

# EFFECT OF COMPUTER SIMULATION ON STUDENTS' PERFORMANCE AND RETENTION IN CHEMICAL REACTION CONCEPTS AMONG SECONDARY SCHOOL STUDENTS' IN KATSINA STATE, NIGERIA

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## ABSTRACT

This study investigated the Effect of Computer-simulation on Students' Performance and Retention in Chemical Reaction concepts among Secondary School students' in Katsina State, Nigeria. The study was guided by two objectives, two research questions and two hypotheses, some of the objectives of the study include; Determine the scores of students when taught chemical reaction concepts of chemistry using computer simulation instructional strategy and those taught using conventional teaching method in Katsina State; Quasi-experimental research design using pretest, posttest and retention test non-randomized groups were used. The Population of the study comprised 4,505 SS2 students from the twelve public secondary schools in Katsina metropolis. Purposive sampling techniques was used to select 128 students' from two intact classes of two public secondary schools. The instruments, chemical reaction performance test was used for data collection. The instruments was validated by 3 experts. Reliability coefficient of the instruments was established at  $r=0.78$ . Mean and standard deviation were used to analyze the research questions. All the hypotheses were analyzed using paired sample t-test at 0.05 Alpha level of significance. The Findings of the study revealed that; significant differences existed between academic performance of students taught chemical reaction concept of chemistry using Computer-simulation instructional strategy and conventional teaching method in favour of Computer-simulation instructional strategy ( $t = 4.345$ ,  $p\text{-value} = 0.00$ ,  $df = 127$ . Since the  $p\text{-value}$  of 0.00 less than alpha value = 0.05,); significant difference existed between the retention ability of the students taught chemical reaction using computer simulation and those taught same concept using conventional method ( $t = 3.103$   $p\text{-value} = 0.002$   $df = 127$ . Since the  $p\text{-value}$  of 0.00 less than alpha value of 0.05). Based on the findings the, study recommended that; Chemistry teachers' should encourage performance and retention rate of students by using Computer-simulation for teaching chemical reaction concepts. Government should encourage teaching using Computer-simulation instructional strategy by providing necessary facilities needed for its effective implementation and organizing seminars, conferences and workshops on teaching using computer simulation.

**Keywords:** Computer-simulation, Performance, Retention and Chemical Reaction

## Introduction

Computer Simulations have been given different meanings by different authors; however, in a broad sense; simulations are imitations of systems. Computer Simulations are computational models of real or hypothesized situations or natural phenomena that allow users to explore the implications of manipulating or modifying parameters within them. It also differs from a dynamic visualization (an animation) because it allows user interaction. In chemistry education, computer simulations can enhance students' understanding of chemical reactions, molecular structures, and processes (Khan, 2019). Research has shown that computer simulations can improve students' academic performance, engagement, and motivation in chemistry (Randel, Morris, and Wetzel 2019). Simulations can also provide immediate feedback, facilitate experimentation, and promote active learning (Liu, Li, and Zhang 2020). Examples of computer simulations in chemistry education include: Molecular modeling software (e.g., PhET Interactive Simulations) Virtual laboratories (e.g. Chem. Collective) Interactive games (e.g., Chemistry Adventure)

Performance is an individual's competence or achievement in a given task. Academic performance is the measurement of student achievement across various academic subjects. Teachers and education officials typically measure achievement using classroom performance, graduation rates, and results from standardized tests.

Retention is the ability of students to retain and recall information over time, which is a critical aspect of learning and academic success (Cepeda, Pashler, Vul, Wixted, and Rohrer 2020). Research has identified several factors that influence retention, including: spaced repetition that is Reviewing material at increasingly longer intervals to improve long-term retention (Eichenbaum, Kinner and Simons 2022), Active learning which involves Engaging students in interactive and participatory learning activities to enhance retention (Freeman, Eddy, McDonough, Smith, Okoroafor, Jordt and Wenderoth 2020), and Emotional connection which has to do with Creating an emotional connection to the material to improve retention and recall (Tyng, Amin and Malik 2021). Some Effective strategies for improving retention include: practice testing that uses quizzing and testing to reinforce learning and improve retention (Roediger and Karpicke 2022), summarizing information in one's own words to improve retention and understanding (Bui, Myerson, and Hale 2020).

