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Effect of Lecture-Enriched Wait-Time on the Performance of Average and High Ability SSII Chemistry Students in Mole Concept

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Abstract

This study investigated the effects of lecture-enriched wait-time on the performance of average- and high-ability SSII Chemistry Students in mole concept. A quasi-experimental design was used. The population comprised all the SSII chemistry students from senior secondary schools in Minna, Niger State, Nigeria. A sample of 50 students was randomly selected from two coeducational schools. The participants were taught the mole concept using lecture-enriched wait-time. A validated Instrument called the Mole Concept Performance Test (MCPT) with a reliability coefficient of 0.73 was used in collecting data. One research question and one null hypothesis were formulated to guide the study. Inferential statistics were used to test the null hypotheses at a 0.05 level of significance. Findings revealed no significant difference between the average and high ability students. The researcher thus concluded that lecture-enriched wait-time was found to help change chemistry students' performance. Therefore, it was recommended that senior secondary school chemistry teachers use lecture-enriched wait-time to improve students' performance in chemistry at different ability levels.

Keywords: Science Education, Chemistry, Wait-time, Performance, Average Ability, High Ability.

Introduction

Science is an important subject in the technological development of any nation. Any nation's scientific and technological attainment depends on the science education of its citizenry (Ochu, 2010). In the same vein, Suleiman (2007); Gongden et al (2011) opined that the scientific development of any nation is enhanced by the quality of science education in its schools. Science educators and concerned Nigerians have been expressing concern over the perennial problems in the teaching and learning of science in secondary schools. This is

because of the importance of science in the development of any nation (Daso, 2013; Sabo, 2017).

Chemistry is central to science education. It is a prerequisite for studying agriculture, medicine, engineering, and technology. It is a subject that deals with composition, properties, and uses of matter (Ababio, 2005). Chemistry is fundamental in investigating substances' basic properties in the physical universe. Abbas (2007) viewed chemistry as one of the fundamental ingredients of technology. Therefore, there is a need for the proper dissemination of chemistry in senior secondary schools. According to Nwosu (2004), the study of the chemical structure of matter has revolutionized technology, especially in the manufacturing industry. Despite the importance of chemistry, it is currently facing several problems. According to West Africa Examination Council (WAEC, 2017-2021) Examiners report, some problems include low enrollment and poor performance of secondary school students. Ayuba (2014) observed that the results of chemistry students are not only getting worse, but the students are also progressively becoming unscientific in their thoughts and approaches to problem-solving. Among the reasons for these problems are teachers' inability to put chemistry ideas across to students and the wrong perception of students that chemistry is complex (Gongden et al., 2011). Some of the reasons why students perceive chemistry as difficult include (Sani, 2011): It is abstract and theoretical nature. One of the learners' factors that generally affect meaningful learning in chemistry is students' misconception of chemistry concepts (Sani, 2006). The increasing need to improve students' performance in science at secondary school (chemistry inclusive) has influenced science education researchers. to now focus on learners' factors that affect conceptual understanding of science concepts as well as the development of a teaching technique that enhances meaningful learning in the classrooms situation (Sani, 2006). According to Adamu (2021), the poor teaching method is the genesis of students' poor academic performance in science. At the same time, Olajide and Adeoye (2010) recommended that a wait time of 3-5 seconds should be allowed for students to respond to a particular question or problem because it is a necessary skill required by teachers of science education in developing effective teaching and learning in classrooms.

Wait-time is when a teacher waits after a question is asked before calling on a student to rephrase a question or supply the answer (Baba, 2018). It is the length of pause preceding any teacher's utterance. This accordingly provides the teacher with direct control over relevant pause(s) within the course of the lesson, it is a variable which could be used to determine the quality and quantity of learners' discourse that occur in a science lesson. Even when the teacher has mastered the skills of controlling the pauses and is teaching a highly receptive class, the teacher's lesson may result in little or no learning if he or she fails to use wait-time properly. Olajide and Adeoye (2010) opined that there are two types of wait time: wait-time I and II. Wait-time I Is the time the teacher waits (5sec) after a question for the student's response. When a question is asked, there is always a time lag before a response is made. According to Iksan and Daniel (2016), Wait-time II is seen as the time a teacher waits (3secs) before commenting or calling on another student following the first student's response to the question asked by the teacher, which is 3secs. The variable of wait-time in learning science is significant in teaching. Rowe in Baba (2018) stated that effective learning could not occur in a science class if it is not used correctly. This is because, according to Olajide (2012), students need a period of "private thought", which helps them put ideas together

during science lessons. Furthermore, the issue of ability level significantly influences students' performance (Anaso, 2008). Therefore, this study investigated the effectiveness of extended wait-time on the performance of average and high ability level SSII chemistry students.

