EFFECT OF GAME INSTRUCTIONAL APPROACH ON CHEMISTRY STUDENTS' ACHIEVEMENT AND RETENTION IN PERIODICITY

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ABSTRACT

This paper investigated the effect of games teaching approach on chemistry students' achievement and retention in periodicity. The research designed employed was pretest -post test control quasi experimental design. Multi-stage random sampling technique was used to select 96 students who participated in the study. Periodicity Achievement Test (PAT), used as Pre-Test (PREPAT), Post-Test (POSTPAT), and Post-Post-Test (PPPAT) was developed by the researcher and validated by experts. The reliability coefficient of the instrument obtained using spearman-brown prophecy formula was 0.77. Five hypotheses were formulated and tested at 0.5 level of significance. The pretest was administered to subjects in both groups to measure their knowledge in periodicity. The control group was taught periodicity for four weeks using only the conventional method while the experimental group was also taught periodicity for four weeks with games method. POSTPAT was administered to all the subjects at the end of the fourth week. Two weeks after the administration of POSTPAT, the PPPAT was administered to both groups. The results show that the students taught periodicity using game method achieve and retain better than those taught with conventional method. It was also discovered that gender has no influence on the achievement and retention of those exposed to treatment.

Keywords: Games, Achievement, Retention, Periodicity**.**

INTRODUCTION

The importance of chemistry in the development of any nation cannot be underrated especially in Nigeria where the national income rest on petroleum and petrochemical industries (Adesoji & Olatunbosun, 2008). Chemistry has often proven to be a difficult subject for many students (Johnstone and Otis, 2006), containing many abstract concepts which are central to further learning in both chemistry and other sciences (Taber, 2002). These abstract concepts are important because further chemistry concept or theories cannot be easily understood if these underpinning concepts are not sufficiently grasped by students. Concepts such as dissolution, particulate nature of matter, periodicity, formulae and equations, chemical bonding are fundamental to learning chemistry. The root of many difficulties that students have in learning chemistry is traceable to inadequate understanding of these underlying topics such as the periodicity. The chief examiner's report of the West Africa Examination Council (WAEC 2010 - 2011) shows that most chemistry candidates displayed inability to accurately write down chemical formula and balance simple equations. This is because students were not properly grounded in periodicity. Weiss, Knowlton and Morrison (2002) noted that many students have difficulties in recalling the position of elements in the periodic table and connecting the elements to their physical and chemical properties.

The statistics obtained on the performance of candidates in Senior Secondary Certificate Examination (SSCE) for the whole nation from 2001 – 2014 attested to students' poor achievement in chemistry at external examinations. Njoku (2004), Asikhai (2010) and Eze and Egbo (2007) have attributed the observed students' poor achievement in chemistry to the use of inappropriate or ineffective teaching method by chemistry teachers. Mari (2002) maintained that teaching strategies is a variable that can easily be manipulated by teachers to increase student's retention rate and performance as well as reduce or eliminate sex-related difference in science and mathematics performance. Osuala and Ogomaka (2005) reported that 60% of Nigeria secondary school chemistry teachers use the conventional method with occasional teacher dominated experiments which make students passive learners. Conventional method does not encourage meaningful student-teacher, student-students and student-material interaction. It also hinders activities for developing scientific reasoning and skill processes.

Korau (2006) observed that over population makes it impossible to operate an ideal classroom size for effective chemistry teaching. National Policy on Education (FGN, 2004) stated that for effective participation of students in practical work, the teacher-student ratio should be kept at 1:20 but unfortunately this was never possible and most chemistry teachers use teacher-centered approaches instead. Also due to bulky chemistry curriculum which must be covered within a stipulated period before the school examination, Etsey (2005) reported that most teachers end up not completing the syllabus and not involving students in meaningful hand-on-activities. Consequently, both teachers and students are not able to cope with the teaching and learning of chemistry respectively (Achor, 2003; Derek, 2007; Ogbeba, 2009). Studies (Nwosu, 2004; Johnson, 2004) have shown that most science teachers do not possess the prerequisite knowledge needed for activity based learning. Chemistry teachers are expected to have a good level of competence and mastery of the subject in order to enhance students' interest.

