



Effect of Computer Simulation on Secondary School Students' Academic Achievement in Acid-Base Reactions

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ABSTRACT

This study investigated effect of Computer simulation instructional strategy on Chemistry students' academic achievement in Acid-Base Reactions in Jalingo Education Zone, Taraba State. Quasi-experimental design was used for the study. The sample size was 168 students, drawn from 2 intact classes. Acid-Base Reactions Achievement Test (ABRAT) was used for data collection using the Kuder-Richardson's formula-20 (K-R20) with a reliability index of 0.92. The research questions were answered using mean and standard deviation while the null hypotheses were tested at 0.05 level of significance using t-test and Analysis of Covariance (ANCOVA). The findings revealed that there is significant difference in the mean achievement scores of students taught Acid-Base Reactions using Computer simulation than the Conventional method. However, findings on gender revealed that there is no statistically significant difference in the mean achievement scores of male and female students taught Acid-Base Reactions using Computer simulation. Based on the findings, it is evident to conclude that the use of Computer simulation enhances performance of students in chemistry than the Conventional method of teaching. It is therefore recommended that Computer simulation instructional strategy should be adopted and practice by teachers in secondary schools to enhance students' academic achievement in Chemistry and promote gender-friendly classrooms.

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INTRODUCTION

Science teachers have applied various conventional methods and strategies like discovery, questioning, field trips, lecture and discussion methods among others for teaching chemistry, yet there has been poor performance among secondary school students in the certificate examination throughout the country (WAEC, 2018). This has denied many Nigerian students the opportunity of getting admitted into institutions of higher learning. There is therefore disturbance from parents, teachers, curriculum planners and other stakeholders in educational industry about the deteriorating achievement of students in

chemistry in both internal and external examination in Nigeria. In addressing this issue, the innovative teaching strategies such among other factors have been reported to be a crucial parameter. To understand the reactions involved, students mainly need to apply the content knowledge which they have learnt in the topic, 'Acids-Bases Reactions'. The Conventional methods of teaching Acid-Base Reactions do not seem to help students understand the reactions involved. Introducing new instructional strategy may help students understand these concepts since previous studies have shown that students have difficulties in understanding the reactions in this topic



(Adesoji, 2008; LongJohn, 2009; Okeke, 2010; Jack, 2014; Jack, Danjuma, & Adul-Kadir, 2017).

The concepts of Acid-Base Reactions are introduced early in secondary school science, are developed and refined as students' progress, and underpin many future topics. Students have a wealth of experience of Acid-Base Reactions accumulated from both school and everyday life. It is worth starting the topic by eliciting their existing ideas by constructing a mind-map together and avoid misconceptions and conceptual difficulties (Kim-Chwee, Ngoh-Khang, Lian-Sai & David, 2003). Introducing new instructional strategy, Computer simulation may help students understand some ideas to engage them, avoid misconceptions, and connect practical work to underlying concepts.

Computer simulations have become a popular method of instruction in the last 15 years (Quellmalz, Tims, Silberglitt & Buckley 2012; Donnelly, Reilly, & McGarr 2012) and this is because of commercially available software that is based on scientific and technological models which replicate actual situations. In a broad sense, simulations are imitations of systems. According to Udo and Etiubon (2011), Computer simulation is a teaching technique that reproduces actual events and processes under test conditions. It is a teaching strategy involving interactive chemistry, computer power point shows which are prepared on a slide. Rutten, Van Jooloinge and Vander Veen (2012) who reviewed 51 articles from 2001 to 2010 show that traditional classroom can be improved by using Computer simulations. Using Computer simulations has been reported to increase learners' experiences up to a maximum effect size of 1.54 (Rutten et al. 2012; Donnelly et al. 2012) and other gains were reported by Howe, Devine and Tavares (2013) where children worked in pairs rather than working individually. Chen, Nurkhamid, Wang, Yang, Lung and Chang (2013) opines that Computer simulations provide near-

authentic environment, context and situation for task-based learning. This shows that learners learn better when they actively interact with Acid-Base Reactions concepts than when they are instructed under Conventional methods of teaching (lectures, discussions and demonstrations).

