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Re-Engineering Chemistry Education for Creativity in Covid-19 Era: Impacts of Improvisation on Students' Academic Achievement and Retention

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ABSTRACT

Aim of the Study: The study examines the influence of improvisation on students' academic performance and knowledge retention as a component of restructuring chemistry education to foster creativity during the COVID-19 pandemic.

Methodology: The research was guided by four research questions and four hypotheses. A quasi-experimental pretest-posttest non-randomized control group design was employed. The study involved 160 SS2 chemistry students from Oyi local government area in the Ogidi education zone of Anambra State. Data was collected using the Chemistry Practical Achievement Test (CPAT). The collected data underwent test-retest analysis, establishing a reliability index of 0.82. Mean, standard deviation, and z-test were utilized to analyze the data and test the null hypothesis at a significance level of 0.05.

Findings: The findings revealed that the use of improvised materials had a significant and superior impact on students' academic performance and knowledge retention compared to standardized materials when teaching chemistry for creativity during the COVID-19 pandemic. However, no significant impact on gender was observed.

Conclusion & Recommendations: Based on these findings, it is recommended that teachers explore strategies to enhance students' science process skills, such as observation, inference, experimentation, and hypothesis formulation. Developing these skills can foster creativity among learners during the COVID-19 era and contribute to improved academic performance and knowledge retention.

Keywords: Re-engineering, Chemistry education, Impact, Creativity, Covid-19 Era, Improvisation, Achievement, Retention.

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Introduction

Chemistry, as an essential subject, necessitates both human and material resources for successful teaching and learning. It is a field driven by human endeavor, therefore active participation of students and teachers is crucial to ensure firsthand experiences that guarantee the acquisition of the most vital and enduring qualities (Nnoli, 2021). Furthermore, chemistry plays a critical role in managing natural

resources, providing healthcare facilities, ensuring an adequate food supply, and creating a favorable living environment. Consequently, a country lacking knowledge of chemistry cannot achieve technological development (Uduchukwu, 2014). Chemistry knowledge is acquired through observation and experimentation. It is a physical science that explores various atoms, molecules, crystals, and other forms of matter, whether in isolation or combination. These studies incorporate concepts of energy and entropy, which relate to the spontaneity of chemical processes (Kin, 2014). Chemistry is concerned with the utilization of natural substances and the creation of artificial ones (Ugwu & Etiubon, 2012). As a practical subject, chemistry requires teachers to employ various techniques in their lessons to enhance students' instructional gains, given its abstract nature (Nnoli, 2019). Therefore, chemistry teachers need to improvise materials to overcome problems such as the scarcity of standardized resources. In this regard, Owolabi and Oginni (2012) argue that the lack of funds or insufficient standard equipment should not serve as excuses for ineffective chemistry teaching.

The COVID-19 pandemic emerged worldwide in 2019, posing significant ethical challenges in areas such as resource allocation, priority-setting, physical and social distancing, public health surveillance, and the rights and obligations of healthcare workers to conduct clinical trials. These challenges also affect the education system (Richard, 2020). The complexities of the COVID-19 era are further compounded by diverse healthcare systems and unique cultural and socio-economic contexts across countries. Consequently, there is a pressing need for guidance to ensure ethical conduct in research, decision-making in clinical care, education, and public health policymaking at all levels of the global response to COVID-19.

In the context of education, improvisation refers to the act of utilizing alternative teaching materials and resources when there is a shortage or absence of the actual materials. It involves not only substituting unavailable materials but also ensuring that the improvised materials serve their intended purpose (Landu, 2015). Hadija (2018) describes improvisation as the creation of instructional materials from local resources, which are sometimes found within the school premises. The improvised materials should effectively convey the same instructional message as the original materials. According to Olagunju (2018), when teachers improvise, it prompts them to rethink and explore more cost-effective, efficient, and expedient methods to facilitate the learning process, benefiting both students and teachers. This demands greater resourcefulness and creativity from both science teachers and students. Examples of locally constructed improvised materials include first aid boxes, test-tube holders, tripod stands, test-tube racks, weighing balances, electric bells, and local torches.

