INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN PROGRESSIVE EDUCATION & DEVELOPMENT

OPEN ACCESS JOURNAL

Vol 13, Issue 2, (2024) E-ISSN: 2226-6348

Effect of Wait Time on Academic Performance of Secondary School Students in Chemistry in Niger State, Nigeria

Baba Haruna[1,2*], Corrienna Abdul Talib[1], Adedayo Taofeek Quadri[3]

[1]School of Education, Universiti Teknologi Malaysia, Malaysia, [2]Niger State College of Education, Nigeria, [3]Ogun State Universal Basic Education Board, Abeokuta, Nigeria

To Link this Article: http://dx.doi.org/10.6007/IJARPED/v13-i2/21326 DOI:10.6007/IJARPED/v13-i2/21326

Published Online: 15 May 2024

Abstract

In chemistry instruction, asking questions and following them with an appropriate wait time is an important component of teaching chemistry. Using wait time by teachers can help improve students' academic performance in chemistry. This study was carried out to investigate the effect of wait time on the academic performance of secondary school students in chemistry in Niger State, Nigeria. The study investigated: i. the effect of wait time on secondary school students' performance in chemistry; ii. the effect of gender on the academic performance of secondary school students in chemistry, and iii. the interaction effect of wait time and gender on academic performance of secondary school students in Chemistry. The study was a quasi-experimental design involving pre-test and post-test research design. The study used two groups; experimental and control. The experimental group (EG) is exposed to experimental treatment (X_1). That is, teaching using the wait time instructional technique. While the control group (CG) is taught using a conventional teaching method (X_0). Three research questions were answered in the study. The study's findings indicated differences in the mean score performance for the experimental group and those in the control group (Experimental group, Mean=18.60, SD=3.46; Control group, Mean=11.73, SD=1.94). These implied that the experimental group performed better than the control group with a difference of 6.87, gender does not influence the performance of the students after using a one-way ANOVA to see the group with favoured performance, it was established that the p-value is greater than the 0.05 which indicated an insignificant difference in the students' performance based on gender and no significant interaction effect of wait time and gender on academic achievement of the secondary school students. It was recommended, among others, that similar studies are suggested to be conducted on other difficult concepts in senior secondary school chemistry as well as some other science subjects like Physics and Mathematics. Also, it is recommended that some other variables like recall, awareness and acceptability of the wait time strategy could be researched in future studies for more robust findings.

Introduction

Chemistry is one of the sciences that has significantly influenced society. It helps students prepare for the real world of work by providing them with career options in disciplines such as medicine, pharmacy, chemical engineering, food science, and environmental studies (Wahyudiati, 2022). The importance of chemistry in our daily lives, in our country, and in businesses are unwavering. This is more obvious when we realise that our daily actions frequently include chemistry. However, despite the importance of chemistry as a science that provides the foundation for many other disciplines, the performance of Nigerian secondary school students in the subject has long been a cause of serious concern (Omwirhiren, 2015).

Chemistry is perceived as a difficult topic and many students have misconceptions regarding terms like electrolysis, redox reaction, acid and base, state of matter, and organic molecules (Borich, 2014). This has been linked to various factors, including the students' attitudes and teachers' teaching methods. For instance, Dallimore, Hertenstein and Platt (2017) discovered that inefficient teaching methods and teaching tools, along with students' negative attitudes toward studying and chemistry, are to blame for students' poor performance in chemistry. According to Dave-Ugwu (2018), various studies have been conducted on secondary school students' learning achievement in chemistry, with results showing abysmal performance and students showing little interest in the subject. This has been linked to a variety of reasons.

However, scholars such as Omwirhiren (2015) observed that the teaching method remains a crucial factor in promoting students' interest in chemistry learning in secondary schools. Given this, some methods have been suggested that may help to promote students' interest in chemistry, thereby enhancing their performance. Bearing this in mind, one important technique that has been advocated by scholars is wait time. As opined by Borich (2014), wait time refers to the period of time a teacher stops after answering a student's question. It typically starts when a teacher pauses and ends, and when the teacher invites a student to answer and the student speaks. It is hoped that the central goal of teaching chemistry will be achieved through this technique.

As a concept, wait time is defined as the period of silence which comes after the teacher has asked a question before calling on a student or a student has answered the question before the teacher makes comment (Iksan & Daniel, 2015). A question, when asked and followed by an appropriate wait time, forms an important component in chemistry instruction. Wait time was defined as the amount of time that a teacher has to wait after a question is asked before calling on a student, repeating the question, rephrasing the question, or supplying the answer. It will be discovered that, the quality of a classroom discourse be very much related to the duration of pauses separating the teacher's question and student's response.

