Effects of Digital Game-Based Instructional Strategy on Students' Achievement in Chemical Reactions among Senior Secondary School in Niger State, Nigeria

By

A.M. Chado

R.W. Gimba

M. Babagana

and

I.A. Yahaya

Abstract

This study determined the effect of digital game- based instructional strategy on senior secondary student Achievement in Niger State. Three research question and three null hypotheses were formulatedand testedat 0.05 level of significance. Quasi experimental design using pre-test posttestnon equivalent control group research design was adopted for the study. Four (4) co-educational schools out of twenty three (23)schools in Minna metropolis Niger state were purposively selected. The selection of the schools was based on availability of computer laboratory. The selected schools were randomly assigned into experimental and control groups. A total number of one hundred and one student (101) (64 males and 37 females) participated in the study. Intact classes of the selected schools were used. Chemistry Achievement Test CAT was adopted from West African School Certificate Examination.The face and content validity of CAT was determined by experts in chemistry education and test and measurement.The reliability coefficient 0.81 was determined on CAT using K-R 20. The data collected were analyzed using analysis of covariance (ANCOVA) using statistical package for social sciences (SPSS) version 20.0. Findings from the study indicated that digital game based instructional strategy enhanced the achievement of chemistry student, the result also revealed that the achievement of chemistry students using digital game based instructional strategy was gender bias in favour of the boys It was recommended that digital game based instructional strategy should be employ to teach senior secondary school students in Niger State and beyond, and Chemistry teachers should be sent on in service training to study educational technology where they can learn the design of instructional materials.

Introduction

Chemistry is the study of matter, its properties, how and why substances combine or separate to form other substances, and how substances interact with energy. Many people think of chemists as being white-coated scientists mixing strange liquids in a laboratory, but the truth is we are all chemists. Doctors, nurses and veterinarians must study chemistry, but understanding basic chemistry concepts is important for almost every profession.Therefore Chemistry is part of everything in our lives.(Bagley 2014)

The role of chemistry in the development of the scientific base of a country cannot be overemphasized and Nigeria is not an exception. Yet with the increasing importance of chemistry to the unfolding world, the performance of Nigerian students in the subject at the secondary school remains a dismal

failure. However it is disappointing to note that the students' performance in chemistry at internal and external examination has remained considerably poor despite the relative importance of chemistry (Chief Examiners Report 2011,2012,2013,2014,2015). Several factors have been advanced to affect students poor performance in chemistry such as the student factor, teacher factor (Okoro2002), societal factor (Aliobu, 2005 and Korau 2006), test related variables(Ekpo-Eloma, 2010), textbook related variables and home related variables (Adebule, 2004).

Reactions in Chemistry are represented with chemical equations through the use of symbols and formulae. Therefore the study of chemical reaction is important in the study of Chemistry. Supporting this Anthony (2009) submitted that the understanding of balancing of chemical equation is a pre-requisite to the comprehension and learning tasks in chemistry such as chemical equilibrium, electrochemistry and organic chemistry. Balancing chemical equations have also been identified as one of the difficult chemical concepts students encounter in both practical and theory. The West African ExaminationCouncil chief examiners' reports of 2009, 2010, 2014and 2015 ascertained that most chemistry students perform poorly in chemistry because of their inability to write chemicalequations correctly, identify reactants and the products as well as to balance the reaction equation correctly. Although efforts have been made by various researchers and science educators to come up with instructional strategies that will promote effective teaching and learning of chemistry concepts, to improve students conceptual understanding and achievement, this has not yielded much result. Therefore, it becomes necessary to adopt instructional strategy that will promote students active learning in chemistry such as digital game based instruction.