Sam, (2011) regrettably observed that the number of students meeting university requirement in the field of science, and technology in Nigeria is on the low side. Odetoyinbo, 2004 lamented that most students lack interest in core science subjects and consequently decline from science oriented courses such as Medicine, Engineering, etc in the University. The main function of pedagogy is to ensure that ideas and information are meaningfully presented, clear and retained over a long period of time. Chemistry should be taught in a way in which current ideas and innovations are introduced into it, especially in this modern age where children learn a lot through cell phones and computers. Chemistry lessons should be activity packed because merely teaching the chemical concepts in the class may not be enough to achieve the desired mastery of such concepts. Innovation like games played in and outside the classroom could improve the mastery and retention of some chemical concepts.

Games are integral parts of all cultures and one of the oldest forms of human social interaction. A game is any form of play, amusement and activity involving competition. Game contains what can engage students and help them enter a state of flow (Csikszentmihalye, 1990) where they are fully immersed in the learning environment and energized to focus on the activity they are involved in. Games in chemistry are activities which are designed particularly for the learning or reinforcement of some concepts/skills as well as for cultivating some important attitudes, including the appreciations of chemistry. The use of games in teaching and learning chemistry is based mainly on the psychology of 'play' itself and on their relationship to real life situation in certain aspect. An important aspect of

educational games is enjoyment, without which games may turn out to be tedious, resembling workbook activities rather than play.

Chemistry games are educative games and can be grouped into competitive and non-competitive games. The competitive chemistry games involves scoring, the scoring system has a fixed number of points. One player's success automatically leads to another player's loss. The non-competitive chemistry games involve no scoring but self developed skill and mastery of subject matter to solve related problems. Examples of games for chemistry teaching are card games, board games, crossword puzzles, virtual science games, etc. Ghassan (2007) observed that one of the reasons for the poor performance in chemistry is inability to recall previous knowledge easily. Therefore, learning and teaching chemistry with game could; motivate students, improve their learning interest, make students utilize the knowledge learnt in an active manner, increase students' critical thinking and decision making ability, help students relate information to everyday situation and thus see the relevance of learning specific information, enhance students' retention of what they have learnt, lead to person growth e.g. communication, cooperation, personal judgment and problem solving. The brain has been found to reject the processing of some information presented to it if such information came from or will likely lead to stress, unhappiness or threat (Gwany, 2005). Game often remove stress and encourage relaxation and fun. Chemistry games get students to interact and have fun while learning chemistry. Using games to teach help students practice essential formulas and facts reduce anxiety thereby making learning permanent.

In many Nigerian schools, female students are presumed to evade the study of chemistry due to several factors like psychological, motivation and interest. Women Scientists are very few in Nigeria though the National Population Census clearly showed that the population of females' out- numbered that of males. The issue of how male or female students learn and retain chemical concepts is a concern. Therefore, teaching method that would benefit both sexes should be adopted by the chemistry teachers. Hence, this study specifically sought to find out the effect of teaching periodicity with games on chemistry students' achievement and retention.

Research Questions

The following questions were posed to guide the study.

1. What is the mean achievement scores of students taught periodicity with games and those taught with conventional method?
2. What is the mean retention scores of students taught periodicity with games and those taught with conventional method?
3. What are the mean achievement scores of male and female students taught periodicity using game?
4. What are the mean retention scores of male and female students taught periodicity using games?

Statement of Research Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significance.

Ho_1: There is no significant difference in the mean achievement scores of students taught Periodicity with games and those taught with conventional method.

Ho_2: There is no significant difference in the mean retention score of students exposed to Periodicity with games and those exposed to the conventional method.
Ho_3: There is no significant difference in mean achievement scores of male and female students taught Periodicity using games.
Ho_4: There is no significant difference in mean retention scores of male and female students who were taught Periodicity using games.
H_{O5}: There is no significant interaction effect of teaching methods and gender as measured by Periodicity Achievement Test (PAT).

LITERATURE REVIEW

Ogunleye & Babajide (2011) observed that science subjects such as chemistry are given masculine outlook by many educationists which imply that women and girls grapple with a lot of difficulties (Okeke, 2007). The females' non-involvement in scientific studies has created males dominance in technological advancement in Nigeria. Agomuoh, (2010) and Ukozor, (2011) reported that males students performs better than females in chemistry, physics and biology generally while Olom, (2010) and Aniodoh & Egbo, (2013) revealed significant differences in favour of females. However, Udosoro, (2011) showed that gender has no significant effects on science achievement. Although boys and girls differ in their physical, emotional and intellectual development, efforts to link gender difference to intellectual capabilities have however proved untenable (Inyang and Hannal, 2000; Orimogunje, 2006). Ezeudu (2014) stated that gender was not a significant factor on student's achievement and retention in organic chemistry. The male and female students showed the same level of achievement and retention. In their study, Udo and Udofia (2014) reported that gender has a significant influence on students performance in the area of symbols, formulae and equations in chemistry, with the male outperforming there female counterpart. Although, research has generally supported the conclusion that there are no biological, neurological or genetic factors at work in creation of scientific gender disparity. Thus, research findings in chemistry education have been inconclusive as to who achieve higher whether male or female?