There are two types of wait time (Rowe, 1974 cited in Sabo, 2017); wait time I and wait time II. Wait time 1 is defined as the length of time that a teacher pauses after a question. It normally begins when a teacher stops speaking and terminates when a teacher calls on a student to respond or the teacher begins to speak again. The sequence is as follows: The teacher asks a question, pauses, calls a student and pauses until the student finishes talking. These two instances constitute an instance of the first wait time. It is calculated by measuring the period from which a teacher stops asking a question to when a student begins to respond to the question. Wait time II is defined as the time a teacher waits after a pupil's response to either comment or asks another question. It is calculated by measuring the period from which a student stops responding to a question to when the teacher speaks again to either accept or reject the answer. These two wait times (I & II) appear to be critical variables in determining

the ability of students and interactions that go on in the classroom, as reported by (Goma *et al.*, 2021).

Owing to the relevance of questioning and wait time in chemistry instruction, many empirical studies on wait time have been conducted, as cited in the study by Abiam and Odok (2021), which investigated the questioning patterns of science teachers in secondary schools in Nigeria. The purpose of the study was to find out the number of questions, the types of questions, and the amount of time teachers wait for a response to their questions. The outcomes of the research were: There was very little variation between chemistry and physics teachers' questions; the number of questions varies among teachers, but the types of questions do not; very few higher-level questions were asked, but physics teachers asked more memory and classroom routine questions than any other types; chemistry teachers do not wait long for their questions to be answered. Chemistry teachers generally have a longer wait time (approximately 2.7 seconds) than physics teachers, who have approximately 2.0 seconds; none of the teachers had an average wait time of less than one second, which according to Rowe (1974) in Gilliam *et al* (2018) was the average wait time for science teachers in the United States of America. On the other hand, none of the teachers attained the wait time of 5 seconds; teachers with longer years of teaching experiences tended to have longer wait time; the two trained teachers (that is teachers with Bachelor of Education degree) had a better distribution of questions. In a study to find out how much time college teachers provide for their students when a question is asked for the first time Sabo (2017), it revealed that when students gave wrong answers when wait time was under three seconds, the teacher rewords the question because it was believed that the first question was not clear. It turned out that the wait time allowed for the second question was not the same as the first one. Sabo (2017) concluded that it was difficult to retrain teachers who had taught for as little as 4 to 5 years on the use of wait time. Another study was conducted by Iksan and Daniel (2015) in Malaysia. The objective of the research was to find out what kinds of wait times occurred during spoken inquiry in science classes. The study was carried out, in particular, to reveal the verbal questioning strategies used by three (3) chemistry teachers during their wait time practices when teaching chemistry in the classroom. Phase I of wait time type I occurred between teachers' questions and reactions, while phase II happened between teachers' actions and students' responses, according to the study's findings. Both phases had durations that were fairly extended. Due to the students lack of cooperation, it was discovered that teachers were reluctant to provide wait time; instead, they would typically just answer the questions.

Methodology

Pre-test, Post-test quasi-experimental research design was the methodology employed for the present study. The experimental and control groups were employed in the investigation. The group receiving experimental treatment (X1) is known as the experimental group (EG). That is, teaching with the wait time method. On the other hand, the control group (CG) is a group that is instructed using the conventional approach (X0). The research design layout for the quasi-experimental design is presented in Table 3.1

Research Design Layout

Group	Pre-test	Treatment	Post-test	Post Post-test
EG	O_1	X_1	O_2	O_3
CG	O_1	X_0	O_2	

EG = Experimental Group, **CG** = Control Group, $\mathbf{X_1}$ = Treatment, $\mathbf{X_0}$ = No Treatment,
$\mathbf{O_1}$ = Pre-test, $\mathbf{O_2}$ = Post-test, $\mathbf{O_3}$ = Post post-test

The population for this study comprises all the secondary school II students of Niger State, Nigeria. There are three zones in Niger State of which only zone B was purposively sampled. Two equivalent schools that were ready to allow their students to take part in the study were involved in this study. Two intact classes each from each school were involved in the study. The first school served as experimental group while the second one served as the control group.

