# Computer-Based Science Simulations, Guided-Discovery and Students' Performance in Chemistry

Mfon Effiong Udo (Corresponding author)
Department of Science Education
Univeristy of Uyo, Uyo, Nigeria
Tel: 234-0802-760-4180 E-mail: mfonudo33@yahoo.com

Rebecca Ufonabasi Etiubon
Department of Science Education
Univeristy of Uyo, Uyo, Nigeria
Tel: 234-0802-706-8894 E-mail: etiubon@yahoo.com

Received: September 21, 2011 Accepted: October 17, 2011 Published: December 1, 2011
doi:10.5539/mas.v5n6p211 URL: http://dx.doi.org/10.5539/mas.v5n6p211

**Abstract**

This study investigated the relative effectiveness of computer-based science simulations on students' achievement in chemistry at the secondary school level when compared with guided-discovery and the traditional expository teaching methods. The study used non- randomized pre-test – post-test control group design. The study sample was 89 Senior Secondary II (SSII) chemistry students drawn from Uyo Local Government Area, Akwa lbom State, Nigeria. Criterion sampling technique was used for sampling. Two hypotheses were tested. The instrument used in collecting data was a researcher-developed 25-item 4-option multiple choice test - the Chemistry Achievement Test (CAT) - designed to measure students' achievement in the area of chemical combination. The test had a reliability index of 0.72 determined using test-retest approach. The results of data analysis using Analysis of Covariance (ANCOVA) showed that students taught by computer-based science simulations performed significantly better than those taught using the traditional expository method, (mean diff. = 4.34; sig. = .032), but had comparable performance with those taught with guided-discovery approach (mean diff. = .85; sig. =.869). That is, computer based simulation method is as effective as guided-discovery, but significantly better than the traditional expository method; and that gender is not a strong determinant of students' performance in chemistry. Based on the findings, it was recommended, among others, that chemistry teachers should adopt computer-based simulation technique in teaching chemistry concepts in view of its high facilitative effect on students' performance.

**Keywords:** Computer-based science simulations, Guided-discovery, Expository method, Students' achievement

## 1. Introduction

The advancement of civilization is making learning even much easier through utilization of electronic devices. Amongst these are the computers and its accessories (the CDs and the programme software packages), the internet, World Wide Web (www), electronic mail and the satellite (Landu, 2003). 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 Wodi and Dokubo (2006) Information Communication Technology (ICT) based learning intervention can either be used to enhance practical investigation or as a virtual alternative to real practical work where a simulation supports exploration of the investigation model through a computerized representation of the phenomena under study. Interesting and well designed programmes can be motivational and students can spend more time on tasks; assessment, diagnostics and remediation can be built into programmes to help learners achieve mastery of the concepts taught (Olele, 2008).

In most Nigerian schools where materials and apparatus for practical are either unavailable or insufficient, the dominant mode of teaching large classes is expository (Njoku, 2004); the use of computer in teaching and learning therefore holds much promise (Ogunsola-Bandele, 2002). Now, computers have been used to enhance expository teaching by the use of presentation software and vivid computer-based demonstrations (Olele, 2008).

The real revolutionary function of computers in education lies in the novel area of Computer-Assisted-Instruction (CAI) – the use of computer systems as learning tools. These include tutorials, drill and practice, games, simulation; discovery and problem-solving programme software packages which incorporate many other factors of instruction to accommodate the different learning styles of the learners. Computer programmed lessons, which allow the learners to interact with the computer in such a way that a specific concept is learnt and mastered as thoroughly as when a teacher does the teaching, or even much more efficient and faster, are now available on easy to install software (Ayodele, 2001; Zhang, 2007).

Computer simulation is a teaching technique that reproduces actual events and processes under test conditions. As a technique for instruction, simulation allows students to deal in a realistic way with matters of vital concern but without dire consequences should they make wrong choices. Simulations enable students to understand complex interactions of physical or social environment factors. As techniques for experimentation, simulations permit researchers to perform exotic "dry lab" experiments or demonstrations without using rare materials or expensive equipment. Time compression is another cost-saving feature of simulation technology. Events that can take anywhere from hours to eons in real time can be simulated in a few minutes (Encyclopædia Britannica, 2010). Realistic graphic simulation with high quality video enables students to observe scientific, industrial, role-playing and decision-making processes; and brings reality into the classroom where conventional practice is out of reach (Wang & Reeves, 2007; Zhang, 2007).

