fuchs, 2021). Diminished Physical Activity resulting from home isolation may worsen a wide range of health conditions, including the chronic ones, such as cardiac and metabolic diseases as well as infectious diseases, due to negative immune-modulation even without substantial weight gain (Antunes, and Frontini, 2021). Therefore, maintaining an active lifestyle at home including mainly Physical Activity is extremely important for the general populations' health, especially for people with additional risk factors including old adults during the quarantine. According to the recommendation of the World Health Organization (WHO), the American College of Sports Medicine (ACSM) Position Stand, and Physical Activity guidelines for healthy adults, adults should do at least 150 minutes of moderate aerobic exercise or do at least 75 min of vigorous aerobic exercise during the week. Engaging in regular exercise is one of the best things for overall health, well-being, and longevity (Cypryańska, Nezlek, 2020). Exercise helps to keep cardiovascular system healthy, to

improve your cognitive function, your mood, and your sleep, and to help you remain healthy into your old age (Antunes, and Frontini, 2021).
It's no secret that, during the Covid-19 pandemic, healthy routines and habits suffered. The covid is an acute respiratory illness in humans caused by a corona-virus, capable of producing severe symptoms and in some cases death, especially in older people and those with underlying health conditions (Wu, Zhao, 2020). It was originally identified in China in 2019 and became pandemic in 2020.The corona-virus disease 2019 (Covid-19) is a communicable respiratory disease caused by a new strain of corona-virus that causes illness which may include headache, loss of smell and taste, nasal congestion and runny nose, cough, muscle pain, sore throat, fever, diarrhea, and breathing difficulties, shortness of breath, and fever. Which resulted to the closure of gyms, limited group fitness and decreases in day to day movement, maintaining activity levels has been a challenge for many (Almeida, Gomes da Silva, and de Dias Marques, 2020).

This lack of exercise not only impacts our physical bodies, but it can also greatly impact our mental well-being. With restrictions easing, it is now more important than ever to get moving, says exercise and public health expert Dr. Patricia Doyle-Baker that, exercise and mental wellness are key to our way out of the effect of the pandemic as restrictions eases Wu, Zhao, and Yu, 2020). Emotions elicited during the Covid-19 pandemic, like fear, have resulted in less healthy habits in people which was seen take effect through increases in alcohol intake, substance use and being less active (Ammar, Trabelsi, Brach, Chtourou, Boukhris, and Masmoudi, 2021). While quarantine and social distancing measures seem indispensable as of now, possible detrimental social, psychological, health and economic consequences must also be considered (Antunes, and Frontini, 2021). Psychological impact of quarantine can be wide-ranging, substantial and potentially sustained. Symptoms include emotional disturbance, depression, stress, low mood, irritability, insomnia, post-traumatic stress symptoms and anxiety. Little is known about the psychological effects of less rigorous intensity, but prolonged benefits (Bird, Karageorghis, and Hamer, 2021).

Moderate intensity exercise may decrease the risk of acquiring an Upper Respiratory Tract Infection (URTI). Research has shown that exercise in moderately fit and active people with a URTI does not prolong or intensify the illness. Regular moderate physical activity has wide reaching health benefits for people of all ages, sexes, races, health conditions and shapes. It manages weight; reduce morbidity and mortality rates, increased quality of life and independence in old age (Brooks, Webster, Smith, Woodland, Wessely, and Greenberg, 2020). Physical exercise can also help reduce the risk of acute life threatening events. To maintain these effects sustained, optimally lifelong physical activity is required, since acute benefits are transient and dissipate over time. However, knowledge about acute impact of single exercise bouts might facilitate the motivation and communication with patients to take up more activity (Cheval, et al., 2021).

The current crisis could potentially be a window of opportunity, a learning moment to initiate long-term activity. These social distancing measures mean that people have far fewer opportunities to be physically active, especially if activities such as walking or cycling as transportation, or taking part in a leisurely activity e.g. jogging, walking, and going to the gym are being restricted. Furthermore, these drastic measures also make it so much easier to be sedentary at home for long periods of time.
The impact of this physical inactivity may likely be seen in many areas such as health and social care and the mental well-being of people all across the globe(Jin, Lin, McLeay, 2020).

Although these social distancing measures are important and needed in a time such as now, our bodies and minds still need physical activity and the many benefits thereof.

The concept of Physical Activity

Physical activity in daily life can be categorized into occupational, sports, conditioning, household, or other activities (Haseler, Crooke, Haseler, 2019). Exercise is a subset of physical activity that is planned, structured, and repetitive and has as a final or an intermediate objective the improvement or maintenance of physical fitness. According to international guidelines, exercise training, widely regarded as the cornerstone of pulmonary rehabilitation, is the best available means of improving muscle function and exercise tolerance in patients with Chronic Obstructive Pulmonary Disease (COPD)(Li, and Liu, 2020). To contextualize the status quo regarding definitions of physical activity, I trace the origin and growth of the most widely accepted definition, published by (Caspersen, (1985) in(Haseler, Crooke, Haseler, 2019). They define physical activity as "any bodily movement produced by skeletal muscles that results in energy expenditure". This definition produces a very specific way of understanding physical activity. The focus on "skeletal muscles" and "energy expenditure" frames physical activity as a specific mechanistic act (Haseler, Crooke, Haseler, 2019).

Covid- 19 and Regular Physical Exercise

Physical activities, personal contact with colleagues, friends and family have been limited due to public health measures to curb the spread of Covid-19, such as quarantine, lockdown, self-isolation, and maintaining social distance (Vancini, 2021). People experienced a general decline in well-being, deterioration in mental health, and an increase in psychological distress such as stress, anxiety, depression, and feelings of isolation. This negative impact may in turn affect compliance with public health measures (Puyat 2020). Hence, there is a need to explore and identify alternative and complementary activities that promote mental health and well-being during Covid-19 and lockdowns. It is well-established that physical activity or exercise is essential to improve and or maintain physical and mental health and improve the quality of life (Vancini, 2021).

Various physiological and psychological mechanisms have been proposed to explain the positive effects of physical activity (Stubbs, 2017). Physiologically exercise may increase the levels of hormones, endorphins and Brain-derived Neurotrophic Factor (BDNF), which could make people feel happy and less stressed (Julia and Wendy 2017). Moreover, psychologically, exercise gives people the opportunity to have "time out" from the stressor, and regular exercise improves self-efficacy to overcome the difficulties they face. The Covid-19 pandemic has heightened people's attention to the positive effects of exercise on physical health. During the pandemic, the news media disseminates a great deal about the therapeutic effects of physical activities on physical health and people with mild corona virus infection (Vancini, 2021).

Regular and long-term physical exercise enhances the body's immune surveillance capabilities, acts as an anti-inflammatory agent, reduces the risk of developing numerous chronic diseases, and improves the general level of physical health and disease prevention and resistance (Li, and Liu, 2020).Initial evidence has shown that individuals can maintain and promote mental health through exercise during the pandemic (Gupta et al., 2021). However, measures restricting the spread of COVID-19 have led to a decline in physical activity for most children and adolescents, especially among boys and older children and adolescents (Yomoda and Kurita, 2021).

Physical Inactivity during Lockdown

There is extensive evidence on the positive impacts of physical activity for both physical and mental health (Jin, Lin, McLeay, 2020). For example, regular physical activity is associated with reduced rates of all-cause mortality, obesity, cancer, cardiovascular disease, stroke, and diabetes, among other physical conditions, as well as depression, anxiety, and other mental health problems. (Li, and Liu, 2020). Regular physical activity also leads to improvements in cardio-respiratory and muscular fitness, functional health, cognitive function, wellbeing, and quality of life. However, levels of physical inactivity are rising in many countries (Jin et al, 2020). Physical inactivity is the fourth leading risk factor for global mortality, causing premature mortality worldwide. Physical inactivity is also one of the most important risk factors for chronic diseases globally. Even short-term physical inactivity, over a period of 1–4 weeks, has been associated with negative changes in cardiovascular function and increased cardiovascular risk factors (Vancini, 2021).

Since December 2019, there has been an outbreak of corona-virus disease (Covid-19). Lockdowns and stay-at-home orders have been announced globally to control the spread of the disease, disrupting people's usual behaviors (Faulkner, Rhodes, Vanderloo, Chulak-Bozer, O'Reilly, Ferguson, 2020). In many countries, this has involved the closure of non-essential businesses, including gyms, outdoor sports amenities, and playgrounds, as well as limits placed on how often people could leave their homes each day.

However, how this has affected physical activity levels has been complex (Lou, Yan, 2020). Large cross-sectional surveys in many western countries have suggested decreases in overall physical activity when comparing self-reports of activity levels before to during lockdowns. The majority of longitudinal studies to date also show an initial drop in physical activity levels at the start of lockdown restrictions as do data from wearable fitness trackers in a number of countries (Faulkner, Rhodes, Vanderloo, Chulak-Bozer, O'Reilly, Ferguson, 2020).

Getting back into exercise routines after lockdown

Doyle (2020), suggested that, those who have become more sedentary re-enter or introduce exercise into their routines."The best way to start is to put more activity into your typical day," she says. "If you can, take the stairs on campus or at home, where you might normally take an elevator. Walk outside instead of inside when moving from classes or meetings or around the block at the start or end of a workday breathing in fresh air is an added bonus for our health. She further suggests that, after more activity has been introduced, start looking into adding more strenuous exercise such as cardio, followed by increasing the duration of workouts, incorporating some resistance training, and maybe considering a local or on-campus group fitness class. Doyle (2020), says there are benefits to working out with other people: "Remember that happy feeling related to exercise, the dopamine response. This neurotransmitter might further increase our need to connect with others, so finding a friend or co-worker to stay active (with) might not only help us stay active, but further improve our well-being and sense of connection."

Physical activity principles and guidelines

The new WHO 2020 Guidelines stress that any amount of physical activity is better than none, even when the recommended thresholds are not met this is a very positive message for much of the population who currently fall well short of the desirable minimum (Faulkner, Rhodes, Vanderloo, Chulak-Bozer, O'Reilly, Ferguson, 2020). These are:

i. **Frequency:** This is how often the individual should go with the exercise programme. For example, exercising on most if not all days of the week or 3-4 days per-week for at least 12 weeks among adults with high blood pressure.
ii. **Intensity:** How hard the exercise is taken, the degree of effort or exertion put forth by a subject workout. Adult with hypertension should engage in moderate intensity aerobic exercise and moderate intensity dynamic resistance exercise one or more repetitions.
iii. **Type:** Mode or kind of exercise, the individual should engage in aerobic and dynamic resistance training. For example, jogging, waking, dancing, climbing stairs and active sports such as basketball or tennis, push-up/ pull-up, weight lifting etc.
iv. **Time:** This is the duration and how long the exercise should go, for example, 30-60 minutes per-day or all days of the week or 150 minutes or more minute's per-week.
v. **Progression:** Advancement of the exercise session; progression should be gradual and avoid large increase in any of the principles of exercise and consider level of BP control; this is done to avoid damages.

The importance of physical activity during and post covid-19 lockdown

Regular exercise has several beneficial effects on your body that can improve the function of your musculoskeletal system, your cardiovascular system, your respiratory system, your metabolism, and even your brain (Vancini, 2021). Engaging in regular exercise significantly reduces your odds of developing heart disease, diabetes, kidney disease, lung disease (Faulkner, Rhodes, Vanderloo, Chulak-Bozer, O'Reilly, Ferguson, 2020).