In the Nigerian education system, classrooms are composed of students of different learning ability levels-high, medium and low. In order words, students of different mental abilities are mixed in classrooms. Anaso (2008) asserted that they are communicated to, given the same assignments and are required and indeed expected to do the same work. Anaso (2008) regarded ability level as a pivotal issue in studies conceptualized as between versus within class-grouping ability level is separated into within-class referred to as comprehensive and between class-level patterns. With this type of grouping, the results become specific and valuable. Baines et al (2001) leaned support for grouping by ability levels. However, Allani (2005) viewed that there are potential disadvantages to ability level; children perform better when in high ability groups (mixed ability). As further stressed by Allani (2005), students are challenged and motivated to meet the average achievement of the higher ability level. Little literature appears to have been reported that examined the use of wait-time and its impact on the academic performance of students of different ability levels. The index for categorizing students in this study is based on ability levels using SSS students' average means scores of their examination results, as recommended by (Anaso, 2008). Those with < 50% were grouped as low achievers (LA), those between 50% and 60% as average achievers (AA), and >61% as high achievers (HA). Hence, high and average achievers are considered in this study.

Statement of the Problem

Despite the relevance of chemistry as a prerequisite for studying medicine, agriculture, engineering and technology, students have consistent problems with chemistry (Ihuarulam, 2012). Sani (2006) and (Ihuarulam, 2012) recommended the need to solve this problem of students' poor performance. As a result, students' performance in the West African Examination Council (WAEC) in chemistry over the years has not been commendable. Table 1 represents the performance of chemistry students in WAEC from 2017-202.

Table 1
Students Performance Trends in (WAEC) Results of Chemistry 2017-2021

Year	Students that sat for the exam	No. of Students pass with (A1-C6)	% of Students that Pass (A1-C6)	Students that Failed (D7-F9)	% of Students that Failed (D7-F9)
2017	4321	1606	37.17%	2715	62.83%
2018	4669	2113	45.26%	2556	54.74%
2019	5176	2198	42.47%	2978	57.53%
2020	7913	2453	31.68%	3132	69.32%
2021	8666	2513	43.53%	2943	56.47%

The result in Table 1 revealed students' dwindling performance in the previous years. According to Adamu (2021), students' poor performance in science could be attributed to the persistent use of the teacher-centered teaching method. Adeyemo (2010); Olajide (2012) opined that the wait-time given to students before responding to a question influences their performance. Therefore, using an alternative teaching strategy cannot be over-emphasized

in redressing this situation and enabling students to perform better in chemistry. Bysen and Bysen (2010); Olajide (2012); Iksan and Daniel (2016); Sabo (2017) advocated for the use of wait time as a strategy for effective teaching and better performance. In the same dimension, different ability levels might influence students' performance. However, very little work was done on the impact of wait-time on ability level. Against this background, this study seeks to see if lecture-enriched wait-time will improve the performance of low-ability and average-ability students in chemistry.

Objective of the Study

The objective of this study is to investigate the effect of lecture-enriched wait-time on academic performance high and average ability of SSII chemistry students' in mole concept.

Research Question

The study sought to answer the following question: What is the difference between the mean academic performance scores of high and average ability SSII chemistry students taught mole concepts using lecture-enriched wait-time?

Study Hypothesis

The null hypothesis is set to be tested at a 0.05 level of significance:

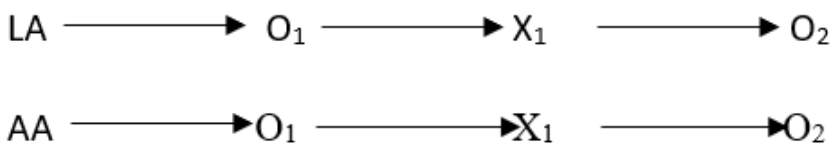
H_O: There is no significant difference between the mean academic performance scores of high and average ability SSII chemistry students taught mole concepts using lecture-enriched wait-time.