Study reports (Otero, 2001; Encyclopædia Britannica, 2010) have shown that computer simulations provide learners conceptual assistance that leads to enhanced performance and retention of concepts learnt. Okolocha (2010) in a research titled: e-learning: A veriTable tool for preparing Business Education teachers in tertiary institutions in Anambra State, Nigeria observed that e-learning holds great potential for enhancing students' performance through students' individualized learning, independent study, and making learning more enjoyable and practical as well as encouraging students to work in a dynamic interactive learning environment. In a study by Mkpanang (2010) on the effect of Computer-Assisted-Instruction (CAI) with drill and practice it was observed that those taught with CAI performed significantly better than those taught with expository method, with the females benefiting more from the instructions given than their male counterparts.

Reports on the relative effectiveness of guided-discovery, student-centred demonstration and inquiry teaching methods compared with expository method abound in the Nigerian scene (Nwachuku & Nwosu, 2007; Udo, 2010). Nwachuku and Nwosu (2007) in a study investigating the relative effectiveness of demonstration methods on different levels of students' cognitive achievement in secondary school biology observed that student-centred demonstration was more effective than teacher-led demonstration which in turn was more effective than the popular expository method. Also, Udo (2010) in a research investigating the effects of guided-discovery, student-centred demonstration and the expository teaching methods observed that students taught with guided-discovery method performed significantly better than those taught with student-centred demonstration and that those taught with student-centred demonstration performed significantly better than those taught with expository method. These findings were explained in terms of greater involvement of the learners in the teaching-learning process in both the guided-discovery and student-centred demonstration strategies as against the teacher dominated expository approach.

The urgent need for Nigeria to shift steadily and progressively from the traditional time tested methods and techniques of instructions as expository, teacher-centred demonstration, and laboratory exercises to demonstrate, visualize or verify known information to those based on Information Communication Technology (ICT) requires a fundamental shift of focus from the teacher to the learner as the centre of education, and a progressive adoption of new methods such as the process approach, discovery, inquiry, problem-solving and Computer Assisted Instruction (CAI). Unfortunately, Nigeria is yet to embrace the concept fully and adopt ICT based methods in teaching, especially at the primary and secondary school levels. Hence, there is paucity of study reports on the relative effectiveness of ICT approaches on students' concept attainment and retention in Nigeria.

## 2. Statement of the Problem

Research reports (Njoku, 2004) on the status of science education in schools in Nigeria show that science classroom activities are still dominated by teacher-centred methods, such as lecture and teacher demonstration methods, which have been found to be ineffective in promoting science learning at the primary and secondary school levels. The resultant effect has been students' persistent poor performances in science, especially, in chemistry, at both internal and external examinations, in Nigeria. In Nigerian schools where materials and apparatus for practical are either unavailable or insufficient, the use of computer simulations could be a welcome solution. But, how effective is this technique compared with recommended student-centred approaches as

guided-discovery and inquiry methods. This study aimed at determining the relative effectiveness of computer-based science simulations on students' achievement in chemistry at the secondary school level when compared with guided-discovery and the traditional expository teaching methods.

**3. Research Questions**

The study provides answers to the following research questions:

(1). How do students taught using computer-based science simulations teaching approach differ in their performance in chemistry when compared with those taught using guided-discovery and the conventional teacher-centred expository methods?

(2). How do male and female chemistry students differ in their performances in chemistry when taught using computer-based science simulations using guided-discovery and the conventional teacher-centred expository methods?

**4. Research Hypotheses**

The study tested the following null hypotheses:

(1). There is no significant difference between the performances of students in chemistry when taught using computer-based science simulations teaching approach, guided-discovery and the conventional teacher-centred expository methods.

(2). There is no significant difference between the performances of male and female students in chemistry when taught using computer-based science simulations teaching approach, guided-discovery and the conventional teacher-centred expository methods.

**5. Methodology**

The study used non-randomized pre-test – post-test control group design. A sample of 89 Senior Secondary II (SSII) chemistry students drawn from three intact classes in three co-educational public secondary schools in Uyo Local Government Area of Akwa Ibom State of Nigeria using criterion sampling technique was used for the study. The intact classes in the three schools were randomly assigned as Experimental groups 1 and 2, and the control group respectively.

