



Teaching Science Concept with Games: A Case of Naming Inorganic Compounds with IUPAC System in Rivers State, Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Background: This study investigated the effect of games teaching approach on students' academic performance in IUPAC inorganic nomenclature in Senior Secondary Schools in Rivers State, Nigeria. Quasi-experimental design, specifically pre-test post-test control groups was adopted. The sample comprised 93 Senior Secondary 2 and 3 chemistry students

Methods: The instrument was IUPAC Inorganic Nomenclature Performance Test validated by two Science Education Lecturers and one expert in Measurement and Evolution. The reliability coefficient of 0.87 of the instrument was determined by test-retest method. Mean and standard deviation were used to answer the research questions and hypotheses tested at 0.05 level of significance using Analysis of Variance.

Results: There was a significant difference in the performance of students taught IUPAC inorganic nomenclature with games approach and those with lecture method. Students taught with games approach performed significantly better in the performance test than those taught with lecture method. There was no significant gender based difference in performance, however, significant

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difference based on class level was obtained. It was recommended among others that, chemistry teachers should incorporate suitable educational games in teaching chemistry and also motivate students towards learning of chemistry.

Keywords: Games; IUPAC system; inorganic compounds; lecture teaching science.

1. INTRODUCTION

Chemical nomenclature is a language of chemistry that is used in assigning names and identifying chemical compounds. The original system of naming chemical compounds did not follow the systematic general rules of information about a compound, rather, trivial names that were merely assigned without considering the stoichiometric composition of elements was used. Therefore, chemical name of compounds had no relationship with chemical formula which brings ambiguity with the attendant complexities into the system. This difficulty caused confusion among chemists and posed a lot of challenges to teaching and learning of chemistry at all levels of education [1,2] and drew the attention of stakeholders in the chemical world. To address this problem and achieve uniformity in naming chemical compounds, International Union of Pure and Applied chemistry (IUPAC) in 1982 introduced a harmonized and generally acceptable system of naming. The name is IUPAC nomenclature of compounds and refers to the systematic method of naming compounds as recommended by International Union of Pure and Applied Chemistry (IUPAC). This system of naming is a based on relationship between chemical name and chemical formula of complex chemical compound that is guided by accepted rules. The new system provide methodology for assigning descriptions (names and formulae) to chemical species so that they can be identified without ambiguity.

Chemistry teaching and learning is based mainly on psychology of play and its relationship to the real life situation in certain aspect. Piaget [3] opined that informal games played by young children are critical components of their social and intellectual development. Vygotsky [4] theory of zone of proximal development which proposed the use of intervention in learning to help students build knowledge or make sense of their personal world provides theoretical basis for the use of games in teaching and learning of chemistry. According to Vygotsky [4], social

interactions is the best way of learning as the child learns better in collaborative activities than learning alone.⁴

Salen, Tekinbas and Zimmerman [5] define game as a system in which players engage in artificial conflict, defined by rules, that results in a quantifiable outcome.⁵ Educational games are specially designed and developed to be used as a teaching medium to increase students' desire to learn by making learning to be "a fun" while at the same time encouraging students-student's interaction [6]. Games are fun-filled exercises with specific goals in mind. It is generally considered as fun alternative media for students because playing while learning is "fun for students" The relevance of games in science teaching and learning cannot be undermined. Games generate fun in the classroom which reduce tension (anxiety) and make the lesson interesting. It promotes active participation of students in learning which is maintained throughout the learning process. Also, games create an active classroom learning environment as students actively seek information for proper building or construction of knowledge. It is very useful in assisting students practice essential formulae and facts [7]. Piaget (1976) outlined the following importance of games in education: games motivate students' interest, encourage proper utilization of information learnt, enhance retention of information, and lead to personal growth.

Generally, the process of naming chemical compounds involves determining the relationship between symbols, ions, formulae, and their names followed by translation of name into its individual ions and finally, combining the ions into correct formulae. The stages involve converting formula of salts into their names and converting name of salt to formula by the following steps. Converting the formula of the salt to formula of ions, converting formula of ions to names, naming the cations and anions; and finally combining names of ions to obtain the name of compound as shown below.