A Computer simulation strategy is an attempt to model a real-life or hypothetical situation on a computer so that it can be studied to see how the system works. According to Gatto (2013), interactive simulation computer power point show, it is a Computer simulations programs that allow the user to interact with a computer representation of scientific model of natural or physical world. The computer has many functions, one of which is to assist in classroom instruction. It is possible to use computer to deliver instruction in the classroom either partially or totally. According to Olele (2008), now, computers have been used to enhance expository teaching by the use of presentation software and vivid computer-based demonstrations. The word 'simulation' comes from the Latin word 'similes' which means 'like', that is, to act like to resemble, to pretend to be (Obeka, 2007 as cited in Okonkwo 2012). Although simulation possesses a high degree of similarity with reality, it is still a reduction and abstraction of reality. Computer simulations are computer programs that can be either small, running almost instantly on small devices, or large-scale programs that run for hours or days on network-based groups of computers (Wikipedia, the free Encyclopedia, 2018). Computer simulations are used to study the dynamic behavior of objects or systems in response to conditions that cannot be easily or safely applied in real life.

Innovative advances in technology according to Guy and Lowness (2015), have introduced a variety of tools to enhance learning in higher education. Among these, Computer simulations have been used (1) to support a variation of



cognitive learning styles, (2) to facilitate higher-order thinking and problem-solving skills, and (3) to augment differential, collaborative, and mastery learning (Koh, Tan, Tan, Fang, Fong, Kan, Lye & Wee, 2010). A widely acceptable tool for teaching and learning, Computer simulations combines visual and interactive learning experiences, promotes application of knowledge, and provides a simplified representation of real-world systems (Eskrootchi & Oskrochi, 2010; Nishikawa & Jaeger, 2011). It also facilitates learning through representation and practice in a repeatable, focused environment. Also, Computer simulations as opined by Lawal (2017), are motivating and enhance learning of factual information. It allows for better understanding of processes, improves critical thinking and transferability to other situations. Computer simulation strategy can be applied to Acid-Base Reactions concepts by providing real life settings for the application of chemistry concepts.

Established from the literatures reviewed is the fact that Chemistry is plagued with problems of poor achievement of students in both national and international examination and that the major factor responsible for this is the teachers teaching methods. In Nigeria, Acid-Base Reactions concepts have not been adequately investigated for conceptual difficulty and/or poor achievement of students in examinations. The Conventional method (lectures, discussions and demonstrations) remains the most popularly used method in Nigerian Chemistry classes despite the fact that it has been highly criticized by educators and researchers. In its stead, educators and researchers suggested the use of student-activity-oriented strategies which aid the attainment of certain values such as student-centered learning, active participation thereby enhancing achievement of students in the subject. Literature (LongJohn, 2009) also revealed that meta-cognitive, innovative strategies that allow active participation of learners

in the entire process of teaching and learning enhance the performance students in all aspects of science generally. Computer simulation could be one of the innovative strategies that may be very effective in promoting learning especially in the sciences and Acid-Base Reactions concepts in Chemistry in particular. This study therefore sought to investigate the effect of Computer simulation instructional strategy on secondary school students' academic achievement in Acid-Base Reactions in Jalingo, Taraba State, Nigeria.

Research Questions

The following research questions have been raised to guide the researcher in the study.

- (i) What is the difference in the mean achievement scores of the students taught Acid-Base Reactions using Computer simulation and that of the students taught using the Conventional method?
- (ii) What is the difference in the mean achievement scores of male and female students taught Acid-Base Reactions using Computer simulation?

Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significance:

H₀₁: There is no significant difference between the difference mean achievement scores of the students taught Acid-Base Reactions using Computer simulation and that of the students taught using Conventional method.

H₀₂: There is no significant difference in the mean achievement scores of male and female students taught Acid-Base Reactions using Computer simulation.

METHODOLOGY

The quasi-experimental design was adopted for the study. Specifically, pre- test, post- test, non-equivalent



control group design was employed for the study. The design is conceptually presented Figure 1:

Group	Instructional strategy	Pre-test	Treatment (X)	Posttest
Experimental group	Computer simulation (CS)	O1	X	O2
Control Group	Conventional method (CM)	O1		O2

Figure 1: Diagrammatic Representation of the Research Design

Where: O1 = Pre-test for all groups O2 = Post – test for all groups
X = Treatment that will be given to Experimental group

