The Effects of Improvised Instructional Materials on Learners' Achievement in Biology Classes in Namibia

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[Abstract] This study, framed within Robert Gagne's Condition of Learning Theory, investigated the impact of improvised educational materials on students' performance in Biology in a selected secondary school. Using a qualitative case study and quasi-experimental design, one Grade 11 Biology class of 30 learners was divided into experimental and control groups. A Biology Achievement Test with pre- and post-tests provided quantitative data, while focus group discussions gathered qualitative insights. Results revealed improved academic performance in both groups, with the experimental group showing greater gains. Learners reported that improvised materials made lessons more engaging and enhanced their understanding of concepts. The study concludes that improvised instructional materials positively influence learner motivation and achievement. It recommends that the Ministry of Education, Innovation, Sport, Arts and Culture invest more in conventional teaching resources and provide raw materials for teachers to develop improvised teaching aids to support effective teaching and learning of Biology in schools.

[keywords] improvised instructional materials, Gagne Condition of Learning Theory, secondary biology level instruction, improvised materials, Namibia education reforms

Introduction

This article explores curriculum and assessment reforms in Namibia, particularly in relation to the teaching of Biology. The Ministry of Education, Arts, and Culture (MoEAC, 2016a) developed a curriculum aligned with Vision 2030, which seeks to build "a prosperous and industrialized Namibia, developed by her human resources, enjoying peace, harmony, and political stability." Curriculum reform is seen as a key strategy for achieving this vision. Within this framework, the Namibia Senior Secondary Certificate Ordinary (NSSCO) curriculum identifies Natural Sciences, including Biology, as vital for fostering a knowledge-based society by equipping learners with scientific skills such as observation, experimentation, and hypothesis formulation.

The NSSCO Biology curriculum is a two-year programme (Grades 10–11) culminating in national examinations that align with the National Curriculum for Basic Education (NCBE) and the National Examination, Assessment and Certification Board (NEACB). The biology syllabus defines three key assessment objectives: (a) knowledge with understanding, (b) information handling, application, and problem-solving, and (c) practical skills and abilities (MoEAC (2018b).

To meet these objectives, the MoEAC recommends the use of appropriate instructional materials and effective teaching methods in all schools

Instructional materials are defined as resources that help teachers communicate concepts clearly and enhance learners' understanding. Scholars such as Igiri and Effiong (2015) and Ibrahim et al. (2019) emphasize that these materials facilitate interaction between teachers and learners, making teaching more effective. However, many Namibian secondary schools face severe shortages of instructional resources due to limited funding (Hamunyela et al., 2022; Nghishongwa, 2017). Verner et al. (2022), in a study conducted in the Kharas region, found that only three of twelve biology teachers reported having adequately equipped laboratories. This lack of resources has been linked to poor learner performance in biology, especially in rural and under-resourced schools (Muyoyeta, 2018; Ndjangala et al., 2021).

In response to these challenges, some educators turn to improvisation, which involves creating teaching aids from locally available materials (Okeke, 2019). Improvised instructional materials are not only cost-effective but also promote creativity, innovation, and learner engagement (Ibrahim et al., 2019; Ibrahim et al., 2021). Research from other contexts, such as Siachifuwe's (2017) study in Rwanda, shows that improvisation enhances experiential learning and allows students to gain practical knowledge through hands-on activities.

Despite its advantages, several studies have highlighted challenges associated with improvisation. Many teachers lack the necessary skills and confidence to design and effectively use improvised teaching aids (Muyoyeta, 2018). In Namibia, Verner et al. (2022) reaffirmed that inadequate instructional resources significantly contribute to high failure rates in NSSCO Biology, urging teachers and learners to embrace improvisation to improve outcomes.

However, there remains a research gap in Namibia regarding the impact of improvised instructional materials on student performance in Biology. While improvisation has been shown in other contexts to stimulate learner interest and enhance understanding, no empirical studies have explored its effects within the Namibian educational context. Therefore, the present study seeks to fill this gap by investigating how improvised instructional materials influence the academic performance of Grade 11 Biology learners at a selected school in Namibia.

Research Questions

Against this introduction background, the following main research question guided our research study: What are the effects of using improvised instructional materials on the Grade 11 learners' achievement in Biology at School X in Omuthiya Circuit? The following sub-research question was also constituted: How do improvised instructional materials contribute to learners' achievement in Biology?

Hypothesis

Based on the main and sub research questions, we tested the following hypotheses:

H_0 There is no statistically significant difference in the performance of the Grade 11 learners' achievement in Biology between those taught with improvised instructional materials and those taught using the usual traditional method.

H_1 There is a statistically significant difference in the performance of the Grade 11 learners' achievement in Biology between those taught with improvised instructional materials and those taught using the usual traditional method.

The level of significance in testing the above hypothesis was as follows: If the p-value is less than or equal to the alpha ($p \leq 0.05$) then the null hypothesis (H_0) will be rejected. However, if the p-value is greater than alpha ($p \geq 0.05$) then the null hypothesis will be accepted.