A
B
C
D

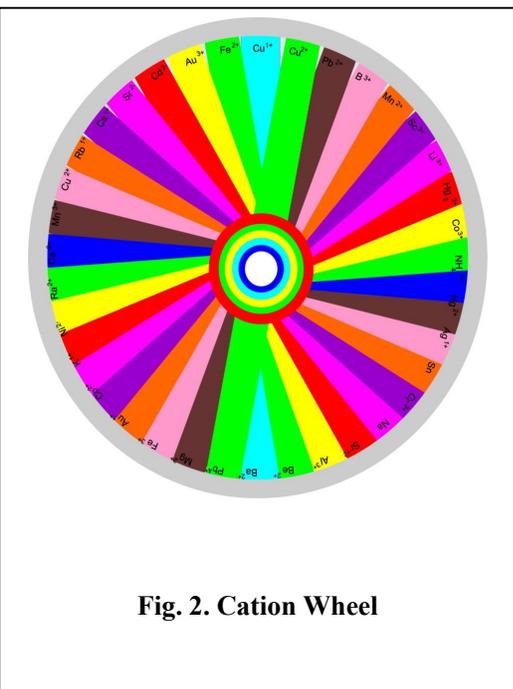
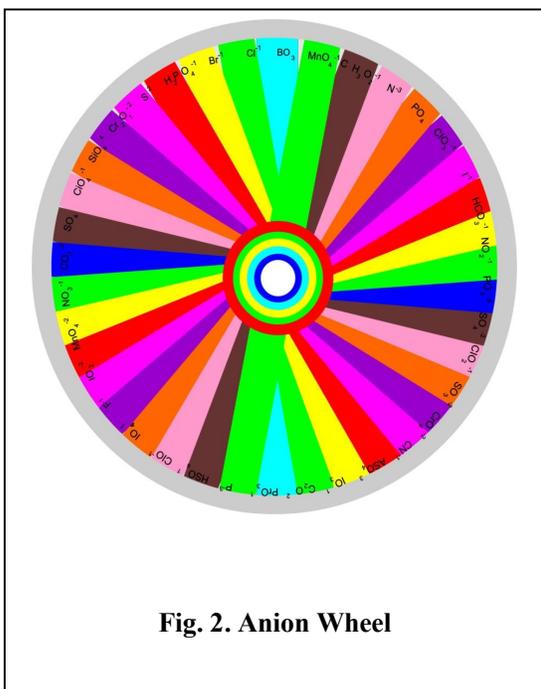
Formula of salt \longrightarrow Formula of ions \longrightarrow Name of ions \longrightarrow combining names to form compounds

There are different categories of educational games. Examples are card games, board games, role play simulations and computer simulations. Fatokun, Egya and Uzoechi [7] classified chemistry games into two categories. Non-competitive games which involve no scoring but self-developed skills and mastery of subject matter to solve related problems and competitive games which involve scoring and the scoring system has a fixed number of points.⁷ One major player's success leads to another player's loss. Rainbow wheel chemical nomenclature game consists of two wheels. The first wheel which has a pie-chart shaped contains 36 cations of common salts around the wheel and is called "cation wheel". The second wheel has the same shape but contains 36 common anions is called "anion wheel". Each student spins the wheel to select ten cations and ten anions each at a time. The selected ion is then placed on a grid sheet where students combine the cations and anions into a common formula in the space provided on a grid sheet. The cations and anions are then combined using stock method nomenclature rule to evaluate the correct compounds and their respective IUPAC names. The names are record on the grid sheet numbered 1-100.

The use of educational games in teaching various concept in chemistry has been established in various studies. Perez and Dolotallas [8] investigated the effectiveness of

Think-Tac-Toe game strategy on the students' performance in chemistry using the familiar three-by-three grid of a tic-tac-toe board. A true experimental pretest posttest control group design was adopted. Wilcoxon Signed-Rank test revealed that there was a significant difference between the students' pretest and posttest scores in Chemistry when exposed to Think-Tac-Toe game strategy and lecture method. This study concluded that Think-Tac-Toe game strategy can improve the students' performance in Chemistry.

Nja [9] explored teaching chemistry games with kitchen resources and students' academic performance in electronic configuration. The study adopted quasi-experimental design using Configuration Kitchen resources such as green, brown red, white and multi colored beans to play electronic configuration games with 100 students drawn from two secondary schools in Calabar Education Zone of Cross River State. The instrument was Chemistry achievement test. Findings showed that teaching electronic configuration using kitchen resources to play games enhanced the academic performance of Chemistry students. There was a significant relationship between students' academic achievement when taught electronic configuration with kitchen games and without. No gender related difference was found.