The instrument used in collecting data was a researcher-developed 25-item 4-option multiple choice test - the Chemistry Achievement Test (CAT) - designed to measure students' achievement in the area of chemical combination. The test had a reliability index of 0.72 determined using test-retest approach. Each correct answer was scored 4 marks, and incorrect answers, 0 (zero). Hence, the maximum score was 100 and minimum zero.

The researchers used the subject teachers in the selected schools as research assistants after duly training them for the purpose using the validated instructional packages developed by the researcher. The research assistants, after administering CAT as pre-test, taught the students in their respective groups, using instructional packages from the researcher in their intact class setting and during the normal chemistry periods.

The experimental group 1 was taught concepts under chemical combination using computer-based science simulation software package, experimental group 2 was taught the same concepts using guided-discovery method, while the control group was taught the same concepts using the conventional teacher-centred expository approach. The assistants administered the reshuffled version of CAT as post-test after treatment. The classroom investigation lasted for 2 weeks. Both the teaching of the concepts and the administration of the pre-test and post-test were strictly supervised by the researcher. The pre-test and post-test scripts were collected immediately after each test by the research assistants and handed over to the researcher for marking. The data obtained were analyzed using Analysis of Co-variance (ANCOVA).

**6. Results and Discussion**

The results for answering the 2 research questions raised are summarized in Table 1 while those for testing the 2 hypotheses which guided the study are summarized in Tables 2 and 3.

*6.1 Research Question 1*

In Table 1, the mean scores of the students in the computer simulations group on post-test and pre-test are 54.14 and 29.43 respectively. These results give a post-test - pre-test mean difference of 24.71. The post-test and pre-test scores of the students in the guided-discovery group are 53.29 and 33.16 respectively, giving a mean difference of 20.13; while those of the students in the control group are 48.80 and 33.33 respectively, giving a post-test - pre-test mean difference of 16.47. The gain in scores show that the students in the experimental group taught by simulation approach (29.43) performed better than their counterparts in guided-discovery group

(20.13); and those in the control group who were taught with expository method (16.47). Considering research question one - How do students taught using computer-based science simulations teaching approach differ in their performance in chemistry when compared with those taught using guided-discovery and the conventional teacher-centred expository methods? – the observations indicate that students taught using simulation teaching approach did better than those taught with guided-discovery and the conventional teacher-centred expository methods.

*6.2 Research Question 2*

With respect to performance by gender, Table 1 shows that the post-test means of the males in the simulation, guided-discovery and control groups were 54.80, 53.75 and 50.59 respectively, while those of their female counterpart in the simulation, guided-discovery and control groups were 53.38, 52.80 and 48.77 respectively. A comparison of these performances indicates that both the males and the females in simulation group had the best performance, followed by those in the guided-discovery group while those in the expository group had the least performance. These observations answered research question two–*How do male and female chemistry students differ in their performances in chemistry? When taught using computer-based science simulations using guided-discovery and the conventional teacher-centred expository methods?*

*6.3 Research Hypothesis 1*

In Table 2, the calculated F-ratio for the main effect of instructional strategy at df 2, 82 is 19.19, while its corresponding significant level is .00 alpha. This significant level is less than .05, indicating that the instructional strategies adopted had a significant effect on the achievement of the students in chemistry. Hence, hypothesis 1 - *There is no significant difference between the performances of students in chemistry when taught using computer-based science simulations teaching approach, guided-discovery and the conventional teacher-centred expository methods* - was rejected. The post-hoc test results in Table 3 were used to determine the direction of significance.

In Table 3, the results show that those taught by simulation method performed significantly better than their counterparts taught with expository teaching method (mean diff. = 4.34; sig. = .032), but had comparable performance with those taught with guided-discovery approach (mean diff. = .85; sig. =.869). That is, computer based simulation method is as effective guided-discovery, but significantly better than the traditional expository method.