Significance of the Study

The Ministry of Education, Innovation, Youth, Sport, Arts, and Culture, through its agencies such as the National Institute for Educational Development (NIED), may benefit from this study by recognising the significance of improvised instructional materials in the teaching and learning of Biology in Grade 11. The study's recommendations may also serve as essential information that can assist Biology instructors in the development, design, and implementation of improvised instructional materials during the teaching of Biology in Grade 11. Additionally, it is anticipated that educators will gain insight into the efficacy of utilising improvised instructional materials to achieve the learning objectives of Biology.

Theoretical Framework

This study is framed within Robert Gagne's Condition of Learning Theory. According to this theory, "there are different types of learning outcomes, each of which is best achieved through its specific instructional design, but also that there is a set of steps required for every learning environment" (Gagne, 1965, as cited in Zimmerman & Schunk, 2002, p. 28).

According to Richey (2000), the Condition of Learning Theory is cemented around four principles, namely:

1. Different instruction is required for different outcomes.
2. Events of learning operate on the learners in ways that constitutes the condition of learning.
3. The specific operations that constitutes instructional events are different for each different learning outcomes.
4. Learning hierarchies define what intellectual skills are to be learned as a sequence of Instruction (p. 94).

As a result, the theory describes specific instructional events and their accompanying cognitive processes (Richey, 2000). However, these events must meet and provide the necessary conditions for learning, as well as aid a program in constructing instructions and selecting relevant instructional materials (Twitchell et al., 1990).

Research Method

Research Paradigm, Approach, and Design

This study adopted a mixed-method research approach grounded in the pragmatism paradigm. Pragmatism recognizes that no single research paradigm—whether positivist or interpretivist—can provide a complete understanding of reality. As Kivunja and Kuyini (2017) contend, truth cannot be derived solely through scientific inquiry or social interpretation; rather, researchers

should select methods that best address their research questions. Similarly, Kallio et al. (2016) assert that pragmatism enables researchers to employ diverse methodologies that align with the nature and objectives of their investigations.

In accordance with the mixed-method design, this study employed two complementary research designs: a quasi-experimental design to collect quantitative data and a case study design to collect qualitative data. The quasi-experimental design used a pre-test and post-test approach to determine the causal relationship between the use of improvised instructional materials and learners' academic performance in Biology. Learners were divided into two equal groups—Group A (experimental) and Group B (control)—allowing for a comparative analysis of the effects of the intervention.

For the qualitative component, focus group discussions (FGDs) were conducted with learners from the experimental group to gain an in-depth understanding of their experiences learning the topic *Gas Exchange in Humans* using improvised instructional materials.

Participants and Sampling Procedures

The study purposively selected Grade 11 learners studying biology from one secondary school, as it was the only school within the circuit with a single Grade 11 class consisting of 30 students. To ensure randomization and reduce selection bias, the learners were randomly assigned to two groups of equal size (15 learners each). Names were written on folded slips of paper, mixed in a jar, and drawn to form Group A (experimental) and Group B (control), ensuring each learner had an equal chance of selection.

The experimental group was taught using improvised instructional materials—specifically, a breathing model and an alveolar structure—supplemented by textbooks and teachers' notes. Conversely, the control group was taught using conventional instructional materials (textbooks and teachers' notes only). From the experimental group, ten learners were randomly selected to participate in the focus group discussions after the intervention period to provide qualitative data.

Research Instruments

Two instruments were used for data collection: the Biology Achievement Test (BAT) and a Focus Group Discussion Guide. The BAT was designed by the researchers and validated by a senior education officer for Biology in the Oshikoto region of Namibia. Validation ensured that the test accurately measured differences in learners' academic achievement in biology and reflected the intended learning outcomes.

The Use of BAT

A BAT focusing on *Gas Exchange in Humans* was administered to both the experimental and control groups as a pre-test to assess their baseline understanding of the topic. This ensured that both groups started at a similar level of knowledge. The intervention lasted for six weeks, with lessons conducted after school for 50 minutes per session. The experimental group was taught using improvised instructional materials in addition to textbooks and notes, while the control group received instruction using only textbooks and notes. After the intervention, the same BAT was administered as a post-test to both groups to measure any change in achievement and determine the impact of improvised instructional materials.

Focus Group Discussion

Following the post-test, ten learners from the experimental group were selected to participate in focus group discussions. The learners were divided into two groups of five, and sessions were conducted face-to-face in the Grade 11 classroom after school hours. Each discussion lasted between 20 and 30 minutes.

The Focus group discussion explored learners' views of being taught Biology with improvised instructional materials. Discussions aimed to elicit learners' views on how the materials influenced their engagement, understanding, and interest in biology. All sessions were audio-recorded to ensure the accuracy and reliability of data.

Data Collection Procedures

The learners were informed at the outset of the study that we, as researchers, would instruct both groups, and all classes or related activities would occur after school hours. On the initial day, researchers conducted a 40-mark Biology Achievement Test (BAT) as a pre-test for one hour for both groups in their respective classes. Subsequently, each group received instruction on eight sessions over six weeks after school hours from the researcher, encompassing learning objectives such as the distinction between breathing and respiration, characteristics of gaseous exchange, and the mechanisms of inhalation and exhalation. In these courses, participants in the experimental group were introduced to an improvised model of the respiratory system, illustrating the effects on the intercostal muscles, ribs, chest, and diaphragm during inhalation and exhalation.