The total sample for the study consisted of 35 Secondary School II Chemistry students. Twenty of the students formed the experimental group while fifteen were found in the control group. The group of students consist of 9 males and 26 females. For the purpose of this study, the research instruments were designed as stated below:

1. Wait time Instructional Technique which is the treatment instrument for the experimental group.
2. Chemistry Students' Performance Test (CSPT) consisting of 30 multiple-choice questions was used as Pre-test and Post-test.

Results and Findings

Research Question 1: What are the effects of wait time on secondary school students' performance in chemistry?

The research question 1 result to hypothesis 1: There is no significant difference between the performance mean scores of students taught chemistry using wait time and those taught using conventional method. This was tested using one-way ANCOVA to confirm the finding from the research question1. Table 1 reveals the analysis of the respondents' performance in the pre-test and the post-test of CSPT in terms of their mean scores.

Table 1
Pre-test and Post-test Scores for the Experimental and Control Group

Group	**Pre-test**	**Post-test**
EXP. Mean	7.80	18.60
N	20	20
Std. Deviation	3.254	3.455
CONT. Mean	10.13	11.73
N	15	15
Std. Deviation	5.566	1.944
Total Mean	8.80	15.66
N	35	35
Std. Deviation	4.477	4.485

It can be observed from Table 1 that the mean score of the respondents in the experimental group and the control group are not far apart in term of performance before the introduction of the intervention, (Experimental, Mean =7.80, SD=3.25; Control, Mean=10.13, SD=5.56), the difference in their performance is 2.3 which is not much, that is they are almost of the same performance before their learning of chemistry using wait time by the experimental group and traditional method by the control group. However, the post-test scores revealed that there is a difference between the performance of the respondents in the experimental group and those in the control group (Experimental group, Mean =18.60, SD=3.46; Control group, Mean=11.73, SD=1.94). this shows that the experimental group performed better than the control group, with a difference of 6.87. The hypothesis was tested further to confirm whether the difference is statistically significant by using one-way ANCOVA.

Table 2
ANCOVA of Effect of Wait Time on Students' Performance in Chemistry
Dependent Variable: Post-test

Source	**Type III Sum** of Squares	Df	Mean Square	F	Sig.	**Partial Eta** Squared
Corrected Model	404.341[a]	2	202.170	23.143 .000	.000	.591
Intercept	1446.560	1	1446.560	165.590	.000	.838
Pretest	.188	1	.188	.022	.884	.001
Group	380.900	1	380.900	43.602	.000	.577
Error	279.545	32	8.736			
Total	9264.000	35				
Corrected Total	683.886	34				

a. R Squared = .591 (Adjusted R Squared = .566)

It can be deduced from Table 2 that the p-value is less than 0.05 which shows that there is statistically significant difference between the experimental group and the control group. The difference is in favour of the experimental group which has higher mean value of 18.60 as revealed in Table 1. This means that the wait time has effect on the students' performance in chemistry. It means the null hypothesis1 There is no significant difference between the performance mean scores of students taught chemistry using of wait time and those taught using conventional method is rejected and the alternative hypothesis that there is significant

difference between the performance mean scores of students taught chemistry using of wait time and those taught using conventional method is uphold which is ascertained statistically that it is in favour of the experimental group taught using wait time. Based on the analysis carried out on the effects of wait time on academic performance of the students in chemistry using one-way ANCOVA, finding revealed that students in the experimental group taught using wait time performed better than those in the control group taught with the traditional method. This means that wait time is effective for teaching difficult concepts in chemistry such as organic chemistry.

Research Question 2: What is the effect of gender on academic performance of secondary school students in chemistry?

Research Question 2 results to Hypothesis 2: there is no significant difference in the academic performance of the respondents based on gender.

Table 3 is the result of the findings of the respondents' pre-test and post-test mean scores based on their gender.

Table 3

Pre-test and Post-test Scores for Male and Female Respondents

Gender	Pretest	Posttest
1 Mean	10.67	13.56
N	9	9
Std. Deviation	4.950	3.609
2 Mean	8.15	16.38
N	26	26
Std. Deviation	4.21	4.588
Total Mean	8.80	15.66
N	35	35
Std. Deviation	4.477	4.485

It is revealed from Table 3 that there is no much difference in the performance of both male and female respondents in the CSPT, the difference in the mean score amounts to 2.52 which is not much and as a result it can be said that they are of comparable performance in CSPT. Thus, their entry performance in term of gender is not too far apart. This is according to their mean score (Male, Mean=10.67, SD=4.95; Female, Mean=8.15, SD=4.21). This means that before their exposure to wait time and traditional method of teaching both the males and the females' respondents' performance are closed.

