Effects of Information Technology-Integrated Teaching Strategies on Secondary School Chemistry Students' Process Skills Acquisition in Lagos State, Nigeria

O. T. Ojo
Department of Science and Technology Education,
University of Lagos, Akoka

Abstract
Effective science teaching combines the knowledge of the content with methods of gaining knowledge through scientific processes and practices. These scientific processes and practices are science process skills. It is imperative therefore, that effective strategies for teaching these skills be developed. Information Technology (IT) has been adjudged by many as improving learning outcomes in other subjects. This study investigated the relative effectiveness IT-integration into guided discovery and teacher demonstration methods on senior secondary school 2 (SSS II) chemistry students' acquisition of science process skills. Two research questions were raised in the study and five domains of science process skills were examined. Also, two hypotheses were tested. *A pretest-posttest quasi experimental research design was adopted. Twelve intact classes of 446 (264 male, 182 female) students from ten schools purposively selected from Education Districts II and III of Lagos State were used for the study out of a total population of 6,507. The sampled students were administered with Science Process skills Test (SPST) which consisted of hands-on activities (section A) and a paper pencil (section B) test. Using Analysis of Covariance (ANCOVA), the results indicated that the effectiveness of IT-integration into the two methods improved the acquisition of science process skills of SSS chemistry students. However, the students who received IT-integration in guided discovery method showed a significant gain in the acquisition of science process skills. Based on the findings integration of IT into teaching strategies were advocated for to improve science process skills acquisition in chemistry.*

Keywords: IT-integration, Guided Discovery, Teacher Demonstration, Science process skills and Skills acquisition.

Introduction

Science is an organised body of knowledge that uses a systematic approach in exploring or investigating nature in a testable and verifiable manner in order to establish presumed relations among phenomena with the basic aim of improving our understanding of nature. There are three major elements involved when talking about science and these are processes, products and human attitudes (National Teachers Institute, 2010). Also, Okebukola (2008) has identified the major component that science should reflect and these are: information domain, process domain, creative domain, attitudinal domain and personal relevance domain. Processes of science are very central to what scientists use in the process of doing science.

The underlying skills which govern the scientific method which is organised and systematic in exploring or investigating nature in a testable and verifiable manner in order to establish presumed relations among phenomena with the basic aim of improving our understanding of nature are referred to as science process skills. These skills are used in the experiments by the scientists and science students, as well as in the everyday life of average person, to a degree.

Skills are qualities of performance which may depend solely on a person's innate capacities, but must be developed through opportunities for training, practice and experiences (Baiyelo & Adeyemo, 2006). Skills are acquired and developed when an individual or learner undertakes routine operations through selected tasks or activities. Activity-based tasks, if properly undertaken help both to develop and reinforce a skill.

The term science process skills are popularised by the curriculum project, Science- A Process Approach (SAPA). It is componential of a set of broadly transferable abilities appropriate to many science disciplines and reflective of the behaviour of scientists which are grouped into two types and these are: basic and integrated (Padilla, 1990). The basic science process skills consist of six types of skills and these are:

- observing
- inferring
- measuring
- communicating
- classifying and
- predicting.

The integrated science process skills consist of another six types of skills and these are:

- controlling variables,

- defining operationally,
- formulating hypotheses
- interpreting data
- experimenting and
- formulating models.

Acquisition of basic science process skills is the prerequisite to the acquisition of higher order skills needed in technology and manufacturing. Hence, the emphasis on basic science process skills.

Teaching methods comprise the principles and methods used for instruction. The choice of teaching method or methods to be used depends largely on the information or skill that is being taught, and it may also be influenced by the aptitude and enthusiasm of the students. Most of the methods used in teaching science have been described as inappropriate and uninspiring (Ikeobi, 2004; Ajeyalemi, 2011; Agogo & Onda, 2014). Nnaobi (2007) asserts that there is no best method of teaching but that effective scientific teaching should be laboratory-centred and activity-oriented rather than textbook or lecture-dominated methods which seem to characterize the Nigerian schools.

The use of teacher demonstration method of teaching in science teaching which do not allow for students‘ involvement is prevalent in Nigerian secondary schools. Justification for this practice include; large class size, availability of limited apparatus, lack of adequate number of teachers and many more. However, the new curricula in most countries often recommend to varying degrees, a transition from a teacher-centred classroom to a student-centred learning environment. An alternative teaching approach for the development of skills and critical thinking is the guided discovery method (FME, 1985). This has been recommended as the appropriate instructional strategy by the developers of science curricula in Nigeria.