Significance of the Study

This study will hopefully give an insight into the effectiveness of lecture-enriched wait-time on the academic performance of SSII chemistry students' in Minna, Niger State, Nigeria. The study reveals how lecture-enriched wait-time will benefit chemistry teachers and students. It also highlights benefits for parents, curriculum planners, educational administrators, and Non-Governmental Organizations (NGOs), among others, in teaching and learning science subjects at all levels of education, the challenges encountered, the progress and how to improve the teaching and learning in science education.

Methodology

This study adopted a pretest, posttest quasi-experimental design as proposed by Kerlinger (1973). The subjects were pretested to determine their ability level. The participants were taught using lecture-enriched with wait-time. After treatment, a posttest was administered to the Subjects to determine the effect of the use of wait-time with the lecture method. The design of the study is illustrated in Figure 1.



Key: HA = High Ability; AA = Average Ability; X_1 = Treatment; O_1 = Pretest; O_2 = Posttest

Figure 1: Research Design

The population for the study comprised all public senior secondary two (SSII) students in Minna Metropolis of Niger State. The schools comprise coeducational and single-sex schools. Twenty-five of the schools were stating government-owned. The average age of the students in the population was 16 years.

Purposive and Simple Random Sampling Techniques were used in the study. Coeducational schools were purposely selected from the population due to gender involvement in the study. Four schools were randomly selected in the zone for participation. A general Chemistry Performance Test (CPT) was administered to SSII chemistry students in each of the four schools selected from the zone to determine their equivalence in terms of academic performance. This was achieved by subjecting the students' scores to the Analysis of Variance (ANOVA) and Scheffer post hoc test. ANOVA was used to determine any significant difference in the selected schools, while the Scheffes Post Hoc test was used to separate the schools and determine which schools were significantly or not significantly different. Two schools were found to be relatively similar statistically.

The status of the schools was then determined by simple coin tossing. As a result of this exercise, one school became the experimental school, and the other became the control school. A sample of 50 male and female students from the two coeducational sampled schools was chosen. This is in line with Usman (2010), who suggested that the sample of 50 was in line with the Central Limit Theorem (CLT), which recommended a minimum of 30 subjects as an adequate sample size. The experimental group was also labeled "School A", while the control school was labeled “School B". Because of the large number of students in the sample schools, one Arm was randomly selected and used from each of the selected schools. Table 2 represents the sample for the study.

Categorization into Ability Groups

Subjects in this study were categorized into high ability and low ability levels based on using average mean scores of SSI chemistry examination results. The average mean scores of the results were calculated: The average ability students were categorized to be those with fifty-sixty (50%-60%) percent as average achievers (AA), while those with sixty-one and(>61%) above as high achievers (HA) were categorized as high ability students based on the recommendation of Allani (2005), and Anaso (2010). Table 2 represents the sample of the study.

Table 2
Sample of the Study

S/n	School Name	Average Achiever	High Achiever	Total
1	School A	12	13	26
2	School B	12	13	25
Total		**24**	**26**	**50**

The Mole Concept Performance Test (MCPT) was used for data collection. The MCPT Consist of 40 multiple choice items with four options (A-D). Three are distracters, while the other is the correct option. Each item in the MCPT carries one (1) mark; 40 marks were awarded. MCPT was adapted from West African Examination Council by the researcher to determine the Academic Performance of Students in chemistry. The instrument was validated

by a panel of experts from science education to: Check the clarity of the statement, Check whether the time allocated to the instrument was sufficient., Check the Content of the test item if it is appropriate to the study's objectives. Verify if the language used is at the same level as the study's participants' ability level. Their comments, correction, suggestion, and recommendation regarding the face and content validity of the test item were noted and helped produce the instrument's final version.

The instrument was pilot-tested in one of the schools that is part of the population but not among the study sample to determine its reliability. Moreover, the reliability was found to be 0.73, which is fit for the study based on the recommendation of Olayiwola (2010), who recommended that the closer the reliability is to 1, the more reliable it is and the closer the reliability is to 0 the more unreliable its. The participants with different learning abilities were identified and were taught using the following steps:

Step 1: Introduce the target concept to be learned.
Step 2: Wait time is used in this situation; when the teacher asks a question, a pause period of five sec. is before a student or the teacher is allowed to speak. It is to allow certain cognitive processes to occur, especially in students.
Step 3: Wait time II. It is further used after the last student speaks or asks a question, as the teacher waits three (3) seconds before he comments or allows another student to speak.
Step 4: In conclusion, questions were asked by both the teacher and students on concepts and the waiting period (pause) of 5 and 3 seconds were used accordingly.

