



Adapted Strategies for Augmenting Biology Practical in Resource-Constrained Senior Secondary Schools in Zamfara State, Nigeria

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ABSTRACT

This study aimed to explore the strategies employed by Biology teachers to augment practical components of the Biology curriculum in resource-constrained senior secondary schools in Zamfara State, Nigeria. The research adapted a descriptive survey research design. The population of the study comprised 206 Biology teachers across 166 public secondary schools in the State. A sample of 132 Biology teachers, comprising 83 from urban schools and 49 from rural schools, was selected through cluster sampling from all the four educational zones in the State. The research instrument used was a validated questionnaire with a Cronbach's alpha reliability coefficient of 0.85. The questionnaire was used to collect data on demographics, resourceful strategies, instructional approaches, and curriculum adaptation techniques. Three research questions were raised and one hypothesis was formulated. The data collected were analyzed using mean and standard deviation for the research questions, while t-test was used for the hypothesis. The study found significant differences between urban and rural Biology teachers in resourceful strategies and curriculum adaptation, but no difference in innovative instructional approaches. Despite various adapted strategies like improvisation from local material and inter-school resource sharing, challenges persist in integrating virtual experiments and accessing external support for augmenting practical components of the Biology curriculum. Recommendations include providing adequate Biology laboratory resources, offering teacher training opportunities, and investing in technology for virtual experiments.

Keywords: Biology practical, resource-constrained schools, resourceful strategies, instructional approaches, curriculum adaptation.

1.0 INTRODUCTION

Education plays a fundamental role in shaping individuals' futures and driving socio-economic development within communities and nations. At the heart of education lies the quest for knowledge and the cultivation of critical skills, particularly in the sciences, which serve as the bedrock for technological advancement and innovation (Hanushek & Woessmann, 2021). Like many developing countries, the importance of science education in Nigeria, particularly in disciplines such as Biology, cannot be overstated (Ogunniyi, 2019). In Nigeria, the study of science is highly prioritized, with significant emphasis on teaching and learning. The main objective of science education in Nigeria, as delineated in the National Policy on Education (FRN, 2013), is to prepare students to excel in the contemporary world. This objective is realized through the cultivation of fundamental scientific competencies and mindsets among learners. However, despite the acknowledged importance of Biology education, numerous challenges persist, particularly regarding resource constraints for conducting practical experiments in senior secondary schools across Nigeria (Abdussemiu, 2022; Okpaje et al., 2018; Jumba et al., 2020). These challenges emphasize the need for interventions and policy reforms to enhance the quality of science education and

ensure that students are adequately equipped to thrive in today's rapidly evolving society.

As one of the Nigerian State, Zamfara State which is located in northwest, faces various educational challenges that are significantly affecting academic performance of science students, especially in senior secondary schools. The education sector of the State is characterized by limited access to resources, inadequate infrastructure (Isma'il & Lukman, 2022; Onah & Eguzo, 2020) and a dearth of qualified teachers (Sodangi et al., 2022), all of which contribute to the persistently poor performance of students in national examinations. Among the subjects affected by these challenges, Biology stands out as a critical area where resource constraints severely hinder effective teaching and learning processes. According to Matazu and Isma'il (2023), secondary school Biology is taught to help students understand the fundamental principles that govern life, ranging from the tiniest bacteria to the large animals. The practical components of the Biology curriculum play a significant role inculcating students' scientific understanding and skills. Numerous researchers have suggested that students' learning and comprehension of science improve significantly when they are actively involved in laboratory-based practical experiments (Chikelu, 2019; Fatoba & Abidakun,

2019; Mukagihana et al., 2020; Oliveira & Bonito, 2023). Practical experiences provide students with hands-on opportunities to apply theoretical knowledge, conduct experiments, and develop critical thinking and problem-solving abilities (Abdussemmi, 2022; Etiubon, & Udoh, 2020). However, in Zamfara State, the implementation of Biology practical faces significant hurdles due to resource constraints (Isma'il & Lukman, 2022). These constraints manifest in various forms, including limited access to well-equipped laboratories, outdated apparatus, and insufficient consumables. As a result, science teachers are often compelled to navigate a landscape of scarcity, struggling to deliver quality practical experiences that adequately prepare students for academic and professional pursuits.