Connolly and Stansfield (2007) defined digital game-based (DGB) instruction as the use of a computer games-based approach to delivered support and enhance teaching, learning, assessment, and evaluation. Stressing the educational value of digital game-based instruction Prensky (2007)defined DGB as an approach based on the integration of educational content into digital games and leading to the achievement of the same or better results, in comparison to traditional instructional approaches. Furthermore, researchers have acknowledge that the use of digital game-based instruction offers opportunities for learning by applying trial-and-error approaches, players engage in active explorations, formulate and test hypotheses within the virtual world of the game, and based on feedback, confirm or reject them (Gee,2007, Shenand Chen 2010, Whitton 2010).

Several research findings showed that the use of DGB improve students achievement. Bottino et al., (2007) in a study observed that engaging students in long-lasting game supported educational activities enhances the development their problem-solving skills and improved their achievement in mathematics exams. Similarly DGB have also been found tosupport students draw links between school-based mathematics and real-world situation. The result of findings shows that using role-playing educational games for designing and implementing meaningful activities allows for providing students with concrete examples highlighting potential uses of abstract mathematical concepts andprocedures in specific domains (Lowrie, 2005 and Williamson, 2006).

There has been contrasting opinions on gender related issues on students'achievement in chemistry. Onyegegbu (2004) in a study reported

that girls participated in fewer sciences related courses thanboys. While Fatokun and Odagboyi (2010) viewedgender as a significant factor in students' achievement in chemistry due to interaction patterns, while Olasheinde and Olatoye (2014) findings showed that there was no significant difference between male and female students in overall science achievement.

The family has been identify to have powerful influence on the child and its importance as a primary agent of socialization could in no doubt enhance or hinder the academic achievement of the child depending on the social climate in the family. Variance in psycho-social emotional fortification in the monogamy and polygamy family background could be an indicator to high or low academic performance of students. Research on this aspect has not been exhaustively looked into in Nigeria where the three types of family system is actively practice Adebule, (2004) and Amato, (2000) in his submission emphasized that in the nuclear family, favorable learning environment is created, while Jeynes, (2002) noted that conflicts are relatively easier to solve in the nuclear than in the extended families. Moreover, less psychological disturbance is envisaged in the former than in the latter from extended familiesand aretherefore likely to experience more problems than students from monogamous families this may invariably affect their academic achievement in chemistry.

It is against this back drop that the study sought to determine the effect of digital game-based instructional strategy on student achievement in chemical reactions among senior secondary school in Minna, Niger state. It also examined the moderating ofstudents gender and family type.

Statement of the Problem

The neglect of students centeredlearning have been identified as a major reason responsible for students' poor achievement in chemistry in secondary schools among teachers. Although several instructional strategies have been used to teach chemistry, but the poor performance of students still persist. Therefore there is need to employ instructional strategy that involve the use of game which promote active learning, such as digital game-based learning. Although several studies have been carried out on DGB in the area of mathematics however not much literature has been documented in the area of chemistry particularly in Niger state. Therefore the study investigated the Effect of Digital Game-Based Instructional Strategy on Students' Achievement in Chemical Reactions in Chemistry among Senior Secondary Schools in Minna, Niger state.

Research Questions

This study will provide answers to the following research questions:

i. Will there bedifferences between the mean achievement scores of students taught chemical reaction using digital game -based instructional strategy and those taught with conventional lecture method?

ii. Will therebe differences between the mean scores of male and female students taught chemical reaction using digital game based instructional strategy?

iii. Will there bedifference between the mean score of student taught chemical reaction using digital game- based instructional strategy and their family type?

Research Hypotheses

The followingnull hypotheses were tested at 0.05 level of significance

HO_1: There is no significant difference in the mean scores of studentstaught chemical reaction using digital game - based instructional strategy and those taught with conventionallecture method

HO_2: There is no significant difference in the mean scores of male and female students taught chemical reaction using digital game-based instructional strategy

HO_3: There is no significant differencebetween the mean scores of student taught chemical reaction using digital game- based instructional strategy and their family type.