The population consisted of all Secondary two (SSII) students offering chemistry in the government grant-aided secondary schools during the 2018/2019 academic session in Jalingo Education Zone of Taraba State, Nigeria. The sample comprised of 168 SS II Chemistry students, made up of 84 males 84 females were randomly drawn from 2 intact classes. The multi-stage random sampling was used in constituting the sample for the study. In the first stage, one education zone (Jalingo) was selected from the nine education zones through simple random sampling by using hat and draw technique. In the second stage, 2 Local Government Areas (LGAs); Jalingo and Ardo- Kola were selected out of the 3 LGAs through simple random sampling. From the 2 LGAs, 2 schools (1 school from each LGA) were purposefully selected and were randomly assigned to two groups (A & B) using hat and draw technique. Group A and B were randomly assigned as Computer simulation (or experimental group= 80 students) and group B was assigned to Conventional method (Control group=88 students).

Two instruments: i) Non-testing instrument which is the lesson plan and ii) Testing instrument which is the Acid-Base Reactions Achievement Test (ABRAT). The Acid-Base Reactions Achievement Test (ABRAT) was made up of two sections, section A sought for demographic data of the respondents on gender variables while Section B sought for the achievement of respondents. In its initial form 50 questions were developed and used for pilot testing where the scores obtained

were subjected to psychometric analysis to determine the difficulty and discrimination index of each item. After subjecting it to psychometric analysis, 30 questions were selected and 20 dropped. In its final form 30 questions selected from the psychometric analysis for the main study. The test items consisted of multiple-choice questions. The students were required to choose the correct answers from the option (A-D) listed against each question. In every question, only one option was correct while other options were wrong. The correct option was scored two marks while wrong option was scored zero marks. The total mark score was 60 while the least mark score is 0.

The options were drawn from the chemistry curriculum and past questions while the objectives as specified in the National Curriculum in Chemistry was used to guide the number of higher order and lower order cognitive questions.

The 30 item ABRAT were generated based on a table of specification and this was given to three experts in the department of science education for face validation. The validators were specially requested to scrutinize the items of the instrument in relation to the research questions, hypotheses and purpose of the study, clarity of instruction to the respondents, clarity of language and lack of ambiguity.

A pilot test of the instrument was conducted to estimate the reliability index of the instrument with 39 SS 2 Chemistry students in school that cannot take part in the main study. The internal consistency



reliability of the Acid-Base Reactions Achievement Test (ABRAT) was determined using the Kuder- Richardson's formula- 20 (K-R20) where a reliability index of 0.92 was obtained indicating that the instrument is reliable and suitable for this particular study.

For the purpose of collecting data for this study, the following procedure was followed based on the stages. In the 1st week (Preliminary stage), there was training of research assistance; in the 2nd week (Pre-treatment stage), administration of pre-test using ABRAT to both experimental and control group; in the 3rd-5th week (Treatment stage), was used for teaching the experimental group and in the 6th week (Post-test stage), revision, completion of selected topics and administration of the post-test. Post-test

using ABRAT to both the experimental and control group in the schools for the period of one week.

The data collected for the study were analyzed using descriptive statistics of mean and standard deviation to answer research questions while inferential statistics of Analysis of Covariance (ANCOVA) and t-test statistics were used to test the research hypotheses at 0.05 level of significance.

RESULTS

Research Question 1: What is the difference in the mean achievement scores of the students taught Acid-Base Reactions using Computer simulation and that of the students taught using the Conventional method?

Table 1: Mean disposition scores and standard deviations of students taught using Computer simulation and that of the students taught using the Conventional method

Group	Difference	N	Pretest Mean	SD	Posttest Mean	SD	Mean Diff.
Computer simulation		80	28.50	8.42	45.99	8.35	17.49
Conventional method		88	21.68	7.33	26.89	7.35	5.21
Mean difference			6.82		19.10		12.28

Results of Table 1 show that the pretest mean score of students taught Acid-Base Reactions using Computer simulation is 28.50 with standard deviation of 8.42, while the posttest mean score is 45.99 with standard deviation is 8.35. The difference between the pretest and posttest of the students in this group is 17.49. In the same vein the Table shows that pretest mean score of the students taught using Conventional method is 21.68 with standard deviation is 7.33, while their post-test mean achievement score is 26.89 with standard deviation of 7.35. The difference between the pre-test and post-test mean achievement scores of this group is 5.21. The difference between the pretest mean scores of the two groups is 6.82, while the difference between

posttest mean scores of the groups is 19.10. Meanwhile, the difference between the groups' pretest and posttest mean differences is 12.28. The differences in the pretest mean (6.82), posttest mean (19.10) and between the groups pretest and posttest mean differences (12.28) are all in favor of Computer simulation. This suggests that students taught using Computer simulation achieved higher than their counterparts taught using Conventional method.