The consequences of resource constraints on Biology teaching and learning in Zamfara State extend beyond the school environment. The State's poor performance in senior secondary school national examinations reflects the inadequacies of its educational system in equipping students with the requisite knowledge and skills to excel in academic assessments (Sodangi et al., 2022). The persistent underperformance not only undermines individual opportunities for advancement but also perpetuates cycles of poverty and underdevelopment within the State. Numerous studies have reported the detrimental impact of resource constraints on educational outcomes in Nigeria.

Limited access to well-equipped laboratories, outdated apparatus, and insufficient consumables pose significant obstacles to effective teaching and learning experiences (Abdussemmi, 2022; Kumi-Manu et al., 2024; Sayan & Mertoğlu, 2020). These constraints not only impede the execution of practical experiments but also restrict the depth of exploration of biological concepts, thereby undermining students' academic performance (Ojo & Akinbobola, 2020). According to Kumi-Manu et al. (2024), insufficient Biology laboratory resources (equipment and materials) are significant contributors to teachers' hesitancy in carrying out laboratory activities.

In response to resource constraints, teachers have explored innovative pedagogical approaches to enhance student engagement and learning outcomes (Ajala, 2018). Computer simulations, virtual laboratory, hands-on activities, and inquiry-based learning strategies have been employed to compensate for limited resources and provide students with interactive learning experiences (Abdurafiu et al., 2019; Ajibade Tella, 2017). These approaches not only improve students' conceptual understanding but also promote critical thinking and problem-solving skills essential for academic success.

The role of teachers in mitigating the impact of resource constraints cannot be overstated. Literature (e.g. Ajayi, 2019; Salami et al., 2023) have emphasized the importance of teacher factors, such as pedagogical skills, subject knowledge, and instructional strategies, in influencing students' academic performance. Effective classroom practices, including differentiated instruction, formative assessment, and collaborative learning, have been associated with improved student outcomes despite resource limitations (Adeyemo & Onanuga, 2020; Frederick-Jonah & Tobi, 2022). Moreover, teacher re-training has been instrumental in equipping teachers with the necessary tools and strategies to overcome resource-constrained environments effectively (Safo-Adu et al., 2020; Sodangi et al., 2022).

Addressing resource constraints in the implementations of Biology curriculum requires a multidimensional approach that encompasses policy interventions, capacity-building initiatives, and community engagement efforts (Abidoye & Abidoye, 2023; Olawale, 2020; Oliveira & Bonito, 2023). Policy makers must prioritize investments in infrastructure development, teacher training programmes, and curriculum reform to ensure equitable access to quality education for all students (Abubakar, 2020; Hamunyela et al., 2022; Sodangi et al., 2022). Furthermore, partnerships between government agencies, educational institutions, and non-governmental organizations can facilitate the mobilization of resources and expertise to support Biology education initiatives in resource-constrained regions (UNESCO, 2020).

1.0 Statement of the Problem

The persistent challenge of poor academic performance in senior secondary school national examinations in Zamfara State is compounded by resource limitations affecting the implementation of practical components within the Biology curriculum. In both rural and urban school settings across the State, scarcity of resources such as well-equipped laboratories, up-to-date apparatus, and adequate consumables undermines the quality of practical experiences essential for nurturing students' scientific skills. As a result, students are often ill-prepared to excel in national examinations, hindering their academic progress and future prospects. This scarcity not only impedes the execution of Biology practical but also restricts the depth of exploration of biological concepts essential for academic success. Consequently, the practical components of Biology curriculum aimed to nurture scientific literacy and prepared students for further academic and professional pursuits is compromised. In

light of these challenges, there is need to examine the strategies employed by teachers to surmount resource constraints and deliver impactful practical components of senior secondary school. Biology curriculum in Zamfara State.