Teaching methods employed in teaching science especially chemistry have significant effect on students' learning outcomes particularly on acquisition of science process skills which is the key to becoming a scientist. The study of Nbina (2013) on relative effectiveness of guided discovery and demonstration teaching methods on students' cognitive achievement at different levels of scientific literacy and acquisition of science process skills found guided discovery significantly superior to demonstration method. Nworgu and Otum (2013) examined the effect of guided inquiry with analogy instructional strategy on students' acquisition of science process skills. The study showed significant positive effect of guided inquiry with analogy instructional strategy on students' acquisition of science process skills as against traditional lecture method. Oloyede (2012) compared the relative effectiveness of guided discovery and teacher demonstration teaching strategies in relation to the students' performance and skills acquisition in Chemistry. The result showed significant positive effect of guided discoveryon the two learning outcomes.

There is an increasing use of computers and other IT tools in teaching in schools. Ability to form mental models of processes is an essential requirement for learning science and computer visualization is an approach that is increasingly being used to help students' developmental models. Technology tools such as computers, mobile learning devices, software applications, video, audio, multimedia, and information technology are been integrated into the classrooms. The shift from teacher-centred teaching approach to students' active participation strategies has led to the inclusion of technology in the classroom like never before. Adeyemo (2010) described Information Technology IT as dealing with the use of electronic computers and computer software to convert, store, protect, process, transmit and retrieved information. The integration of such tools has contributed to efficiency and effectiveness of teaching and learning. According to Oloyede and Olorundare, (2009) reasonable application of IT makes teaching more diversified, flexible, and effective. The reasonable use of IT makes our scientific teaching methods more effective, flexible, and multiple. The application of IT in the classroom enables teachers to stimulate students' learning and challenge their higher order thinking skills because people are more of visual learners. Therefore, appropriately designed software materials can help students build mental links to strengthen their logical framework of conceptual understanding and to achieve a mastery level in understanding of chemical concepts (Arasasingham, Taagepera, Potter, Martorell & Lonjers, 2005).

For some years now, advances in IT educational environments have been accompanied with great hopes for their ability to foster interest and improve learning in science. Integration of IT materials brings about good science teaching, offers the students an opportunity for active learning and the use of visualization for clarity of difficult concepts. Research on utilization of IT resources in enhancing achievement abound. However, studies on integration of IT into particular teaching strategy and especially, the commonly used method of teaching science (teacher demonstration) and the curriculum recommended guided discovery and their effects on acquisition of science process skills are sparse.

Purpose of the Study

This study investigated the relative effectiveness of IT-integration into guided discovery (IGD) and IT-integration teacher demonstration (ITD) teaching methods on acquisition of science process skills in chemistry. Specific objectives are to determine:

(1) the impact of IT-integration in the two teaching methods on chemistry students acquisition of science process skills
(2) the relative effectiveness of IT-integration in the two teaching methods on chemistry students acquisition of science process skills

Research Questions

(1) What is the impact of IT-integration in the two teaching methods (guided discovery and teacher demonstration) on chemistry students acquisition of science process skills
(2) What is the relative effectiveness of IT-integration in the two teaching methods on chemistry students acquisition of science process skills

Hypotheses

The following null hypotheses were formulated

$H_0$1: There is no significant impact of IT-integrated guided discovery and IT-integrated teacher demonstration teaching methods on chemistry students' acquisition of science process skills.

$H_0$2: There is no significant difference between IT-integrated guided discovery (IGD) and IT-integrated teacher demonstration (ITD) teaching methods on chemistry students' acquisition of science process skills.

Methods

The study adopted a pretest-posttest non-equivalent quasi experimental research design to determine the effect of integration of IT into two strategies of teaching (guided discovery and teacher demonstration) on senior secondary school students' acquisition of science process skills (observing, classifying, measuring, communication, predicting and inferring). The two experimental groups are; IT-integrated Teacher Demonstration (ITD) and IT-integrated Guided Discovery (IGD) while the control groups are Teacher Demonstration (TD) and Guided Discovery (GD).

Twelve intact classes of 446 (264 male and 182 female) from twelve senior secondary schools were purposively selected from Education Districts II and III of Lagos State for the study. The criteria for selecting the sschools are:

(i) presence of a well-equipped chemistry laboratory
(ii) availability of ICT resources for teaching
(iii) availability of professionally qualified teachers.
(iv) willingness of the required chemistry teachers in the school to participate in the study and
(v) the schools must be co-educational

All the schools sampled for the study have one science class therefore, one intact science class per school was taught by one strategy. The total number of students sampled and which completed the pre- and post-tests were 446.

The instrument for the study, Science Process Skills Acquisition Test (SPST) has two sections A and B. Section A which was constructed by the researcher containing hands-on activities from each of the basic science process skills considered. Each of the activities contained four simple activities to be carried out on each of the six skills considered. Each simple activity was scored 1 mark. Total marks in this section are 24. Sample of the test item

TEST ITEM 1

You are provided with a weighing balance and containers of different substances:

A. Sugar, B. salt C. Copper(II) tetraoxosulphate (VI) D. marble and E. sand
   (i) Record the details of the observed characteristics of the substances
   (ii) Classify the substances in two (giving your reasons)
   (iii) Write the procedure you will follow to differentiate the sample by mass
   (iv) Write the procedure you will follow to find the number of moles of each sample
   (v) Mix each sample in $50cm^3$ of water, what inferences can you make from your observation?
   (vi) Discuss your observation and inference.