Musculoskeletal Benefits

Some of the most obvious benefits of exercise relate to your musculoskeletal system: you get stronger muscles and bones (Haseler, Crooke, Haseler, 2019). As one age, you will have less chance of developing serious joint problems and fractures, and your balance (and chances of falling) will be reduced. With decreased physical activity there is the likelihood of musculoskeletal reconditioning. During periods of lockdown where many people's daily activity movements are restricted, musculoskeletal reconditioning is likely to happen in most people (Andersen, Rambaut, Lipkin, Holmes, Garry, 2020). In fit and healthy people this will be less noticeable, but in older people, people with diagnosed health conditions or people who were already functioning very close to the functional threshold, musculoskeletal reconditioning will be more pronounced (Li, W.; and Liu, 2020). This musculoskeletal reconditioning may have a significant impact on these vulnerable populations and may potentially increase the risk of injuries related to falls, such as hip fractures. This will in turn have implications for health and social care services already under stress (Lou, Yan, 2020).

Some specific musculoskeletal benefits of exercise include:

i. Exercise increases the size and strength of your muscle fibers.
ii. Exercise increases the strength of your ligaments and tendons.
iii. Exercise increases the number and density of the capillaries that supply blood to your skeletal muscles.
iv. Exercise increases the number and the size of the mitochondria (the power plants) in your muscle tissue, which allows your muscle to burn more energy (Zbinden-Foncea, Francaux, Deldicque, and Hawley, 2020).

Cardiovascular Benefits

According to (Klaperski and Fuchs, 2021). People who exercise regularly have a much lower chance of developing serious heart disease and vascular disease. These are:

i. Exercise improves your overall cardiac function so that you can pump more blood with each heartbeat.
ii. Exercise reduces your blood pressure, especially if you have essential hypertension.
iii. Exercise improves your overall vascular function.
iv. Exercise helps to prevent atherosclerosis, the disease that causes heart attacks, and many kinds of stroke.

Respiratory Benefits

Regular exercise helps to prevent chronic lung disease:

i. Exercise improves your lung capacity.
ii. Exercise increases the blood flow to your lungs, allowing the lungs to deliver more oxygen into the blood (Lou, Yan, 2020).

Metabolic Benefits

Physical activity exerts a major influence on human metabolism. Physical activity acutely increases glucose uptake, thus lowering circulating blood glucose level (Zhong, Huang, Wang, Che, Song, 2020). This uptake by contracting skeletal muscles takes place through insulin independent mechanisms. A single exercise bout also induces beneficial metabolic effects after exercise (Lum, and Simpson, 2021). Even relatively low volume of simple physical activity, such as walking or cycling has been shown to induce favorable effects on various metabolic markers in healthy and diseased population (Klaperski, and Fuchs, 2021). As little as 15 min of post-meal walking may blunt the glycemic response in healthy women and in women at risk of diabetes. (Lou, Yan, 2020), found that 6 min of another easily available physical activity, stair climbing and descending sufficed to reduce post-prandial glucose levels in inactive middle aged men with impaired glucose tolerance. A single bout of physical activity is followed by an acute decrease in blood pressure, known as post-exercise hypotension (Lum, and Simpson, 2021). A current systematic review based on 65 individual studies found that physical activity, regardless of participant and exercise characteristics, leads to a clinically relevant reduction in blood pressure (Li, and Yuan, 2020).

Muscle insulin sensitivity is increased for up to 48 h after exercise in healthy individuals. Regular exercise greatly improves your overall metabolic function, which helps to maintain your general health and to:

i. Increases muscles ability to burn fat more efficiently.
ii. Increases the mobilization of fatty acids into the bloodstream, from your fat deposits. (These last two effects of regular exercise "tune" your metabolism into more of a fat-burning machine.)
iii. Exercise reduces your triglyceride blood levels.
iv. Exercise increases your HDL cholesterol (good cholesterol).
v. Exercise reduces insulin resistance. Regular exercise helps to prevent type 2 diabetes in people who are at increased risk for this disease (Zhong, Huang, Wang, Che, Song, 2020).

Exercise and the immune system

The immune system is very responsive to exercise, depending on both the duration and the intensity of effort. Exercise causes multiple micro-injuries to the muscles, triggering a local and systemic inflammation reaction (Lum, and Simpson, 2021). During a moderate to high intensity exercise session lasting less than 60 minutes, the number of leukocytes (white blood cells) and several cytokines (proteins produced by the immune system to stimulate the proliferation of defense cells) increases rapidly in the bloodstream. The increase in the

number of neutrophils (a type of white blood cell) often lasts for up to 6 hours after the end of the exercise session (Vancini, 2021). This physiological response to stress caused by exercise is followed, during the recovery period, by a drop in the number of leukocytes in the bloodstream to a level below that measured at the start of the exercise session (Yarimkaya, and Esentürk, 2020).

Other Benefits

i. Exercise improves your immune function, which reduces your chance of infections.
ii. Exercise appears to reduce your chances of getting breast cancer, pancreatic cancer, and certain other gastrointestinal cancers.
iii. Exercise helps to prevent gallstones.
iv. Exercise helps to prevent the physical and cognitive decline of aging.
v. Exercise reduces your risk of Alzheimer's disease.
vi. Exercise helps with smoking cessation.
vii. Exercise plays an important role in preventing and treating obesity.
viii. Exercise improves cognitive function in people of all ages.
ix. In older people, regular exercise is associated with a reduced risk of falls.
x. In pregnant women, exercise lowers the risk of gestational diabetes and postpartum depression (Haseler, Crooke, Haseler, 2019).

Given all the physiologic benefits it produces, it is easy to see how regular exercise can help to prevent cardiovascular disease. In addition to the direct beneficial effects of exercise on the heart, regular exercise also improves several important cardiac risk factors (Zhong, 2020). Exercise lowers blood pressure, helps prevent obesity, reduces triglyceride levels, increases HDL cholesterol levels, and improves insulin resistance and thus helps to prevent or even reverse metabolic syndrome. (Li, and Yuan, 2020).An exercise routine has even been shown to be helpful in achieving smoking cessation.

Regular exercise is one of the most beneficial habits you can develop for your overall health, well-being, and longevity. Regular moderate physical activity has wide reaching health benefits for people of all ages, sexes, races, health conditions and shapes, as shown in reduced morbidity and mortality rates, increased quality of life and independence in old age (Haseler, Crooke, Haseler, 2019). Physical fitness can also help reduce the risk of acute life threatening events. To maintain these effects sustained, optimally lifelong physical activity is required, since acute benefits are transient and dissipate over time, unless physical activity stimulus is repeated (Li, and Yuan, 2020). However, knowledge about acute impact of single exercise bouts might facilitate the motivation and communication with patients to take up more activity now. The current crisis could potentially be a window of opportunity, a learning moment to initiate long-term activity (Li, and Yuan, 2020).

Conclusion

Lockdown implemented in an attempt to contain the SARS-CoV-2 virus is unprecedented for most countries, and represents a major societal challenge with conceivable repercussions for people’s mental and physical health. Physical activity has the potential to ward off detrimental cardio-metabolic effects of inactivity and to strengthen psychological resources and coping skills. Physicians and other health care professionals should use this time as a window of opportunity to provide physical activity counseling to their patients.

Recommendations

Considering the possible impact of physical inactivity during and after the lockdown, the following are some of the recommendations stated. These are:

i. Physiotherapist should encourage people to break their periods of inactivity
ii. Encourage people to engage in aerobic activity on a daily basis, because, very short periods of exercise have been reported to have real health benefits
iii. Physiotherapists need to focus on effective messaging during lockdown. This may include positive messages about the benefits of physical activity aligned with the concerns that people have during lockdown and pandemic.

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ASSESSING THE AWARENESS AND AVAILABILITY OF NATIONAL HEALTH INSURANCE SCHEME SERVICES AMONG TERTIARY INSTITUTION STAFF IN NORTHERN STATES, NIGERIA

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Abstract
This paper assessed the awareness, availability, utilization, impact and satisfaction of National Health Insurance Scheme (NHIS) services among staff of tertiary institutions in Northern States, Nigeria. Ex post-facto research design was used on a sample size of 764 respondents. To achieve the stated objective, the researchers developed questionnaire as an instrument for data collection. The population of the study comprised of 64,986 academic and non-academic, male and female staff of tertiary institutions in Northern States, Nigeria. The data collected were analyzed using mean scores and standard deviation, and one sample t-test statistics at 0.05 level of significance. The result showed that significant difference existed between one academic institution and the other in their satisfaction on utilization of NHIS services in Northern States. Based on the finding, the study recommended that explicit consideration should be given to the needs for equal distribution of health care services in Northern States tertiary institutions irrespective of the status of the institutions. Government should ensure effective monitoring and evaluation of the scheme to ensure satisfactory service delivery to the clients and the management and authorities of the partner clinics/hospitals should improve and let the workers utilize some services such as radiology and medical imaging diagnostic test.
Keywords: NHIS, impact, utilization, satisfaction, tertiary institutions

Introduction

National Health Insurance Authority (NHIA) in Nigeria is a government agency established to oversee the implementation and regulation of the National Health Insurance Scheme (NHIS). The NHIS was introduced in 1999 with the primary goal of providing universal health coverage and affordable healthcare services to all Nigerians (Akande, Adedovin & Aderibigbe, 2022). The NHIA plays a pivotal role in the administration and management of the scheme, ensuring its efficient and effective operation. One of the key responsibilities of the NHIA is the registration and accreditation of healthcare providers, including public and private hospitals, clinics, and healthcare facilities. This process involves evaluating the facilities' infrastructure, equipment, personnel, and adherence to established standards to ensure they meet the required criteria for participation in the NHIS (Adewole, Dairo & Bolarinwa, 2019). By accrediting healthcare providers, the NHIA aims to guarantee the delivery of quality healthcare services to enrollees under the scheme.

The NHIA is also responsible for the enrollment and registration of individuals and organizations into the NHIS. This includes formal sector employees, self-employed individuals, and vulnerable groups such as children, pregnant women, and the elderly (Adewole *et al.,* 2019). The enrollment process involves the collection and management of relevant data, ensuring accurate record-keeping and efficient administration of the scheme. Another crucial role of the NHIA is the management and disbursement of funds collected through contributions from enrollees and government subsidies. The authority oversees the pooling of these funds and ensures their equitable distribution to accredited healthcare

providers based on the services rendered to enrollees (Akande et al., 2022). This financial management aspect is critical to maintaining the sustainability and viability of the NHIS. Furthermore, the NHIA is tasked with developing and implementing policies, guidelines, and regulations that govern the operation of the NHIS. This includes setting the contribution rates, defining the benefit packages, and establishing the rules and procedures for claims processing and reimbursement (Adewole *et al.,* 2019). The authority also plays a crucial role in monitoring and evaluating the scheme's performance, identifying areas for improvement, and making necessary adjustments to enhance its effectiveness.