Methodology

The research design adopted for this research is quasi experimental design using pretest posttest non-equivalent, non-randomized control group experimental design. Purposive sampling technique was used to select four secondary schools four (4) schools within Minnametropolis. The selections of the schools were based on some criteria: (i) schools that have computer laboratory ii) schools that are co-educational. The selected schools wererandomly assigned to experimental and control groups. A total of101 (64 male and 37 females) students participated in the study.Intact classes from the four selected schools were used in the study. Chemistry Achievement Test was used for used for data collection.

The treatment instrument is the digital game-based instruction developed by the researcher with the help of a programmer.The game that was selected to support the proposed educational activities "chemical lab for chemistry".It isasimulation game which engages players in activities requiring the use of laboratory apparatus to carryout chemical reactions, strategic thinking on the element that can react putting them in the selected apparatus, heating if necessary to have a product. The game allows players to test various reactionsbetween elements from different groups. The face and content validity of the (DGBL) was established by expert in educational technology from Federal University of Technology, Minna to determine the clarity, suitability, appropriateness and interaction of the game.The test instrumentChemistry Achievement Test (CAT) was adopted from West African School Certificate Examination. The CAT is a multiple choice instrumentwith 30 items with four options. The face and content validity of CAT was determined by experts in chemistry education and test and measurement. Reliability coefficientindex of 0.81 was established using Kurder-Richardson (KR-20). CAT was administered as pre-test, to ascertain the entry behavior of the groups before the administration of treatment while post-test was administered after treatment was administered on the groups but the questions were reshuffled. The study lasted four weeks.The data collected were analyzed using mean, standard deviation and analysis of covariance (ANCOVA) and estimated marginal mean.

Results

Ho_1: There is no significant difference in the mean scores of students taught chemical reactionexposed using digital game-based instructional strategy and those taught with conventional lecture method.

Table 1 Estimated marginal mean of students' achievement in experimental group

Experimental group	Mean	N	Standard deviation
Pre-test	8.175	57	3.268
Post-test	15.211	57	5.787
Control group			
Pre-test	7.386	44	2.180
Post-test	9.886	44	2.432

Table 1 revealed that student exposed to digital game-based learning has the highest posttest mean score $\bar{x}$ = 15.211 and the control $\bar{x}$ =9.886. This implies that student in DGBL group had the highest contribution to the observed significant difference followed by the conventional lecture method.

Table 4 also indicates that there is a significant main effect of treatment on students' achievement in chemistry [$F_{(1, 93)}$ = 22.43, P< 0.05:η^2=0.19] therefore the null hypothesis is rejected. This implies that there is significant difference in the mean posttest score of student taught chemical reactionusing digital game-based instructional strategy than conventional lecture method.

Ho_2: There is no significant difference in the mean scores of male and female students taught chemical reaction using digital game-based instructional strategy.

Table 2 :Estimated marginal mean of gender

Gender	N	Mean	Standard deviation
Male	32	14.055	5.472
Female	25	12.324	5.365

Table 3 revealed that student exposed to digital game -based learning has the highest posttest mean score of male$\bar{x}$= 14.055 and the female$\bar{x}$=12.324. This implies that male students in DGBL group had the highest contribution to the observed significant difference than the female students.

Table 1 also showed that the main effect of gender is significant [$F_{(1, 93)}$ = 5.055, P< 0.05:η^2=0.052] therefore the null hypothesis is rejected. This implies that gender has significant effect on student achievement posttest score in chemical reaction.

Ho_3: There is no significant difference between the mean scores of students taught chemical reaction using digital game based instructional strategy and their family type?

Table 3: Estimated marginal mean of family type

Family type	N	Mean	Standard deviation
Nuclear	35	14.055	5.472
Extended	19	11.000	4.619
Single parent	03	12.278	5.200

Table 3 revealed that students from nuclear family exposed to digital game-based learning has the highest posttest mean score x= 14.055 followed by

student from single parent x =12.278 and lastly students from extended family $\bar{x}$= 11.000. This implies that students from nuclear home had the highest contribution to the observed significant difference followed by the single parent and then the extended family.