Section B is a 25 item multiple-choice test propounded by Coulson (2009) adopted to measure the respondents' acquisition of the six basic science process skills: observing, measuring, classifying, predicting, inferring and and communication with five questions on each basic science process skill.

Results

The effects of the treatment (experimental and control) strategies on science procss skills are presented below:

Table 1: Results of statistical analysis of post-treatment of Acquisition of Science Process Skills scores based on treatment

Serial Number	Treatment	Mean Scores (pre-test)	Std Dev (SD)	Mean Scores (Post-test)	Std Dev (SD)	Mean Difference
1	IT-Integrated Teacher demonstration (ITD	31.27	2.027	33.49	2.681	2.22
2	IT-Integrated Guided Discovery (IGD)	31.22	2.008	36.17	2.219	4.95
3	Guided Discovery (GD)	31.36	2.001	34.11	2.079	2.75
4	Teacher Demonstration(TD)	31.27	1.981	33.23	2.327	1 .96

Table 1 shows the mean, standard deviation and mean differences of the chemistry students' acquisition of science process skills in the experimental and the control groups. The mean difference of students taught with ITD (2.22) is higher than that of TD (1.96). The mean difference of students IGD group (4.95) is higher than students in GD group (2.75). Thus, the treatment had positive impact on acquisition of science process skills.

The null hypothesis H_01 was tested using analysis of covariance. Table 2 shows the result.

Table 2: Summary of Analysis of variance of Treatment on acquisition of science process among chemistry students

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2981.011[a]	16	186.313	365.916	.000	.932
Intercept	12.213	1	12.213	23.986	.000	.053
PRESPST	1716.997	1	1716.997	3372.157	.000	.887
TREATMENT	694.820	3	231.607	454.872	.000*	.761
Error	218.433	429	.509			
Total	503388.000	446				
Corrected Total	3199.444	445				

a. R Squared = .932 (Adjusted R Squared = .929) b.* significant at 0.05

Table 2 shows that for the treatment condition, the calculated F-value of 454.872 was significant at $p<.05$ given ($F_{(3, 429)}$ = 454.872, p = 0.000). The partial eta squared of .761 accounts for 76% contribution of the treatment condition to the acquisition of science process skills among chemistry students. This means that there is a significant effect of treatment on science process skills acquisition among chemistry students. Therefore, the null hypothesis was rejected

Research Question 2

Comparing IT-integrated Teacher Demonstration (ITD) with Teacher Demonstration (TD) and IT-integrated Guided Discovery (IGD) with Guided Discovery (GD), it can be seen from Table 1 that the experimental groups were more effective than their corresponding control groups for acquisition of science process skills using the mean difference. However, IGD was more effective than ITD on acquisition of science process skills.

Null hypothesis two (H_02) was tested to compare the significance relative effectiveness of the treatment using Bonferoni pairwise comparison. Table 3 shows the result.

Table 3: Bonferoni Post Hoc Pairwise comparison on experimental and control groups

(I) TREATMENT	(J) TREATMENT	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
IT-integrated Teacher Demonstration (ITD)	IT-integrated Guided Discovery (IGD)	-2.570*	.211	.000	-2.984	-2.156
	Guided Discovery (GD)	.230	.169	.173	-.102	.562
	Teacher Demonstration (TD)	2.082*	.170	.000	1.747	2.417
IT-integrated Guided Discovery (IGD)	IT-integrated Teacher Demonstration (ITD)	2.570*	.211	.000	2.156	2.984
	Guided Discovery (GD)	2.800*	.197	.000	2.412	3.188
	Teacher Demonstration (TD)	4.652*	.199	.000	4.261	5.043

Based on estimated marginal means
*. The mean difference is significant at the .05 level.

TD group was significantly different from ITD strategy group, IGD strategy group and GD strategy group. Also, ITD strategy group differed significantly from IGD strategy group. Thus, the null hypothesis is rejected. There was a significant difference between IT-integration guided discovery (IGD) and IT-integration teacher demonstration (ITD) teaching methods on chemistry students' acquisition of science process skills.

Discussion

The finding that IT-integrated teaching strategies (ITD and IGD) were more effective for acquisition of science process skills than strategies without IT-integration (TD and GD). This is so, because information technology activities promote active students particitipation/ involvement with full concentration and this finding reinforces the results of previous studies that IT-integrated instructions enhance student learning outcomes (Oloyede & Olorundare, 2009).