Creativity plays a crucial role in improvisation, as it involves utilizing previous knowledge, experiences, and skills to generate new ideas or products. It is a vital skill in the process of improvisation (Kin, 2014). Creativity is also the ability to employ imagination to produce novel concepts or items. In chemistry practical work, standardized materials encompass equipment, reagents, and chemicals necessary for effective hands-on activities. Fasakin (2017) explains that standardized materials are manufactured by certified experts or personnel in the field and contain known concentrations of chemicals and instrument calibrations. Examples of such standardized materials used in this research include beakers, funnels, burettes, pipettes, starch solution, conical flasks, and more. These materials are typically acquired from the market and stored in the laboratory.

Statement of Problem

The challenging economic conditions resulting from the COVID-19 pandemic have rendered it nearly impossible for the government to adequately supply scientific equipment, chemicals, and facilities for meaningful hands-on activities in senior secondary schools. This poses a significant obstacle to effective teaching of practical chemistry. The availability of these materials and chemicals is crucial, although their cost is gradually increasing (Anele, 2020). As a result, the desired objectives of practical chemistry education in secondary schools become unattainable, leading to poor performance in this subject. Numerous issues contribute to this situation, including unqualified chemistry teachers, a lack of

laboratories or poorly equipped ones, and a scarcity of essential chemicals such as H2SO4, NaOH, and HCl, as well as the expensive nature of scientific equipment. These challenges hinder the successful implementation of chemistry practicals in secondary schools. To address these difficulties and achieve the objectives of chemistry teaching and learning, some teachers resort to improvising materials or encourage students to create their own teaching resources. This approach helps to make the abstract nature of chemistry more tangible, enhances creativity, and fosters a concrete understanding of the subject (Tafa, 2018). Against this backdrop, the researcher was motivated to investigate the impact of improvisation on student academic achievement and retention in re-engineering chemistry education for creativity during the COVID-19 era.

Purpose of the Study

Specifically, the study seeks to determine the following:

1. The impact of using improvised materials in teaching chemistry for students' achievement.
2. The extent to which the use of improvised materials will help students to retain knowledge gained in chemistry.
3. The gender difference on academic achievement of students that were taught chemistry with improvised materials.
4. The gender difference on the knowledge retention of students taught chemistry with improvised materials.

Research Questions

The following research questions were formulated to guide this study.

1. What are the mean achievement scores of students exposed to improvised materials and those exposed to standardized materials?
2. What are the mean retention score of students exposed to improvised materials and those exposed to standardized materials?
3. What are the mean achievement scores of male and female students exposed to improvised materials and those exposed to standardized materials?
4. What are the mean retention score of male and female students exposed to improvised materials and those exposed to standardized materials?

Hypotheses

The understated null hypotheses were tested at 0.05 level of significance.

1. There is no significant difference in the mean rating on achievement scores of students exposed to improvised materials and those exposed to standardized materials.
2. There is no significant difference in the mean rating on retention scores of students exposed to improvised materials and those exposed to standardized materials.
3. There is no significant difference in the mean rating on achievement scores of male and female students exposed to improvised materials and those exposed to standardized materials.
4. There is no significant difference in the mean rating on retention scores of male and female students exposed to improvised materials and those exposed to standardized materials.

Method

The research employed a quasi-experimental design with a non-randomized control group, using a pretest-posttest approach. The study took place in the Ogidi Education Zone of Anambra State. The target

population consisted of Senior Secondary School three (SS2) chemistry students from six government-owned co-education public secondary schools in the local government area. From these schools, four intact classes were randomly selected, totaling 160 SS2 chemistry students who participated in the study. Two of the intact classes were assigned to the experimental group, while the remaining two intact classes formed the control group.

Data collection was conducted using a Chemistry Practical Achievement Test (CPAT), which also served as a knowledge retention test. The chemistry teachers in the experimental schools underwent a one-week training program. They were provided with improvised materials for teaching the experimental group, while the control groups were taught using the standardized lecture method by their regular teachers. Both the experimental and control groups followed detailed lesson plans with identical instructional objectives, materials, content, and teaching methods.

