

Crosswords Puzzle, Flashcards Teaching Strategies and Senior Secondary School Students' Academic Performance in Chemistry

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Abstract

This study examined the effects of crossword puzzle and flashcards teaching strategies on senior secondary school students' academic performance in chemistry in Mkpat Enin Local Government Area. A quasi-experimental research design was adopted for the study. The population of the study consisted of one thousand seven hundred and forty (1740) Senior Secondary Two (SS2) chemistry students in all the 16 public secondary schools in the study area. A sample size of 104 SS2 chemistry students was used for the study. Simple random sampling technique was used in selecting two co-educational secondary schools and in each of the selected schools, intact class of SS2 chemistry students was used for the study. The instrument used for data collection was Periodic Table Performance Test (PTPT) with reliability coefficient of 0.88 obtained using Kuder-Richardson Formula-20. Data were analyzed using mean and standard deviation to answer research questions and Analysis of Covariance for hypotheses formulated at .05 level of significance. Findings showed that students taught the concept of periodic table using crossword puzzle teaching strategy performed better than those taught using flashcards teaching strategy. Gender was not a significant determinant of students' academic performance. Based on the findings, it is concluded that crosswords puzzle teaching strategy enhances students understanding and consequently higher academic performance on the concept of periodic table in chemistry. It is recommended among others that chemistry teachers should adopt crosswords puzzle teaching strategy in teaching periodic table in chemistry.

Keywords: Crosswords puzzle teaching strategy, flashcards teaching strategy, periodic table academic performance

Introduction

Chemistry is the gateway to scientific, technological and. economic development of any nation. The knowledge of chemistry is required for successful study in many professions. As a building block for a range of science disciplines, chemistry has the potential to link other sciences together and to foster greater scientific literacy (Tera, 2018). It is a core science subject needed as a pre-requisite to study any science or technological related discipline such as medicine, pharmacy, engineering and agriculture. This is because Chemistry education equips the learners with knowledge, attitude and skills through which they understand the world around them and explore the wider implications of science in relation to man (Ayayi & Ogbeba, 2016). It plays an important role in meeting human needs for food, health shelter, transportation, products and other materials aimed at improving the quality of life (Khanam, 2018).

The National Policy on Education in Nigeria (NPE, 2014) emphasizes that the teaching of science should evoke students' curiosity in scientific concepts and processes. Therefore, the objectives of senior secondary school Chemistry curriculum are to enable students to:

- i. develop interest in the subject of Chemistry;
- ii. acquire basic theoretical and practical knowledge and skills;
- iii. develop interest in Science, Technology and Mathematics (STM);
- iv. acquire basic STM knowledge and skills;
- v. develop reasonable level of competence in ICT applications that will engender entrepreneurial skills;
- vi. apply skills to meet societal needs of creating employment and wealth;
- vii. be positioned to take numerous career opportunities offered by Chemistry;
- viii. be adequately prepared for further studies in Chemistry (NERDC, 2009).

These objectives would not be actualized without the use of appropriate and effective teaching strategies that promote students' understanding in Chemistry. This is because adequate and effective teaching of Chemistry can lead to the achievement of scientific and technological greatness for Nigeria to attain the state of national development it desires and to rank favorably among the developed nations of the world.

Despite the importance of Chemistry as the central science that forms the basic foundation for many science disciplines and in improving the quality of life, the performance of students in Chemistry in senior secondary schools has consistently been poor in external examinations such as West African Senior School Certificate Examination (WASSCE). The West African Examination Council Chief Examiners' reports (WAEC, 2017-2021) confirm that students' performance in Chemistry has been below expectation over the years. The statistics obtained on the performance of candidates in Senior Secondary Certificate Examination in Chemistry for the whole nation from 2017 to 2021 attested that candidates that had credit and above were 62.68%, 61.95%, 64.18%, 65.24% and 65.0% respectively. It is very clear from these statistics that students' performance in Chemistry has not been excellent. This poor performance in Chemistry in secondary schools in Nigeria has been a major concern to Chemistry educators.