An improvised model depicting the architecture and characteristics of gaseous exchange in an alveolus was utilised for the same group. Despite identical lesson objectives for both groups, the control group was instructed solely using conventional materials, including board diagrams, textbooks, and instructors' notes. To prevent intergroup interference, each group was instructed independently by relocating the group not being supervised by the researchers, to an accessible vacant classroom at that moment. Following six weeks of intervention, the designated content was addressed in all groups, after which the post-test of the biology accomplishment assessment was conducted.

Three days after writing the post-test, the ten Grade 11 learners from the experimental group were randomly selected to participate in a focus group discussion. The discussions were conducted in the Grade 11 classroom after school hours and lasted for 20-30 minutes. In addition, an audio recorder was used to record the discussion sessions in order to maintain the validity and credibility of the discussion sessions.

Data Analysis

Two sources of data, namely, quantitative (pre-test and post-test) and qualitative (focus group discussions) were analysed differently. The quantitative data was analysed and presented using descriptive statistics (mean). Furthermore, an Excel spreadsheet for the paired and unpaired t-test was used to test the effects of improvised instructional materials on learners' academic achievement in biology. The researchers set the level of significance in testing our study hypothesis (whether improvised instructional materials have a positive effect on the Grade 11 learner's achievement in biology) on the premises that if the p-value was less than or equal to the alpha ($p \leq 0.05$) then the null hypothesis (H_0) would be rejected. However, if the p-value is greater than

alpha ($p \geq 0.05$) then the null hypothesis would be accepted. A thematic approach was used to analyse qualitative data where issues arising were coded and organised into themes. The quantitative and qualitative were broadly compared for triangulation purposes to ascertain whether improvised instructional materials have a positive effect on the Grade 11 learner's achievement in Biology. The reason for the triangulation of data was to ensure that major biases arising from the use of a single source are limited.

Research Findings

We first start with the presentation of quantitative results and then qualitative data after.

Treatment Strategies

A BAT concerning *Gas exchange in humans* was administered to both groups at the study's outset as a pre-test prior to the intervention. The BAT comprised two components: Section A, which included multiple choice questions, and Section B, which contained structured questions. The two stages were allocated a total of 40 marks and had to be completed within 60 minutes. Subsequent to the pre-test, an intervention was implemented over a duration of 6 weeks, during which each group received instruction on 'Gas exchange in humans' in 50-minute classes. In the intervention, the Experimental group was instructed on the subject of gas exchange in humans utilising two improvised instructional materials (Appendix B): a breathing system model comprising two balloons, two drinking straws, a clear plastic sheet and a two-litre plastic bottle to demonstrate inhalation and exhalation in humans. An additional improvised instructional resource utilised was a model of alveolar structure, constructed from boxes and blank white paper, to illustrate the architecture of the alveoli.

Conversely, the control group was instructed on the same subject utilising conventional teaching resources (textbook and teacher's notes) during the intervention. Subsequent to the intervention, the identical BAT was re-administered to both the experimental and control groups independently to function as a post-test. Subsequently, the data from the two groups (pre-test and post-test) were documented for analytical reasons as detailed in the following subsections.

Biology Achievement Pre-test Results

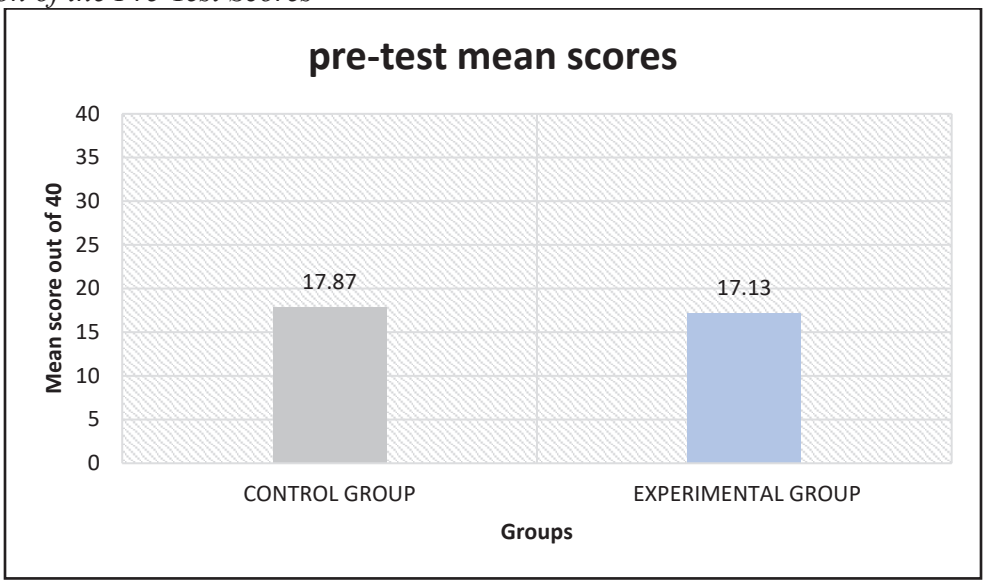
This subsection presents the findings of the BAT for the Experimental group and Control group in their pre-test (Table 1.1)