Likewise, as seen in Table 3, the post-test scores of the two categories of respondents are almost the same, meaning that there is no much difference in the performance of male and female respondents after the intervention. this is evidence in their mean values in Table 3 (Male, Mean= 13.56, SD=3.61; Female, Mean=16.38, SD=4.59). This shows that the respondents differed in their performance in term being male or female after the intervention. And as a result there is the need to test further whether the difference is significant or not. Hence, Hypothesis 2: there is no significant difference in the academic performance of the respondents based on gender. Therefore, hypothesis 2 was tested using one-way ANCOVA.

Table 4
ANCOVA of Effect of Gender on Students' Performance in Chemistry
Test of Between-Subjects Effects
Dependent Variable: Post-test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	63.239[a]	2	31.619	1.630	.212	.092
Intercept	1479.364	1	1479.364	76.275	.000	.704
Pretest	9.729	1	9.729	.502	.484	.015
gender	39.799	1	39.799	2.052	.162	.060
Error	620.647	32	19.395			
Total	9264.000	35				
Corrected Total	683.886	34				

a. R Squared = .092 (Adjusted R Squared = .036)

As it is evidence on Table 4, the p-value is greater than 0.05 which means that There is no significant difference between the performance mean scores of students taught chemistry based on gender. Hence, the null hypothesis formulated is not rejected. Both male and female respondents' performance is not statistically significant, although there is difference in their performance but it is not statistically significant, thus, it can be said that they are of the same performance.

Research Question 3: What is the interaction Effect of Wait Time and Gender on Academic Performance of Secondary School Students in Chemistry

Table 5
Descriptive Statistics of Effect of Wait Time and Gender on Academic Performance of Students in Chemistry
Dependent Variable: Post-test

Treatment	Gender	Mean	Std. Deviation	N
EXP.	Male	16.50	3.416	4
	Female	19.13	3.364	16
	Total	18.60	3.455	20
Control	Male	11.20	1.304	5
	Female	12.00	2.211	10
	Total	11.73	1.944	15
Total	Male	13.56	3.609	9
	Female	16.38	4.588	26
	Total	15.66	4.485	35

Table 5 shows the mean values of male and female respondents in the experimental group that is those exposed to the intervention as well as the male and female respondents in the control group, these are the respondents taught using traditional method. It can be deduced from the table that mean difference exist between male and female in the experimental group and those in the control group which are 2.63 and 0.8 respectively. This means that the mean difference between male and female respondents in the experimental group is greater

than the mean difference between the two categories of gender in the control group, as a result there is need to further this analysis by testing the hypothesis generated based on this interaction to confirm whether the difference is statistically significant or not.
Research question 3 results to hypothesis 3: there is no significant interaction between the effect of wait time and gender on academic performance of secondary school students in chemistry.

Table 6
Two Way ANCOVA of Effect of Wait Time and Gender on Academic Performance of Students in Chemistry
Dependent Variable: Post-test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	433.474[a]	4	108.369	12.983	.000	.634
Intercept	899.703	1	899.703	107.787	.000	.782
Pretest	5.138	1	5.138	.616	.439	.020
Group	255.802	1	255.802	30.646	.000	.505
Gender	22.930	1	22.930	2.747	.108	.084
Group * gender	8.564	1	8.564	1.026	.319	.033
Error	250.412	30	8.347			
Total	9264.886	35				
Corrected Total	683.886	34				

a. R Squared = .634 (Adjusted R Squared = .585)

As it can be seen on Table 6, the p-value is greater than 0.05 which means that there is no interaction effect of wait time and gender on academic performance of secondary school students in chemistry since the p-value>0.05. although there is difference in the mean values as it is evident on Table 5 from Table 6, it can be said that the difference did not result to significant interaction. Hence, the null hypothesis is not rejected and there is no interaction on the effect of wait time and gender on academic performance of the secondary school students in chemistry.

Conclusion
The traditional teaching method characterized by teacher-centeredness and neglect of students' participation in the instructional process has made teaching more boring to the students in the classroom. Thus, their poor performance in senior secondary school certificate examination in chemistry. It is therefore apparent to identify and adopt more student-centred instructional strategy to help students improve their academic performance in chemistry. Following the findings of the study, these conclusions were made in accordance with the three research questions in the study.