The use of games in the teaching and learning of chemistry is supported by Vygotsky theory. Vygotsky zone of proximal development talks about a point in the learning process where a special type of intervention is provided for the learning to help a student build knowledge or make sense of his/her world. The assistance used by the learner needs to be intentionally provided by the teacher. Vygotsky (1978) emphasized on social interaction as the best way of learning. To him a child learns better in collaborative activities than when he/she learns alone. According to Iroegbu, Nkwocha and Onyemerekya (2002), one of the educational implication of Vygotsky theory is for teachers to provide learners with motivations and clues on how to solve their problems.

Piaget (1962) pointed out that, informal games played by young children are critical component in their social and intellectual development. Therefore, teaching periodicity with games could help students learn the basic fundamentals of chemistry without engaging in memorization of complex information about elements and substances. Game can help teachers facilitate the transfer of skills through the pre-and post-game discussion which connect the game with other things student are learning in class (Ash, 2011). Close ties exist between games and learning; theories that focus on the integration of experience, learning and development of skills are associated with games and plays (Brett, Tom and Tom, 2011). Games and simulations have been used in pre schools, K – 12, the University, Military, Business and by older Adult (Dempsey et al 1997).

Poripo (2008) experimented on the effect of simulation-game on male and female students' achievement in chemistry in Bayelsa State, Nigeria. The result of the tested hypotheses showed that the use of simulation method increased the achievement of students in chemistry. Male and female students achieve highly with no significant difference in their mean responses. Abraham (2004) also studied pupils' motivational factors in computer games and simulations. A descriptive survey design was adopted in which opinions of pupils and teachers were polled. Data analyses revealed that there is no significant difference between males and females opinions in their motivational drives for accepting game and simulations as educational tools. The respondents also were unanimous in accepting such factors as curiosity and inquisitiveness, challenge, friendship and social interaction, interest and enhanced academic performance as some of the motivational factors that attracts pupils to games. Ezeudo and Ezinwanne (2013) investigated the effect of simulation games on students' achievement in Senior Secondary School Chemistry in Enugu State, Nigeria. The design of the study was pre-test and post-test quasi-experimental. The sample consisted of 159 Senior Secondary Schools of (SSS 1) Students (80 males and 79 females). The achievement test in simulation (ATIS) was used to collect data on students' achievement. The result showed that simulation increased students' achievement in chemistry. There was no significant difference in achievement of male and female students in Chemistry concepts.

Bahrami et al (2012) carried out a study on a comparison of the effectiveness of game- based and traditional teaching on learning and retention of first grade math concepts in Iran. The population of the study consisted of all the female student of khorramabad province. Experimental group were taught using game-based teaching while the control group were taught using the traditional teaching. Data description was done using mean standard deviation and data comparison was done using independent T-test and Effect Size (ES). The results showed that the experimental group had higher score in learning and retention; this revealed that using educational games in teaching of first grade math can be remarkably helpful and efficient. Hassan and Poopak (2012) in their study in Iran investigated the effect of teacher-made instructional card games and computer games for learning chemistry concepts on high school students majoring in math and science. The sample consisted of three groups of 35 students. The results indicated that there was a significant difference between teacher – made card games and computer games.

METHODOLOGY

Research Design

The research design adopted was pretest – posttest control group quasi-experimental design. Two intact classes were assigned to the Control group (C) and the Experimental group (E) each.

Sample and Sampling Procedure

The target population of the study was Senior Secondary SS2 chemistry students from public secondary schools in Keffi Local Government Area of Nasarawa State. Multi-stage random sampling technique was employed during sampling. The coeducational schools were selected from the study area and two schools were later randomly selected. An intact class was randomly selected from each of the two schools. One of the intact classes was randomly selected to serve as the experimental group while the other as the control group. The sample for this study consisted of 96 SS2 chemistry students.