Table 1.1
The Actual Pre-test Scores of the Experimental and Control Group

Experimental Group				**Control Group**		
Learners' Pseudonyms	***Sex***	***Pre-test scores***		***Learners' Pseudonyms***	***Sex***	***Pre-test scores***
L1	F	15		L16	F	18
L2	F	17		L17	M	24
L3	M	17		L18	F	16
L4	M	12		L19	M	13
L5	M	19		L20	F	11
L6	M	8		L21	M	19
L7	M	18		L22	M	11
L8	F	22		L23	M	11
L9	F	12		L24	M	20
L10	M	22		L25	M	16
L11	M	19		L26	M	31
L12	F	15		L27	M	19
L13	F	20		L28	M	30
L14	M	18		L29	F	20
L15	M	23		L30	F	9
Mean score		**17.13**		**Mean score**		**17.87**

The above experimental group and control group pre-test actual scores are then translated into a bar chart to compare the two groups' pre-test mean scores (Figure 1.1)

Figure 1.1
Comparison of the Pre-Test Scores



The experimental group's mean score on the pre-test was 0.74 points lower than the control groups. The unpaired t-test examined the following hypotheses to see if this difference is statistically significant: $\boldsymbol{H_0}$*: There is no statistically significant difference in the Biology Achievement test pre-test scores of the experimental group and control group.* $\boldsymbol{H_1}$*: There is statistically significant difference in the Biology Achievement test pre-test scores of the Experimental group and Control group.*

Table 1.2
Biology Achievement Test Pre-test Statistics of the Experimental and Control Groups

Summary of test statistics (pre-tests)		
	Experimental	Control Group
Observations	15	15
Missing	0	0
Mean	17.13	17.87
Median	18	18
Range	15	22
Mode	15	11
Standard Deviation	4.17	6.65
Variance	17.40	44.27
T-value	0.72	
T-critical value	2.06	
Degree of Freedom (df)	24	

The results show that with an alpha value of 0.05 (95% significance threshold) and 24 degrees of freedom, the t-test yielded a t-calculated of 0.72 and a t-critical of 2.06. Consequently, it can be inferred that H_0 is upheld, which posits that there is no statistically significant difference in the pre-test scores of the biology achievement tests between the experimental and control groups. The next subsection present comparison of the post-test scores of the experimental group and control group in the biology achievement test.

Biology Achievement Test Post-test Results

This subsection contains the post-test results for the Biology Achievement test, which was administered to both the Experimental and Control groups. The actual ratings of learners from the post-test are presented in Table 1.3 below.