Álvarez-Herrero and Valls-Bautista [10] investigated the relationship between learning the periodic table and the type of strategy that students choose to achieve the learning outcomes related to it. This study adopted longitudinal research using an active methodology to teach the contents of the periodic table to high school students, based on project-based learning and WebQuest. Findings of the study showed that after giving total freedom to 260 students (during 5 years of investigation) in the construction of instructional materials which helped them learn the periodic table, 195 of them chose to develop a game as a tool. There was no significant difference between genders, showing that students prefer to learn in a playful, motivating and exciting way since they felt a greater interest and had a better evaluation of what they had learned about, reaching a deeper and lasting understanding, hence, a significant learning.

CheN, Husnaini and Chen [11] investigated the time effect of cooperative games on students' emotions of learning science and the treatment effect on their chemistry achievement by compared the use of cards, board games, and riddles, and the use of conventional paper-and-pencil exercises to learn the basics of chemical elements and compounds. Quasi-experimental design was adopted using 114 ninth graders at an urban public high school in Taipei. The results revealed that the experimental group had significantly higher positive emotion and lower negative emotion throughout the intervention period. While no time effect was observed for the experimental group, a significant time effect on positive and negative emotions in the comparison group using exercises was found: high achievers decreased their positive emotion, and middle to high achievers increased their negative emotion. Furthermore, low and middle achievers performed better when using games. However, no significant difference for the high achievers of the two groups was discovered.

Lutfi and Hidayah [12] explored the effect of internet-assisted Chemmy card 6-1 game as a teaching medium on IUPAC nomenclature of inorganic compounds materials for X grade 6 and 7 senior school students at SMA Negeri Sidoajora, Indonesia using "One – Group Pretest–Posttest" design and motivation questionnaire as instrument. Results revealed that the use of internet assisted Chemmy card 6-1 game in instructing IUPAC nomenclature of inorganic compounds was very effective in

enhancing students' achievement and learning objectives. Students were highly activated and motivated as they listened to teacher's explanations and answered questions correctly. Their ability to solve problems in naming inorganic compounds increased.

Gelata [13] in a study titled "How can I improve N12 students' ability to write simple chemical entities using chemical symbols and formulas on introductory general chemistry course-1(CHM101) used all the twenty-five N12 biology students as sample.⁹ Results of the study showed that after intervention, there was an increase in students' achievement score accompanied by a remarkable improvement in the posttest scores while students were able to symbolize elements and write formulae of compounds. Al-Taraweh [14] investigated the effectiveness of educational games on scientific concepts acquisition by first grade students in science using 53 students in Um Atiyah Amman as sample.¹⁰ Results showed a statistically significant difference in student's scientific concepts acquisitions due to the method of teaching in favor of experimental group. Also there were no statistical difference in students' scientific concepts acquisition due the gender or interaction between method of teaching and gender.

Fatokun, Egya and Uzoечи [7] explored the effects of game teaching approach on chemistry students' achievement and retention in periodicity in Keffi Local Govt Area of Nassarawa State, Nigeria.⁷ The design was pre-test post-test control group design using 96 SS2 chemistry students selected by multi-stage random sampling as the sample and Periodicity Achievement Test(PAT) as instrument. Results showed a significant difference in mean retention scores of students taught periodicity using games and those taught using conventional method. No significant difference in the mean score of male and female students taught periodicity with game was found, but there was significant interaction effect of teaching method and gender as measured by Periodicity Achievement Test (PAT). Also, gender had no influence on the achievement and retention of those exposed to the treatment. Njidi & Sheikh [15] found that students develop positive attitude towards learning chemistry after using educational games. Further evidence from the results of the study revealed that educational games are very useful in building bridges between learning science and acquisition of knowledge of chemical phenomenon.

Rayan and Raiyn [16] investigated the effect of CHEMDRAW software on college of education students' performance in examinations using 24 students from AlQasemi academic college as sample and found that integrating modelling tools in chemistry education is helpful in improving student's performance in examinations.¹² Students' feedback following the initiative was positive and very supportive. Findings of the study further revealed that incorporating CHEMDRAW software in teaching chemistry aided in understanding the studied concepts and implementation of IUPAC rules in converting chemical names to structures and vice versa.

