

An Examination of the Facilitative Effect of the Computer Assisted Instruction (CAI) in Students' Achievement in Chemical Reaction and Equilibrium

Emmanuel E. Achor^{1,*}, Joel O. Ukwuru²

¹Department of Curriculum and Teaching, Benue State University, Makurdi, Nigeria

²Department of Chemistry, College of Education, Oju, Benue State Nigeria

Abstract This study is an examination of the effect of the Computer Assisted Instruction (CAI) on senior secondary school students' achievement in chemical reaction and equilibrium. The study employs a pretest, posttest non-randomized control group design. The sample size of the study comprises of 128 male and 112 female students ($n=240$). Simple random sampling was used to assign intact classes to experimental and control groups, while purposive sampling was used to select 10 public senior secondary schools in Oju LGA of Benue State. The instrument used for the study is the Chemical Reaction and Equilibrium Achievement Test (CREAT). The students' scores from CREAT were collected and analyzed using mean and standard deviation to answer the research questions and ANCOVA was used to analyse data for testing the hypotheses at 0.05 level of significance. The result showed that there is a significant difference between the mean achievement of students taught chemical reaction and equilibrium using CAI and those taught same using conventional strategy ($F_{1, 239}=309.572; P=0.000 < 0.05$). Conversely, there is no significant difference in mean achievement between male and female students taught chemical reaction and equilibrium using CAI strategy ($F_{1, 127}=1.13; p=.733 > 0.05$). Based on the findings, the study recommends that, government should increase funding for the entire educational sector in order to procure reasonable number of computers and its software like CAI for senior secondary school to enhance teaching and learning with CAI strategy to aid achievement in chemistry.

Keywords CAI, Chemistry achievement, Chemical reaction and equilibrium, Chemistry teaching, Gender

1. Introduction

Observation over the years is that students' achievement in chemistry at Senior Secondary School level (SSCE) has not been very encouraging. According to WAEC[1], candidates that offered chemistry performed poorly in the areas of understanding of the concepts of equilibrium of reversible reaction, writing of formulae and correct balanced chemical equations as well as explanation of basic chemical principles, concepts and their applications. Chemistry is one of the subjects in which the students' achievement at the SSCE level has remained persistently low in recent time[2].

The poor performance of students in chemistry at SSCE is attributed to a number of factors ranging from teachers' attitude, the learners' attitude, and the curriculum, method of instruction and instructional materials, mathematical deficiency among others[1]. The problem of underachievement in chemistry is of great concern to the

government, parents, chemistry teachers and researchers in chemistry and several attempts have been made to tackle the problem. These attempts focused more on methods adopted for teaching. For instance, Masek and Yamin[3] found that students' critical thinking ability in the problem based learning (PBL) group had not been significantly different from their counterparts in the conventional approach group, an indication that most of the so called innovative strategies have not given us the needed result. Though tried with other science subjects, the use of the Computer Assisted Instruction (CAI) is not common in chemistry especially at the SSCE level which is the focus of this study. The Computer is an electronic device used for executing precisely stated rules with accuracy, rapidity and with real reliability. According to Eriba in Unongo[4], computer is capable of making calculation, storing information in various fields of study, designing devices, and making graphical representation of engineering parts and providing leisure in form of music. Studies have shown that computer self-efficacy has a positive effect on information literacy self-efficacy. Tuncer,[5] and Geban, Askar, and Ozkan[6] as well as Inci, John, Nilgun and Ozge[7] and Mudasiru and Adedeji[8] all found the use of the computer in teaching to

* Corresponding author:

nuelachor@yahoo.com (Emmanuel E. Achor)

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facilitate achievement in chemistry and other sciences. However, integration of ICT into education system in Nigeria is poor[9].

Adoption of CAI as teaching strategy is one prominent aspect of use of ICT worldwide. In classroom, CAI holds the promise of carrying the learners along as well as making them active rather than passive participants especially in the sciences. The fact that CAI could be prepared to meet target presupposes that it is adaptable which renders its usage wide acceptance.