Table4 also showed that the main effect of family type is significant [$F_{(1, 93)}$ = 11.020, P < 0.05:η^2=0.106.] therefore the null hypothesis is rejected. This shows that family type has significant difference on students' achievement in chemistry.

Table 4: Summary of 3 × 2× 2 ANCOVA of a posttest Achievement Scores of Students by gender, family type and treatment

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Model	17640.790[a]	8	2205.099	103.719	.000	.899
Pretest	354.384	1	354.384	16.669	.000	.152
TREATMENT	476.840	1	476.840	22.429	.000	.194
GENDER	107.461	1	107.461	5.055	.027	.052
FAM_TYPE	234.281	1	234.281	11.020	.001	.106
Error	1977.210	93	21.260			
Total	19618.000	101				

R Squared = .899 (Adjusted R Squared = .891)

Discussion of Results

Findings of the study showed that students in the experimental group performed better than the control group. This implies that students in the experimental benefitted from the treatment, this may be attributed to the fact that students in the DGBL group feels they are the ones doing the reaction and their ability to react any element together which the game will tell whether the element can react or not, for that reason they were able to know element and compound that can undergo reaction. This finding is in agreement with these findings of De Freitas and Griffiths, (2008) that established better performance of students expose to DGBL compare to student using CCI.

Digital games also provide virtual worlds which are effective contexts for learning, because acting in such worlds allows students to view concrete examples highlighting potential uses of abstract concepts in chemistry that encourage critical thinking and problem-solving. Shaffer, (2008) and Bottino et al. (2007) claimed that appropriate educational designs,supported by the use of educational games, can promote the development of critical thinking skills by engagingstudents in formulation and testing of hypotheses, reflection activities, and drawing inferences.

The finding of this study showed that, the male students performed better than the female student in DGBL group,this implies that male student have high ability to manipulate digital game than the female due to the fact that male students generally are been attached to gadgets which give them an edge over the female student. This is in agreement with the findings of (Zenbar and Blume, 2009) which shows that male performed better in mathematics and science than their females' counterparts.

The finding of this study shows that student from nuclear family exposed to digital game instruction performed better than those from extended family. This is may be attributed to the fact students from nuclear family sometimes have access to some of this facilities due to either the nature of their parent occupation or socio economic status which make them familiar with the computer game. This however may not be the case with students from extended family that leave in a noisy overcrowded home were some of this game may not be available. This however

is in agreement with the findings of Adebule, (2004) who emphasized that in the nuclear family, favorable learning environment is created, while Adika (1987) noted that conflicts are relatively easier to solve in the nuclear than in the extended families, which often affect students psychologically.

Conclusion

The findings of the study showed that the use digital game -based instructional strategy enhances students' achievement in balancing of chemical reactions. The students taught using conventional lecture method had low achievement scores. This however may be attributed to the method of instruction adopted for teaching the concept. It was however concluded that giving the enabling environmentand the type family the students come from the use of digital game- based instructional strategy encourages active participation of students and bring about improved achievement of students in chemistry.

Recommendations

Based on the findings of the study the following were recommended.

Chemistry teachers should adopt digital game- based instructional strategy to teach chemistry concepts in secondary schools. This can be achieved by exposing the students to various games that are related to mathematical game to be covered in the lesson.

- Chemistry teachers should be sent on in service training to study educational technology where they can learn the design of instructional materials
- School principals should support chemistry teachers for powerful utilization of multimedia in teaching and learning of chemistry in secondary schools.

Reference

Adebule, S.O. (2004). Gender differences on a locally standardized anxiety rating scale in mathematics for Nigerian secondary schools in Nigerian. J. Counsel. Appl. Psychol. 1:22-29.

Adika JA (1987). Family types and Academic performance: A comparative study of selected secondary school students in two local government areas of Oyo State. *UnpublishedM.Ed. Dissertation,University of Ilorin.*

Amato, P.R. (2000). The Consequences of Divorce for Adults and Children.*Journal of Marriage and Family, 62,* 1269-1287.