Accordingly, after treatment, a posttest was given, and the data collected were recorded for analysis.

Results

The study's main objective is to investigate lecture-enriched wait-time on academic performance of high and average ability SSII chemistry students in Minna, Niger State, Nigeria. The data collected were answered and analyzed using descriptive statistics and inferential statistics using the Statistical Package for Social Science (SPSS). The significance level adopted for rejecting or retaining the stated hypothesis was set at 0.05. The results obtained are presented as follows.

Research Question: What is the difference between the mean academic performance scores of low and average ability SSII chemistry students taught mole concepts using lecture-enriched wait-time? To answer this research question, the data generated via Mole Concept Performance Test (MCPT) were subjected to descriptive statistics of mean and standard deviation and the summary of the result is presented in Table 3:

Table 3
Mean and Standard Deviation of Students' Performance Scores in the Experimental and Control Groups.

Factor	Ability Level	*n*	Mean	Std. Dev.	Mean Dev.
Mean	Average	24	45.5	7.60	2.0
Performance	High	26	47.5	8.54	

From the descriptive statistics in Table 3, among the different ability groups, the mean performance score for average ability students was 45.5 and a standard deviation of 7.60, while the mean performance score for their counterparts in the low ability group was 47.5 and a standard deviation of 8.54 with the mean difference of 2.0 respectively. This indicates a relative difference in the mean performance scores of average-ability and high-ability students when taught using lecture-enriched wait-time.

Null Hypothesis: The null hypothesis is set to be tested at a 0.05 level of significance:

H_O: There is no significant difference between the mean academic performance of high and average ability SSII chemistry students taught mole concepts using lecture-enriched wait-time.

The data generated via Mole Concept Performance Test (MCPT) were subjected to independent sample t-test statistics. The results obtained were computed and used to draw Table 4.

Table 4
Summary of t-test on the difference between the Mean Performance Scores for Experimental and Control Groups

Variable	Ability Level	n	Mean	SD	MD	*df*	t-cri.	t-cal.	p-value	Remarks
Mean Performance	Average	24	45.5	7.60	2.0	48	1.96	1.26	0.08	Not Supported
	High	26	47.5	8.54						

Significant at $p \leq 0.05$.

The independent t-test statistics in Table 4 show no significant difference between the mean Academic Performance scores of average and high-ability students. The reasons are that the t-critical of 1.96 is greater than the T-calculated of 1.26 and the P-value of 0.08 is greater than the adopted 0.05 alpha level of significance at the degree of freedom (df) 48. This confirmed that there is no significant difference between the groups. This is a result of the treatment lecture-enriched wait-time on students in the experimental group. Therefore, the null hypothesis is that there is no significant difference between the mean academic performance of average and high ability SSII chemistry students taught mole concepts using lecture-enriched wait-time.

Discussion of Findings

The result in Table 4 shows no significant differences between the performance scores of average and low ability students when exposed to lectures with wait-time. The null hypothesis was therefore retained. This showed that using the lecture method with wait-time positively affected the academic performance of both average and high-ability students in chemistry. This is because wait-time allows the students to reflect upon the length made by the teacher and is essential to students thinking (Albergarria, 2010). The length and the quality of students' answers depend on the length of time given to them by the teacher after asking the questions. This is because the wait-time enhanced the students' thinking skills in the verbal questioning process (Iksan & Daniel, 2016). The quality of answers given by students was better because wait-time gave them time to think and reflect on the question raised before answering. The result of this study is in agreement with the findings of (Ejilo,

2002; Nja and Aroha, 2013; Danjuma, 2014). Who reported that average-ability and high-ability students perform equally in chemistry.

Conclusion

Under a wide variety of instructional situations and levels ranging from the primary through university, classrooms, the quality of discourse can be markedly improved using wait-time. Wait-time used by teachers after a question and after responses, during those pauses which are ordinary so brief, allowed an adequate exchange of ideas and nurturing of new ideas. By allowing teacher-student verbal interaction, wait-time plays a significant role in improving the academic performance of students at different ability levels. Wait time has a significant influence on students' academic performance.

Recommendation

It is recommended that chemistry teachers should use wait time when teaching chemistry concepts. In the classroom, interaction wait-time is used in such a way that it can maximize learners' involvement in cognitive learning. Several other types of research are carried. The use of a wait-time instructional strategy should be encouraged.

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