The extent at which students fail in Chemistry pose a lot of questions about the teaching-learning process in Chemistry, although many factors have been attributed for the observed poor academic performance of students in the subject. One of the reasons according to Umanah (2017) is that Chemistry is perceived as an abstract and difficult subject by students. Several researchers have reported that some of the topics considered by students as abstract and difficult are: stoichiometry, balancing of chemical equations, chemical combination, periodic table of elements, electrochemistry, thermodynamics and chemical equilibrium. This could be because Chemistry teachers in secondary schools teach Chemistry using the conventional lecture method which does not give students the opportunity to participate actively in the learning process; they become passive listener during lessons which at the end makes the students see the subject as an abstract and uninteresting subject. Nja, Cornelius-Ukpebi, Edoho and Neji (2020) attest that the consistent poor performance of senior secondary

school students in Chemistry is caused by defective teaching methods employed by chemistry teachers. Fatokun, Egya and Uzoechi (2016) maintained that teaching strategies can be easily manipulated by teachers to increase students' understanding and performance as well as reduce the abstract nature of concepts in Chemistry. The main function of pedagogy is to ensure that ideas and information are meaningfully presented, clear and retained over a long period of time to enhance students' performance. For effective instruction, Chemistry teachers should de-emphasize the use of teacher-centered method of teaching to more innovative, student-centered and activity-based teaching strategies which have been reported to be more effective in enhancing students' academic performance and realizing the objectives of Chemistry education (Azeez, Omanany, Kwasi & Omachoko, 2022).

The Chief Examiner's report of West African Examination Council (2019) shows that most Chemistry candidates displayed inability to accurately balance chemical equations, write correct formula of compounds and symbols of elements. This is because students were not properly grounded in the periodic table of elements. Fatokun, Egya and Uzoechi (2016) noted that many Chemistry students have difficulties in recalling the position of elements in the periodic table and connecting the elements to their physical and chemical properties. The periodic table is a tabular display of the chemical elements, which are arranged by atomic number, electron configuration, and recurring chemical properties. The structure of the table shows periodic trends. The seven rows of the table, called periods, generally have metals on the left and non-metals on the right. The columns, called groups, contain elements with similar chemical behaviors. Chemistry teachers are expected to have good level of competence and mastery of the concept of periodic table in order to enhance students' performance and interest in the concept (Betul, 2018). In an attempt to facilitate the teaching and learning of the periodic table, Chemistry teachers should adopt innovative teaching strategies such as crossword puzzle and flashcards which played in and outside of the classroom could improve the mastery and performance of the students in the concept. The question then is will the use of crosswords puzzle and flashcards teaching strategies enhance students' academic performance in the concept of periodic table in chemistry? Hence, this study investigates the effectiveness of crosswords puzzle and flashcards teaching strategies on students' academic performance in the concept of periodic table in Chemistry.

Crosswords puzzle teaching strategy is an activity based approach to learning that allows students to interact with the learning materials, encourages discussion among students and permits investigation of concepts by exploration through questioning (Umoru, Adejoh & Iji, 2016). A crossword puzzle teaching strategy is a game teaching strategy in which word puzzles that take the form of a square, rectangular or diagonal grid of white or blank or shaded squares are used in the teaching-learning process. The goal is to fill the blank squares with letters forming words or phrases by solving clues which lead to the answer (Joshua & Okoli, 2019). Crosswords puzzle teaching strategy is a teaching strategy that can be used to teach terminology, definitions, spelling, trends of elements, periodicity, variation down the group and across the period as well as pairing key concepts in chemistry (Umoru, Adejoh & Iji, 2016). Since students need to spell items correctly to complete the puzzle, they gain greater retention

and development of positive attitude towards learning as puzzle learning makes learning of the concept simple and not complex (Wiwat, 2013).