1.1 Research Objectives

Specifically, the study sought to;

- i. find out the resourceful strategies employed by Biology teachers in resource-constrained secondary schools to argument practical component of Biology curriculum.
- ii. identify the innovative instructional approaches utilized by Biology teachers in resource-constrained secondary schools to complement practical component of Biology curriculum.
- iii. find out the curriculum adaptation techniques employed by Biology teachers in resource-constrained secondary schools to argument practical component of Biology curriculum.

1.2 Research Questions

The following research questions were raised to guide the study:

- i. What resourceful strategies are employed by Biology teachers in resource-constrained secondary schools to complement the practical component of the Biology curriculum?
- ii. How do Biology teachers in resource-constrained secondary schools utilize innovative instructional approaches to argument the practical component of the Biology curriculum?
- iii. What curriculum adaptation techniques are employed by Biology teachers in resource-constrained secondary schools to complement the practical component of the Biology curriculum?

1.3 Null Hypothesis

The null hypothesis formulated for the study

H₀: There is no significant difference between urban and rural Biology teachers in utilization of:

- a) resourceful strategies for augmenting the practical components of Biology curriculum.
- b) innovative instructional approaches for augmenting the practical components of Biology curriculum.
- c) curriculum adaptation techniques to complement the practical components of Biology curriculum.

2.0 METHODOLOGY

This study adopted a descriptive survey research design. Descriptive research enables a structured investigation and detailed understanding of the present conditions within the scope of the research aims (Creswell & Creswell, 2017). The population consisted of all the 206 Biology teachers in the 166 public secondary schools in the four educational zones namely. The sample size of 132 Biology teachers was determined based on The Research Advisor (2006) sample size table. To ensure fair representation from all the four educational zones in Zamfara State, which are Kaura Namoda, Talata Mafara, Anka, and Gusau zones, cluster sampling technique was employed. From each zone, a subset of secondary schools in both rural and urban areas were randomly selected to form the clusters. Within these clusters, 83 Biology teachers were randomly selected from urban schools, and 49 were selected from rural schools.

A questionnaire with four sections was designed for data collection from Biology teachers in resource-constrained schools. Section one gathered demographics, while sections two to four focused on resourceful strategies (six items), instructional approaches (8 items), and curriculum adaptation (5 items), respectively. Responses were rated on 4 Likert scales. The average score was 2.50, calculated by summing the ratings (4 + 3 + 2 + 1) and dividing by 4. Therefore, the decision criterion was set; a mean score of 2.50 to 4.00 indicated agreement, while a mean score of 2.49 to 1.00 indicated otherwise.

The questionnaire was subjected to content validation by Senior Lecturers in Science Education, and Instructional Design. Their feedback was incorporating in the final questionnaire. The questionnaire was pretested by administering it to 18 Biology teachers not included in the study sample. Its internal consistency reliability, assessed using Cronbach's alpha coefficient, yielded a high coefficient of $\alpha = 0.85$. The researcher personally administered and collected the questionnaires with the assistance of two research assistants. The collected data were analyzed using measures of central tendency, specifically the mean and standard deviation.

3.0 RESULTS AND DISCUSSION

3.1 Results

Research Question One: What resourceful strategies are employed by Biology teachers in resource-constrained secondary schools to complement the practical component of the Biology curriculum?

Table 1: Resourceful Strategies for Biology Practical in Resource-Constrained Schools

SN	Item Statement	n	M	SD	Decision
1	I frequently use locally available materials to improvised needed materials/apparatus for conducting practical	132	3.05	.79	Employed
2	I encourage students to bring everyday items from home (e.g., empty bottles, containers) for use in experiments	132	2.15	.96	Not Employed
3	I collaborate with colleagues to share teaching resources and materials for practical science concepts	132	1.89	.81	Not Employed
4	I organize field trips to local science-related facilities (e.g., farms, factories) to supplement practical learning	132	2.45	.88	Not Employed
5	I seek donations or sponsorships from local businesses or organizations to acquire laboratory equipment and materials	132	1.61	.72	Not Employed
6	I collaborate with nearby schools to share laboratory equipment and resources for practical science experiments	132	3.15	.80	Employed
Grand Mean \pm SD for Resourceful Teaching		2.38 \pm 0.83			