In recent years, the NHIA has focused on expanding the coverage of the NHIS to include more Nigerians, particularly those in the informal sector and rural areas. This effort aims to bridge the gap in access to healthcare services and promote equity in the healthcare system (Akande , Dairo & Bolarina, 2022). The authority has also been working on strengthening its operational capacity, improving its information technology infrastructure, and enhancing collaboration with stakeholders, such as healthcare providers, employers, and state governments (Adewole *et al.,* 2019). However, the NHIA faces several challenges in its quest to achieve universal health coverage in Nigeria. These challenges include inadequate funding, inefficient administrative processes, limited awareness and understanding of the scheme among the public, and the reluctance of some healthcare providers to participate due to concerns over reimbursement delays and bureaucratic bottlenecks (Akande *et al.,* 2022). To address these challenges, the NHIA has been advocating for increased government support and funding, streamlining administrative processes, and intensifying public awareness campaigns (Adewole *et al.,* 2019). Additionally, the authority has been exploring innovative strategies, such as leveraging technology and fostering public-private partnerships, to improve the scheme's efficiency and reach (Akande et al., 2022).

Although the concept of the scheme was targeted at the formal sector, that is the public service and organized private sector, the policy trust later changed to include people in the other sectors of the economy which include people in the rural community, the self-employed, the vulnerable groups and workers in tertiary institutions. This becomes necessary so as to ensure universal coverage and access to adequate and affordable health for all (Millinium Development Goals (MDGs 2016; Inegbedion, 2015). The NHIA is saddled with the mandate of universal coverage of all citizens by the end of 2020. As part of strategies to pursuit this mandate, the scheme, has design various programmes targeting the various segments of the Nigeria economy, the scheme has three different programmes to address different segments of the Nigeria society.

In addition every society large or small needs the best healthcare services for her people, the tertiary institutions cannot be left out of this noble course. As a matter of fact, the tertiary institutions need to play a leading role in the provision of healthcare services to the people because of the enlightened nature of the institutions and the belief that they should be more health conscious because of their knowledge. The continuous cost of health care services is a major concern to persons and all spheres of government in both developed and developing countries, particularly Nigeria, The fact that many policies have failed to mobilized enough financial, human and material resources to meet the existing or anticipated health needs of people. Perhaps this was the reason why availability of doctors, nurses and other health workers fall below a certain level. Access to health is fundamental human right, this assertion is enshrined in many global resolutions and declarations and merely the absence of diseases or infirmity. Access to health care services by the workers of tertiary institutions in Northern States, Nigeria is considered relatively low in Northern States, Nigeria. Also the facilities available in the health establishment, availability of alternative medical attention in the locality, perception of the attention received in the health care centre and the distance to the

centre's in terms of travel cost and time of reaching the health centre were perhaps hindrance to the utilization of NHIA health facilities.

While this phenomenon may hold true for all nations of the world, the developing countries, Nigeria inclusive are worst in achieving even minimal adequacy of health care services for its populace. The basic health needs of vast number of people remain unmet and the pursuit of improved standard of health has become a primary concern over the years (WHO, 2010). The sources of these problems, among others are perhaps poor government allocation of funds to the health sectors, inadequate supply of physicians accentuated by brain-drain syndrome in the health sector, poor distribution of health facilities or urban biased establishment of health facilities, shortage of drugs, corruption and attitude of the health workers. Obsolete and dilapidated health infrastructures, perhaps, are traceable to issues concerning efficiency, equity and resource constrains.

Purpose of the Study

To assess the impact of satisfaction with National Health Insurance Scheme services on utilization among tertiary institutions staff in Northern States, Nigeria.

Research Question

Are staff of tertiary institutions in Northern States satisfied with the utilization of National Health Insurance Scheme?

Hypotheses

The satisfaction with National Health Insurance Scheme on the utilization of health care services for staff of tertiary institutions in Northern States is not significant.

Material and Methods

Ex-post-facto research design was considered suitable for this study, since there will be manipulation of information from the respondents by the researchers hence the information needed is already in existence. According to Sambo (2008), the ex-post- facto research design leads to evaluation and identification of behavioural phenomena. The ex-post-facto research design was therefore, considered appropriate for this study.

The population of the study consisted of sixty-four thousand, nine hundred and eighty-six 64,986 (40,024 males and 24,940 females) Academic, and Non-Academic staff of nineteen (19) tertiary institutions in Northern States, Nigeria.

The sample size used in this study consisted of three hundred and eighty two (764) staff which was drawn from the sampled tertiary institutions in Northern States using Research Advisor (2006) Table for determining sample size from a given population. Research Advisor (2006) stressed that for a population of 60,000 to 74,999, the sample size should be 764 at 0.05 level, 5% margin of error and 95.0% degree of accuracy. The sampling procedure adopted for this study was stratified sampling technique, simple random sampling, proportionate sampling technique and systematic sampling technique.

The research instrument used for data collection was a close-ended questionnaire and it was structured using 4-point Likert scale, meant to determine the respondents' satisfaction with NHIS services on utilization among staff of tertiary institutions in Northern States, Nigeria

Descriptive statistics of frequency distribution and percentage count was used to describe demographic data of the respondents. Mean and standard deviation as used to analyze responses to the research questions, inferential statistics off one sample t-test was used to test the null hypotheses on the assessment of the impact of awareness, availability and satisfaction with the NHIS services on utilization among tertiary institutions; staff in Northern States, Nigeria.

Results

Research Question: Are staff of tertiary institutions in Northern States satisfied with the utilization of National Health Insurance Scheme Services?

Table 1.1; Mean Scores of Respondents and standard deviation on satisfaction of National Health Insurance Services

	Items	Mean	Std. Deviation
1	Hospitals and Inpatient Care (Hospital Admission) are satisfactorily cover for clients	2.58	1.133
2	The Prescribed Drugs and Pharmaceuticals in NHIS partner hospitals/ clinics are satisfactorily given because I never lack.	2.60	1.113
3	Specialist Consultation Services in NHIS partner hospitals/ clinics are provided to the clients satisfactorily	2.52	1.123
4	Maternal and Health Child Care Services in NHIS partner hospitals/ clinics are satisfactory.	2.64	1.112
5	Diagnostic Laboratory Test Services provided by NHIS partner hospitals/ clinics are promptly and satisfactorily covered.	2.47	1.122
6	Restorative and Rehabilitative Services for Physiotherapy provided by NHIS partner hospitals/ clinics are satisfactorily covered.	2.57	1.116
7	Accident and Emergency Services are promptly given to the sudden illness and causalities in NHIS partner hospitals/clinics satisfactorily	2.49	1.127
8	Dental Care Services provided by NHIS partner hospitals/clinics are satisfactory	2.50	1.122
9	Surgical Services provided by NHIS partner hospitals/clinics are satisfactorily taken care of	2.53	1.090
10	Obstetrics' and Gynecology Services provided by NHIS partner hospitals/clinics are satisfactory	2.49	1.134
11	Radiology and Medical Imaging Services provided by NHIS partner hospitals/clinics are satisfactory	2.46	1.112
12	Ophthalmology and Optometric (Eye) Care Services provided by NHIS partner hospitals/clinics are satisfactory	2.58	1.114
13	Preventives and Control Health Care Services provided by NHIS partner hospitals/clinics are satisfactory	2.50	1.134
14	Mental Health Care Services provided by NHIS partner hospitals/clinics are satisfactory	2.51	1.134
15	Outpatient Care Services provided by NHIS partner hospitals/clinics are satisfactory	2.61	1.131
16	Medical Test Services provided by NHIS partner hospitals/clinics are satisfactory	2.57	1.113

17	Basic Health Coverage Services provided by NHIS accredited partner hospitals/clinics are satisfactory	2.52	1.090
18	Ambulance Services provided by NHIS partner hospitals/clinics are satisfactory	2.47	1.129
19	Chronic Disease Management Services provided by NHIS partner hospitals/clinics are satisfactory	2.49	1.141
20	Family Planning Services provided by NHIS partner hospitals/clinics are satisfactory	2.58	1.128
21	Pediatrics' Services provided by NHIS partner hospitals/clinics are satisfactory	2.60	1.090
22	Ear, Nose and Throat (ENT) Services provided by NHIS partner hospitals/clinics are satisfactory	2.61	1.112
23	Primary Health Care services provided by NHIS partner hospitals/clinics are satisfactory	2.58	1.116
	Aggregate Mean Score	**2.54**	**1.119**

Table 1.1 shows respondent responses on satisfaction with utilization of health care services available under National Health Insurance Scheme in tertiary institutions in Northern States, Nigeria. This study sought to evaluate staff satisfaction with healthcare services available through Nigeria's National Health Insurance Scheme (NHIS) in tertiary institutions across Northern states. Satisfaction was measured across 23 specific services and an aggregate average using a 4-point adopted Likert scale. The aggregate mean satisfaction score was 2.54, just above the mid-point of 2.5. Standard deviation of 1.119 shows responses clustered closely around the mean. Individual item means ranged from 2.49 to 2.64. Most fell between 2.5 to 2.6, similar to the aggregate. This suggests that staff perceived satisfaction as leaning towards moderate rather than high levels.

Items number 15, 22, 2, 21, 1, 12, 20, 23, 6, and 16 had the highest mean scores of 2.57 to 2.61 which indicates that the respondents are in agreement with the idea that outpatient care services, ear, nose and throat (ENT) care services, prescribed drugs and pharmaceutical, pediatrics care services, hospital an inpatient care, ophthalmology an optometric (eye) care services, family planning services, primary health care services, restorative an rehabilitation services for physiotherapy and medical test services. Next are items number 9, 3, 13, 14 and 17 with second highest mean scores of 2.50 to 2.53, while items number 5, 7, 10, 11, 18 and 19 had the least mean scores of 2.51 to 2.54 respectively.

Looking more closely, means hovering around 2.50 denote satisfaction rated predominantly as moderate. Scores closer to the scale endpoints would indicate stronger feelings of (dis)satisfaction. The narrow range and clustering near the midpoint therefore point to moderate, middling assessments of overall satisfaction. While Natural variation was evident, evaluations remained constrained within one scale point of respective means. Responses form a consolidated body indicating shared moderate perspectives.

Hypothesis One: The satisfaction with National Health Insurance Scheme health care services for staff of tertiary institutions in Northern States, Nigeria, is not significant

Table 1.2: One sample t-test Analysis on the satisfaction with National Health Insurance Scheme services for staff of tertiary institutions in Northern States, Nigeria

Variable	N	Mean	Std	Df	t-cal	p-value
Satisfaction	764	2.54	1.119	762	0.99	.069
Test Mean		2.50	.000			

t(762) = .99, p> .05

This one sample t-test examined whether the mean satisfaction rating of 2.54 among 764 staff differed significantly from the test value of 2.50, the midpoint of the 4-point scale.
The t-test yielded a calculated value of 0.99 with 762 degrees of freedom. This value does not surpass the critical value of 1.96 needed for significance at the 0.05 level.
Additionally, the p-value was reported as 0.069, which exceeds the cut-off value of 0.05. Therefore, as the p-value is greater than 0.05, the researcher fails to reject the null hypothesis that the sample mean is equal to the test value. While the sample mean satisfaction rating of 2.54 was slightly higher than the scale midpoint of 2.50, which indicated least satisfaction. This difference is not statistically significant according to the one sample t-test results. It cannot be claimed that reported satisfaction levels were significantly higher or lower than moderate. Therefore, the satisfaction with the NHIS health care services is not significant.