Also related to achievement in chemistry is the gender issue. Result from research findings have revealed that male students perform better than the females in physics, chemistry and biology generally[10] while Agwagah as cited by Olom[11] revealed significant difference in achievement in favour of the females. Researcher such as Aiyedun[12] found no significant difference in the performance of boys and girls in mathematics. What appears not to be very clear is whether these performances vary with method of instruction. Thus there may be need to try use of the CAI so as to be well informed of the achievement of male and female students. The purpose of the study therefore was to investigate the effect of the CAI on students' achievement in senior secondary chemical reaction and equilibrium in Oju LGA of Benue State of Nigeria.

2. Theoretical Basis for the Study

According to Skinner[13], nearly all identifiable human behaviours fall into two categories namely; respondent and operant behaviours. Respondents' behaviours are involuntary (reflex) behaviours and result from special environmental stimuli. Skinner further posits that in order for behaviour to occur, it is first necessary that a stimulus be applied to the organism. Only a few of human behaviours are respondent behaviours.

Appropriately, computer based instruction can be applied as a stimulus to the students' responses of interest, motivation and consequent achievement in chemistry learning. In the same vein, the design of computer based instruction programme makes immediate feedback as response to the chemistry student to stimulate him or her to generate commitment to the learning using his or her present status as a basis. This Skinner stimulus-response and the response-stimuli theory provide a strong framework for computer based instruction innovation.

In the computer facilitated learning, students' behaviours are reinforced by being permitted to proceed to the next frame when they get the right answer[14]. Ogunz[15] indicates that skinner illustrated how to develop programmed learning sequence which is being used directly to design tutorial modules. According to Owusu in Ogunz[15], the use of the CAI especially in tutorial mode is supported mostly by the behaviourist view of learning. This is due to the principle of practice and reinforcement. Therefore, the developers of tutorials mostly incorporate this theory of learning in their

programme. Working on the computer compares with working in the laboratory and the mere regular attendance in the laboratory is found to assist learning[16, 17, 18]); this suggests that CAI could be probably be self motivating.

3. Research Questions

The following research questions guided the researcher in this study;

1. To what extent does the use of CAI in teaching chemical reaction and equilibrium improve students' achievement as against the use of conventional method?
2. What is the achievement of male and female students who are exposed to CAI method in chemical reaction and equilibrium?

4. Hypotheses

Based on the purpose of the study the following null hypotheses were tested at 0.05 level of significance.

1. There is no significant difference in the mean achievement scores between students taught chemical reaction and equilibrium using conventional method and those taught using CAI.
2. There is no significant difference in the mean achievement scores of male and female students taught chemical reaction and equilibrium using CAI strategy.

5. Methodology

A quasi-experimental design was employed for the study. Specifically, the non-randomized control group, pretest, post-test design was adopted for the study. A total of 240 senior secondary (SS) 2 students were drawn from 10 public schools in Oju Local Government Area of Benue State. This comprises of 127 male and 113 female students. The number of students taught chemical reaction and equilibrium were made of 128 students that consist of 68 male and 60 female students and 112 students were taught using conventional strategy.

The sampling was concluded by random sampling of 4 intact classes from 4 schools that have computer facilities out of the 10. Similarly, by random sampling 2 classes were assigned to experimental group and the other 2 to control group. Accordingly, the respective biology teachers in each of the schools who were previously trained and ascertained to meet the selection criteria were used. Thus a total of 4 graduate biology teachers (2 in each study group) were engaged.

A 20 items multiple choice questions constructed by the researchers were patterned after West African Examination Council (WAEC) Senior School Certificate Examination Chemistry paper 2 called Chemical Reaction and Equilibrium Achievement Test (CREAT). It was validated

by two experts from the department of curriculum and teaching Benue State University, Makurdi. They were requested to do face, content and construct validity. Their comments further improved the quality of the instrument. From the trial testing the reliability of the instrument was determined using the Kuder-Richarson formula 21 ($K-R_{21}$) and was found to be 0.70. Thus the instrument was considered good for use based on literature. The students in experimental and control groups were both exposed to Chemical Reaction and Equilibrium Achievement Test (CREAT) as pretest. The control group students were taught using the conventional strategy while the experimental group was taught using CAI strategy. The treatment for all the groups lasted for six weeks. Each group had equal contact hours (2hrs 40 minutes per week) with the students. While it took longer time to teach the CAI group because of its individualized nature, the control group used the same time but spread into teaching, interaction time and drawing summary of each lesson. After the treatment, the two groups were exposed to the CREAT which has been reshuffled as posttest. The mean and standard deviation were used to answer the research questions while data for the hypotheses were analysed using the Analysis of Covariance (ANCOVA) and testing done at 0.05 level of significance.