Chemical reactions are fundamental concepts in chemistry that explain how substances change to form new products. Understanding chemical reactions helps students interpret many natural and industrial processes such as rusting, combustion, and food digestion. Among the major principles used to explain chemical reactions are the rate of reaction and chemical equilibrium. The rate of reaction describes the speed at which reactants are converted into products. It is influenced by factors such as temperature, concentration, pressure, surface area, and the presence of catalysts. A proper understanding of reaction rates enables students to predict how quickly a reaction will occur and how different conditions can alter the outcome of a chemical process.

One of the fundamental and essential sciences that aim to equip students with the knowledge and abilities of pertinent scientific concepts and procedures is chemistry. Base on the experiences of the researcher as a chemistry teacher observed that Students are finding it difficult to understand most of chemistry Concept using Conventional method that is consistently been used by teachers in our Secondary Schools, the researcher after reviewing several researches find out that using different teaching method like the use of computer simulation and drill-and-practice enhance students' Academic Performance and retention better than the conventional teaching method. The picture emerging from research reports, (WEAC) Chief Examiners Reports (2024) showed that students have difficulty in explaining the conditions which affects rate of a Chemical reaction. This section might be part of the area contributing to the students' poor performances. This level of dismal performance could be

attributed to the abstract nature of the concept, which usually makes teachers to teach it using lecture method. Consequently, student resort to relying on cramming to pass chemistry a situation which drastically affects their academic performance and by extension making it highly difficult for them to retrieve learnt material initially stored through that process.

The reasons for poor performance in Chemistry as identified by researchers over the years include: poor instructional strategies, abstract nature of science concepts, lack of qualified teachers; poor infrastructure and inadequate laboratory facilities and curriculum implementation (Omoniyi and Akinsete, 2022). The appraisal of candidates' performance in the West African Senior School Certificate Examination which attribute the tendency to students' incapacity to comprehend abstract ideas, lack of real-world experience, and excessive dependence on conventional teaching techniques. These difficulties have an impact on students' academic performance as well as their long-term memory recall, which is essential for future research and practical applications.

Innovative teaching techniques including computer simulations approaches have surfaced as a result of the growing integration of information and communication technology (ICT) into education. These methods have the potential to enhance mental comprehension and memory. However, it's still unknown how beneficial they are in comparison, especially when it comes to Nigerian education. To support evidence-based teaching strategies, it is necessary to conduct an empirical investigation of the Effect of Computer-simulation on Students' Performance and Retention in Chemical Reaction concepts among Secondary School students' in Katsina State, Nigeria.

### **Objectives of the Study**

The objective of the study are to:

1. Determine posttest scores of students when taught Chemical reaction concepts of chemistry using conventional teaching methods and those taught using computer simulation instructional strategy in Katsina State, Nigeria.
2. Determine the retention ability of students taught chemical reaction using computer simulation. Instructional strategy in Katsina State, Nigeria.

### **Research Questions**

The following research questions were answered in the study

1. What is the posttest scores of students when taught chemical reaction concepts of chemistry taught using conventional teaching method and those taught using computer simulation instructional strategy in Katsina State, Nigeria?
2. What is the retention ability of students when taught chemical reaction concepts of chemistry using computer simulation instructional strategy in Katsina State, Nigeria?

### **Hypotheses**

The following null hypotheses were tested at 0.05 level of significance

**H<sub>01</sub>:** There is no significant difference in the academic performance of students taught chemical reaction concepts of chemistry using computer simulation and those taught using conventional teaching method in Katsina State, Nigeria.

**H<sub>02</sub>:** There is no significant difference in the retention ability of students taught chemical reaction using computer simulation and those taught using conventional teaching method in Katsina State, Nigeria

### **Methodology**

The study was conducted using pretest, posttest, and post-posttest non-randomized group's Quasi-experimental research design. Specifically, two intact classes were used for the study. (Nworgu, 2015), quasi-experimental research design permits the use of intact classes. This design was adopted because it will not be possible for the researcher to randomly sample the subjects and assign them to groups without disrupting the academic programme and the

timetable of the senior secondary schools involved in the study. Hence, the design was considered quite suitable for conducting this study.