Discussion of Findings

The study was on assessment of the impact of satisfaction of National Health Insurance Scheme (NHIS) health care services on utilization among staff of tertiary institutions in Northern States, Nigeria showed that there is significant satisfaction of National Health Insurance Scheme services among staff of tertiary institutions in Northern States, Nigeria.
Findings of this study revealed that satisfaction is a state of pleasure or commitment with an action or service, especially one that was previously desired and when applied to medical care, patient's satisfaction can be considered with context of participants' appraisal of their desire and expectations of health care (Ilochonwu & Adedigba, 2017). Morgan, Anderson and Mittal (2015) in their study suggested that satisfaction is related to perception of the outcome of care and the extent to which it meets patients' satisfaction. This is supported by Newsome and Wright (2017) who demonstrated that a relationship between satisfaction and expectation is not necessarily direct but content that, it then seems reasonable to suggest that expression of figure to some extent. Odo and Ogye (2022) asserted that, it is difficult to sell services if individuals are dissatisfied with the services because in a competitive health care environment, patients waiting time play an increasingly important role in a clinic's ability to attract new business. However, this study revealed that health care services under the National Health Insurance Scheme impact on Academic and non-Academic staff of tertiary institutions of Northern States, Nigeria. This agreed with Muriithi (2013) and Varian, (2014) who concur that, in terms of benefits, health insurance scheme was discovered to have two side of its coin; Empirical studies suggested that workers in jobs with health insurance coverage had higher productivity and lower turnover than workers without health insurance benefits. On the other hand, other studies suggested that offering health insurance has very little or no effect on job turnover (Muriithi, 2013; Varian, 2014). However, it is generally believed that people without health insurance are more likely to be in worse health condition and have higher death rates than those people with health insurance coverage because they are less likely to seek medical care. Cunningham in Odo and Ogye (2022) asserted that patient's satisfaction through enhanced medical care, long waiting time has frequently been mentioned as one factor which may limit health care service utilization by any community.

Conclusion and Recommendations

Based on the results of the findings, this study concludes that satisfaction with NHIS services on utilization among tertiary institutions staff in Northern States, Nigeria cannot be over emphasized. Therefore, the following recommendations are made:

1. Government at both federal and state should provide equal NHIS services to all the tertiary institutions in Northern States, Nigeria irrespective of the status of the institutions.
2. The management and authorities of the partner clinics/hospitals should improve and let the workers utilize some services such as radiology and medical imaging diagnostic test.
3. Government at all of governance should ensure effective monitoring and evaluation of the scheme to ensure satisfactory service delivery to the clients

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INFLUENCE OF SUPERVISION ROLES OF HEADS OF HOME ECONOMICS DEPARTMENT ON LECTURERS' PERFORMANCE IN COLLEGES OF EDUCATION NORTH-CENTRAL, NIGERIA

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Abstract
This study assessed the influence of the supervision roles of Heads of the Home Economics Department on Lecturers' performance in Colleges of Education in North-Central, Nigeria. The study had three (3) objectives among which was to examine the level of influence of HODs' supervision roles on Lecturers' instructional performance in Colleges of Education in North-Central, Nigeria. Three (3) research questions were raised and a descriptive survey design was used to carry out the research. The population of the study comprised eighty-eight (88) respondents: eleven (11) HODs and seventy-seven (77) Home Economics Lecturers. The whole population was used as a sample size for the study. Two instruments titled HODs Supervision Roles Questionnaire (HSRQ) and the Lecturers' Performance Questionnaire (TPQ) constructed by the Researcher were used for data collection. The HSRQ had section A, containing 10 items to answer RQ one. TPQ had sections A and B. Each section had 10 items to answer RQ two, and RQ three. Three experts validated the instruments. The reliability coefficient of the instruments was established through the Cronbach Alfa Correlation Coefficient. The reliability index for HSRQ and TPQ instruments were 0.81 and 0.91 respectively. Eleven (11) copies of HSRQ and seventy-seven (77) copies of TPQ were administered, but eleven (11) copies of HSMRQ and sixty-six (66) copies of TPWQ were returned successfully. Mean was used to analyze all the RQs. The analysis of the responses was interpreted as the benchmark of mean 3.0. The study's findings revealed that the level of influence of HODs supervision roles had a high influence on Lecturers' instructional performance (Aggregate Mean 3.38). More so, HODs' supervision roles had a high influence on Lecturers' instructional preparation (Aggregate Mean 3.57), and delivery skills (Aggregate Mean 3.62). Based on the findings, it can be concluded that HODs' supervision roles such as planning, discussion of challenges, weekly vetting of the lesson plan, observation of instructional process, providing feedback, monitoring, and motivation influence the Lecturers' quality of instructional preparation and delivery skills. Because of the findings, the Researcher recommended among others that HODs should consistence and sustain a high level of instructional supervision roles to enhance the enthusiasm of Lecturers' instructional performance. HODs should ensure Lecturers' compliance with NCCE minimum standards, regulations, and policies to help the Department of Home Economics maintain its accreditation and reputation.
Keywords: Instructional, Performance. Roles, Supervision.

Introduction

Globally, the demand for quality education at all levels has increased in response to globalization and the challenges of the 21st century. There is a consensus among scholars that the quality of education is one of the most potent factors that account for inequality that differentiates developed countries from developing countries (Ibrahim, 2019). Standard education practices would enhance the effective implementation of the nation's educational goals. Thus, the Quality Teacher Education Programme (QTEP) is valuable for the social and economic development of a nation. Many literatures support the fact that quality education is strongly based on quality input, quality process, and quality outcomes (Obanya, 2014; Okoye,

Onyali, & Ezeughor, 2016; Ngole & Mkulu, 2021). The development of any society depends on the quality of education, and in turn quality of education depends on the quality of Lecturers, teaching and learning process, quality roles of Heads and students, and effective involvement of parents in education. To promote quality and effectiveness in education, supervision in schools is important (Paschal, Nyoni, & Mkulu 2020). An increasing role of monitoring has been adopted as a standard of persuading the enhancement of quality education (Safaryan, 2020). More so, Supervision has become an accepted tool of good administrative actions within and across educational institutes to enhance performance and attainment of desired results.

The Home Economics program is among the several fields of Teacher Education where the curriculum leader administers their professional responsibility towards the Quality Home Economics Teacher Education Programme (QHETEP). Thus, implementing a Home Economics Teacher education programme for quality output requires the commitment of all stakeholders in terms of performing their Roles and responsibility for effective implementation. These include the government, institution management, HODs, lecturers, and Students. In the context of this study, the quality performance of Lecturers is the key to quality education because Lecturers are the critical educational agents and leaders that operate the dynamic environment for the delivery of educational services to achieve a society's aspiration. Equally, the leadership roles of HODs in terms of supervision of curriculum and instructional activities are imperative for the delivery of QHETEP.

The roles of HODs as instructional supervisors and officers in achieving QHETEP have more than ever before become very crucial. Particularly the issue of instructional improvement through effective learning and quality teaching in Nigeria Colleges of Education is the major concern. Presently, the NCE Minimum Standard emphasizes a learner-centered approach. The document establishes high expectations for the quality of Teacher's instructional preparation and delivery. Lecturers are expected to utilize suitable learning materials, assessments, and instructional strategies. Lecturers also are expected to keep adequate records of the instructional activities of the department. In this regard, the HOD's role is to supervise and monitor the Teacher's instructional activities. Perform instructional supervision and monitoring roles in the department demands that the HOD plan the supervision activities to capture the vision, set achievable goals, and establish policies to achieve set goals. Besides planning, HOD needs to observe the teaching skills of Lecturers and use appropriate feedback mechanisms, monitor their performance, and motivate them to influence Lecturers' performance.

In reality, the Researcher observed that there is little check and balance between HOD instructional supervision roles and Lecturers' instructional performance as required by the minimum standard. This scenario could make some Teachers not perform their duty as expected and result inappropriately. Evidence of inappropriate manners is displayed by changing of lecture timetable, unsuitable method of teaching, quality of assessment given to learners, and delay in submission of marked examination scripts and score sheets. It is the responsibility of Lecturers to give lessons and realistic assignments according to the established minimum standards. These standards can be achieved when HODs perform effective supervision. Alhassan (2015) noted that excellent schools have good administrators; these leaders have been identified as performing supervisory roles very well, whereas failing schools have weak administrators who pay little attention to supervisory roles.

Statement of the Problem

In line with the implementation of quality teacher education policies, the NCCE mandates the establishment of a directorate of quality assurance in the colleges to monitor the effective implementation of NCE minimum standards. The directorate works hand in hand with HOD to ensure quality teaching and learning at the departmental level through supervision of instruction to improve Lecturers' performance. However, the question is, to what level do instructional supervision roles of Heads of Department of Home Economics influence Lecturers' instructional performance in Colleges of Education in Nigeria? Thus, among other factors to address quality issues in Teacher Education are Teacher excellence of instructional preparation, teaching skills, quality of assessment and other instructional tasks performance are very momentous. Another issue of concern is do HODs' instructional supervision influences the commitment of Lecturers to prepare and deliver quality lessons, and dedication to perform instructional tasks. To buttress this, Ngole et al. (2021) reported that ineffective supervision by Heads of schools contributes to poor quality of teaching and learning in most schools. Thus, the need to assess the influence of the supervision roles of the Head of the Home Economics Department on Lecturers' performance at work in Colleges of Education North Central, Nigeria become necessary.

Objectives of the Study

The major objective of this study is to assess the influence of supervision and monitoring roles of Heads of Department of Home Economics (HODs) on Lecturers' performance at work in Colleges of Education North-Central, Nigeria. The specific objectives of the study are to:

i. examine the level of influence of HODs' supervision roles on Lecturers' instructional performance in Colleges of Education North-Central, Nigeria.
ii. examine the influence of HODs' supervision roles on the quality of Lecturers' instructional preparation in Colleges of Education North-Central, Nigeria.
iii. determine the influence of HODs' supervision roles on the quality of Lecturers' instructional delivery skills in Colleges of Education North-Central, Nigeria.

Research Questions

The following research questions guided the study:

i. What is the level of influence of HODs' supervision roles on Lecturers' instructional performance in Colleges of Education North-Central, Nigeria?
ii. What is the influence of HODs' supervision roles on the quality of Lecturers' instructional preparation in Colleges of Education North-Central, Nigeria?
iii. What is the influence of HODs' supervision roles on the quality of Lecturers' instructional delivery skills in Colleges of Education North-Central, Nigeria?

Research Methodology

Research Design

This study adopted a descriptive survey design. Descriptive survey design is considered appropriate for this study because it enables the Researcher to establish the dimension and the predictive value of the variables of the research questions.

Population and Sample Size of the Study

The population of the study comprised a total number of eighty-eight (88) respondents. Specifically, eleven (11) Heads of the Home Economics department, and seventy-seven (77) Home Economics Lecturers obtained from the departmental staff list of the Colleges of Education North-Central, Nigeria. There are no sampling techniques applied because all

members of the population for the study were chosen as the size was manageable and individual views are considered important for the study.

Instruments for Data Collection

The instruments used for data collection were structured questionnaires constructed by the Researcher titled HODs Supervision Roles Questionnaire (HSRQ) and Lecturers' Performance Questionnaire (LPQ). The HSRQ instrument has one section with 10 items related to RQ one of the study. The instrument was used for data collection from HODs. The LPQ instrument has two sections with 20 items used for data collection from Lecturers. The questions were scored on a four-point Likert scale, with High Influence = 5, Above Average Influence = 4, Average Influence= 3, Below Average Influence = 2, and Very Low Influence =1. as the possible answers. Two specialists from the Home Economics department verified the tool. Pilot tests were carried out at the College of Education, FCT, Zuba, and Kaduna State College of Education, Gidan Waya. Two HODs and sixteen Lecturers participated in the pilot testing. Cronbach's Alpha was used to evaluate the instrument's dependability; the result showed reliability coefficient values of 0.81 and 0.91 for HSRQ and LPQ respectively. The questionnaire's alpha ratings were deemed sufficient for this study. This is consistent with Bashir and Marudhar's (2018) confirmation test of dependability. They contend that an instrument is deemed dependable if it falls between 0 and 1, that the closer the estimated reliability coefficient is to 0, the less reliable the instrument, and that the higher the calculated reliability coefficient is to 1, the more reliable the instrument.