Research Question 2: What is the difference in the mean achievement scores of male and female students taught Acid-Base Reactions using Computer simulation?



Table 2: Mean achievement scores and standard deviations of male and female students taught using Computer simulation

Gender	N	Pretest		Posttest		Mean Difference
		Mean	SD	Mean	SD	
Male	46	28.35	7.51	45.83	8.50	17.48
Female	34	28.71	9.62	46.21	8.26	17.50
Mean difference		0.36		0.38		0.02

Results of Table 2 show that the pretest mean score of the male students taught Acid-Base Reactions using Computer simulation is 28.35 with standard deviation of 7.51, while their posttest mean score is 45.83 with standard deviation is 8.50. The difference between the pretest and posttest of the male students is 17.48. In the same vein the Table shows that pretest mean score of female students is 28.71 with standard deviation 9.62, while their post-test mean achievement score is 46.21 with standard deviation of 8.26. The difference between the pre-test and post-test mean achievement scores of the female students is 17.50. The difference between the pretest mean scores of the male and

female students is 0.36, while the difference between posttest mean scores of the male and female students is 0.38, all in favor of female students. Similarly, the difference between the mean differences (pretest and posttest) is 0.02, also favors the female students. This suggests that female students taught using Computer simulation achieved higher than their male counterparts.

Hypothesis 1: There is no significant difference between the difference in the mean achievement scores of the students taught Acid-Base Reactions using Computer simulation and that of the students taught using the Conventional method?

Table 3: One-way Analysis of Covariance of the mean achievement scores of the students taught Acid-Base Reactions using Computer simulation and those taught using Conventional methods

Sources of Variation squared	Sum of Squares	df	Mean F Square	Sig	Partial eta
Corrected Model	19325.201 ^a	2	9662.601	258.495	.000
Intercept	6371.679	1	6371.679	170.456	.000
Pretest	4036.106	1	4036.106	107.974	.000
Group	7742.371	1	7742.371	207.125	.000
Error	6167.745	165	37.380		.557
Total	243005.000	168			
Corrected Total	25492.946	167			

On Table 3, the results of the main effects of methods of teaching Acid-Base Reactions on mean achievement indicated by $F(1, 165) = 207.125$ is significant at $P = .000 < .05$. This result affirms that there is a significant difference between the mean achievement scores of students taught Acid-Base Reactions using Computer simulation and those taught using

Conventional methods. Thus, the hypothesis of no significant difference is not retained. The statistical significance, eta squared = .557 shows the actual difference in the mean scores between the groups is large. The implication is that 55.7% of difference in mean scores of students is attributable to method of teaching.

Hypothesis 2: There is no significant difference between the difference in the mean achievement scores of male and

female students taught Acid-Base Reactions using Computer simulation.

Table 4: Independent – Samples t – test analysis of significance significant difference between the mean achievement scores of male and female students taught Acid-Base Reactions using Computer simulation

Achievement Score	Levene's Test for Equality of Variances			t-test for Equality of Means		
	F	Sig	t	df 2-tailed	Sig	Mean Difference
Equal variance assumed			-.200	78	.842	-.379
	.005	.945				
Equal Variances not assumed			-.201	72.38	.841	-.379

On Table 4, Levene's test for equality of variances shows that the variance (variation) of scores for male and female is the same as $p = .945$. The independent – samples t-test shows that there is no significant difference in the post-test scores of male students ($M = 45.83; S = 8.50$) and female students [$M = 46.21; S = 8.26; t(78) = -.200, p = .842$]. The magnitude of the difference in the mean scores was very small ($e: S_1 = \frac{t^2}{t^2 + (N-2)} = .0006$). Thus, there is no statistically significant difference in the achievement scores of male and female students taught Acid-Base Reactions using Computer simulation.