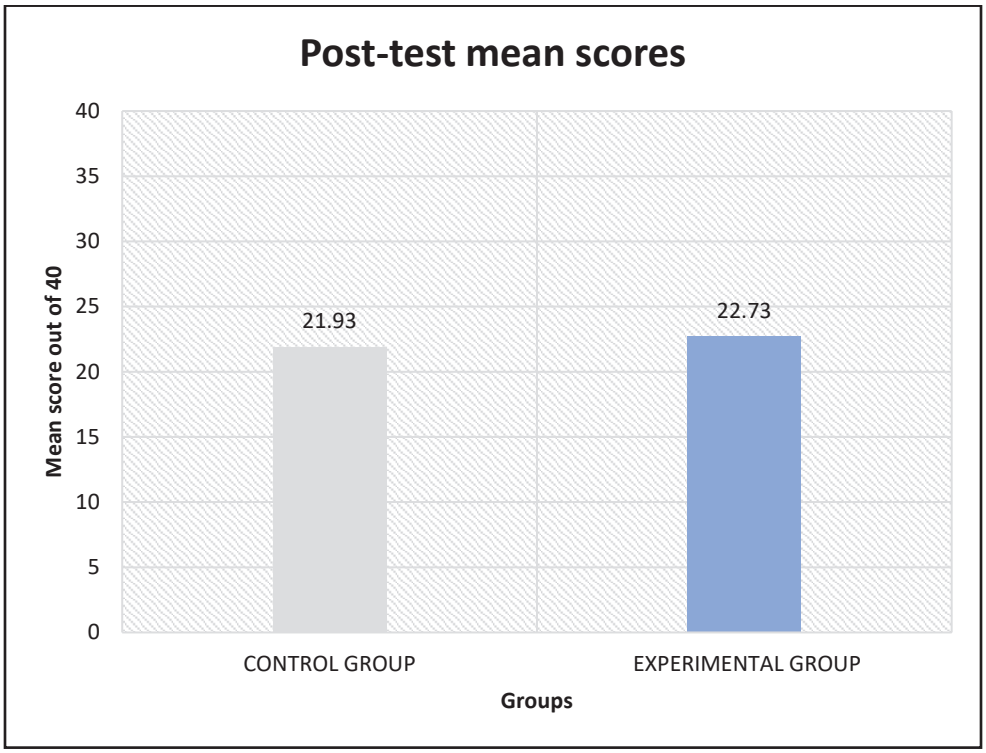
Table 1.3

The Actual Post-Test Scores of the Experimental and Control groups

Experimental Group				**Control Group**		
Learners' Pseudonyms	***sex***	***Post-test scores***		***Learners' Pseudonyms***	***Sex***	***Post-test scores***
L1	F	29		L16	F	28
L2	F	20		L17	M	23
L3	M	22		L18	F	17
L4	M	19		L19	M	19
L5	M	21		L20	F	16
L6	M	13		L21	M	21
L7	M	19		L22	M	13
L8	F	25		L23	M	18
L9	F	21		L24	M	30
L10	M	26		L25	M	19
L11	M	24		L26	M	34
L12	F	20		L27	M	23
L13	F	28		L28	M	28
L14	M	25		L29	F	27
L15	M	29		L30	F	13
Mean score		**22.73**		**Mean score**		**21.93**

Experimental group and control group post-test actual scores (Table 1.3) are then translated into a bar chart to compare the two groups' post-test mean scores (Figure 1.2).

Figure 1.2
Comparison of the Post-test Scores



This comparison indicates that the mean score of the Experimental group exceeded that of the Control group by 0.8 points. To ascertain the statistical significance of this difference, an unpaired t-test is illustrated which evaluated the following hypotheses (Table 1.4).

> **H_0:** There is no statistically significant difference in the Biology Achievement test post-test scores of the Experimental group and Control group.
> **H_1:** There is a statistically significant difference in the Biology Achievement test post-test of the Experimental group and Control group.

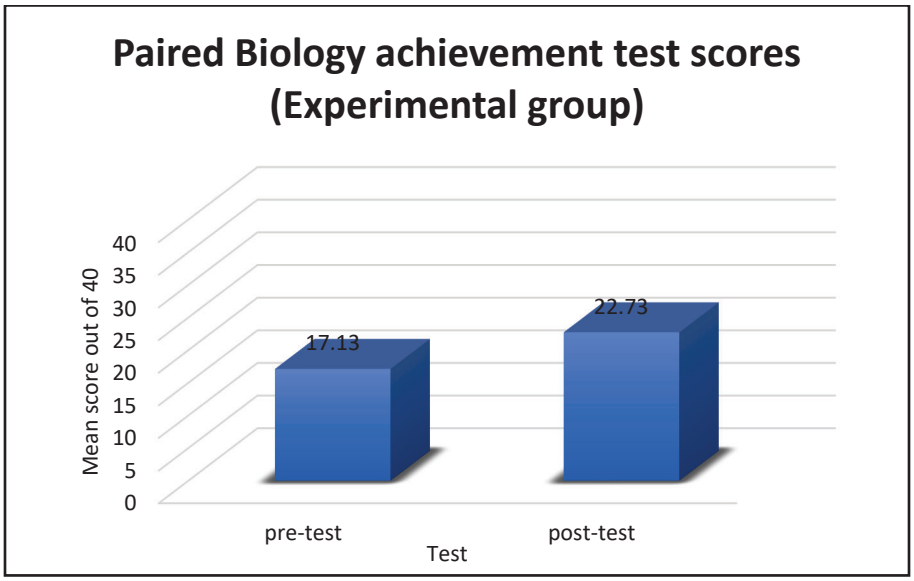
Table 1.4
Biology Achievement Test Post-test Statistics of the Experimental and Control Groups

Summary of Test Statistics (post-tests)		
	Experimental	Control Group
Observations	15	15
Missing	0	0
Mean	22.73	21.93
Median	22	21
Mode	29	28
Range	16	21
Standard Deviation	4.42	6.35
Variance	19.50	40.35
T-value	0.69	
T-critical value	2.06	
Degree of Freedom (df)	25	

These statistics indicate that at $\alpha = 0.05$ and $df = 25$, the computed t-value of 0.69 is less than the crucial t-value of 2.06 (Table 1.4). Consequently, it may be stated that there was no statistically significant difference between the biology achievement post-test scores of the experimental group and the control group. The next subsection presents the comparison of the biology achievement pre-test and post-test scores of the experimental group and control group.

Biology Pre-test and Post-test Scores of the Experimental Group and Control Group
This subsection provides a comparison of the pre-test and post-test scores in biology achievement for both the experimental and control groups and illustrates the matched pre-test and post-test scores in biology for the experimental group (Figure 1.3).

Figure 1.3
Comparison of Paired Biology Achievement Test Scores



This indicates that the post-test mean score exceeded the pre-test mean score by 5.6 points. A paired t-test (Table 1.5) was conducted to ascertain the statistical significance of this difference, testing the following hypotheses: $\mathbf{H_0}$**:** There is no statistically significant difference between the Biology Achievement pre-test and post-test mean scores of the Experimental group. $\mathbf{H_1}$**:** There is a statistically significant difference between the Biology Achievement pre-test and post-test mean scores of the Experimental group.