The CAI was developed jointly by two experienced biology teachers and a computer expert reflecting relevant contents of chemical reaction and equilibrium. It was made interactive such that the learners could be engaged in dialogue and feedbacks provided immediately to enable learners proceed. Details are available for consultation on request.

6. Results

Research question 1: Data relevant to the research question one are presented in Table 1.

Table 1. Mean, Standard Deviation of Pretest and Posttest Scores of Students taught with CAI and conventional strategy

Method		Pretest	Posttest	Mean Gain
CAI	Mean	35.3906	62.2656	26.8750
	N	128	128	
	Std Dev	7.7513	8.6000	
Conv Strategy	Mean	26.4732	39.1071	12.6339
	N	112	112	
	Std Dev	8.4266	8.2532	
Mean diff				14.2411

Table 1 shows that the pretest mean achievement scores of students in the CAI method is 35.3906 with a standard deviation of 7.7513, while the conventional strategy has mean and standard deviation of 26.4732 and 8.4266 respectively. Results further show that the posttest mean achievement score and standard deviation in the CAI method are 62.2656 and 8.6002 respectively, while the conventional strategy has a mean score of 39.1071 and standard deviation

of 8.2532. This implies that students in both methods improved in the achievement after treatments, however students in the CAI gained by mean achievement difference of 26.8750 while those in the conventional strategy gained only 12.6339 with a difference of 14.2411 in favour of CAI method. Thus students taught using the CAI achieved better than those taught using conventional strategy.

Data relevant for research question 2 are presented in Table 2.

Table 2. Mean and Standard Deviation of Pretest and Posttest scores of Male and Female Students in CAI Class

Gender		Pretest	Posttest	Mean Gain
Male	Mean	35.3676	62.0588	26.6912
	N	68	68	
	Std Dev	8.3002	9.5117	
Female	Mean	35.4167	62.2656	26.8489
	N	60	60	
	Std Dev	7.1485	7.5071	
Mean diff				0.1577

Table 2 shows the mean achievement scores of male to be 35.3676 with standard deviation of 8.3002, while the female has mean achievement scores and standard deviation of 35.4167 and 7.1485 respectively. The Table further shows the posttest mean achievement scores and standard deviation of male to be 62.0588 and 9.5117 respectively, while female has a mean achievement score and standard deviation of 62.2656 and 7.5071. The mean gains are 26.6912 and 26.8489 for males and females respectively and with a mean difference of 0.1577 in favour of the females. This means that the female students performed slightly better than their male counterparts in CAI strategy.

Data relevant to research hypothesis 1 are presented in Table 3.

Table 3. Tests of Between-subjects Effects on Means of Pretest and Posttest of Students Taught with CAI and Conventional Strategy

Source	Type III Sum of Squares	df	Mean square	F	Sig
Corrected Model	38604.956a	4	9651.239	218.404	.000
Intercept	14123.864	1	14123.864	319.617	.000
Pretest	6557.095	1	6557.095	148.384	.000
Method	13679.959	1	13679.959	309.572	.000
Sex	13.701	1	13.701	.310	.578
Method *Sex	.299	1	.299	.007	.934
Error	10384.627	235	44.190		
Total	684500.000	240			
Corrected Total	48989.583	239			

a. Mean interaction

Table 3 reveals that there is a significant difference between students taught chemical reaction and equilibrium

using conventional method and those taught using CAI ($F_{1, 239}=309.572, P<0.05$) which indicates that teaching with CAI method is more effective than teaching with conventional strategy. Hence null hypothesis 1 was rejected, it then implies that there is a significant difference in the mean achievement score of students taught with CAI and those taught with conventional strategy in chemical reaction and equilibrium.