A schematic representation of the research procedure is as follows:

|                              |                |                |                |                |
|------------------------------|----------------|----------------|----------------|----------------|
| Group A (Experimental) ----- | O <sub>1</sub> | X <sub>1</sub> | O <sub>2</sub> | O <sub>3</sub> |
| Group B (control) -----      | O <sub>1</sub> | x <sub>0</sub> | O <sub>2</sub> | O <sub>3</sub> |

**Where:** O<sub>1</sub> and O<sub>1</sub> are pretest scores for experimental and control group A and B  
 O<sub>2</sub> and O<sub>2</sub> are posttest scores for experimental and control group A and B.  
 O<sub>3</sub> and O<sub>3</sub> are Retention test scores for experimental and control group A and B  
 X<sub>1</sub> is treatments for control group A

The Population of this study comprised 4505 SS2 students. The study was carried out in Katsina State, Nigeria, covering the twelve 12 public senior secondary schools offering Chemistry in Katsina metropolis.

The sample of this study comprised 128 students from two intact classes randomly selected from two public senior secondary schools from the population of the study. The schools were purposefully selected from 12 senior secondary schools because of the availability of ICT facilities in the institutions.

The instrument chemical reaction Performance Test (CRPT); was subjected to Content and face Validity by 3 experts. 1 expert from Chemistry Department, Federal College of Education Katsina and 1 expert from science Education Department, Umaru Musa Yar'Adua University Katsina and an experienced secondary school teacher from government science secondary school sandamu. The instrument consist of 30 items of chemical reaction Performance Test (CRPT). The validators of the test instrument made suggestions were strictly followed. The chemical reaction academic performance and retention test was subjected to item analysis after the trial testing on 48 students from Family Support Programme Secondary School Katsina State.

The reliability of the instrument; chemical reaction Performance Test (CRPT); in this study, test retest was used to determine the reliability coefficient of the instrument. The instrument was administered on the same group of students two times after two weeks interval as recommended by (Yero, 2015). The scores obtained were analyzed using Pearson Product Moment Coefficient (PPMC) and was  $r=0.78$

After the development of the chemical reaction performance Test (CRPT), the instrument was pilot-tested using an intact SS2 class from Family Support Programme Secondary School, Katsina. Item analysis was conducted to assess the quality of the 30 multiple-choice items based on two Classical Test Theory (CTT) indices: the difficulty index and the discrimination index.

Following standard psychometric guidelines, all items with negative discrimination indices were removed, as such items fail to effectively distinguish between high- and low-performing students. As a result, a total of ten (10) items were eliminated. Items with low but positive discrimination indices (typically between 0.00 and 0.20) were revised to improve their clarity and discriminatory power. These include Q2, Q12, Q16, Q18, Q22, & Q29. Only items with acceptable discrimination values ( $D \geq 0.20$ ) and moderate difficulty levels ( $p$  between 0.30 and 0.70) were retained without modification. These include Q1, Q3, Q5, Q6, Q7, Q10, Q13, Q20, Q24, Q25, Q27, Q28 and Q30. Before the intervention, a pre-test using the Chemical Reaction Performance Test (CRPT) was administered to all two groups to assess their baseline knowledge of the topic "Chemical reaction".

Following the pre-test, each group was taught for three weeks, with each group receiving instruction according to their designated teaching strategy. The content and duration of instruction remain the same across groups to ensure uniformity in content exposure. Immediately after the completion of the teaching phase, a post-test was administered using the same version of the CRPT. Two weeks later, a retention test was conducted using a parallel

form of the same test covering the same objectives but with re-ordered and paraphrased items to assess long-term retention of the topic.

Throughout the data collection process, the researcher ensure standardization of test administration, strict adherence to ethical considerations, and confidentiality of student responses. All test scripts were collected immediately after each session to minimize external influence and preserve the integrity of the data. The data that was collected from the pretest, posttest and post posttest on the instruments (Chemical reaction performance test) were kept separately for each group For the purpose of answering the research questions and also testing the hypotheses.

Computer-simulation instructional package (CSIP) was used as a treatment to the two groups to clearly explain chemical reaction concepts of chemistry. The Treatment Plan is as follows:

**Phase – 1:** During weekly class sessions, learners were taught Chemical reaction i.e reactants, products and Collision Theory using CSIP as a medium for computer technology integration strategy, observed pictorial illustrations, do exercises and do assignments to enhance understanding of the content.

**Phase – 2:** During weekly class sessions, learners were taught rate of chemical reaction and factors affecting rate of chemical reaction using CSIP as a medium for computer technology integration strategy, observe pictorial illustrations, do exercises and do assignments to enhance understanding of the content.