Keys: n = Number of teachers; M = Mean; SD = Standard deviation; Decision mean: 2.5

Source: Field survey, 2024

Table 1 presents statistics on resourceful strategies for conducting Biology practical in resource-constrained secondary schools. Biology teachers frequently use locally available materials (Mean = 3.05, SD = 0.79) and collaborate with nearby schools (Mean = 3.15, SD = 0.80). However, they are less effective in encouraging students to contribute items (Mean = 2.15, SD = 0.96), organizing field trips (Mean = 2.45, SD = 0.88), seeking external support (Mean = 1.61, SD =

0.72), and collaborating with colleagues (Mean = 1.89, SD = 0.81). The grand mean of 2.38 ± 0.83 indicates overall low effectiveness in employing resourceful strategies.

Research Question Two: How do Biology teachers in resource-constrained secondary schools utilize innovative instructional approaches to argument the practical component of the Biology curriculum?

Table 2: Innovative Instructional Approaches for Biology Practical in Resource-Constrained Schools

SN	Item Statement	n	M	SD	Decision
1	I use visual aids such as diagrams and charts to facilitate students' understanding of practical components in Biology.	132	2.15	.70	Not Utilized
2	I use multimedia (video/computer) to supplement Biology practical when apparatuses are unavailable.	132	1.02	.41	Not Utilized
3	I offer extra time for discussions with students struggling to understand concepts requiring hands-on lab work.	132	1.45	.60	Not Utilized
4	I organize students into groups whenever possible to conduct laboratory practical.	132	1.98	.65	Not Utilized
5	I integrate problem-solving activities to stimulate critical thinking in topics that require practical experiments.	132	1.61	.45	Not Utilized
6	I use demonstrations to compensate for practical given the constraints of Biology learning resources in my school.	132	2.78	.80	Utilized
7	I employ guided inquiry method to teach abstract concepts that require ample resources for laboratory practical	132	2.11	.68	Not Utilized
8	I resort to providing detailed instructions because of limited hands-on resources.	132	2.41	.79	Not Utilized
Grand Mean \pm SD for Innovative Instruction		1.94 \pm 0.64			

Keys: n = Number of teachers; M = Mean; SD = Standard deviation; Decision mean: 2.5

Source: Field survey, 2024

Table 2 provides statistics on innovative instructional approaches for Biology practicals in resource-constrained secondary schools. The use of demonstrations (Mean = 2.78, SD = 0.80) and detailed instructions (Mean = 2.41, SD = 0.79) are relatively effective. However, challenges persist in using visual aids (Mean = 2.15, SD = 0.70), multimedia (Mean = 1.02, SD = 0.41), allocating extra discussion time (Mean = 1.45, SD = 0.60), organizing

group activities (Mean = 1.98, SD = 0.65), integrating problem-solving (Mean = 1.61, SD = 0.45), and guided inquiry methods (Mean = 2.11, SD = 0.68). The grand mean of 1.94 ± 0.64 indicates that Biology teachers in Zamfara State are generally not highly effective in using innovative instructional strategies to augment Biology practical due to limited resources.

Research Question Three: What curriculum adaptation techniques are employed by Biology teachers in resource-constrained secondary schools to complement the practical component of the Biology curriculum?

Table 3: Curriculum Adaptation Techniques for Biology Practical in Resource-Constrained Schools

SN	Item Statement	n	M	SD	Decision
1	I modify the sequence of experiments in the curriculum to align with the availability of laboratory facilities	132	3.35	.85	Employed
2	I adapt the curriculum to focus on only practical components that require minimal resources	132	3.55	.68	Employed
3	I complement Biology practical with real world examples to enhance students' understanding	132	2.88	.79	Employed
4	I integrate virtual experiments as alternatives to physical experiments in my teaching	132	1.15	.20	Not Employed
5	I consistently update my teaching materials to stay current despite the limited hands-on resources at my school	132	2.61	.71	Employed
Grand Mean \pm SD for Curriculum Adaptation			2.71	± 0.65	

Keys: n = Number of teachers; M = Mean; SD = Standard deviation; Decision mean: 2.5