Bahrami, et.al, [17] compared the effectiveness of game-based and traditional teaching on learning and retention of first grade math concepts using all the female student of khorramabad province of Iran as sample.¹³ Results game-based teaching improves learning and retention of math concepts while traditional teaching method did not. Also, game-based learning group obtained higher scores in concept with higher scores than those in lecture. There was a significant difference between the game-based and lecture I group in retention of concept of equality with the game-based group scoring higher in retention test. A significant difference was observed only in the retention scores of the two groups.

Alpat and Ellez, [18] studied the effects of jigsaw on the academic achievement of students in chemical nomenclature using 260 students of University in Turkey as sample.¹⁴ Quasi experimental design was adopted and the instruments were Pre-Knowledge Test (PKT), Chemical Nomenclature Achievement Test (CNAT), and semi-structured interviews. Results showed a significant difference in the posttest mean score of students in chemical nomenclature between the experimental and control groups in favor of the experimental group. The academic achievement of students in the experimental group were higher than those in the control group.

1.1 Statement of the Problem

Complexities in old system of naming chemical compounds prompted the introduction of new system by International Union of Pure and Applied Chemist (IUPAC) system as a replacement to the old one. The new system has the advantage of being flexible because students can conveniently translate the name of a

chemical compound to its formula and also the formula to its name. Despite, this development, students most often experience difficulties in naming and writing formulae chemical compounds, especially inorganic compounds. It therefore, becomes imperative to provide ways of helping students to efficiently use IUPAC system of nomenclature to write correct names and formulae of chemical compounds. Different teaching approaches has been explored by researchers in attempting to provide solution to this problem. Although, the use of games in games approach has explored in other places, there seems to be no evidence of any study in Rivers State. This study is there for carried out to address this issue

1.2 Research Questions

1. What is the performance of students taught IUPAC inorganic nomenclature using games teaching approach and those taught using conventional lecture method in Senior Secondary Schools in Rivers State?
2. What are the performances of male and female students taught IUPAC inorganic nomenclature using games teaching approach in Senior Secondary Schools in Rivers State?
3. What are the performances of SS2 and SS3 students taught IUPAC inorganic nomenclature using games teaching approach in Senior Secondary Schools in Rivers State?

1.3 Hypotheses

- HO₁.** There is no significant difference in performance between students taught IUPAC inorganic nomenclature using games teaching approach and conventional lecture method in Senior Secondary Schools in Rivers State.
- HO₂.** There is no significant difference in performance between male and female students taught IUPAC inorganic nomenclature using games teaching approach in Senior Secondary Schools in Rivers State.
- HO₃.** There is no significant difference in performance between SS2 and SS 3 students taught IUPAC inorganic

nomenclature using games teaching approaching in Senior Secondary Schools in Rivers State.

rainbow wheel games approach recorded higher mean performance and higher standard deviation than female students.

2. METHODOLOGY

The study adopted quasi-experimental design using the pre-test post-test control group. 93 SS2 and 3 chemistry students representing 60 males and 33 females in intact classes of the selected schools formed the sample. The instrument was IUPAC Inorganic Nomenclature Performance Test (IINPT). Two lecturers in Science Education and one lecturer in Measurement and Evaluation validated the instrument. The reliability coefficient of 0.72 was determined by test retest method. Mean and standard deviation were tools for answering research questions while the hypotheses were tested using Analysis of Variance (ANOVA) .05 level of significance.

3. RESULTS

3.1 Research Question 1

What is the performance of students taught IUPAC inorganic nomenclature using games teaching approach and lecture method in senior secondary schools in Rivers State?

Results in Table 1 showed that the pretest mean performance score of students in IUPAC inorganic nomenclature in the experimental and control groups were 39.75 and 42.45 with standard deviations of 2.16 and 12.28 respectively while that of the posttest group were 50.56 and 38.94 with standard deviations of 14.40 and 19.63 respectively. This indicates that student in experimental group taught with games teaching approach obtained higher performance score in IUPAC inorganic nomenclature than those in the control group taught with conventional lecture method.