Procedure for Data Collection

The Researcher collected a letter of introduction from the office of the Head of the Department of Home Economics, Faculty of Education, Ahmadu Bello University, Zaria for permission to administer the questionnaire. The Researcher visited the Colleges of Education and introduced herself to HODs. Presented the letter of introduction for permission to administer the questionnaire. With permission of HODs, the Researcher administered the questionnaire to the respondents and retrieved it after completion. There was difficulty in retrieving the entire questionnaire at once but the opportunity was given to respondents to send it to the Researcher through e-mail WhatsApp or post. Eighty-eight (88) questionnaires were administered, but seventy-seven (77) filled instruments were returned successfully thereby giving 87.5 percent returned.

Procedure for Data Analysis

After the collection of data, the Researcher cross-examined the questionnaires to ascertain the return rate, completeness, and clarity. The data obtained from the respondents was analyzed through the use of SPSS Version 26. Descriptive statistics (Mean) and inferential statistics (Chi-square) were used to present the data from the field. The research questions 1-3 were answered with an option of five (5) point rating scale. The limit for decision rule: An average mean of 3.0 and above was considered as high influence while an average mean below 3.0 was considered as low influence.

Results

Research Question One: What is the level of influence of HODs supervision roles on Lecturers' instructional performance in Colleges of Education in North-Central, Nigeria?

Table 1: Mean Score of Respondents on the Level of Influence of HODs Supervision Roles on Lecturers' Instructional Performance in Colleges of Education in North-Central, Nigeria.

S/N	Items	N	Mean	Decision
1	Planning of instructional supervision process promotes Lecturers' teaching performance.	11	3.18	High Influenced
2	Discussion of challenges in the preparation of the scheme of work improves the Lecturer' lesson preparation.	11	3.09	High Influenced
3	Weekly vetting of lesson plans enhances the Lecturers' lesson preparation.	11	3.64	High Influenced
4	Ensuring lesson objectives are achievable increases the quality of Lecturers' lesson plan	11	3.36	High Influenced
5	The classroom supervision observation process enhances the Lecturers' quality of instructional delivery.	11	3.72	High Influenced
6	The provision of supervision feedback improves the Lecturers' pedagogical weaknesses.	11	3.36	High Influenced
7	Monitoring Lecturers' performance improves the quality of instructional delivery.	11	3.18	High Influenced
8	Monitoring Lecturers' performance advances the quality of instructional tasks.	11	3.91	High Influenced
9	Motivations of Lecturers through immediate recognition of good work strengthen their performance.	11	3.27	High Influenced
10	Motivations of Lecturers through recommendations for promotion reinforce quality performance.	11	3.09	High Influenced
Aggregate Mean			3.38	

Sources: Field Survey, 2023.

Table 1 depicts the mean scores of the responses on the level of influence of HODs supervision roles on Lecturers' instructional performance at work in Colleges of Education North-Central, Nigeria. From Table 1 the results of each variable indicated an aggregate mean of 3.38 which is higher than the decision mean score of 3.0. The deduction is that the level of HODs supervision roles was above average for all the tasks. However, monitoring Lecturers' instructional performance is dominant among HODs while discussion of challenges of the scheme of work and motivation of Lecturers through recommendation for promotion are equally high based on the majority of responses.

Research Question Two: Influence of HODs Supervision Roles on Lecturers' quality of instructional preparation in Colleges of Education, North-Central, Nigeria**.**

Table 2: Mean Score of Respondents on the Influence of HODs Supervision Roles on Lecturers' Quality of Instructional Preparation in Colleges of Education North-Central, Nigeria.

S/N	Items	N	X	Decision
1	Prepare a scheme of work appropriately in a semester.	66	3.64	High Influenced
2	Break course contents into manageable units for each lesson period in a semester.	66	3.76	High Influenced
3	Prepare lesson plans regularly in a semester.	66	3.30	High Influenced
4	Prepare a lesson plan with performance objectives that cover the three domains of teaching and learning.	66	3.67	High Influenced
5	Formulate adequate performance objectives for each lesson.	66	3.58	High Influenced
6	Select appropriate instructional materials.	66	3.56	High Influenced
7	Prepare the instructional materials.	66	3.42	High Influenced
8	Update the lecture notes before teaching in a semester.	66	3.45	High Influenced
9	Check laboratory facilities before the practical lesson.	66	3.84	High Influenced
10	Set lecture assessments before entering the class in a semester.	66	3.52	High Influenced
	Aggregate Mean		**3.57**	

Field Survey, 2023.

Table 2 depicts the mean scores of responses on the influence of HODs supervision roles on Teachers' quality of instructional preparation in Colleges of Education North-Central, Nigeria. The results for 10 variable items show an aggregate mean of 3.57 which is higher than the decision mean score of 3.0. From the results of the analysis, it is indicated that HOD instructional supervision has a high influence on Teachers' preparation of scheme of work, breaking course contents into manageable units for each lesson period, preparing lesson plans regularly, preparing lesson plans with performance objectives that cover the three domains of teaching and learning, formulate adequate performance objectives for each lesson, select appropriate instructional materials, prepare the instructional materials, update the lecture note before teaching, check facilities in the laboratory before a practical lesson, and set lecture assessments before entering the class in a semester based on the majority responses.

Research Question Three: What is the influence of HODs supervision roles on quality of Lecturers' instructional delivery skills in Colleges of Education North-Central, Nigeria**?**

Table 3: Mean Score of Respondents on the Influence of HODs Supervision Roles on Quality of Lecturers' Instructional Delivery Skills in Colleges of Education North-Central, Nigeria.

S/N	Items	N	Mean	Decision
1	Communicate effectively in the class.	66	3.63	High Influenced
2	Cover content of lesson.	66	3.59	High Influenced
3	Present the content of the lesson logically.	66	3.53	High Influenced
4	Engage Students in the class activities during the lesson.	66	3.68	High Influenced
5	Use different teaching methods.	66	3.70	High Influenced
6	Use instructional materials to support the lesson.	66	3.41	High Influenced
7	Use time effectively.	66	3.70	High Influenced
8	Motivating the Students.	66	3.67	High Influenced
9	Evaluating the lesson appropriately.	66	3.76	High Influenced
10	Establishing positive emotional conduct in the class.	66	3.59	High Influenced
	Aggregate Mean		**3.62**	

Field Survey, 2023.

Table 3 depicts the mean scores of responses on the influence of HODs supervision roles on Teachers' quality of instructional delivery skills in Colleges of Education North-Central, Nigeria. The results for all variable items had an aggregate mean of 3.62 which is higher than the decision mean score of 3.0. The results of the analysis showed that HODs' supervision roles have a high influence on Teachers' quality of instructional delivery skills in the areas of communicating effectively in the class, covering the content of the lesson, presenting the content of the lesson logically, Engaging Students in the class activities during the lesson, using different teaching methods, using instructional materials to support the lesson, using time effectively, motivating the Students, evaluating the lesson appropriately and establishing positive emotional conduct in the class based on the majority responses.

Summary of Major Findings

The findings from the descriptive statistic (Mean) used to analyze the data collected from the respondents in this study revealed that all three RQs were highly influenced. The results established that:

i. HODs supervision roles had a high influence on Lecturers' instructional performance with an aggregate mean rating of 3.38. Shown in Table .1
ii. HOD supervision roles had a high influence on Lecturers' instructional preparation with an aggregate mean rating of 3.57. Shown in Table 2.
iii. HODs supervision roles had a high influence on Lecturers' instructional delivery skills with an aggregate mean rating of 3.62. Shown in Table 3.

Discussion of Findings

The finding in Table 1 revealed that there is a high influence of HODs' supervision roles on Lecturers' instructional performance. Indicating that HODs' supervision roles involve planning of instructional supervision process, discussing challenges in preparation of the scheme of work, weekly vetting of the lesson plan, ensuring that lesson objectives are achievable, observing the instructional process, providing supervision feedback, monitoring

Lecturers' performance influence Lecturers' instructional performance. In addition, the findings revealed that HODs' supervision roles in the aspect of motivating Teachers through immediate recognition of good work do strengthen their performance. Also, motivations of Teachers through recommendation for promotion reinforce their quality of performance in Colleges of Education North-Central, Nigeria. This is in line with the submission of Diana and Demetria (2021) who established that HOD supervision roles were valued very highly. It also established that supervision of curriculum activities and timetables improves the quality of instruction. The findings further substantiate that of Ngole and Mkulu (2021) whose study stated that Heads of Schools are key instructional Supervisors in Schools and that effective supervision was found to be the key factor for academic performance in Schools. Nwankwoala (2020) also indicated that classroom observation and holding conferences with Teachers before the actual classroom observation are significantly related to Lecturers' job performance. More so, Niyivuga, *et al.* (2019) declared that HODs are the ones entrusted with the supervisory Roles of the Faculty members. Also, Lyonga (2018) affirmed that instructional supervision has a positive influence on different aspects of Lecturers' job performance. Laska (2016) established that School Principals who carried out monitoring and evaluation roles by engaging in planning for Teacher observation in the classroom, actual observation, monitoring and evaluating the Teachers, and providing feedback after observation enhanced Lecturers' job performance. However, the findings of the present study negate the assertion of Kamotho (2019) which indicated that Principals' supervision Roles did not influence Lecturers' job performance. Disagreements between the findings of the present study and Kamotho (2019) could be due to population characteristics and the different locations of the two studies. Practical implications of the finding in Table 1. HODs' planning of supervision roles ensures quality assurance. When HOD instructional supervision roles are carried out consistently and systematically, it helps to maintain and improve the quality of teaching and learning processes.

The findings in Table 2 indicated that there is a high influence of HODs' supervision roles on Lecturers' instructional preparation, signifying that HOD supervision roles influence Lecturers' preparation of scheme of work appropriately, breaking course contents into manageable units, preparing lesson plans regularly, formulating adequate performance objectives, selection, and preparation of instructional materials, update lecture note, check laboratory facilities before practical class and set lecture assessments before entering the class in a semester in Colleges of Education in the North-Central, Nigeria. The finding was validated by Godwin's (2019) result which established that there is a significant relationship between the Head Teacher's supervision and the Lecturers' preparation of pedagogical documents. Equally, the finding agreed with that of Lyonga (2018) who indicated that instructional leaders positively influence Lecturers' job performance when they regularly check Lecturers' schemes of work and lesson plans, correct Lecturers' lesson plans, and hold meetings with Teachers individually and as groups to guide how to improve teaching and learning activities. Also, Oryema (2017) in his study declared that supervision of pre-teaching activities has a significant influence on Teacher performance. Similarly, Aseka (2016) in his study revealed that supervision of pre-teaching has a significant influence on Teacher job performance. However, the findings of the present study are against Yego *et. al.* (2020) which indicated that there is a significant inverse and weak relationship between Lecturers' performance in lesson preparation and instructional supervision. Also, Samuel *et. al.* (2019) established that Supervision of pre-teaching activities does not influence Teacher performance. Differences in the findings of previous studies and the present study could be due to the research design used for the studies. Practical Implications of the findings in Table 2. A well-prepared scheme of work and lesson plan with achievable goals provides a clear

roadmap for Lecturers' quality instructional delivery. This enables teachers to know what content to cover, how to cover it, and what outcomes to expect. Clear goals help Teachers allocate appropriate time for each lesson component, ensuring that essential topics are adequately covered within the allocated class time. Well-selected instructional materials can capture Students' interest and engage them actively in the learning process. This engagement fosters a positive learning environment and promotes Student participation. Proper selection and preparation of instructional materials reinforce key concepts, facilitate understanding, and help students achieve desired learning outcomes.