DISCUSSION OF FINDINGS

Acid-Base Reactions Achievement Test (ABRAT) made up of multiple-choice items was used to collect data for the study. In order to answer the research questions and test hypotheses, the research adopted the descriptive statistics (mean and standard deviation) and inferential statistics of analysis of covariance (ANCOVA). Based on the data collected and analyzed, the following findings were recorded:

- Students taught using Computer simulation achieved higher than their counterparts taught using Conventional method.

- There is no statistically significant difference in the mean achievement scores of male and female students taught Acid-Base Reactions using Computer simulation.

The result of the study as shown in Table 1 and 3 reveals a significant difference between students taught Acid-Base Reactions using Computer simulation and those who were taught using Conventional method. The study therefore reveals that students who were Acid-Base Reactions using Computer simulation had higher achievement mean scores than those who were taught using Conventional method. This implies that the Computer simulation teaching strategy is highly significant enhancing and improving students' performance in Acid-Base Reactions than the conventional teaching strategy that is teacher centered.

The result of the study also is in consonance with the findings of Udo and Etiobun (2011) in Nigeria, Candida, Jose and Armando (2013), John, Robert and Israel (2013) from Uganda, Guy and Lowness- Jackson (2015) from Tennessee, USA, Okwuduba, Offiah and Madichie (2018) from Anambra State, Nigeria who all attested that Computer simulation students performed better than the conventional group students. The use of Computer simulation teaching strategies



was more effective than the conventional teaching method. Furthermore, the superiority of Computer simulation over conventional teaching method could be attributed to the manner with which instruction was presented to the students. Students who are exposed to this type of strategies are more likely to possess a meaningful and in-depth knowledge of the content area.

A student who is exposed to this type of strategy is more likely to possess a meaningful and in-depth knowledge of the content area. Further, Computer simulation create room for tangible thinking because using Computer simulation to manipulate the computer or carry out the teaching using power point slides with teachers interacting with the students, make the teaching close to real life situation. This against the conventional teaching method were thoughts are made in abstraction in the teaching and learning process because most teachers rarely use adequate aids or connect with physical realities. As such students see science as abstract and easy to forget.

The result of the study as shown in Table 2 and 4 revealed that female students taught using Computer simulation achieve higher than their female counterpart; though the differences in the mean achieve scores in Acid-Base Reactions of male and female students were not significant. Thus, there is no statistically significant difference in the achievement scores of male and female students taught Acid-Base Reactions using Computer simulation. The results contradict the findings of John et al. (2013) in Nigeria, Ezeudu and Okeke (2013) who found that there is no significant difference in gender of the students taught using this method. The reason for the insignificant or negligible difference in mean scores of male and female students may not be unconnected with the fact that both saw themselves as equals capable of competing in classroom activities. Thus, the adaptation of and use of Computer simulation teaching strategy

in Acid-Base Reactions can be one of the strategies for addressing inequality in our educational system especially in Acid-Base Reactions and chemistry in general.

CONCLUSION

It is evident from the findings of this study that the use of Computer simulation strategy could provide a good way for students to learn Acid-Base Reactions and chemistry in general. The study therefore concludes that there is significant difference between the mean achievement score of students taught Acid-Base Reactions using Computer simulation and Conventional method. To understand the reactions involved in Acid-Base Reactions concepts, students mainly need to apply the content knowledge which they have learnt in the topic effectively, through Computer simulation. This is because the Conventional methods of teaching Acid-Base Reactions do not seem to help students understand the reactions involved.

The study also concluded that there is difference in the mean achievement scores of male and female students taught using Computer simulation that is male students achieved higher than the female students, though the difference was insignificant or negligible. This strategy can be used to address the present trend of poor academic achievement of secondary school students in chemistry. Chemistry teachers at secondary school level can explore the potential of Computer simulation teaching strategy in order to improve the teaching and learning of chemistry since it is not gender bias.

RECOMMENDATIONS

The implication of the results of this study and the associated recommendations as it borders on chemistry education are as follows:

- i. Pre-service and in-service Chemistry teachers should be trained on the use of Computer simulation



- teaching strategy since it improved the academic achievements of students better and is gender-friendly.
- ii. Science teachers and curriculum planners should incorporate innovative, problem and activity based pedagogical strategy like Computer simulation in all teacher education institution since it helps in improving students' achievement and is not gender bias.
- iii. Computer simulation instructional strategy should be adopted and practice by teachers in secondary schools to enhance students' academic achievement in Chemistry and promote gender-friendly classrooms.

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