**Phase – 3:** During weekly class sessions, learners were taught Chemical equilibrium reversible reactions and factors affecting equilibrium using CSIP as a medium for computer technology integration strategy, observe pictorial illustrations, do exercises and do assignments to enhance understanding of the content. Teacher's role is to facilitate the presentations and the learner's activities is to ensure strict compliance.

The data collected from the administration of chemical reaction Performance Test (CRPT) was analyzed using both descriptive and inferential statistical methods. The analyses was aligned with the research questions and hypotheses guiding the study. Mean and standard deviation were used to analyze all the research questions. For the inferential analysis independent sample t test was used to analyze  $HO_1$ ,  $HO_2$ , All the hypotheses were analyzed at  $\alpha$  0.05 alpha level of significance. All data were analyze using the Statistical Package for the Social Sciences (SPSS). The results from these analyses were used to draw conclusions regarding the effects of computer simulation and drill-and-practice on student's performance and retention in chemical reaction among secondary schools in Katsina.

#### Results

Research Question 1: What is the Posttest scores of students taught chemical reaction concepts of chemistry using conventional teaching method and computer simulation instructional strategy in Katsina State, Nigeria?

**Table 1: Mean and Standard Deviation on performance of Students Taught Using Computer-simulation**

| Group         | N  | Mean  | S. D  | Mean difference |
|---------------|----|-------|-------|-----------------|
| Conventional  | 49 | 5.385 | 1.752 | 2.038           |
| Comp. Simuln. | 79 | 7.423 | 1.964 |                 |

The result presented in table 1 show that students taught using conventional teaching method obtain a mean score of 5.385 and 7.42 for computer simulation instructional strategy at posttest indicating a mean difference of 2.038, this indicates that students performed better after being taught using computer simulation and the strategy has effect on student's performance.

**Research Questions 2:** What is the retention ability of students when taught chemical reaction concepts of chemistry using computer simulation instructional strategy in Katsina State, Nigeria?

**Table 2: Mean and Standard Deviation on retention ability of Students Taught Using Computer-simulation**

| Group    | N  | Mean  | Std. Deviation | Mean difference |
|----------|----|-------|----------------|-----------------|
| Posttest | 79 | 7.423 | 1.964          | 1.385           |
| Posttest | 79 | 6.038 | 1.597          |                 |

The result presented in table 2 shows that students taught using computer simulation instructional strategy obtain a retention mean score of 7.423 at posttest and it reduces to 6.038 at post posttest indicating a mean difference of 1.385 this indicated a decline in performance during post posttest, which indicated that the memory of students on the concepts taught begin to decline.

### Hypotheses

**H<sub>01</sub>:** There is no significant difference in the academic performance of students taught chemical reaction concept of chemistry using computer simulation and those taught using conventional teaching method in Katsina State, Nigeria.

**Table 3: Independent t-test Statistics on Difference between Academic Performance of Students Taught Using Computer-simulation and Conventional teaching method**

| Group        | N  | Mean  | SD    | Mean d | Df  | T     | P     |
|--------------|----|-------|-------|--------|-----|-------|-------|
| Simulation   | 79 | 7.423 | 1.964 | 1.607  | 125 | 4.345 | 0.000 |
| Conventional | 49 | 5.816 | 2.128 |        |     |       |       |

**$P=0.00<0.05$ ,  $t_{computed}=4.345>1.98$  at  $df$  127**

Table 3 shows that  $t = 4.345$ ,  $p\text{-value} = 0.00$ ,  $df = 127$ . Since the  $p\text{-value}$  of 0.00 less than  $\alpha$  value = 0.05, there is significant difference between the mean academic performance of the students taught chemical reaction using computer simulation and those taught same concept using conventional method. Therefore, the null hypothesis which States that there is no significant difference between the mean academic performance of the students taught chemical reaction using computer simulation and those taught same concept using conventional teaching method is said to be rejected.