The results in Table 3 revealed that HODs' supervision roles had a high influence on Lecturers' instructional delivery skills. Representing that HODs' supervision roles influence Lecturers' communication skills in the classroom, cover and present contents of the lesson logically, engage Students in-class activities during the lesson, use different teaching methods and instructional materials to support the lesson, use time effectively, motivate Students; evaluate lesson appropriately and establish positive emotional conduct in the classroom. This confirms the finding of Nwankwoala (2020) that classroom observation by Supervisors influences Lecturers' job performance in schools. Also, Godwin (2019) confirmed that a significant relationship exists between Head Teacher's supervision and Lecturers' classroom instruction and management. Similarly, Samuel *et al.* (2019) established that School Heads' lesson planning supervision and lesson delivery supervision had a significant influence on Teacher role performance. In addition, Mustapha *et al.* (2018) revealed that Supervisors' roles are positively related to the quality delivery of education. More so, Oryema (2017) confirmed that supervision of actual teaching activities has a significant positive influence on Teacher performance. However, the finding of the present study on RQ 3 disagreed with that of Namutebi (2019) who maintains that lecturers were not performing their instructional responsibility which may affect the quality of Students' performance and the department at large. Similarly, Mwaniki and Guantai (2018) revealed that instructional supervision exercises in Schools have no positive influence on the improvement of Teachers‟ pedagogic skills. This difference may be a result of differences in research location and sample size. Effective communication skills during instructional delivery by Home Economics Teachers ensure that instructions, explanations, and expectations are conveyed to Students. This clarity minimizes misunderstandings and confusion, enabling students to engage with the curriculum more effectively. Clear and effective communication captivates Students' attention and maintains their interest in the lesson. It fosters a positive learning environment where Students feel motivated to participate actively and contribute to discussions.

Conclusion

Based on the findings of the study, it can be concluded that HODs' supervision roles such as planning, discussion of challenges, weekly vetting of the lesson plans, observation of instructional process, providing feedback, monitoring, and motivation influence Lecturers' quality of instructional preparation, and delivery skills. High level and consistency in HODs supervision roles are indispensable for quality Lecturers' instructional performance and attainment of standards in implementing NCE Home Economics curriculum and instruction.

Recommendations

In the light of the findings of this study, the following recommendations were made:

1. HODs should be consistence and sustain a high level of instructional supervision roles to enhance the enthusiasm of Teachers' instructional performance.

2. Home Economics Teachers should intensify more effort in instructional preparation. Both HODs and Teachers should ensure that the scheme of work, lesson plan, and instructional materials are prepared and documented before the beginning of the new semester.
3. HODs and Home Economics Teachers should support peer collaboration and facilitate peer observation of the instructional delivery process. Encouraging collaboration among Home Economics Teachers would foster a culture of best practices and have a prodigious significant influence on the quality of instructional delivery skills by Home Economics Teachers.

Limitations of the Study

It should be noted that this study was conducted in the North-central of the country. The restriction is useful for controlling variability and for increasing precision, but caution is necessary for the generalization of the study.

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ISOLATION AND CHARACTERIZATION OF FUNGAL PATHOGENS FROM ONION SEEDLINGS

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Abstract
The prevalence of fungal pathogens in agricultural crops poses significant challenges to crop production and food security worldwide. This study aimed to isolate and characterize two major fungal pathogens, Alternaria porri and Penicillium digitatum, from diseased onion (Allium cepa) seedlings. Alternaria porri, known for causing leaf blight, and Penicillium digitatum, responsible for post-harvest decay, were successfully isolated and identified based on their colony morphology, pigmentation, and growth rates. Pathogenicity tests revealed that Alternaria porri caused severe leaf blight with a disease severity score of 4.3, while Penicillium digitatum primarily affected stored onion bulbs, with a disease severity score of 3.8. Growth rates for the fungi were recorded at 10.5 mm/day and 12.0 mm/day, respectively, with optimal growth observed under temperatures between 25°C and 30°C. The findings underscore the potential for significant yield and post-harvest losses due to these pathogens, highlighting the critical need for integrated disease management strategies. Early detection, the use of resistant cultivars, and targeted fungicidal treatments are recommended to reduce crop damage and ensure food security.
Keywords: Alternaria porri, Penicillium digitatum, fungal pathogens, onion seedlings, pathogenicity, food security.

Introduction

Fungal diseases present a significant challenge to agricultural productivity, contributing to substantial crop losses, reduced market quality, and negative economic impacts for farmers worldwide. These diseases affect a broad range of crops, including vegetables, grains, and fruits, often resulting in a decline in both yield and quality. According to recent studies, fungal pathogens are responsible for up to 30% of global crop losses, with diseases like downy mildew, rusts, and blights affecting major staple crops and horticultural produce (Bebber *et al.*, 2019). The onion (*Allium cepa*), a critical agricultural crop, is widely cultivated for its nutritional, medicinal, and economic value. It serves as a staple vegetable in many households, is used extensively in food processing, and provides essential vitamins and minerals.

However, onion production is severely threatened by various fungal pathogens, with *Alternaria porri* and *Penicillium digitatum* being among the most devastating. *Alternaria porri* is primarily responsible for leaf blight, a disease that causes dark lesions on onion leaves, which leads to leaf necrosis and a substantial reduction in crop yield (Khan *et al.*, 2021). This pathogen thrives in humid conditions and can rapidly spread through wind and water, making its management difficult, particularly in regions with favorable climates for fungal growth (Niranjana *et al.*, 2023). On the other hand, *Penicillium digitatum* is a well-known cause of post-harvest decay in onions, particularly affecting stored bulbs. The fungus induces soft rot, characterized by watery, spongy tissue, which leads to significant losses during storage and transportation (Solomon *et al.*, 2023). The global importance of onion production is evident in its high cultivation volume; onions are grown in over 170 countries, with an annual production exceeding 100 million tons (FAO, 2022). The vulnerability of

onion crops to fungal pathogens threatens not only food security but also economic stability, especially in regions where onion farming is a key agricultural activity. In particular, developing countries, where post-harvest handling practices are often inadequate, are more susceptible to losses due to fungal infections (Ertas *et al.*, 2022). The environmental conditions in many onion-producing regions, such as high humidity and fluctuating temperatures, further exacerbate the spread of these fungal diseases.

Given the critical role of onions in both local and global food systems, it is imperative to address the challenges posed by fungal pathogens. This study isolated and characterized *Alternaria porri* and *Penicillium digitatum* from diseased onion seedlings collected from local farms. By identifying the morphological and physiological traits of these fungi, the study sought to contribute to the understanding of their pathogenicity and to proffer the development of integrated disease management strategies. Such strategies could include the use of resistant onion varieties, improved agronomic practices, and targeted fungicide applications to mitigate the impact of these pathogens on onion production.

Materials and Methods

Experimental Site

The research was conducted at the Mycology Laboratory, Department of Botany, Usmanu Danfodio University, Sokoto, Nigeria. The dry season in Sokoto, with an average temperature range of 27°C to 40°C and relative humidity between 20% and 30%, provided an ideal environment for the proliferation of fungal pathogens. Onion (*Allium cepa*) is a key crop in this region, making it suitable for studying fungal diseases that impact both yield and post-harvest quality. The laboratory was equipped with sterile handling environment to ensure the accurate isolation and identification of fungal pathogens.

Sample Collection

Onion seedlings showing visible symptoms of fungal infections such as wilting, leaf blight, necrosis, and soft rot were collected from local farms in Sokoto State. Infected seedlings were stored in sterile polyethylene bags and transported to the laboratory within 24 hours to minimize microbial contamination and ensure sample integrity. The seedlings displayed symptoms typically associated with *Alternaria porri* (leaf blight) and *Penicillium digitatum* (post-harvest decay), making them suitable candidates for pathogen isolation.

Isolation of Fungal Pathogens

Tissue samples from infected seedlings were first surface sterilized using a 2% sodium hypochlorite solution for one minute to eliminate surface contaminants, followed by rinsing in sterile distilled water to remove residual chemicals. The sterilized tissues were aseptically plated on two types of media: Onion Dextrose Agar (ODA), a specialized medium to support the growth of onion pathogens, and Czapek-Dox Agar (CDA), which supports a wide range of fungal growth. Plates were incubated at room temperature (27±3°C) for five to seven days.

Colonies of *Alternaria porri* were identified by their dark green to black pigmentation, woolly texture, and slow growth rate of 10.5 mm/day. *Penicillium digitatum* formed colonies with a characteristic greenish-blue color and a powdery texture, exhibiting a faster growth rate of 12.0 mm/day. These characteristics were consistent with previous studies by Sharma et al. (2020), which provided a benchmark for fungal identification through colony morphology and pigmentation.

Pathogenicity Test

Pathogenicity tests were performed to confirm the disease-causing potential of the isolated fungi. Healthy onion seedlings, grown in sterilized soil-filled pots, were inoculated with spore suspensions of *Alternaria porri* and *Penicillium digitatum* at a concentration of 1×10^6 spores/mL. Control groups were mock-inoculated with sterile distilled water. The inoculated seedlings were monitored over a two-week period for the development of disease symptoms, including lesions, wilting, and rot.

Disease severity was assessed using a five-point scale (Khan *et al.,* 2021), where 0 indicated no visible symptoms and 5 represented severe symptoms, such as widespread necrosis and collapse of plant tissues. *Alternaria porri* inoculated plants developed significant leaf blight within seven days, scoring an average disease severity of 4.3. In contrast, *Penicillium digitatum* caused post-harvest decay of bulbs, with visible fungal mycelium and rot symptoms appearing after 10 days, leading to a severity score of 3.8. These results corroborate previous findings by Niranjana *et al.* (2023), highlighting the importance of these pathogens in onion crop losses.

Data Analysis

Data were analyzed using descriptive statistics to summarize the occurrence and severity of fungal infections. The mean values of pathogenicity scores were compared using one-way ANOVA, with a significance level set at $p < 0.05$.

Results and Discussion

Isolation of Fungal Pathogens

From the diseased onion seedlings, two fungal pathogens *Alternaria porri* and *Penicillium digitatum* were successfully isolated. The identification of these fungi was based on their colony morphology, pigmentation, and growth patterns, which were observed on Oatmeal Dextrose Agar (ODA) and Czapek Dox Agar (CDA).

On ODA, *Alternaria porri* produced dark green to black colonies, characterized by a woolly texture. In contrast, *Penicillium digitatum* exhibited its distinctive greenish-blue coloration with a powdery texture. The growth rate of these fungi was measured over a five-day period, revealing that *Penicillium digitatum* exhibited a faster growth rate, averaging 12.0 mm/day, compared to *Alternaria porri*, which grew at 10.5 mm/day (Table 1). These growth rates align with previous studies that have shown optimal growth conditions for *Penicillium* species, particularly at temperatures ranging from 25°C to 30°C (Sharma *et al.,* 2020).