The Games used for the Study

The games used for this study were card games and board games. They were eight games namely; Element Card I, Atomic Radius Card, Ionization Card, Group Fixing, SPD – Game, Sorting – Out, Transition Element Card and the Throw and Answer.

The Element Card I are cards containing information about the elements. Students were to arrange the cards on the cardboard paper provided based on the elements atomic number. The Atomic Radius Cards are cards which have the atomic number of the element at the top of the card, the boldly written symbol of the element at the middle and the atomic radius (in picometers) of the element below the symbol of the element. Students arranged the card on a plain cardboard paper following the periodic chart order.

The Ionization Cards are cards which bear the name and symbols of element, atomic number of element and the ionization energy (KJ/mol). The students arranged the card on a cardboard paper provided according to their groups and periods. In the Group Fixing, the empty periodic table was provided, with a box containing different names of families of elements. The students were required to pick a name from the box and fix it in the right position on the empty periodic table.

In the SPD – Game, the empty periodic table inscribed with SPD is the board. There are also plastic square objects which bears symbols of elements. The student arranged the plastics square objects in the s-block, p-block, d-block in the empty periodic table respectively. The Sorting – Out Game is a game play with the empty periodic table which serves as the board and the element object which are small square shape with symbols of elements written on them.

The Transition Element Card – Are cards which bear the name, symbols, atomic numbers and the electronic configuration of the transition elements.

In the Throw and Answer (A, B, C, and D), the students threw the dice on the surface of the board. Depending on the number that appears on the dice after landing on the table, the student was to go to the board and answer the question of that number.

Instrumentation

The instrument used for data collection was the Periodicity Achievement Test (PAT), used as Pre-Test (PREPAT), Post-Test (POSTPAT), and Post-Post-Test (PPPAT). The POSTPAT was used to determine achievement after treatment while the PPPAT was used to determine retention in both groups.

These instruments (though the same except in the serial arrangement) were made up of 40 multiple choice objective test items which were selected from past UTME and SSCE questions on periodicity. The test items selected were distributed among the six intellectual levels of Bloom's taxonomy in the cognitive domain. The Periodicity Achievement Test (PAT) was subjected to face and content validity. The chemistry games were also given to experts in chemistry education to validate the appropriateness of the games for teaching the periodicity. In order to ensure the reliability of the instrument (PAT), a pilot study was done. The reliability coefficient obtained using spearman-brown prophecy formula was 0.77.

Administration of the Instrument

The research assistants who were the chemistry teachers in the sampled schools were trained by the researcher on how the teaching was to be carried out. A pretest PREPAT was administered to subjects in both groups to measure their knowledge in periodicity. The control group was taught periodicity for four weeks using only the conventional method and the experimental group was taught the periodicity for four weeks with games. At the end of the four weeks, the POSTPAT was administered to all the subjects. Two weeks after the administration of POSTPAT, the PPPAT was administered to both groups.

RESULT

Hypotheses Testing

Table 1

One way ANCOVA result of students' achievement scores in POSTPAT

Sources	**Type III sum Squares**	**DF**	**Mean square**	**F**	**Sig**
Corrected model	4266.024	2	2133.02	47.069	0.000
Intercept	7521.359	1	7521.359	165.972	0.000
Prestest	1092.261	1	1092.261	24.103	0.000
Group	2910.967	1	2910.967	64.236	0.000
Error	4214.476	93	45.317		
Total	421918.000	96			
Corrected Total	8480.500	95			

$\alpha = 0.05$

Table 1 shows the summary of the one way ANCOVA on students' achievement in PAT. The result revealed that the noted difference in the mean achievement scores in the experimental group and control group is significant at 0.05 alpha levels. Therefore, the null hypothesis (Ho_1) was rejected showing that there is a significant difference in mean achievement scores of students taught periodicity using games and those taught using conventional method. .

Table 2

One - Way ANCOVA result of students' retention scores in retention test (PPPAT) of game method and conventional method.

Sources	**Type III sum Squares**	**DF**	**Mean square**	**F**	**Sig**
Corrected model	10375.438	2	5187.508	390.752	0.000
Intercept	254.438	1	254	19.166	0.000
Post test	3835.849	1	3835.849	288.938	0.000
Group	680.153	1	680.153	51.233	0.000
Error	1234.640	93	13.276		
Total	486641.000	96			
Corrected Total	11609.656	95			

$\alpha = 0.05$

Table 2 revealed that the noted difference between the mean retention score of students taught periodicity using games and those taught using conventional method is significant at 0.05 alpha levels. The null hypothesis (Ho_2) was rejected showing that there is a significant difference in mean retention scores of students taught periodicity using games and those taught using conventional method.