**H<sub>02</sub>:** There is no significant difference in the retention ability of students taught chemical reaction using computer simulation and those taught using conventional teaching method in Katsina State, Nigeria

**Table 4: Independent t-test Statistics on Difference between Retention Ability of Students Taught Using Computer-simulation and conventional teaching method**

| Group        | N  | Mean  | SD    | Mean D | Df  | t    | P     |
|--------------|----|-------|-------|--------|-----|------|-------|
| Simulation   | 79 | 6.038 | 1.597 | 0.996  | 125 | 3.10 | 0.000 |
| Conventional | 49 | 5.042 | 1.989 |        |     |      |       |

**$P=0.00<0.05$ ,  $t_{computed}= 3.103 > 1.98$  at  $df$  125**

Table 4 shows that  $t = 3.103$   $p\text{-value} = 0.002$   $df = 127$ . Since the  $p\text{-value}$  of 0.00 less than  $\alpha$  value = 0.05, there is significant difference between the retention ability of the students taught chemical reaction using computer simulation and those taught same concept using conventional

method. Therefore, the null hypothesis which States that there is no significant difference between the retention ability of the students taught chemical reaction using computer simulation and those taught same concept using conventional method is said to be rejected. The mean retention ability for computer simulation group is 6.038 and that of conventional teaching method group is 5.042 which indicated a decline in performance.

### **Discussion of Findings**

The data analyzed revealed that there was a significant difference in academic performance, and retention between those taught chemical reaction concepts using computer simulation and those taught with conventional teaching method among secondary school students' in Katsina State Nigeria. This may be attributed to the fact that computer simulation improves deeper learning when information is presented in both text and Graphics than by text alone.

The finding from the analysis of the research question number one shows that significant differences existed between academic performances of students taught chemical reaction concepts of chemistry using Computer-simulation instructional strategy before and after treatment in favour of experimental group in Katsina State. This shows that the treatment given is effective and when maintained very good performance among secondary school students' in chemical reaction would be maintained and Computer-simulation should be employed in teaching chemical reaction as a means of improving students' performance in the subject. This finding is in conformity with that of Okwuduba (2018), who recommended that computer simulation should be employed in chemistry teaching as a means of improving students' achievement in the subject and providing a real life experiment for dangerous chemistry practical's, this is also in conformity with the findings of Lanre (2021), the effectiveness of each of the treatment was not dependent on academic ability and finally that each treatment was effective in improving students' performance. Mammam and Garba (2019), recommended that teachers should be trained on development and utilization of multimedia facility in their teaching through seminar, workshop and conference; Teachers should be encourage to adopt the use of appropriate multimedia facilities that would improve students' performance and retention.

The finding from the analysis of the research question two shows that the performance of students is declined after some period of time and if the teachers of chemistry will be trained in how to utilize Computer-simulation packages in teaching there will be high rate of retention ability by the students, this is in consonant of the recommendation made by Aireruor (2024), recommended government and NGOs should fund development of computer-aided instructional packages and train manpower to produce software for teachers of chemistry to enhance achievement and retention.

The decline of performance after some period of time may be avoided if the teachers of chemistry will be trained in how to utilize Computer-simulation packages in teaching there may be high rate of retention ability by the students, this is in consonant of the recommendation made by Sadiq (2019), recommend for ICT training and re-training of teachers by the federal ministry of education through periodic seminars and workshops. And also recommendation made by Salihu (2019), that since creativity of students' are enhanced when computer animation, virtual blended model is better than lecture method, lecturers should be motivated by the university management to adapt the strategy in their lecturing.

### **Conclusion**

Based on the findings of this study, the following conclusions were made:

1. There was significant differences between academic performances of students' tauht chemical reaction concepts of chemistry using Computer-simulation instructional strategy and those taught using conventional teaching method. Computer simulation have positive effect on chemistry students' academic performance in chemical

reaction, the treatment given is effective and when maintained very good performance on students in chemical reaction would be maintained and Computer-simulation should be employed in teaching chemical reaction as a means of improving students' performance in the subject. Therefore, academic performance is enhanced significantly by using computer simulation

2. There was significant differences between the retention ability of students taught chemical reaction concepts of chemistry using Computer-simulation instructional strategy and those taught using conventional teaching method. Using computer simulation promotes students' retention ability of learnt concept of chemical reaction than conventional teaching methods, decline of performance after some period of time may be avoided if the teachers of chemistry will be trained in how to utilize Computer-simulation packages in teaching there may be high rate of retention ability by the students In other words, better retention of learnt concept is achieved by using computer simulation

### **Recommendations**

Based on the findings of this study, the following recommendations were made:

1. Chemistry teachers' should encourage performance and retention rate of students by using modern teaching strategies such as Computer-simulation for teaching chemical reaction concepts that will increase student's performance and retention rate.
2. Government should encourage teaching using Computer-simulation instructional strategy by providing necessary Solar Powered ICT facilities needed for its effective implementation and by sponsoring teachers by organizing seminars, conferences and workshops on learning how to teach using computer simulation.

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