Table 1: Morphological Characteristics of Isolated Fungal Pathogens

Fungal Species	Colony Color	Texture	Growth Rate (mm/day)
Alternaria porri	Dark green to black	Woolly	10.5
Penicillium digitatum	Greenish-blue	Powdery	12.0

These observations are consistent with findings by Ertas et al. (2022), who documented similar colony morphology and growth characteristics for *Penicillium* species isolated from onion bulbs. Colony pigmentation and texture are crucial markers for distinguishing between fungal species, as they provide early visual cues in laboratory settings for identifying specific pathogens (Solomon *et al.,* 2023). The consistency in morphological features further strengthens the reliability of the identification process used in this study.

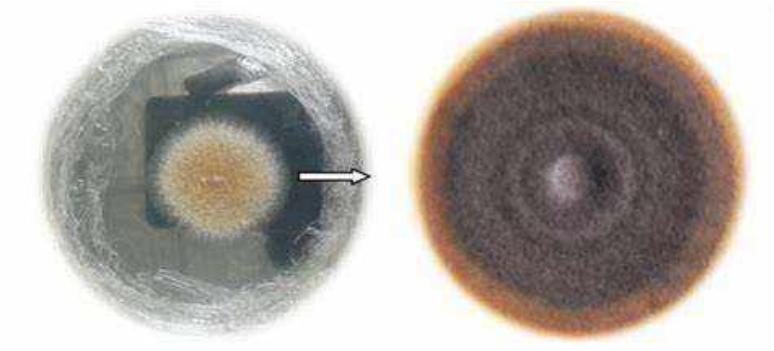

Plate I: Microscopic view of *Alternaria porri*

Plate II Microscopic view of *Penicillium digitatum*

Pathogenicity of Isolated Fungi

Pathogenicity tests were conducted to assess the ability of the isolated fungi to cause disease in healthy onion seedlings. For *Alternaria porri*, the inoculated seedlings developed characteristic symptoms of leaf blight within seven days post-inoculation. These symptoms included dark lesions on leaves, followed by leaf wilting and necrosis (Figure 1). The average disease severity score for *Alternaria porri* was calculated as 4.3 on a scale of 0 to 5, indicating a severe impact on the infected onion seedlings (Table 2). This is consistent with previous studies that report *Alternaria porri* as a major pathogen causing blight in onion crops, leading to significant yield reductions (Niranjana *et al.*, 2023).

Pathogenicity Symptoms of *Alternaria porri* on Onion plant

Plate III: Onion plant infested with *Alternaria porri*

In contrast, *Penicillium digitatum* was primarily responsible for post-harvest decay of onion bulbs. Symptoms of soft rot, coupled with the appearance of fungal mycelium on the bulb surface, became apparent after 10 days of inoculation. The average disease severity score for *Penicillium digitatum* was 3.8, demonstrating a moderate but concerning impact, particularly on stored onion bulbs (Table 2). Studies by Khan *et al*. (2021) confirm that *Penicillium digitatum* is a prevalent cause of post-harvest losses in onion storage, leading to significant economic losses due to rot and spoilage during storage and transportation.

Table 2: Disease Severity Scores of Fungal Pathogens on Onion Seedlings

Fungal Species	**Disease Severity Score (0-5)**
Alternaria porri	4.3
Penicillium digitatum	3.8

The pathogenic potential of *Alternaria porri* and *Penicillium digitatum* observed in this study highlights the importance of implementing effective management strategies to control these fungi. For instance, integrated disease management techniques, including the use of resistant onion cultivars, early disease detection, and fungicidal treatments, have been suggested as crucial methods for mitigating the damage caused by these pathogens (Sharma *et al.*, 2020). In addition, improved post-harvest practices, such as proper storage and handling, could help reduce losses associated with *Penicillium* decay (Solomon *et al.*, 2023).

Conclusion

This study successfully isolated and characterized *Alternaria porri* and *Penicillium digitatum* from diseased onion seedlings, providing valuable insights into their morphological traits and pathogenic potential. The findings underscore the urgent need for integrated disease management strategies to mitigate the impact of these pathogens on onion crops. The use of resistant cultivars, early detection, and targeted fungicides should be prioritized to reduce

yield losses and improve post-harvest quality. Furthermore, promoting awareness of best practices in onion production and storage will be essential for minimizing the economic impact of these fungal pathogens on the agricultural sector.

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INFLUENCE OF SUPER ABSORBENT POLYMER AND IRRIGATION INTERVALS ON THE PERFORMANCE OF TWO TOMATO (*Solanum lycoperiscum)* VARIETIES.

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Abstract
Water deficit is one of the most important limiting factors in crop production, it is becoming an increasingly severe problem in many parts of the world. The growth and yield of tomato an important vegetable crop in agricultural economy and one of the most widely consumed vegetable crop in the world is often constrained by water deficit. Irrigation wtervis becoming scarce and costly, hence there is need to find a reliable water management strategy to cope with water scarcity. The addition of water-saving superabsorbent polymer (SAP) in soil can improve soil physical properties, crop growth and yield and also reduce the irrigation requirement of crops. Pot experiment trials were conducted in the Horticultural nursery site of Department of Crop Production, Federal University of Technology, Minna and the nursery site of Ministry of Forestry Buruku, Kaduna to evaluate Influence of Super Absorbent Polymer (SAP) and irrigation intervals on the performance of two tomato (Solanum lycopersicum L.) varieties during the 2013 dry season. It was a 5 x 4 x 2 factorial experiment laid out in a completely randomized design (CRD) and replicated three times. The treatments were five rates of polymer (0, 1, 2, 3 and 4 g kg^{-1}), four irrigation intervals (daily, 2days, 4days, and 6days intervals) and two tomato varieties (Roma VF and UC82B). Result showed that Roma VF produced taller plants, higher number of fruits and fruit yield than UC82B while the measured parameters were increased with polymer rate of 3g kg^{-1}. Irrigating at 2days interval also had significant effect on the plant height, stem girth, fruit weight and yield. Based on the findings of this study, it is recommended that for higher growth and yield of tomato farmers should plant Roma VF with the application of 2g kg^{-1} or 3g kg^{-1} polymer into the soil irrigated at 2days intervals.
Keywords: Polymer, Irrigation, Tomato.

Introduction

Tomato (*Solanum lycoperiscum* L.) is a herbaceous, sprawling plant which belongs to the family *Solanaceae*. It is an annual plant, typically reaching up to 1-3m in height with weak, woody stem that often vines over other plants (Aquaah, 2005). Tomato is a rich source of minerals like potassium, magnesium, calcium, iron, zinc, vitamins (A, B1, B2, C and E), dietary fiber (Pectin), citric Acid and antioxidants (Islam et al., 2006). The fruits are used as salad for preparation of sauce and tomato juice in canning industries (Anyanwu *et al*., 2005). It contains lycopene which has been found to prevent prostate cancer (Durrant, 2008). Over 160 million tons of tomatoes was produced in the world in 2013, with china as the largest producer (50,644,255) tones and Nigeria ranked as second largest producer of tomato in Africa and fifteen in the world, producing 1,565,000 million tons annually at an average of 20-30 tonnes per hectare (FAO, 2013).

Statement of Research Problem Inconsistencies in water application have been reported to increase physiological disorder such as blossom end root (BER) and fruit cracking (saure,2010). Water deficit is a major environmental constraint that strongly affect cultivated plants, reducing growth and yield especially in tomato production (Umezana *et al*., 2006).

Moisture stress decreases growth and development which lead to reduced photosynthesis a process in which plants combine water, carbon dioxide and light to synthesize carbohydrates for energy (Nyabundi, 2009). Photosynthetic response to drought is highly complex in tomato plants. Vegetable crops are sensitive to water shortage, any deficit in providing water to the plants lead to considerable reduction in yield (Sadregahaen *et al.,* 2010). Tomatoes are very sensitive to water deficit during and immediately after transplanting, at flowering and during development (Nuruddin, 2007).

Tomato plants need a controlled supply of water throughout their growing periods for optimum yield and quality (Kirnak *et al*., 2005). Addina (2008) stated that is it important to improve the water use efficiency (WUE) of tomato plants, since virtually all physiological and biochemical functions of plant cells and tissues take place in the medium of water. There is need to improve water additive that will supply water needed by the plant which will reduce the frequency of water supply and energy waste. The excellent water absorbency and water retention capacity of super absorbent polymers (SAP) may prove especially practicable in Agricultural and Horticultural application for efficient water and nutrient utilization by plants. Information on the effect of SAP on tomato production in Nigeria are few, hence the need for the study. The objective of this study was to evaluate the effect of Super Absorbent Polymer and irrigation intervals on growth and fruit yield of tomato in the Southern and Northern guinea savanna of Nigeria.

Materials and Methods

A multi-locational trial was conducted at the Horticultural nursery of the Department of Crop Production, Federal University of Technology (Gidan kwano campus) Minna, (lat. 9º37'N; long.6º 28'E) located in the Southern Guinea Savannah and Ministry of Forestry nursery at Buruku, Kaduna (lat.10º 15'N; long. 7º 45'E) located in the Northern Guinea Savanna of Nigeria during the 2013 dry season. Top soils were collected at random along a transect across the study site bulked to obtain a composite sample which was subjected to routine physical and chemical analysis using standard laboratory procedures as described by Agbenin, (2005) to determine the characteristics of the soil.

The experiment was a 5 x 4 x 2 factorial experiment laid out in a completely randomized design (CRD) and replicated three times. The treatments were: five rates of polymer (0, 1, 2, 3 and 4 kg^{-1}), four irrigation intervals (daily, 2days, 4days and 6days) and two tomato varieties (Roma VF and UC 82B). the tomato seed were obtained from an Agro-allied company along Maitumbi road, Minna while super absorbent polymer (Potassium polyacrylamide acrylate copolymer) was obtained from Makfaz petro-chemical limited, Kado Estate, Abuja.

The tomato seeds were sown in seedling trays in the nursery and watered on daily basis for four weeks. Poly pots measuring 24cm x 22.5cm were washed and dried. 6kg top soil was used to fill each poly pots (Wong *et al.,* 2003). The different SAP level were then thoroughly mixed with 5kg of top soil out of the 6kg top soil to be used while the remnant 1kg was spread on top of the 5kg top soil mixed with the various SAP levels to prevent breakdown of the polymer. Seedlings were then transplanted into the poly pots at four weeks at two seedlings per pot and later thinned to one stand per pot. In the first week of transplanting, poly pots were irrigated daily with 500ml of water to reduce water stress and to ensure proper establishment of the seedlings after which the experimental irrigation intervals commenced with 1750ml of water (water required to saturate the pores of 6kg of soil). Weeds that emerged were hand pulled weekly. Fresh neem leaves were collected, crushed and soaked in

tap water for 30 minutes and the solution was filtered through a filter paper, 100ml of the solution was mixed with 1 liter of water and sprayed on the leaves of the tomato to serve as insecticide against insect infestation as described by (Biswas, 2008). Harvesting of tomato fruits was done when the fruits were firm and greenish yellow at intervals of 3 days.

Parameters measured includes, plant height, stem girth, number of branches at 6 and 9 WAT, days to first flowering, number of fruit and fruit yield in grams. The data collected were subjected to analysis of variance (ANOVA) and means separated using least significant difference (LSD) at 5% probability.