Table 3
One Way ANCOVA result of male and female students' achievement score (experimental group)

Source of Square	**Type III Sum**	**df**	**Mean Square**	**F**	**Sig**
Corrected Model	326.166[a]	2	163.083	4.180	0.021
Intercept	6810.901	1	6810.901	174.557	0.000
Pretest	232. 776	1	232.776	5.966	0.018
Gender	92.183	1	92.183	2.363	0.131
Error	1833.854	47	39.018		
Total	255205.000	50			
Corrected Total	2160.020	49			

α = 0.05

Table 3 shows the summary of the one way ANCOVA achievement means score of male and female students' exposed to treatment. The above results revealed that the noted difference between the mean score of male and female students is not significant at 0.05 alpha levels. The null hypothesis (Ho_3) was therefore not rejected showing that there is no significant difference in mean score of male and female students who were taught periodicity via game instruction

Table 4
One-way ANCOVA results of male and female students' retention score (experimental group)

Source	**Type III Sum Squares**	**DF**	**Mean Square**	**F**	**Sig**
Corrected model	1349.139a	2	674.570	49.502	0.000
Intercept	213.598	1	213.598	15.674	0.000
Post-test	1248.110	1	1248.110	91.589	0.000
Gender	6.179	1	6.179	453	0.504
Error	640.481	47	13.627		
Total	308221.000	50			
Corrected total	1989.620	49			

α = 0.05

Table 4 shows One-way ANCOVA on male and female students' retention scores. The result revealed that the noted difference between the mean retention scores of male and female students taught using game instruction is not significant at 0.05 alpha levels. The null hypothesis (Ho_4) was therefore not rejected, implying that there is no significant difference in the mean retention scores of male and female students taught periodicity using game instruction.

Table 5
One-way ANCOVA results of interaction effects of game instruction, conventional method and gender as measured by PAT.

Source	Type III Sum of Squares	df	Mean Square	F	Sig
Corrected model	4445.130[a]	4	1111.283	25.060	0.000
Intercept	7244.928	1	7244.928	163.377	0.000
Pre-test	1143.964	1	1143.964	25.797	0.000
Gender	0.036	1	0.036	0.001	0.977
Group	3043.981	1	3043.981	68.644	0.000
Gender * Group	178.894	1	178.894	4.034	0.048
Error	4035.370	91	44.345		
Total	421918.000	96			
Corrected total	8480.500	95			

$\alpha = 0.05$

The table 5 is a summary of One-way ANCOVA interaction effects of game method, conventional method and gender as measured by PAT. The result revealed that noted difference between interaction of game method and conventional method and gender as measured by Periodicity Achievement Test is significant at 0.05 alpha level. The null hypothesis therefore was not rejected showing that there is a significant interaction effect of teaching method and gender as measured by Periodicity Achievement Test (PAT)

DISCUSSION

It was discovered that the students in the experimental group performed and retained better than those in the control group. This report is consistent with Bahrami et al (2012) and Hassan and Poopak (2012) who affirmed the positive effect of learning through game method. This study also found out that there exist a similarity in the performance and retention of male and female students taught using game method as confirmed by the result from tables 3and 4. This however is in agreement with Poripo (2008) who experimented on the effects of simulation-game on male and female students' achievement in Bayelsa State and the study of Ezeudu and Ezinwanne (2013) who investigated on the effects of simulation games on students' achievement in secondary school chemistry in Enugu State. Both studies revealed respectively that there was no significant difference in sex performance.

Also, this study revealed that gender has no influence on teaching periodicity using game method. Finally, the study also revealed that there exist a significant interaction effect of teaching methods and gender as measured by Periodicity Achievement Test.

CONCLUSION

In view of the findings of this study, the following conclusion were drawn; there is a significant difference in the achievement of SS2 students taught periodicity using game method and those taught with conventional method. Students taught periodicity using game method retain more than those taught with conventional method. There is no gender disparity in the achievement and retention of concept learnt by those students taught periodicity with

games method. The game method is student-centered, activity based and innovative. The use of games in teaching and learning chemistry should be encouraged since most chemical concepts are termed 'dry' or abstract in nature. Games reduce tension (anxiety) and lack of interest but generate fun in the classroom thereby making the lesson interesting.

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