The first research question *"what are the effects of wait time on secondary school students' performance in chemistry".* This research question was answered with sampled 35 secondary school students who were subjected to pre-test by administering a 30-item questionnaire to them before teaching them organic chemistry and post-test after teaching them organic chemistry, the items of the test question were reshuffled. The pre-test scores of both groups

(experimental and control groups) were compared, this was done to ascertain whether they are comparable. Subsequently, the post-test scores of the two groups were compared as well; this was done to determine the difference between them. In determining the difference between the mean score performance of pre-test and post-test groups, a one-way ANCOVA was adopted.

The result indicated that the mean score of the respondents from both the experimental and the control groups are close based on their performance before the introduction of the intervention, (Experimental, Mean =7.80, SD=3.25; Control, Mean=10.13, SD=5.56), the 2.3 difference in their performance is not much, this implies that, they have a very close performance before learning chemistry using wait time for the experimental group and traditional method for the control group. Meanwhile, the post-test scores showed difference in their mean score performance for the experimental group and those in the control group (Experimental group, Mean=18.60, SD=3.46; Control group, Mean=11.73, SD=1.94). This is an indication that the experimental group performed better than the control group with the difference of 6.87. It can be deduced from this that, wait time improve students' performance in the learning of Chemistry by secondary school students.

Research question two which states that "*what is the effect of gender on academic performance of secondary school students in chemistry"* This was answered by asking the respondents from the two groups (experimental and control groups) to indicate their gender during the pre-test and post-test, this indicated 9 males and 26 females totalling 35 respondents all together. The research analysis indicated no much difference in the performance of both male and female respondents in the CPT, this is evident in the mean score difference of 2.52 between the two groups (Male, Mean=10.67, SD=4.95; Female, Mean=8.15, SD=4.21) which is an indication that the two groups has relatively similar performance in CPT based on gender as their entry performance. This implied close performance for the two groups before they were exposed to wait time (experimental group) and traditional (control group) method of teaching.

However, after the introduction of the intervention, there exist a slight difference in performance of the gender from their mean values (Male, Mean= 13.56, SD=3.61; Female, Mean=16.38, SD=4.59). with this, a further analysis using one-way ANCOVA was done to see the groups the difference favoured. But as showed from the analysis, the p-value is greater than 0.05 which indicated insignificant difference in the performance mean scores of students taught chemistry based on gender. Though there is difference in their performance but not statistically significant, thus, it can be said that they are of the same performance. Hence, gender has no influence on the performance of the students.

On research question three *"what is the interaction effect of wait time and gender on academic performance of secondary school students in chemistry*" This investigation become apparent to know the effect of combining the two variables (wait time and gender) on the secondary school students' performance in chemistry. This was carried out using the data collected from the respondents through CPT for both the experimental group (group taught using intervention) and the control group (group taught using traditional method) putting into consideration the gender of the two groups involved. The analysis was carried out using two-way ANCOVA, this is necessary because, two independent variables are involved (the groups and gender both occurring at two levels) i.e. wait time and traditional method as the group and male and female as gender respectively.

The descriptive analysis of the mean values, standard deviation and number of respondents based on the group and gender are revealed. A mean difference exists between male and

female in the experimental group and those in the control group which are 2.63 and 0.8 respectively. This implied that the mean difference between male and female respondents in the experimental group is greater than the mean difference between the two categories of gender in the control group. The result revealed that the p-value is greater than 0.05 which indicated no interaction effect of wait time and gender on academic performance of secondary school students in chemistry. Although there is difference in the mean values but it does not result to significant interaction. Hence, no interaction on the effect of waits time and gender on academic performance of the secondary school students in chemistry. Similarly, no significant interaction effect of wait time and gender on academic achievement of the secondary school students. It could be concluded that no interaction exists on the effect of wait time and gender on academic performance and academic achievement of secondary school students in chemistry.

In summary, students find chemistry lessons more tedious in the classroom due to the traditional teaching approach, which emphasises teacher-centeredness and disregards students' active engagement in learning. As a result, students perform poorly in their examinations for senior secondary school certificates in chemistry. To help students enhance their academic performance in chemistry, it is evident that a more student-centred instructional method, such as wait time, should be identified and implemented. Therefore, this study recommends that school administrators conduct relevant and regular training for chemistry teachers on the effective use of wait time to enhance improved students' performance in chemistry. Teachers, on their part, should effectively and regularly use wait time techniques while teaching chemistry to achieve an improved student' performance in chemistry.

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