According to Mohammed, Razia, Mohammad, Mohammad, Waqas, Haroon and Sreekanth (2018) crossword puzzle teaching strategy provides a good learning atmosphere in the classroom situation as they are traditionally associated with recreational activity. Additionally, the advantage of using the crosswords puzzle teaching strategy is that it allows students to continue their learning by themselves. Involvement in this activity improves the attention span of the students for the remaining part of the learning process and ensures that students review the key concepts covered in a teaching-learning process. Olagunju and Babayemi (2014) opined that crossword-picture puzzle teaching strategy improves students' performance and should be adopted by teachers in teaching science. Duyilemi (2013) also reported that puzzles are wonderful tool that can enhance students' attention and help them develop positive attitude towards learning. This implies that puzzle-based teaching strategy enhances students' academic performance than the traditional teaching method which is deficient in meeting the learners need. Hence, this study attempts to investigate the effects of crosswords puzzle and flashcards teaching strategies on students' academic performance in the concept of periodic table in chemistry.

Flashcards teaching strategy is an activity-based teaching strategy that makes use of a set of cards bearing information such as words or numbers, formulas, picture, a sentence or subject matter on either or both sides, used in the classroom for the purpose of teaching and learning of concepts (Astuti, 2015). Flashcards are set of cards on which are written items to be studied. According to Komachali and Khodareza (2012) flashcards are used as a learning drill to aid memorization by way of spaced repetition and are useful for drilling new letters, syllables, words, and other information. The use of flashcards teaching strategy facilitates students' involvement in the class work by sharing answers, participating in the lesson, interacting with each other, utilizing the new words, working on the vocabulary and pronunciation. Flashcards teaching strategy makes learning fun and enjoyable, increases the learners' ability to memorize, analyze a problem and enrich vocabulary. Apart from the cognitive side, flashcards teaching strategy increases the learners' self-confidence, develop good and effective communication and enhance creativity (Singh, 2022).

Gender is one of the factors that influence students' performance in science in senior secondary schools. It is a concept that calls for research review from time to time. Gender is a psychological term describing behavior and attributes expected of individuals on the basis of being male or female (Umanah, 2017). Gender differences in students' performance have been of great concern to Chemistry educators, yet research findings have been inconsistent. Some researchers are of the opinion that male students perform academically better than their female students, others found the opposite; on the other hand, other researchers found no differences at all between male and female students' academic performance in Chemistry. Fatokun, Egya and Uzoechi (2016) reported no significant difference in the mean score of male and female students' academic achievement who were taught the concept of periodicity using game instructional approach. Etiubon, Etiubon and Akpan (2021) found no significant difference in

the mean score of male and female students' academic achievement who were taught the concept of energy transformation using computer tutorials and drill-practice strategies. Jack and Gamnjob (2020) also found no statistically significant difference in the performance of male and female students taught the concept of acid-base reactions using computer simulation instructional strategy. On the contrary, Gongden (2016) found significant difference in academic performance between male and female students when taught electrolysis using analogy teaching strategy; male students performed better than female students. Okoroafo (2014) also found that boys achieve better academically than girls while Olarewaju (2014) reported that girls outperform boys. However, with the contradictions and lack of a clear trend on the influence of gender on students' performance in chemistry, more investigation is imperative. Hence, there is a need to further investigate the influence of gender on students' academic performance when taught using crosswords puzzle and flashcards teaching strategies on the concept of periodic table in chemistry.