Source: Field survey, 2024

Table 3 provides statistics on curriculum adaptation techniques for Biology practical in resource-constrained schools. The most effective practices are adapting the curriculum to focus on practical components requiring minimal resources (Mean = 3.55, SD = 0.68) and modifying experiment sequences to match available facilities (Mean = 3.35, SD = 0.85). Supplementing practical with real-world examples (Mean = 2.88, SD = 0.79) is also effective. However, integrating virtual experiments (Mean = 1.15, SD = 0.20) and updating teaching materials (Mean = 2.61,

SD = 0.71) are less effective. The grand mean of 2.71 ± 0.65 indicates general effectiveness of Biology teachers in resource-constrained schools in curriculum adaptation techniques.

3.2 Testing Null Hypothesis

H₀: There is no significant difference between urban and rural Biology teachers in the utilization of (a) resourceful strategies, (b) innovative instructional approaches, and (c) curriculum adaptation techniques to complement the practical components of the Biology curriculum.

Table 4: Comparison of Urban and Rural Biology Teachers' Adapted Strategies for Augmenting Biology Practical in Resource-Constrained Schools

Variable	Group	N	Mean	Std. Dev.	df	t-value	p-value	Remark
Resourceful Strategies	Urban	83	20.04	3.011	130	2.00	0.048	Reject H _{0a}
	Rural	49	17.13	4.126				
Innovative Instruction	Urban	83	16.03	2.503	130	1.80	0.073	Fail to Reject H _{0b}
	Rural	49	15.10	3.210				
Curriculum Adaptation	Urban	83	22.41	4.001	130	2.50	0.014	Reject H _{0c}
	Rural	49	19.01	3.503				

$p\text{-value} < 0.05$

The analysis in Table 4 shows significant differences between urban and rural Biology teachers' strategies for augmenting practical components of Biology. Specifically, the p-values for resourceful strategies ($p = 0.048$) and curriculum adaptation ($p = 0.014$) are below the significance level ($\alpha = 0.05$), leading to the rejection of null hypotheses H_{0a} and H_{0c}. This indicates significant differences between urban and rural teachers in these areas. However, the p-value for innovative instructional approaches ($p = 0.073$) is

above α , resulting in the failure to reject null hypothesis H_{0b}, indicating no significant difference in this aspect.

4.0 DISCUSSION

The findings from Table 1 reveal the resourceful strategies of Biology teachers in resource-constrained secondary schools to complement the practical components of Biology curriculum in resource-constrained schools in Zamfara State. The most proactive measures employed was utilizing locally available materials and collaborating with nearby

schools, while seeking external support and collaborating with colleagues were less common. This infers that teachers in resource-constrained environments often rely on utilizing materials accessible within their communities and collaborating with nearby schools. These results are consistent with previous studies. For instance, Abdullahi and Umar (2020), Safo-Adu et al. (2020), Ogbuze and Okoli (2020) and Ibrahim and Abdullahi (2019) findings have reported Biology teachers' resourcefulness in using local materials for experiments. This contrasts with Daba's et al. (2016) findings, which revealed that Biology teachers in the Borena zone of South Ethiopia do not make attempts to utilize local materials in their resource-constrained schools. The emphasis on collaboration with nearby schools is in line with Ajibade and Tella's (2017) research, which highlighted the benefits of collaborative partnerships in resource sharing. However, challenges in seeking external support may not be far-fetched, as Abdussemiu's (2022) report revealed a scarcity of external funding and support for education initiatives in Lagos.

The findings presented in Table 2 offer an understanding into how Biology teachers in resource-constrained secondary schools utilize innovative instructional approaches to augment the practical component of the Biology curriculum. The data reveal that, only Demonstrations stand out as a compelling approach, with a mean score of 2.78. This finding implies that demonstrations serve as an effective alternative when resources for hands-on experiments are limited. This contrasts with Daba's et al. (2016) findings, which revealed that Biology teachers in resource-constrained schools in the Borena zone of South Ethiopia made no efforts to use demonstrations for their students. Detailed instructions also show relative effectiveness (mean score: 2.41). However, responses from Biology teachers indicated challenges persist in utilizing visual aids, multimedia, and problem-solving activities. These findings resonate with previous research in similar contexts. For example, studies by Abdullahi and Umar (2020) and Oladokun (2015), affirming the ease with which teachers utilize demonstrations as replacements for hands-on laboratory activities.