Table 1.5
Paired Biology Achievement Test Statistics

Summary of the Test Statistics (experimental group)		
Mean	*Pre-test*	*Post-test*
	17.13	22.73
Variance	17.41	19.50
Df	14	
P(T<=t) two-tail	8.99	
t Critical two-tail	2.14	

These results indicate that at $\alpha = 0.05$ and $df = 14$, the calculated t-value of 8.99 exceeds the crucial t-value of 2.14. Consequently, it may be stated that a statistically significant difference existed

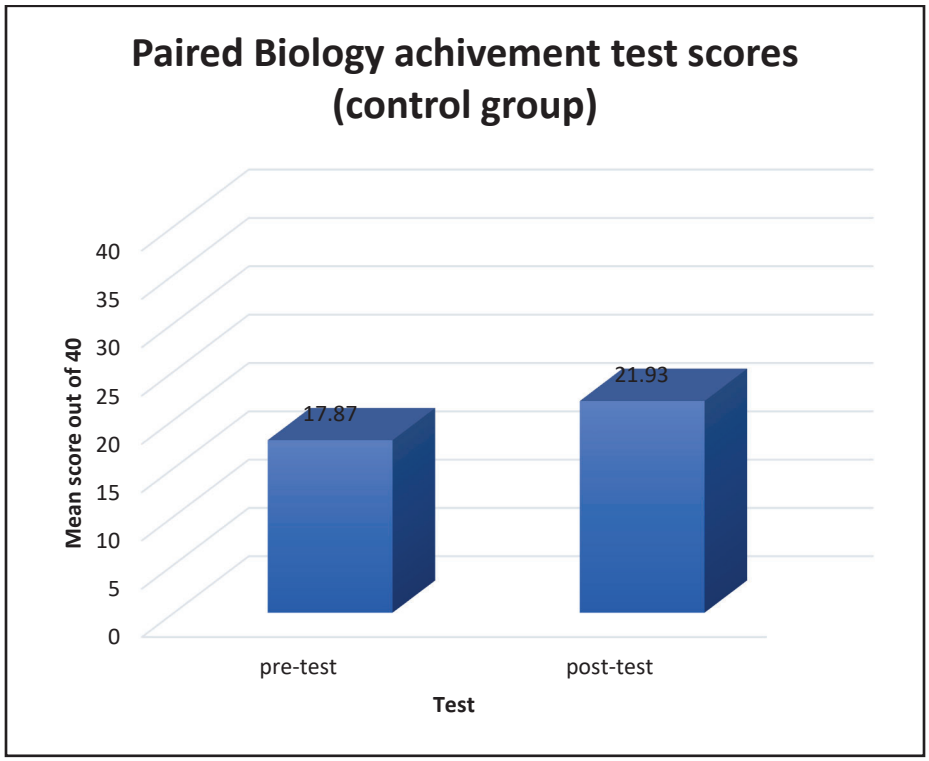
between the mean scores of the pre-test and post-test for the experimental group biology achievement test. The next subsection presents the comparison of the biology achievement pre-test and post-test mean scores of the control group.

Biology Achievement Test Pre-test and Post-test Mean Scores of the Control Group

The biology achievement pre-test and post-test of the control group are compared in this subsection (Figure 1.4).

Figure 1.4

Comparison of Paired Biology Achievement Test Scores



This subsection compares the pre-test and post-test results of the control group in biology achievement (Figure 1.4) illustrating the pre-test and post-test scores of the control group for the biology accomplishment test.

H_0: There is no statistically significant difference between the Biology Achievement pre-test and post-test scores of the Control group.

H_1: There is a statistically significant difference between the Biology Achievement Pre-test and post-test Control group.

Table 1.6
Paired Biology Achievement Test Statistics

Summary of the Test Statistics (control group)		
	Pre-test	*Post-test*
Mean	17.87	21.93
Variance	44.27	40.35
Df	14	
P(T<=t) two-tail	0.0005	
t Critical two-tail	2.14	

The t-calculated value of 0.0005 is less than the t-critical value of 2.14 at $\alpha = 0.05$ and df = 14, as illustrated in Table1.6 above. Consequently, it can be inferred that the control group's mean score on the biology achievement test did not exhibit a statistically significant difference between the pre-test and post-test.

Qualitative Findings

Data were collected through focus group discussions and analysed thematically. Four themes emerged: (1) the ability to see what is being taught, (2) provision of opportunities for imagination and easier remembrance, (3) the effect of using improvised instructional materials (IIMs) on understanding the topic, and (4) the shortcomings of using IIMs in Biology.