Anthony A.D. (2009). The Effect of Simulation Game on Senior Secondary School Students Performance and Attitude towards Balancing of Chemical Equations. *An MPHIL dissertation presented to the department of science education, Winneba Ghana, 444.*

Bagley, M. (2014). Live science contributor.

Bottino, M. et al. (2007).Developing strategic and reasoning abilities with computer games at primary school level.*Computersand Education*, *49*(4), 1272–1286.

Chen, Z.H. and Chan, T.W. (2010).Using Game Quests to Incorporate Learning Tasks within a Virtual World.*Proceedings of10th IEEE International Conference on Advanced Learning Technologies 2010*, Sousse, Tunisia, 750–751.

Connolly, T.M. and Stansfield, M.H. (2007). From eLearning to games-based eLearning: Using interactive technologies inteaching an IS course. *International Journal of Information Technology Management*, *26*(2/3/4), 188–208.

De Freitas, S. and Griffiths, M. (2008). 'The convergence of gaming practices with other media forms: what potential for learning? A review of the literature', *Learning, Media andTechnology*, 33, 1, 11–20.

Ekpo-Eloma, E.O.(2010). *Improvisation of instructional materials for primary schools.*Teachers' professional development: Workshop manual. Cross River State.

Fatokun, K.V.F. and Odagboyi, I.A. (2010).Gender disparity and parental influence on secondary school student's achievement in Nasarawa State. *Journal of Research in National Development,* 8(2a):8–12.

Gee, J.P. (2008). 'Learning and games.' In: Salen, K. (Ed) *The Ecology of Games: Connecting Youth, Games, and Learning* (The John D. and Catherine T. MacArthurFoundation Series on Digital Media and Learning). Cambridge, MA: The MIT Press.

Jeynes, W.H. (2002). Examining the Effects of Parental Absence on the Academic Achievement of Adolescents: the Challenge of Controlling for Family Income.*J. Fam.Econ. Issues,* 23(2): 189 210.Mary Bagley (2014). Live science contributor.

Lowrie, T. (2005). Problem solving in technology rich contexts: Mathematics sense making in out-of-school environments.*Journal of Mathematical Behavior*, *24*(3-4), 275–286.

Okoro, C.C.(2002). *Basic concepts in educational psychology*. Nsukka.UCO-Academic Publishers Nig. Ltd.

Olasheinde, K. J., and Olatoye, R. A. (2014).Comparison of male and female senior secondary school students' learning outcomes in science in Katsina State, Nigeria. Mediterranean *Journal of Social Sciences,* 5(2):518–523.

Onyegegbu, N. (2004). Interaction and gender in senior secondary school science classroom. Journal of the Nigerian Academy ofEducation, 2(1):33-41.

Prensky, M. (2007).*Digital Game-Based Learning*. Minnesota: Paragon House.

Shaffer, D.W. (2008). *How Computer Games Help Children Learn*. New York, NY: Palgrave.

WAEC, (2009)"Chief Examiners' Report May/June West African Senior School Certificate Examination", Lagos:WAEC Pub., 2009.

WAEC,(2010)"Chief Examiners' Report may/June West African Senior School Certificate Examination. Abuja: FME Pub., 2010.

WAEC,(2014) "Chief Examiners' Report may/June West African Senior School Certificate Examination. Abuja: FME Pub., 2014.

WAEC,(2015) "Chief Examiners' Report may/June West African Senior School Certificate Examination. Abuja: FME Pub., 2015.

Wakefield, J.F. (1996). Educational Psychology: Learning to be a Problem-Solver. Boston: Houghton Mifflin.

Williamson, S.D. (2006). Epistemic frames for epistemic games. *Computers and Education*, *46*(3), 223–234.

Whitton, N. (2010). *Learning with Digital Games: A practical guide to engaging students in higher education.* New York, NY: Routledge.

Zenbari, M.J. and Blume, L.B. (2009). G ender and Academic Achievement.Education.com. http://www.education.com/reference/article/gender-academic-achievement