Table 1: effect of super absorbent polymer and irrigation intervals on plant height of two tomato varieties at Minna and Kaduna during the 2013 cropping season.
Plant Height (cm)

	6WAT		9WAT	
	Minna	Kaduna	Minna	Kaduna
Varieties (V)				
Roma VF	25.9	26.8	35.6	37.6
UC 82B	25.1	25.0	33.0	34.5
LSD (0.05)	1.52	1.45	4.57	3.03
Polymer rates(P)				
0g/kg	20.1	23.4	32.9	34.6
1g/kg	20.3	25.6	37.9	37.7
2g/kg	26.3	27.7	33.9	38.8
3g/kg	30.1	27.3	35.7	36.9
4g/kg	2.30	2.42	7.24	4.18
LSD (0.05)	2.30	2.42	7.24	4.18
Irrigation intervals (I)				
Daily	26.9	25.3	37.3	38.1
2 days	27.9	27.8	38.4	38.2
4 days	26.9	27.2	41.0	40.2
6 days	21.1	23.3	20.3	25.5
LSD (0.05)	2.06	0.61	6.47	4.29
Interaction				
VxP	NS	NS	NS	NS

VxI	NS	NS	NS	NS
PxI	NS	NS	NS	NS
VxPxI	NS	NS	NS	NS

Table 2: effect of super absorbent polymer and irrigation intervals on stem girth of two tomato varieties at Minna and Kaduna during the 2013 cropping season.
Stem Girth (cm)

		6WAT		9WAT	
	Minna	Kaduna	Minna	Kaduna	
Varieties (V)					
Roma VF	0.60	0.64	0.91	0.89	
UC 82B	0.59	0.65	0.88	0.89	
LSD (0.05)	0.05	0.04	0.13	0.08	
Polymer rates(P)					
0g/kg	0.55	0.61	0.80	0.89	
1g/kg	0.58	0.63	0.95	0.94	
2g/kg	0.63	0.67	0.94	0.97	
3g/kg	0.61	0.64	0.92	0.88	
4g/kg	0.60	0.62	0.84	0.87	
LSD (0.05)	0.07	0.06	0.02	0.12	
Irrigation intervals (I)					
Daily	0.60	0.62	0.61	0.89	
2 days	0.61	0.68	0.97	0.95	
4 days	0.58	0.65	0.98	0.92	
6 days	0.59	0.62	0.63	0.79	
LSD (0.05)	0.07	0.05	0.18	0.11	
Interaction					
VxP	NS	NS	NS	NS	
VxI	NS	NS	NS	NS	
PxI	NS	NS	NS	NS	

VxPxI	NS	NS	NS	NS

Table 3: effect of super absorbent polymer and irrigation intervals on number of branches of two tomato varieties at Minna and Kaduna during the 2013 cropping season.

Number of Branches

		6WAT		9WAT	
	Minna	Kaduna	Minna	Kaduna
Varieties (V)				
Roma VF	8.0	8.0	10.0	10.0
UC 82B	7.0	8.0	9.0	10.0
LSD (0.05)	0.45	0.43	1.31	0.79
Polymer rates(P)				
0g/kg	7.0	8.0	9.0	10.0
1g/kg	8.0	8.0	10.0	10.0
2g/kg	8.0	9.0	9.0	10.0
3g/kg	8.0	9.0	10.0	10.0
4g/kg	7.0	8.0	9.0	8.0
LSD (0.05)	0.71	0.68	1.90	1.12
Irrigation intervals (I)				
Daily	8.0	8.0	10.0	10.0
2 days	8.0	9.0	11.0	11.0
4 days	7.0	8.0	10.0	10.0
6 days	7.0	8.0	6.0	8.0
LSD (0.05)	0.64	0.61	1.90	1.12
Interaction				
VxP	NS	NS	NS	NS
VxI	NS	NS	NS	NS
PxI	NS	NS	NS	NS
VxPxI	NS	NS	NS	NS

Table 4: effect of super absorbent polymer and irrigation intervals on days to first flowering, number of seeds per fruit, seed weight and fruit yield of two tomato varieties at Minna and Kaduna during the 2013 cropping season.

	Days to first flowering		*number of fruits*		*Fruit yield (s)*	
	Minna	Kaduna	Minna	Kaduna	Minna	Kaduna
Varieties (V)						
UC 82B	96.0	102.0	1.00	2.00	11.85	18.67
LSD (0.05)	12.93	11.99	0.36	0.56	1.92	2.24
Polymer rates (P)						
0g/kg	100.0	100.0	1.58	1.33	12.24	17.64
1g/kg	108.0	106.0	1.67	2.54	13.47	19.45
2g/kg	82.0	88.0	2.13	2.33	11.73	22.03
3g/kg	94.0	107.0	1.67	2.04	13.88	17.35
4g/kg	102.0	103.0	1.46	1.16	11.36	11.85
LSD (0.05)	20.44	18.96	0.57	0.81	3.02	3.54
Irrigation intervals (I)						
Daily	105.0	102.0	1.87	2.07	13.61	17.84
2 days interval	102.0	102.0	1.90	2.17	14.76	21.54
4 days interval	103.0	102.0	2.07	2.60	12.91	19.50
6 days interval	79.0	93.0	0.97	1.50	8.87	2.76
LSD (0.05)	18.29	16.96	0.51	0.73	2.70	3.17
Interaction						
V x P	NS	NS	NS	NS	NS	NS
V x I	NS	NS	NS	NS	NS	NS
P x I	NS	NS	NS	NS	NS	NS
V x P x I	NS	NS	NS	NS	NS	NS

Results and Discussion

Plant height

The height of tomato plant differed significantly (P≤0.05) in Kaduna at 6 WAT only (table 4), such that, Roma VF produced taller plants than UC 82B. polymer rate has a significant (P≤0.05) effect on height of tomato in both locations at 6 WAT only, while polymer rate of 3 g kg^{-1} produced taller plants than other rates. Irrigation intervals also had a significant (P≤0.05) effect on height of tomato in both locations at 6 and 9 WAT, such that irrigation intervals of 2 and 4days produced similar taller plants compared to 6days irrigation intervals which recorded shorter plants. The differential growth with respect to plant height observed between the varieties with Roma VF being the tallest may be attributed to difference in genetic characteristics of the individual varieties including rapid growth rates, tallness or shortness of species. This finding is in line with Olaniyi *et al*. (2009) who reported variation in plant height among tomato varieties. The taller plants produced by polymer rate of 3 g kg^{-1} might be attributed to the presence of polymer in the soil which store and releases water gradually for the crop requirement over a period of time. This result is in agreement with that of Tulaee *et al.* (2009) who reported increase in height of olive tree as the concentration of polymer increases.

Stem girth

The stem girth of tomato plants was not significantly (P≤0.05) different between the varieties in both locations throughout the sampling periods (Table 2). Polymer rates differed significantly (P≤0.05) on stem girth, stem girth increases with increase in polymer rate in both locations. Irrigation interval had a significant (P≤0.05) effect on stem girth. In both locations 2days irrigation intervals produced thicker stems than 6days irrigation intervals at 6 and 9 WAT. The thicker stems produced by 2g kg^{-1} polymer rate may be attributed to the conducive environment created by the polymer in the soil which enhanced water availability to the plant. This finding is similar to that obtained by Azevedo *et al.* (2009) in coffee with the application of polymer.

Number of Branches

The number of branches of tomato was not significantly (P≤0.05) different between the varieties in both locations (Table 3). Polymer rate had a significant (P≤0.05) effect on number of branches in Minna at 6 WAT and in Kaduna at 9 WAT. Polymer rate of 3g kg^{-1} produced more branches than the other polymer rates in Minna at 6 WAT and polymer rate of 1g kg^{-1} produced more branches than the other polymer rates in Kaduna at 9WAT. Irrigation interval had a significant (P≤0.05) effect on number of branches of tomato in both locations such that, 2days irrigation intervals produced more branches than 6days irrigation intervals which recorded fewer branches. The higher number of branches produced by polymer rate of 3g kg^{-1} and 1g kg^{-1} than other polymer rates and control may be due to less excessive water in the soil than higher polymer rates and less water in the control which supported efficient plant growth and development and hence higher number of branches of tomato. This finding is at par with the report of Ghasemi and Khoshkhuy (2006) who reported higher number branches with the application of polymer to the soil.

Days to first flowering

The days to first flowering of tomato plants was not significantly (P≤0.05) different between the varieties in both locations (table 4). Polymer rate had a significant (P≤0.05) effect on days to first flowering with polymer rate 2g kg^{-1} flowered earlier than the other polymer rates. Irrigation interval had a significant (P≤0.05) effect on days to first flowering of tomato in Minna only. With 6days irrigation intervals flowering earlier than the other irrigation intervals. The earliest days to first flowering produced by 2g kg^{-1} than other polymer rates

could be attributed to adequate amount of polymer in the soil that retained moisture in the soil thereby enhancing the growth and yield of the crop. Similar result was reported by Ghasemi and Khoshkhuy, (2006).

Number of fruits

The number of fruits of tomato plant was significantly ($P \leq 0.05$) different between the varieties in Minna (table 4), where Roma VF had higher number of fruits than UC82B, no significant difference was observed in Kaduna. On the effect of polymer rates on the number of fruits highly significant differences was observed, polymer rates of 1 g kg^{-1} and 2 g kg^{-1} had higher number of fruits in Kaduna which was similar to Minna while polymer rate 4 g kg^{-1} had lower number fruits. Irrigation intervals also showed significant difference on the number of fruits at both locations where 4days interval had higher of fruits than other intervals.

Fruit yield

The fruit yield of tomato plants was not significantly ($P \leq 0.05$) different between the varieties in both locations (table 4). Polymer rate had a significant ($P \leq 0.05$) effect on fruit yield in Kaduna, polymer rate of 2 g kg^{-1} produced higher fruit yield similar with polymer rate of 1gkg^{-1} compared to other polymer rates. Irrigation intervals influenced fruit yield of tomato with 2days irrigation intervals producing higher yield of tomato similar with 4days irrigation intervals than the other irrigation intervals in both locations respectively. The higher fruit yield produced by polymer rate of 2g kg^{-1} could be attributed to the ability of SAP to increase the reserve pool of nutrients in the soil and increased the uptake efficiency in the plant. Similar results were reported by Zohreshah *et al*. (2013).

Conclusion

In conclusion, plant height, stem girth, number of branches, fruits and fruit yield were significantly higher in Roma VF with addition of SAP as compared to the control. Plants grown in soil amended with polymer rate of 3gkg^{-1} performed better than the other polymer rates except for polymer rate of 2g kg^{-1} that is not significantly different from 3g kg^{-1}. The improved growth and yield of the tomato plants could be attributed to improved physical properties of the soil as it is able to utilize the nutrients in the soil more efficiently due the presence of the polymer. Irrigation interval also had significant influence on the growth and yield parameters measured with the 2days irrigation intervals produced taller plants, thicker stems, earliest days to first flowering, higher number of fruits and higher fruit yield than the 6days irrigation intervals.

Recommendation

Based on the findings of the study, it is recommended to use 2g kg-1 polymer rate in order to obtain significantly higher number of fruits and 3g kg^{-1} for other parameters while irrigation interval should be at 2days to avoid drought stress as SAP is necessary for improving water use and crop productivity as it moderates drought stress. Roma VF variety is also recommended in terms of growth and yield. It is recommended that there should be further trials in the field as this is only a nursery experiment.

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