The topics covered during the study included alkanols (ethanol), esterification reaction, fats and oils (lipids), and the extraction of Trioxonitrate v acid (HNO3). Prior to commencing the experiment, a pretest was administered to both the experimental and control groups. After six weeks of teaching, three days were allocated for revision, and the CPAT items were rearranged to appear different from the pretest. These items were given to the students as a post-test. Three weeks after the post-test, the CPAT was rearranged again and administered as a retention test. The research questions were analyzed using mean and standard deviation, while the hypotheses were tested using a z-test at a significance level of 0.05.

Research Question 1: What are the mean academic achievement scores of students taught chemistry using improvised materials and those taught with standardized materials?

Table 1: *Mean and Standard Deviation of Students' Achievement Scores by Methods*.

Groups	**Number of students**	**Mean pre-test ($\bar{x}$)**	**S.D**	**Mean ($\bar{x}$) post-test**	**S.D**	**$\bar{X}$ diff**
Experimental (improvised)	80	11.81	3.44	26.13	3.47	14.32
Control (standardized)	80	16.06	4.39	20.41	4.39	4.45

In table 1, the experimental groups which were taught using improvised materials had a post mean score of 26.13 with standard deviation of 3.47. The mean post achievement score of the experimental group is higher than the control group.

Research Question 2: What are the mean retention scores of students taught chemistry using improvised materials and those taught with standardized materials?

Table 2: *Mean and Standard Deviation of Students' Retention Scores by Methods*.

Groups	**Number of students**	**Mean ($\bar{x}$)**	**S.D**
Experimental (Improvised)	80	27.53	3.96
Control (Standardized)	80	23.11	3.14

In table 2, the retention scores of students in experimental and control group are 17.53 and10.03 with standard deviation (SD) of 3.96 and 3.14 respectively. Therefore, the experimental group performed better than the control group.

Research Question 3: What are the mean academic achievement scores of male and female students taught chemistry using improvised materials to standardized materials?

Table 3: *Mean and Standard Deviation of Achievement Scores on Improvised Due to Gender*.

Groups (Experimental)	**No of students**	**Mean (x) pre-test**	**S.D**	**Mean (x) post-test**	**S.D**	**($\bar{x}$) Diff.**
Females	47	9.90	3.15	29.28	5.41	19.38
Males	33	7.81	2.79	22.89	4.78	15.08

Table 3 showed that female students had a higher post mean achievement score of 29.28 with SD of 5.41 more better than the male counterpart.

Research Question 4: What is the mean retention score of male and female students taught chemistry using improvised materials to standardized materials?

Table 4: *Mean and Standard Deviation of Retention Scores on Improvised Due to Gender*.

Groups (Experimental)	**Number of students**	**Mean ($\bar{x}$)**	**S.D**
Males	33	61.43	8.50
Females	47	60.99	9.21

In Table 4, males had a higher post mean retention score of 61.43 with SD of 8.50 than the females who had a mean score of 60.99 with SD of 9.21.

Hypothesis 1

There is no significant difference in the mean achievement scores of students taught chemistry using improvised materials and those taught using standardized materials.

Table 5: *Z-test Mean Differences of the Two Groups Experimental and Control on Post Achievement*.

Groups	**No of subjects**	**Mean ($\bar{x}$)**	**S.D**	**Df**	**z-cal**	**z-crit**
Experimental (improvised)	80	26.13	3.47			
				158	2.17	1.960
Control (standardized)	80	20.41	4.39			

In table 5, Improvised had a significant impact on students' achievement in chemistry in favor of the experimental group. The calculated z-value (z-cal) is 2.17 against the table value (z-critical) which is 1.960 at 2 and 158 degree of freedom at 0.05 level of significance.

Hypothesis 2

There is no significant difference in the mean retention scores of students taught chemistry using improvised materials and those taught using standardized materials.

Table 6: *Z-test Mean Differences of the Two Groups Experimental and Control on Retention*.

Groups	**No of subjects**	**Mean ($\bar{x}$)**	**S.D**	**Df**	**Z-cal**	**Z-crit.**
Experimental (improvised)	80	27.53	3.96			
				158	4.66	1.960
Control (standardized)	80	23.11	3.14			

In table 6, Improvised had a significant impact on students' knowledge retention in chemistry in favour of the experimental group. The calculated z-value (z-cal) is 4.66 against the table value (z-critical) which is 1.960 at 2 and 158 degree of freedom at 0.05 level of significance.