Statement of the Problem

Despite the importance of chemistry, the performance of students in chemistry in our secondary schools has consistently been poor in external examinations. The West African Examination Council (WAEC) Chief Examiners' reports from 2017 to 2021 confirm that students' performance in chemistry is poor. Specifically, the Chief Examiner's report of West African Examination Council (2019) indicated that most Chemistry candidates displayed inability to accurately balance chemical equations, write correct formula of compounds and symbols of elements. This is because students were not properly grounded in the concept of periodic table of elements and its applications probably due to the ineffective teaching method employed by Chemistry teachers in teaching the concept. The concept of periodic table of elements is considered abstract and difficult by students. They find it difficult attempting task and answering questions that require the knowledge of periodic table, yet the understanding of this concept is fundamental to successful learning of chemistry concepts for the realization of the objectives of teaching chemistry and consequently optimum performance in the subject. The question now is, will the use of crosswords puzzle and flashcards teaching strategies enhance students' academic performance in the concept of periodic table in chemistry? It on this basis the study is undertaken.

Purpose of the Study

This study investigates the effects of crosswords puzzle and flashcards teaching strategies on students' academic performance on the concept of periodic table in chemistry. The specific objectives are to:

1. determine the difference in the mean performance scores of Chemistry students taught the concept of periodic table using crosswords puzzle and flashcards teaching strategies.
2. compare the academic performance of male and female Chemistry students taught the concept of periodic table using crossword puzzles and flashcards teaching strategies.

Research Questions

1. What differences exist in the mean performance scores of Chemistry students taught the concept of periodic table using crossword puzzles and flashcards teaching strategies?
2. What differences exist in the mean performance scores of male and female Chemistry students taught the concept of periodic table using crossword puzzles and flashcards teaching strategies?

Null Hypotheses

1. There is no significant difference in the mean performance scores of students taught the concept of periodic table using crossword puzzles and flashcards teaching strategies.
2. There is no significant difference in the mean performance scores of male and female students taught the concept of periodic table using crossword puzzles and flashcards teaching strategies.

Methodology

This study employed quasi-experimental pretest posttest design. This study in the context of this design employed two experimental groups; experimental group 1 and experimental group 2. This can be illustrated as:

$O_1 X_1 O_2$ (Experimental Group 1)

$O_3 X_2 O_4$ (Experimental group 2)

Where:

O_1 – Pretest for experimental group 1,

O_2 – Posttest for experimental group 1;

O_3 – Pretest for experimental group 2,

O_4 – Posttest for experimental group 2.

X_1 – Treatment for experimental group 1;

X_2 – Treatment for experimental group 2.

This study was carried out in Mkpato Enin Local Government Area of Akwa Ibom State, Nigeria. The population of the study consisted of 1740 Senior Secondary School Two (SS2) students in the sixteen public secondary schools in Mkpato Enin Local Government Area. A sample of 104 Chemistry students from two public secondary schools was used for the study. Simple random sampling technique was used in selecting the two (2) secondary schools out of 16 public secondary schools in the study area. In each of the schools sampled intact class was used, one intact class was assigned to experimental group 1 and the other intact class to experimental group 2. The instrument used for data collection was Periodic Table Performance Test (PTPT). The PTPT consisted of 20 multiple choice questions with options A-D based on the concept of periodic table. The instrument was validated by three lecturers of test, measurement and evaluation in Department of Science Education, Akwa Ibom State University. The reliability of the instrument was determined using a sample of 20 Senior Secondary Two (SS2) Chemistry students selected from a school in the study area but was not part of the sample for the study. The scores obtained were analyzed using the Kuder-

Richardson Formula-20 and a reliability coefficient of 0.88 was obtained. The PTPT was administered to students as pretest and posttest. Two chemistry teachers were recruited and instructed to serve as research assistants on the use of the lesson packages for the experimental groups 1 and 11 respectively. The lesson package for the experimental group I was designed using crosswords puzzle teaching strategy while experimental group II lesson package was based on flashcards teaching strategy. Pretest was administered to students in the two groups before treatment started. Students in experimental group I were taught the concept of periodic table using crosswords puzzle teaching strategy while students in experimental group II were taught using flashcards teaching strategy. The treatment lasted for four weeks after which the PTPT was reshuffled and administered as post-test to students in the two groups. Pretest and Post-test scripts from the two groups were collected, scored and used for data analysis. The research questions were answered using mean and standard deviation while the hypotheses were tested using Analysis of Covariance (ANCOVA) at .05 level significance.