*6.4 Research Hypothesis 2*

With respect to Hypothesis 2, the results in Table 2 showed that the calculated F-value for the main effect of gender at df 1, 82 is 0.29 while its corresponding significant level is 0.75 alpha. The observed significant level is greater than 0.05 in which the decision is based. This indicates that the influence of gender on students' performance in chemistry is not statistically significant considering the teaching methods used. Hence, *hypothesis 2 - There is no significant difference between the performances of male and female students in chemistry when taught using computer-based science simulations teaching approach, guided-discovery and the conventional teacher-centred expository methods- was upheld.*

*6.5 Discussion of Findings*

This study investigated the relative effectiveness of computer-based simulations in facilitating students' achievement in chemistry compared with guided-discovery and the traditional expository method given their gender differences. The results in Tables 1, 2 and 3 showed that students taught using computer-based science simulations performed significantly better than those taught using the traditional expository method but had comparable performance with those taught with guided-discovery approach. The better performance of students taught using simulation and guided-discovery teaching methods compared with those taught with expository method underscores the importance of greater involvement of the learners in the teaching-learning process and the ineffectiveness of the expository method in the teaching and learning of the science (Nwachuku & Nwosu, 2007; Udo, 2010). It should be noted that e-learning methods, as the computer-based simulations, allow learners to work in a dynamic interactive environment which facilitate their knowledge reformulation and concept attainment besides evoking and sustaining interest, concretizing learning and making learning less stressful. The observed facilitative effect of computer-based simulations on students' concept attainment in chemistry supports Okolocha (2010) assertion that e-learning holds great potential for enhancing students' performance.

On gender effect, hypothesis 2 predicted that there is no significant difference between the performances of male and female students in chemistry when taught using computer-based science simulations teaching approach, guided-discovery and the conventional teacher-centred expository methods. The findings from the results in

Table 2 supported this prediction, hence the hypothesis was upheld. The comparable performance of the males and females observed agree with earlier findings by Nwachuku and Nwosu (2007) and Udo (2010) and indicate that gender is not a strong determinant of students' academic achievement in chemistry rather the instructional approach.

## 7. Conclusion

Consequent upon the findings from this study, it is hereby concluded that computer-based science simulation software packages has a greater enhancing effect on students' performance than the traditional expository method, but comparable with guided-discovery approach; and that students' achievement in chemistry is significantly dependent on teaching strategy adopted rather than gender differences among students. Hence, it is recommended that Chemistry teachers should adopt computer-based simulation technique in teaching chemistry concepts in view of its high facilitative effect on students' performance. It is also recommended that a similar study should be conducted in other parts of the country and in other subject areas to allow for meaningful generalization.

## References

Ayodele, S. O. (2001) Quality, quantity, production and distribution of teaching resources. In O. Nnoli & I. Sulaiman (Eds.). *Reassessing the future of education in Nigeria*, pp. 63-74. Abuja: Education Tax Fund.

Landu, I. T. (2003). Information Communication Technology (ICT): Science teachers' awareness. In M. A. G. Akale (Ed.). *Proceedings of 44th annual conference of Science Teachers Association of Nigeria (STAN)*, pp. 41-44. Ibadan: Heinemann Educational Books (Nigeria) Plc.

Mkpanang, J. T. (2010). Effects of Computer-Assisted Instruction (CAI) with drill and practice on academic achievement of students in physics. *Nigerian Journal of Science and Science Education*, 8 (2), 72-86.

Njoku, Z. C. (2004). Fostering the application of science educational research findings in Nigeria classrooms: Strategies and needs for teachers professional development. In M. A. G. Akale (Ed.). *Proceedings of 45th annual conference of Science Teachers Association of Nigeria (STAN)*, pp.217-222. Ibadan: HEB Plc.

Nwachukwu, J. N., & Nwosu, A. A. (2007). Effects of demonstration method on different levels of students' cognitive achievement in senior secondary school biology. *Journal of Science Teachers Association of Nigeria*, 42 (1 & 2), 50-59.

Ogunsola-Bandele, M. F. (2002). Use of computer simulators in science practical. In M. A. G. Akale (Ed.). *Proceedings of 43rd annual conference of Science Teachers Association of Nigeria (STAN)* Ibadan: HEB Plc, pp.537-538.

Okolocha, C. C. (2010). E-learning: A veriTable tool for preparing Business Education teachers in tertiary institutions in Anambra State. Nigeria. *African Research Review*, 4 (4), 260-276.

Olele, C. N. (2008). Emerging issues for computers in schools: A bridge for digital divide phenomenon in Nigeria. In N. Udofia (Ed.). *Proceedings of 49th annual conference of Science Teachers Association of Nigeria (STAN)* Ibadan: HEBN Publishers Plc, pp.195-199.