Data relevant to hypothesis 2 are presented in Table 4.

Table 4. ANCOVA Tests of Between Subjects Effects of Pretest and Posttest Means of Male and Female Students Taught with CAI

Source	Type III Sum of Squares	Df	Mean square	F	Sig
Corrected model	3497.011	2	1748.505	37.070	.000
Intercept	8546.517	1	8546.517	181.194	.000
Pretest	3490.807	1	3490.807	74.008	.000
Sex	5.307	1	5.307	.113	.738
Error	5895.958	125	47.168		
Total	505650.000	128			
Corrected Total	9392.969	127			

Table 4 reveals that gender has no significant effect on students' achievement when taught chemical reaction and equilibrium using CAI strategy ($F_{1, 127} = 0.113$; $P = .738 > 0.05$) which implies that the difference is not significant. Therefore the null hypothesis 2 is retained.

7. Discussion

Achievement of students taught chemical reaction and equilibrium using CAI is significantly higher than those students taught same with conventional strategy. This shows that the use of CAI in teaching chemical reaction and equilibrium can improve students' achievement. This finding agrees with the findings of Geban, Askar, and Ozkan[6] and that of Inci, John, Nilgun and Ozge[7] which are directly on chemistry. Similarly, the finding agrees with the studies of Mudasiru and Adedeji[8] in biology, thus establishing that the CAI is effective in enhancing students' achievement in chemical reaction and equilibrium in chemistry in similar manner as found by the afore mentioned authors in chemistry and biology from previous studies.

It could be explained that the use of CAI as emphasized in the theoretical frame work engages learners, makes them active participants and alert as well as motivates or enhances their interest through constant feedback mechanism. Feedback as noticed in this study could have served as link, how to follow instruction as well as an eye opening to where they must have missed the link or instruction. Thus it was possible for students to improve in their achievement since it acted like a reinforcer and source of stimulation. In similar manner like other innovative student centered methods, students do not only listen but were involved in doing and

thinking which are found to aid remembrance and retention. Thus the finding in this study is seen as commensurate with the efforts put in to actively engage learners.

Though the use of CAI might not have been the only variable that must have influenced achievement in this study, the effects of all other variables were to some extent held constant (that is, applicable to both control and experimental groups). Thus, teachers of same qualification and same experience were engaged, initial difference in learners was taken care of by using ANCOVA in data analysis to remove the starting difference. Also, the use of intact classes was expected to neutralize the differences in abilities of learners. Thus it was assumed that Hawthorne Effect was taken care of in the study.

The study revealed that gender has no significant effect on the achievement of students in chemical reaction and equilibrium when taught with CAI strategy. This finding on gender agrees with the earlier findings of Mudasiru and Adedeji[8], Husaini and Mohammed[17] on gender. Thus it can be said that the use of CAI method enhanced the achievement of both male and female students similarly in chemical reaction and equilibrium. The implication of this finding could be that what matters in teaching and learning is the effectiveness of the instructional strategy. Accordingly, once an instructional strategy is motivating and engages students' attention, it does not discriminate in the performance of males and females. The corollary could be that where male and female students' achievement differs after teaching, the interactive nature of the method should be questioned.

8. Conclusions and Recommendations

The use of the CAI in teaching chemistry concepts facilitated the achievement of students in chemical reaction and equilibrium better than the use of conventional strategy. The gender difference among students exposed to CAI was not significant implying that CAI is capable facilitating learning in similar manner among male and female students in chemical reaction and equilibrium.

It is recommended therefore that:

1. Computer literacy and operation in the secondary schools should be encouraged while relevant CAI packages should be accorded attention and developed for use within the Nigeria school system. This can be done by bringing experts in biology and computer together to design something in line with the senior secondary curriculum.
2. Educational curriculum planners should endeavour to integrate a practical computer application course in their curriculum design for pre service teachers. This will enable them to use computer to teach chemistry and other science subjects effectively.

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