Results

Research Question 1: What differences exist in the mean performance scores of Chemistry students taught the concept of periodic table using crosswords puzzle and flashcards teaching strategies?

Table 1: Mean and standard deviation of students’ pretest post-test performance scores based on teaching strategies (N=104)

Teaching Strategies	N	Pretest Mean	SD	Posttest Mean	SD	Mean Gain scores
Crosswords Puzzle	48	6.6	3.6	15.3	3.0	8.7
Flashcards	56	6.5	3.2	12.1	3.4	5.6

Table 1 revealed that the mean gain performance scores (8.7) of students taught the concept of periodic table in Chemistry using crosswords puzzle teaching strategy is greater than the mean gain performance scores (5.6) of those taught using flashcards teaching strategy. This implies that students taught using crosswords puzzle teaching strategy performed better thereby scoring high in their mean gain than those that were taught using flashcards teaching strategy. Hence, crosswords puzzle teaching strategy has proven to be an effective teaching and learning strategy in enhancing students’ performance on the concept of periodic table in Chemistry.

Research Question 2: What differences exist in the mean performance scores of male and female Chemistry students taught the concept of periodic table using crosswords puzzle and flashcards teaching strategies?

Table 2: Mean and standard deviation of male and female students’ pretest posttest performance score on strategies (N=104)

Strategies	Gender	N	Pretest	Posttest
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			Mean	SD	Mean	SD	Mean Gain scores
Crosswords Puzzle	Male	22	6.6	3.6	15.5	2.6	8.9
	Female	26	6.7	3.7	15.0	3.4	8.3
Flashcards	Male	27	6.9	3.3	12.3	3.7	5.4
	Female	29	6.1	3.1	12.9	3.3	6.8

As shown in Table 2, the mean gain performance scores (8.9) (8.3) of male and female students taught the concept of periodic table in Chemistry using crosswords puzzle teaching strategy is greater than the mean gain performance scores (5.4) (6.8) of male and female students taught using flashcards teaching strategy. This implies that male and female students taught using crosswords puzzle teaching strategy performed better, thereby scoring high in their performance more than their counterparts taught using flashcards teaching strategy.

Null Hypothesis 1: There is no significant difference in the mean performance scores of students taught periodic table using crosswords puzzles and flashcards teaching strategies.

Table 3: ANCOVA result on students' academic performance in Chemistry based on strategies of teaching (N = 104)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	4700.643	1	4700.643	432.597	.000
Pretest	28.569	1	28.569	2.629	.108
Teaching Strategies	251.068	1	251.068	23.106	.000 ^S
Gender	4.586	1	4.586	.422	.517 ^{NS}
Teaching Strategies * Gender	.002	1	.002	.000	.988 ^{NS}
Error	1075.743	99	10.866		
Total	20607.000	104			
Corrected Total	1354.837	103			

S = Significant @ $p < .05$

Analysis of covariance test results in Table 3 revealed that there is a significant difference between the mean performance scores of students taught the concept of periodic table in Chemistry using crosswords puzzle teaching strategy and those taught using flashcards teaching strategy in favor of those taught using crosswords puzzle teaching strategy;

$F(1,103)=23.106$, $p<0.05$). The null hypothesis is therefore rejected. This implies that crosswords puzzle teaching strategy significantly enhanced students' performance in the concept of periodic table when compared with those taught using flashcards teaching strategy. Thus, the mean difference earlier observed is statistically significant at .05 level of significance.

Null Hypothesis 2: There is no significant difference in the mean performance scores of male and female students taught the concept of periodic table using crosswords puzzle and flashcards teaching strategies.