The findings in Table 3 reveal curriculum adaptation techniques used by Biology teachers in resource-constrained Zamfara State secondary schools to to

4.1 Implications of the Findings for Pedagogical Practices

The lack of effective utilization of resourceful strategies and innovative instructional approaches by Biology teachers in Zamfara State not only hampers

argument practical components of Biology curriculum. Adapting the curriculum to focus on resource-minimal practical components was common. This could reflect teachers' commitment in ensuring hands-on learning despite limitations. Similarly, modifying experiment sequences to match available facilities was second most admitted adaptation techniques employed by Biology teachers in Zamfara State. This could be attributed to teachers' efforts in prioritizing experiments having existing resources to optimize student laboratory skills. Supplementing Biology practical with real-world examples was also prevalent among the teachers. This may be attributed to Biology teachers' belief that connecting theoretical concepts to real-life applications enhances students' scientific skills in resource-constrained environments, which could have been achieved through laboratory practical. These findings corroborate previous research by Abdullahi and Umar (2020) and Oladokun (2015), whose study also revealed that teachers are aware of the underlying significance of curriculum adaptation and real world contextualization as substitutes for laboratory practical.

The findings from the analysis of Table 4, significant differences observed in resourceful strategies and curriculum adaptation between urban and rural teachers could be as a result of varying approaches to addressing limitations in Biology practical resources. Biology teachers in urban secondary schools appear to take advantage of available resources more effectively and adapt their teaching methods to suit the context of practical components of Biology curriculum, potentially benefiting from greater access to resources opportunities. Conversely, the absence of a significant difference in innovative instructional approaches could be because of commonality between urban and rural Biology teachers in employing these methods. While both groups may employ similar approaches in delivering instruction, the findings stressed the need for targeted support and resources to ensure equitable access to effective teaching strategies, particularly in rural areas. This is consistent with the findings of Okpaje et al. (2018), who found significant differences between urban and rural science teachers in utilizing resources to complement practical in Abuja. Okpaje et al. (2018) also found that, rural teachers lacked awareness of techniques and opportunities for sourcing resources, unlike their urban counterparts in Abuja.

students' academic performance but also severely inhibits the development of their scientific skills and competencies. The total neglect of practical components deprives students of key hands-on learning experiences essential for understanding complex biological concepts and honing their

scientific inquiry skills. Consequently, students are at a disadvantage, as they are unable to fully grasp fundamental principles and apply them in real-world contexts. It also limits students' future academic and career prospects in scientific fields. Urgent interventions are imperative to rectify this situation and ensure that students receive a comprehensive Biology education, especially the practical components, that nurtures their intellectual growth and prepares them for success in higher education and beyond.

5.0 CONCLUSION

This study found a significant difference between urban and rural Biology teachers in resourceful strategies and curriculum adaptation, while no difference was observed in innovative instructional approaches. Despite the challenges posed by limited resources, Biology teachers employ various adapted strategies to augment Biology practical experiences for students, including utilizing locally available materials, collaborating with neighboring schools, and adapting the curriculum to focus on practical components. Obstacles remain in encouraging student participation in resource collection, accessing external support, integrating virtual experiments, and effectively integrating innovative instructional approaches.

6.0 RECOMMENDATIONS

Based on the findings of the study, the study

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recommended that;

- i. To optimize the utilization of limited available resources, school principals should encourage collaboration among schools within Zamfara State to share laboratory equipment, materials, and resources,
- ii. Zamfara State Ministry of Education should provide training for Biology teachers, focusing on innovative instructional approaches that encourage practical learning experiences.
- iii. Relevant curriculum development committee should review and revise the Biology curriculum to prioritize hands-on practical components that require minimal resources.
- iv. Zamfara State Ministry of Education should invest in technology infrastructure to integrate virtual experiments and digital resources into Biology education, as alternative avenues for practical learning.

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