Hypothesis 3

There is no significant difference in the mean achievement scores of male and female students taught chemistry using improvised materials and those exposed to standardized materials

Table 7: *Z-test Mean Differences on Experimental CPAT Due to Gender*.

Groups	No of subjects	Mean ($\bar{x}$)	S.D	Df	z-cal	z-crit
Females	47	29.28	5.41	78	1.52	1.960
Males	33	22.89	4.78			

In table 7, the interaction difference between improvisation and chemistry achievement test due to gender is 1.52 against the z-critical or table value of 1.960 at 2 and 78 degree of freedom at 0.05 level of significant. Hence, there is no significant difference on students' achievement in chemistry due to gender. This implies both subjects achieved equally, since z-calculated is less than the z-critical or table value.

Hypothesis 4

There is no significant difference in the mean retention scores of male and female students taught chemistry using improvised materials to standardized materials.

Table 8: *Z-test Mean Differences on the Experimental group CPAT Due to Gender*.

Groups	No of subjects	Mean ($\bar{x}$)	S.D	Df	Z-cal	Z-crit
Males	33	61.43	8.50	78	0.045	1.960
Females	47	60.99	9.21			

In table 8, the effect between teaching method and knowledge retention in chemistry test due to gender is 0.045 against the z-critical or table value of 1.960 at 2 and degree of freedom 78 at 0.05 level of significant. Hence, there is no significant difference on students' knowledge retention in chemistry due to gender. This implies both of them retained equally, since z-calculated is less than the z-critical or table value.

Discussion

The results of the research indicated that students who were taught using improvised materials demonstrated better achievement and retention compared to those taught using standardized materials. These findings offer valuable insights into the impact of improvised materials on students' academic performance and ability to retain knowledge during the current covid-19 era. The use of improvised materials has proven beneficial in enhancing the creativity of chemistry students, particularly in the face of the social and economic challenges experienced in learning during the covid-19 era (Islam, 2020). This suggests that active engagement of students in utilizing improvised materials during this time has facilitated effective learning, fostered creativity, and reduced the abstract nature of chemistry (Nnoli, 2021).

Conclusion

The results demonstrated the superiority of improvised materials compared to standardized materials. Although female chemistry students achieved higher mean scores than males, males had higher mean retention scores than females. The experimental group exhibited higher mean post-achievement scores

compared to the control group. Similarly, students exposed to improvised materials achieved higher mean retention scores than the control group. Female students outperformed their male counterparts in post-achievement scores, while males had higher post-retention scores than females. The use of improvised materials had a significant positive impact on students' achievement in chemistry, favoring the experimental group. The tested hypotheses indicated no significant differences between males and females in the utilization of improvised materials during the covid-19 era, as evidenced by the mean achievement and retention scores. The mean post-achievement score of the experimental group exceeded that of the control group, and the mean retention scores of students exposed to improvised materials were higher compared to the control group.

Recommendations

The study's findings led to the following recommendations:

1. Those responsible for designing the curriculum and authors of chemistry textbooks should incorporate the use of improvised teaching materials into the chemistry curriculum and textbooks, particularly during and after the covid-19 era.
2. Chemistry teachers should not solely rely on pre-made materials but should acquire the skills to improvise materials for effective teaching during and beyond the covid-19 era, ensuring academic achievement and retention.
3. Teachers should encourage students to actively participate in sourcing instructional materials from their environment, as this fosters creativity and enhances their process skills.
4. Science educators and stakeholders should organize seminars, workshops, and in-service training sessions for teachers on the utilization of improvised instructional materials in the current covid-19 era. Both teachers and students should learn how to improvise materials to enhance academic achievement and retention.
5. Emphasize the importance of continuous professional development for science teachers to keep them updated on the latest educational developments and to refine their teaching practices with a focus on skill development.
6. The international ethics community should collaborate to address the ethical implications of the covid-19 pandemic on science, technology, and mathematics (STM) education systems.
7. The Global Health Ethics team should work towards strengthening the educational environment, promoting communication, collaboration, and cooperation in these endeavors.

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Conflict of Interest

Authors have no conflict of interest.

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