Table 4: ANCOVA result of male and female students' academic performance in Chemistry based on teaching strategies (N = 104)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	4700.643	1	4700.643	432.59	.000
Pretest	28.569	1	28.569	2.629	.108
Teaching Strategies	251.068	1	251.068	23.106	.000 ^S
Gender	4.586	1	4.586	.422	.517 ^{NS}
Teaching Strategies * Gender	.002	1	.002	.000	.988 ^{NS}
Error	1075.743	99	10.866		
Total	20607.000	104			
Corrected Total	1354.837	103			

NS = Not significant @ $p<.05$

As shown in Table 4, the analysis of the pretest scores of male and female students taught the concept of periodic table in Chemistry using crosswords puzzle and those taught using flashcards teaching strategies is not significant since the calculated p-value (.108) is greater than the significant level (.05), indicating the groups were comparable. The table also showed that the calculated p-value (.517) of gender is greater than alpha level (.05) { $F(1,103) = .042$, calculated $p.517 > 0.05$ }. Therefore, the null hypothesis is retained. This result implies that there is no significant difference in the mean performance scores of male and female students when taught the concept of periodic table using crosswords puzzle and those taught using flashcards teaching strategies. Hence, the teaching strategies are gender friendly.

Discussion of Findings

This study examined the effects of crosswords puzzle and flashcards teaching strategies on students' academic performance on the concept of periodic table in chemistry. The findings of this study indicated a significant difference between the mean performance scores of students taught the concept of periodic table using crosswords puzzle and those taught using

flashcards teaching strategies. Hence, students taught the concept of periodic table using crosswords puzzle teaching strategy had higher performance scores than their counterparts taught using flashcards teaching strategy. The finding of the study is in accordance with Umoru, Adejoh and Iji (2016) who reported that puzzle based-learning strategy had a significant effect on students' attitude and academic performance. The findings also agree with Olagunju and Babayemi (2014) who reported that crossword-picture puzzle (CPP) teaching strategy had significant main effect on students' achievement score. Duyilemi (2013) reported that puzzles are wonderful tool that can enhance students' attention and help them develop positive attitude towards learning. This implies that puzzle-based teaching strategy enhanced students' academic performance than the traditional teaching method which is deficient in meeting the learners need.

The analysis of results on the difference in the mean performance scores between male and female students taught the concept of periodic table using crosswords puzzle and flashcards teaching strategies as presented in Table 2 and 4 indicated that there is no significant difference in the mean performance scores of male and female students taught the concept of periodic table using crosswords puzzle and flashcards teaching strategies. Hence, the teaching strategy is gender friendly. This finding is in line with Olagunju and Babayemi (2014) in their study on the effect of crossword-picture puzzle (CPP) teaching strategy and gender on students' achievement found that the use of crosswords puzzle gender had no significant influence on students' achievement. Also in support of this finding Umoru, Adejoh and Iji (2016) report that there was no significant difference between the mean attitude rating of male and female students in the experimental group and those in the control group as such puzzle based-learning strategy is gender friendly.

Recommendations

Based on the findings, the following recommendations were made:

1. Chemistry Teachers should use crosswords puzzle teaching strategy in teaching periodic table and other concepts in chemistry to enhance students' understanding and higher performance in chemistry.
2. chemistry Students should be assisted and encouraged by teachers to constantly practice the use of crosswords puzzle to reduce learning difficulties particularly on concepts considered abstract and difficult.
3. School administrators should organize workshops and seminar for teachers on appropriate use of crossword puzzle teaching strategy.

Conclusion

In conclusion, from the findings of the study, crosswords puzzle teaching strategy improved students' academic performance on the concept of periodic table than flashcards teaching strategy. There was no significant difference in the performance of male and female students' using crosswords puzzle and flashcards teaching strategies. This implies that crosswords puzzle and flashcards teaching strategies enhanced both male and female students' academic performance when taught the concept of periodic table in chemistry.

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