Ability to See What Is Being Taught

During the focus group interview, the participants were asked to give their thoughts about being taught with improvised instructional materials. Participant L2 from the first focus group discussions responded that "it helps us to see things we are being taught with our own eyes. Similarly, Participant L6 from the second focus group discussion mentioned that "It is good, it makes lessons fun and gives us a sense of pride because sometimes we are learning with things we made ourselves.*"* In addition, Participant L12 from the first focus group discussion stated that "I think it is more practical, so it is very informative as you can see the materials that are being taught, and sometimes it is us using the materials even." To emphasise, Participant L8 from the second focus group discussion made a comparison that "it is better than a teacher presenting the lesson without anything to demonstrate what he/she is teaching for us to see, theory alone without demonstrations is very boring sometimes.*"*

Provision of an Opportunity for Imagination and Easy Remembrance

When study participants were asked about what they liked most about being taught biology with improvised instructional materials, ParticipantL14 from the second focus group discussion responded that "I like improvised instructional materials because, that pictorial print the materials leaves in your mind can really help a person to answer the questions, especially practical questions.*"* In support, Participant L2 from the first focus group discussion stated that "I like being taught with improvised instructional materials because they make me comfortable, and they help me to imagine more about the topic we are being taught. Example, the topic of 'gas exchange in humans' that we just did.*"* Participant L9 from the second focus group discussion asserted that:

> Because I was able to feel the materials, it really helped me to remember the content during the test, it was more like I could still see the demonstration moments that occurred during the lesson. Also, sometimes one does not even need to study that much at that area or topic anymore.

Correspondingly, Participant L8 from the second focus group discussions confirmed that "what I like most is being able to touch and feel the materials. So, it helps me to recognize and remember the content. Also, it makes labelling and identifying of structures/parts on a diagram easy for me."

The Effect of Using Improvised Instructional Materials in Understanding Gas Exchange in Humans Easily

When participants were asked if improvised instructional materials helped them understand the topic of *Gas exchange in humans*, Participant L10 from the first focus group discussions responded that:

> Of course, the materials made me to be more interested in the lesson, which then helped me to understand the content even faster, I even tried to make my own improvised instructional materials at home just to keep repeating what was demonstrated and to make sure I get every information.

It is evident from these answers that the study participants found improvised instructional materials effective since they could understand the content better. Participant L13 from the first focus group discussions concurs that one gets to understand the topic better because the teacher is explaining and demonstrating at the same time, therefore when you do not understand what is being explained at time, I am sure the demonstration will help you understand better. In the same vein, Participant (L2) from the first focus group discussion agreed and recommended that, "*teachers should continue or use more instructional materials in lessons because those materials can really help us learners to get better symbols at the end"*.

Participant L15 from the first focus group discussions also insisted for the use of improvised instructional materials in Biology to happen more often by claiming that the model helped me to understand the topic of gas exchange in humans. I used to struggle with this topic since grade 8 but now I am comfortable with this topic, so I think these materials should be used more often.

During the interview, when learners were asked about the disadvantages of using improvised instructional materials in Biology, the following points were also raised. For example, a learner (L6) from the second focus group discussion noted that "I think improvised instructional materials could be dangerous sometimes as well, based on the materials they are made from." Participant L10 from the first focus group discussions added that "Sometimes the materials used to come up with the improvised instructional materials can be dangerous, more especially if a teacher does not have enough knowledge about them. Therefore, I think teachers need enough training just for safety purposes." Participant L9 from the second focus group discussion reported that *"for me, it is time-consuming to use those. I think using these materials when one is not well prepared can waste time, and in the end, he/she might end up not presenting more of what they wanted to."*

Discussion of Findings

The Effect of Improvised Instructional Materials on Learners' Achievement in Biology

Biology Achievement Test Scores Unpaired Comparison

The mean scores of the Experimental and Control groups on the pre-test and post-test were compared to assessing learners' performance. Both groups underwent a pre-test before the intervention and a post-test after the intervention. The pre-test results (Figure 1.1) showed that the Control group scored marginally higher than the Experimental group, with a mean difference of 0.74. This outcome aligns with Uugwanga (2020), who found near-identical mean scores between Experimental and Control groups in a study on authentic learning activities for natural science among seventh-grade learners. Similarly, Perez (2007) reported no significant difference in pre-test results when examining the effectiveness of learner-centered approaches in teaching acids and bases.

The results indicate that learners in both groups possessed nearly identical knowledge regarding *Gas exchange in humans* prior to the intervention, and the minor difference could be attributed to prior knowledge, which significantly influences learning outcomes (Van Riesen et al., 2022). An unpaired t-test confirmed that the pre-test difference was not statistically significant (t-calculated = 0.72 < t-critical = 2.06). Therefore, both groups commenced the study with comparable knowledge and comprehension of the topic, corroborating Nsa et al., 2013), who observed identical pre-test mean scores in practical agriculture.

The post-test results (Figure 1.2), indicate that the experimental group achieved slightly higher mean scores than the control group, with a mean difference of 0.8. However, an unpaired t-test indicated no statistically significant difference (t-calculated < t-critical). These results support the null hypothesis: there is no statistically significant difference in Grade 11 learners' biology achievement between those taught with improvised instructional materials and those taught using traditional methods. Did you account for differences in learner styles pretest?

Previous research supports these findings. Kambeyo and Ngcoza (2017) reported that improvised teaching materials produced comparable performance to standard resources, suggesting that students can benefit from accessible local resources. Munir and Atiku (2018) emphasized that when outcomes from improvised and traditional materials are equivalent, stakeholders should ensure the availability of resources for improvisation, especially in contexts with limited funding. Despite the lack of statistical significance, the experimental group's

marginally higher post-test score may be attributed to the use of improvised instructional materials, supporting studies by Chinna (2010), Nwoke and Nwamen (2016), and Obodo et al. (2020), who found that such materials can enhance academic performance.