Otero,V. (2001). *The role of computer simulators in students' construction of explanatory models of static electricity*. A paper presented at NARST conference at St Louis, Missouri.

Simulation (2010). *Encyclopædia Britannica. Encyclopaedia Britannica Ultimate Reference Suite.* Chicago: Encyclopædia Britannica.

Udo, M. E. (2010). Effects of guided-discovery, student-centred demonstration and the expository instructional strategies on students' performances in chemistry. *African Research Review*, 4 (4), 389-398.

Wang, S., & Reeves, T. C. (2007). The effects of a web-based learning environment on students' motivation in a high school earth science course. *Journal of Education Technology Research and Development*, 55 (2), 169-192. http://dx.doi.org/10.1007/s11423-006-9016-3

Wodi, S. W., & Dokubo, A. (2006). The relevance of ICT in science and technology. *Journal of Curriculum Organization of Nigeria*, 13 (1), 200-206.

Zhang, J. (2007). A cultural look at information and communication technologies in eastern education. *Journal of Education Technology Research and Development*, 55 (3), 301-314. http://dx.doi.org/10.1007/s11423-007-9040-y

Table 1. A comparison of pretest–post-test mean score of students on CAT classified by treatment and gender

| Variable + Category | Sample Size | Pretest | | Post-Test | | Mean Difference (Pre-test – Post-test) |
|---|---|---|---|---|---|---|
| | | Mean | Dev'n | Mean | Dev'n | |
| **Computer simulation** | 15 | 30.40 | 8.66 | 54.80 | 6.32 | |
| Male | 13 | 28.31 | 7.20 | 53.38 | 5.25 | 24.40 |
| Female | 28 | 29.43 | 7.94 | 54.14 | 5.78 | 25.07 |
| **Total** | | | | | | 24.71 |
| **Guided-Discovery** | 16 | 34.00 | 7.16 | 53.75 | 7.55 | |
| Male | 15 | 32.27 | 8.48 | 52.80 | 8.58 | 19.75 |
| Female | 31 | 33.16 | 7.74 | 53.29 | 7.94 | 20.53 |
| **Total** | | | | | | 20.13 |
| **Expository** | 17 | 35.53 | 6.46 | 50.59 | 4.23 | |
| Male | 13 | 30.46 | 5.04 | 48.77 | 2.77 | 15.06 |
| Female | 30 | 33.33 | 6.33 | 49.80 | 3.73 | 18.31 |
| **Total** | | | | | | 16.47 |

Table 2. Summary of Analysis of Covariance (ANCOVA) of student's post-test performance classified by treatment and gender with pre-test as covariate

| Source of Variation | Sum of Squares | Df | Mean Square | F-cal | Sig. | Decision at p<.05 level |
|---|---|---|---|---|---|---|
| **Covariate**: *Pre-test* | 1 812.36 | 1 | 1 812.36 | 110.83 | .00 | Significant |
| **Main Effects**: | | | | | | |
| *Instructional Strategy* | 627.48 | 2 | 313.74 | 19.19 | .00 | Significant |
| *Gender* | 5.35 | 1 | 5.35 | .33 | .57 | Not Significant |
| **2-Way Interaction** | | | | | | |
| *Instructional Strategy* * *Gender* | 9.42 | 2 | 4.71 | .29 | .75 | Not significant |
| **Residual** | 1 | 82 | 16.35 | - | - | - |
| **Total** | 340.94 | 88 | - | - | - | - |
| | 3 511.01 | | | | | |


ISSN 1913-1844 E-ISSN 1913-1852

Table 3. Scheffe post-hoc of the students' posttest scores classified by the teaching methods

| (I) Teaching Method | (J) Teaching Method | Mean Difference (I-J) | Sig. |
|---|---|---|---|
| **Computer** | | | **Simulation** |
| Guided-Discovery | | .85 | .869 |
| | Expository | | |
| 4.34* | | .032 | |
| **Guided-Discovery** | | Computer | Simulation |
| -.85 | | .869 | |
| | Expository | | |
| 3.49 | | .093 | |
| **Expository** | | Computer | Simulation |
| -4.34* | | .032 | |
| | Guided-Discovery | | |
| -3.49 | | .093 | |