3.2 Research Question 2

What are the performances of male and female students taught IUPAC inorganic nomenclature using games teaching approach in Senior Secondary Schools in Rivers State?

Results in Table 1 showed that the posttest mean performance score of male and female students taught IUPAC inorganic nomenclature using games teaching approach were 54.53 and 50.93 respectively with standard deviations of 25.64 and 19.63. Male students taught using

3.3 Research Question 3

What are the performances of SS2 and 3 students taught IUPAC inorganic nomenclature using games teaching approach in Senior Secondary Schools in Rivers State?

Results in Table 3 showed that the mean performance score of SS2 and SS3 students taught IUPAC inorganic using games teaching approach were 52.02 and 42.25 respectively with standard deviations of 14.51 and 17.26. The SS3 students exposed to game teaching approach recorded higher mean performance score and higher standard deviation than SS2 students.

3.4 Hypothesis 1

There is no significant difference in performance between students taught IUPAC inorganic nomenclature using games teaching approach and conventional lecture method in Senior Secondary Schools in Rivers State.

From Table 1, the calculated value of F-ratio = 10.476 is greater than the table value ($p < 0.05$). Therefore, the null hypothesis is rejected. This infers that there is a significant difference in performance between students taught IUPAC inorganic nomenclature using games teaching approach and those taught using conventional lecture method in Senior Secondary Schools in Rivers State.

From Table 5 above, the calculated value of F-ratio = 1.065, ($P = .05$) is less than the table or critical value indicating that there was no significant difference in mean performance of students between pretest experimental and control groups in inorganic nomenclature. This confirms the group equivalence of students in the two groups before treatment procedure. Consequently, any observed difference denotes the effect of treatment on the subjects not by chance.

3.5 Hypothesis 2

There is no significant difference in performance between male and female students taught IUPAC inorganic nomenclature using games teaching approach in Senior Secondary Schools in Rivers State.

From Table 2, the calculated value of F-ratio = 0.144 is less than the table value ($p < 0.05$). Therefore, the null hypothesis is accepted. This implies that there is no significant difference in performance between male and female students taught IUPAC inorganic nomenclature using games teaching approach in Senior Secondary Schools in Rivers State.

3.6 Hypothesis 3

There is no significant difference in performance between SS2 and SS 3 students taught inorganic

nomenclature using games teaching approaching in Senior Secondary Schools in Rivers State.

From Table 6, the calculate value of F-ratio = 8.675 is greater than the table value at $p = .05$. Therefore, the null hypothesis. This infers there is a significant difference in mean performance between SS2 and SS3 students taught IUPAC inorganic nomenclature using games teaching approaching in Senior Secondary Schools in Rivers State.

Table 1. Mean and standard deviation of performance of students taught IUPAC inorganic nomenclature using games teaching approach and those taught using conventional lecture method

Group	N	Mean			Standard Deviation		
		Pretest	Posttest	Diff.	Pretest	Posttest	Diff.
Control	48	42.58	38.94	3.60	12.28	19.63	7.35
Experimental	45	39.75	50.56	10.8	2.16	14.40	12.24
Diff. between		0.29	5.11	7.2	10.12	5.23	4.89

Table 2. Mean and standard deviation analysis of performance of male and female students taught IUPAC inorganic nomenclature using games teaching approach

Gender	N	Mean	S D
Male	60	54.53	15.64
Female	33	50.93	19.63
Difference		3.60	4.23

Table 3. Mean and standard deviations SS2 and SS3 students taught IUPAC inorganic nomenclature using games teaching approach in Senior Secondary Schools in Rivers State

Class	N	Mean	SD
SS3	45	52.02	14.51
SS2	48	42.25	17.26
Difference		9.80	2.75

Table 4. Analysis of Variance (ANOVA) of post-test mean performance score of students taught IUPAC inorganic nomenclature using games teaching approach and those taught using conventional lecture method

Source of Variance	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	3135.001	1	3135.001	10.476	.002
Within Groups	27231.924	91	299.252		
Total	30366.925	92			

Table 5. Analysis of Variance (ANOVA) of pre-test mean performance of students taught IUPAC inorganic nomenclature with games teaching approach and those taught using conventional lecture method

Source of Variance	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	176.581	1	176.581	1.065	.305
Within Groups	15088.645	91	165.809		
Total	15265.226	92			