Biology Achievement Test Scores Paired Comparison

A paired comparison of pre-test and post-test mean scores for the Experimental group revealed a substantial improvement, with a mean increase of 5.6. A paired t-test confirmed that this improvement was statistically significant (t-calculated > t-critical), indicating that the use of improvised instructional materials contributed to enhanced learner performance in the topic *Gas exchange in humans*. This aligns with Effiong and Igiri (2015), whose study in senior secondary schools demonstrated significant performance improvement following instruction with improvised materials. Munir and Atiku (2018) also highlighted that such resources improve comprehension, resulting in better academic performance.

In contrast, the control group's mean scores increased by 4.06 from pre-test to post-test. The paired t-test indicated that this improvement was not statistically significant (t-calculated < t-critical), suggesting that conventional teaching methods contributed to some performance gains but were less impactful than the improvised materials. The observed gains are consistent with Uugwanga (2020), who reported improved performance in both Experimental and Control groups following interventions using authentic learning activities.

T-tests comparing the experimental and control groups' mean scores confirmed no statistically significant differences, despite the Experimental group's 0.8 mean score advantage in the post-test. These results suggest that improvised instructional materials can exert an equivalent positive influence on academic performance in biology as conventional methods.

Learners' Perceptions of Improvised Instructional Materials

Focus group discussions with ten Grade 11 learners from the Experimental group revealed predominantly positive perceptions of improvised instructional materials. Participants in this study expressed that they appreciated the ability to see and interact with what they were being taught, particularly for practical questions where hands-on demonstrations enhanced understanding. Many participants reported a sense of pride and ownership when engaging with familiar materials. These findings align with Ibe et al. (2021), who reported that improvised instructional materials enhance academic retention in Chemistry by creating a sense of practicality, and Osei-Himah et al. (2018), who noted improved understanding during teaching.

Participants valued the tactile and visual nature of the materials, which facilitated memory retention and comprehension, corroborating findings by Obodo et al. (2020) and Ajoke (2017), who reported improved performance and engagement when instructional materials were used effectively.

However, participants also expressed concerns regarding safety, emphasizing the potential hazards depending on the materials' composition. They highlighted the need for teachers to ensure safe usage and consider precautions to avoid injury, echoing Mensah (2015), who advocated for teacher training to ensure safe implementation. Additionally, from their perspective as learners they further noted that improper preparation or unavailable materials could waste instructional

time. Obidike (2021) recommended that teachers fully prepare and test improvised materials prior to lessons to avoid inefficiency.

Conclusion

Most participants responded positively that improvised instructional materials helped them grasp the content of *gas exchange in humans* easily. Through focus group discussions they further expressed that improvised instructional materials made the lesson fun and it stimulated their interest in the topic. The majority of the participants requested the use of improvised instructional materials in biology to continue as it helps with understanding the content being taught and the stimulation of the brain, which will then help learners to retain the content.

In the pre-test, the experimental group achieved a mean score of 17.3, while the control group achieved a mean score of 17.87. The experimental group and control group had mean scores of 22.73 and 21.93, respectively, in the post-test. Consequently, the experimental group had a slight advantage of 0.8 in the post-test. Conversely, an unpaired t-test demonstrated that the statistical t-test yielded a t-calculated value of 0.69 and a t-critical value of 2.06 when the α was set at 0.05 and the df was 25. In this instance, the t-critical was marginally higher than the t-calculated. Therefore, the findings failed to reject the null hypothesis (H_0) which stated that:

> **H_0** There is no statistically significant difference in the performance of the Grade 11 learners' achievement in Biology between those taught with improvised instructional materials and those taught using the usual traditional method.

However, it is important to note that the post-test mean scores of the experimental group and control group (Table 4.4) differed by 0.8. This discrepancy may be attributed to the utilisation of improvised instructional materials during the learners' instruction. Additionally, the experimental group and control group demonstrated an improvement in their academic performance in both groups when the pre-test and post-test scores were compared. The positive impact of improvised instructional materials and traditional instructional materials on the academic performance of learners in biology is evidenced by the improvement observed between the assessments of both groups following the intervention. Therefore, it is necessary to promote the use of improvised instructional materials in schools, as they appear to assist students in comprehending the concepts, thereby resulting in enhanced academic performance.

Recommendations

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

Recommendation for the Ministry of Education, Innovation, Youth, Sports, Arts, and Culture

Improvised teaching resources and conventional instructional materials demonstrated equivalent effects on learners' achievement. Consequently, officials in the Ministry of Education, Innovation, Youth, Sports, Arts and Culture curricula should promote the incorporation of both instructional resources in biology lessons during teacher training sessions.

Recommendation for the Senior Education Officers of Biology

The Biology Senior Education Officers shall conduct workshops to equip teachers with the necessary abilities for creating improvised educational materials and the pertinent considerations for their effective use.

Recommendations for Biology teachers

Because they both raise learners' academic performance, biology teachers should include both traditional and improvised teaching resources in their class presentations.

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