IT-integrated Guided Discovery was found to be most effective. This may be due to the fact that guided discovery on its own has been confirmed to be effective in science teaching (FME, 2007) as it applies the principles of effective questioning, appropriate directives and activity oriented. This method coupled with integration of technology increases the effectiveness of the strategy on acquisition of science process skills. This is supported by Oloyede and Olorundare (2009) in their study of development and validation of a computer instructional package on chemistry on electrochemistry. The findings of the study among others include that the computer instructional package enhanced acquisition of science process skills.

Integration of IT into teacher demonstration improved the performance of the students in the acquisition of science process skills more than the teacher demonstration alone because research has shown that integration of IT into instruction enhances retention and acquisition of skills. According to Paul (2002), integration of ICT into chemistry teaching makes the subject more meaningful and familiar to the students.

Conclusion

When science process skills are a specific planned outcome of a science program, those skills can be learned or acquired by students. This was true with the SAPA. The study established that the integration of IT into strategies of instruction is effective in improving senior secondary school students' acquisition of science process skills. If IT is integrated into the recommended Guided Discovery for teaching science, students would be fully involved in the teaching-learning process. The integrationof IT into teaching methods creates a friendlier teaching–learning environment which is able to improve students' participation.

Recommendations

Based on the results obtained from this study, the following recommendations are made:

- The IT learning environment with learning environment should be provided for the teaching and learning of chemistry so that the students can easily handle and manipulate apparatus thereby enhancing acquisition of science process skills.
- Chemistry teachers should be encouraged in computer training and workshops to integrate computer interactive instructional package into instructions to foster scientific knowledge, skills acquisition and adequate attitudes. This would make them better equipped for effective delivery.
- Teachers need to select teaching methods which enhance science process skills acquisition. In addition they need to capitalize on opportunities in the activities normally done in the classroom.

References

Adeyemo, Sunday A. (2010). The impact of information and communication technology (ICT) on teaching and learning of physics. *International Journal of Educational Research and Technology* 1(2), 48-59.

Agogo, P. O. & Onda, M. O. (2014). Identification of students' perceived difficult concepts in senior secondary school chemistry in Oju Local Government Area of Benue State. *Global Educational Research Journal* 2(4), 44-49.

Ajeyalemi, D. (2011). Practical work in School Science. Are the aims and objectives being achieved? 2011 *Memorial Lecture, 52nd Annual Conference Proceedings of the Science Teachers Association of Nigeria.*

Arasasingham, R. D., Taagepera, M., Potter, F., Martorell, I., & Lonjers, S. (2005). Assessing the effect of web-based learning tools on student understanding of stoichiometry using knowledge space theory. *Journal of Chemical Education* 82(8), 1251-1262.

Baiyelo, T. D. & Adeyemo, S. A. (2006). The development and validation of skills assessment strategy. In T.D. Baiyelo (ed). *Measuring, assessing and reporting skills in science, technology and mathematics.* Lagos: Dedun Educational books.

Federal Ministry of Education (2007). *National policy on education.* Lagos: Nigerian Educational Research and Development Press.

Ikeobi, I. (2004). Identification and teaching of difficult concepts in chemistry. *STAN Bulletin* 11(2), 3-5.

National Teachers' Institute (2005). *Post Graduate Diploma in Education PGDE by DLS subject methods Integrated Science.* Kaduna: NTI.

Nbina, J. B. (2013). The relative effectiveness of guided discovery and demonstration teaching methods on achievement of chemistry students of different levels of scientific literacy. *Journal of Research in Education and Society* 4(1), 43-58.

Nnaobi, A. F. (2007). Teaching qualitative inorganic component analysis in Colleges using multiple methods. *Journal of Science Teacher Association of Nigeria* (3), 87-91.

Nworgu, L. N. & Otum, V. V. (2013). Effect of guided inquiry and analogy instructional strategy on students' acquisition of science process skills. *Journal of Education and Practice* 4(27), 35-42.

Okebukola, P. (2008).Setting up and managing a web-based instructional delivery system. *Proceedings of the Annual Convention and International Conference of Nigerian Association for Educational Media and Technology* 3, 6-9.

Oloyede, O. A. (2012). The relationship between acquisition of science process skills, formal reasoning ability and Chemistry achievement. *International Journal of Advances in Applied Sciences* 8(1), 1-4.

Oloyede S. O. & Olorundare, A. S. (2009). Development and validation of a computer instructional package on electrochemistry for secondary schools in Nigeria. *International Journal of Education and Development using Information and Communication Technology (IJEDICT)* 5(2), 88-104.

Padilla, M.J. (1990). The Science Process Skills. Retrieved from http:/www.edu.stuca/narstsite/publication/research/skillhtm on 15th April, 2012.

Paul, C. (2002). Literature Review: The impact of ICT on learning and teaching, available at http://www.det.wa.edu.au/pdf