Table 6. Analysis of Variance (ANOVA) of the mean performance score of male and female students taught IUPAC inorganic nomenclature using games teaching approach

Source of Variance	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	45.794	1	45.794	.144	.705
Within Groups	28876.013	91	317.319		
Total	28921.806	92			

Table 7. Analysis of Variance (ANOVA) of mean performance score of SS2 and SS3 students taught IUPAC inorganic nomenclature using games teaching approach

Source of Variance	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	2217.979	1	2217.979	8.675	.004
Within Groups	23265.978	91	255.670		
Total	25483.957	92			

4. DISCUSSION OF FINDINGS

Findings of this study revealed that students taught IUPAC inorganic nomenclature with games approach performed significantly better in performance test with higher mean score than those taught with lecture method (Table 1). There was a significant difference in performance of students taught using games teaching approach and those taught using conventional lecture method (Table 4). The improved performance of students taught with games approach could possibly be due to the fact that, playing games promote students' active participation in classroom activities. The learning process was "fun" and "stress-free" which increase students' desire to learn. Also, playing games during learning challenged students to compete, socialize and have fun with each other. This provide opportunities to take responsibility of their own learning and construct knowledge in line with scientific conceptions. These learning attributes are not obtainable absent in the conventional lecture learning environment where there is no interaction among the students and between the teacher. This undermined motivation and self-confidence and impair understanding of concepts. Lecture classroom environment tends to be boring and stressful to students resulting in lack of interest and possibly poor attitude towards the subject and poor performance. Also, there was complete absence of interaction between the students. Findings of this study corroborate that

Findings of this study corroborated that of Nja [9] which Findings showed that teaching electronic configuration using kitchen resources to play games enhanced the academic performance of Chemistry students. There was a significant relationship between students' academic

achievement when taught electronic configuration with kitchen games and without while No gender related difference was found. It further corroborates studies of Álvarez-Herrero and Valls-Bautista (2021) where it was discovered that after giving total freedom to 260 students (during 5 years of investigation) in the construction of instructional materials which helped them learn the periodic table, 195 of them chose to develop a game as a tool. There was no significant difference between genders. It further corroborates the findings of Chen, Husnaini and Chen [11] The results revealed that the experimental group had significantly higher positive emotion and lower negative emotion throughout the intervention period, high achievers decreased their positive emotion, and middle to high achievers increased their negative emotion. Furthermore, low and middle achievers performed better when using games. However, no significant difference for the high achievers of the two groups was discovered. Similar corroborations is observed in the studies of Lutfi and Hidayah [12] where the use Chemmy card 6-1 games was very effective in enhancing students' achievement and learning objectives of IUPAC nomenclature of inorganic compounds. As well as that of Fatokun, Egya and Uzoechi [7] where a significant difference in mean retention scores of students taught periodicity using games and those taught using conventional method was found. Students taught periodicity using game method achieving and retaining better than those taught with conventional method.

Furthermore, there was no significant difference in performance of male and female students taught IUPAC inorganic nomenclature using games teaching approach. This implies that the use of games in teaching is not influenced by

gender. This result agrees with findings of Al-Taraweh [14] and Fatokun, Egya and Uzoechi [7] where no significant difference in mean performance of male and female students taught IUPAC inorganic nomenclature using games teaching approach was found.^{10,7} Furthermore, there was a significant difference in mean performance score of SS 2 and SS 3 students taught IUPAC inorganic nomenclature using game teaching approach. SS3 students performed significantly better than SS2 students in the performance test. The observed higher performance of SS3 students could be attributed to progression in students' understanding of naming inorganic compounds according to class level. This could possibly be due to the fact that students could have come across these names severally while learning different concepts in chemistry at the lower classes.

5. CONCLUSION

From the finding of the study, it was concluded that games teaching enhance students understanding of chemistry and other science concepts and is not gender selective.

6. RECOMMENDATIONS

The following recommendations were made.

1. Teachers should incorporate suitable educational chemistry games in teaching necessary chemistry concepts.
2. Teachers should use educational games to motivate students towards chemistry.
3. Curriculum designers should recommend the use of games in chemistry.

DECLARATION

The author wish to declare that this research paper has not been submitted for publication or published in any other journal.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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