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EFFECT OF CHEMISTRY-BASED PUZZLES ON PERFORMANCE IN CHEMICAL PERIODICITY AMONG SECONDARY SCHOOL STUDENTS IN KATSINA ZONAL EDUCATION QUALITY ASSUARANCE

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ABSTRACT

The study investigated the effect of chemistry Based puzzles on academic performance in chemical periodicity among senior secondary students in Katsina Zonal Education Quality Assurance, Katsina State. The research has two specific objectives, two research questions which were answered using descriptive statistic of mean and standard deviation. Two null hypotheses were formulated to guide the study and tested using independent sample t-test at 0.05 level of significance. The study adopted a quasi-experimental design of the pre-test post-test control group type. A sample size of 149 students were drawn from the target population of 15495 students using cluster and simple random sampling techniques. Intact classes from two schools were used for both the experimental and control groups. The experimental group with 77 students (44male, 33 female) were taught using the chemistry based puzzles while control group with 72 students (42 male, 30 female) were taught using lecture method. The instrument used for collection of data, the Chemistry Performance Test (CPT), was validated by experts and a reliability co-efficient of 0.651 was found. The findings of the study showed a significant difference between the mean academic performance scores of students taught chemical periodicity using Chemistry Based puzzles and those taught using lecture method. The result also revealed there was no significance difference between the mean performance scores of the male and female students taught chemical periodicity using chemistry based puzzles teaching strategy. . It was concluded that the use of chemistry-based puzzles is effective in enhancing students' performance, interest and retention in chemistry. It was recommended among others that there is the need for curriculum planners and curriculum development bodies in Nigeria like NERDC to design programs and policies that will incorporate the use of Chemistry-based puzzles in teaching and learning sciences at senior secondary school level.

Keywords: Chemistry-Based puzzles, Chemical periodicity, Academic performance

Introduction

Senior Secondary Education is defined as that level of education for children aged 15-years plus and which serves as transition between the upper basic and tertiary levels of Education. Subjects taught at Senior Secondary Schools in Nigeria are divided into Arts, Social Sciences and Sciences, depending on the nature, contents or combination of the subjects. In Nigeria, the science contents are taught in subjects such as Chemistry, Physics and Biology. The National Curriculum for Senior Secondary Schools states the specific objectives to be achieved by each subject (curriculum) (Ajaja, 2014).

Chemistry as observed by Ababio (2011), is a science which deals with the composition, properties and uses of matter. Chemistry education aims at providing knowledge that prepares learners for further study, vocations and to appreciate their environment. Chemistry can be viewed as a 'bridge' because it incorporates knowledge acquired from a variety of subjects like physics and biology and has a wide range of applications in different fields like medicine, agriculture, biotechnology and engineering (Iftekhar, 2013). A lot of emphasis is therefore placed on the application of the knowledge of chemistry, in order to solve environmental and other issues that currently affect the society.

Chemistry-based puzzles fall under the category of serious games called edutainment, which is educating through entertainment (Michael and Chen, 2016). According to Micheal and Chen (2016) see game as having explicit and carefully thought out educational purpose are not to be played primarily for amusement. Studies with games show that peoples motivation increase when they participate in game-based activity. For this reason, puzzles which are part of educational games are considered in this study. A puzzle is a problem designed as a mental challenge, whose solving often provides a rewarding experience, helping the solver to think in a way. Slocum cited in Adzape (2015) added that a puzzle can be constructed intentionally or is used to perplex and to stimulate thinking of potential solutions. Slocum defines a puzzle as a game of skill or intelligence. Also, a puzzle is a problem or enigma that tests the ingenuity of the solver. In a basic puzzle, one is intended to put together pieces in a logical way in order to come up with the desired solution in this study, chemistry-based puzzles are the focus of consideration.

Theoretical framework

The purpose of this study is to investigate the efficacy of chemistry-based puzzles on students' Academic performance. This study is predicted on two theories, viz: Dewey's Philosophy of Reflective Practice (1859 – 1952), Walberg theory of Academic Performance (1984).

1 Philosophy of Reflective Practice by John Dewey's (1859 – 1952)

Dewey (1938) believes that reflective practice entails turning a subject over in the mind and giving it serious and consecutive consideration. Dewey's work is focused on integration of theory and practice; the cyclic

pattern of experience and the conscious application of the learning experience. In the area of education, Dewey's reflective practice centers on construction and reconstruction or reorganization of experience which adds to experience and increase the ability to direct the course of subsequent experience. Dewey's key concepts of teaching and learning include experience, construction, reconstruction, reorganization, growth, development, reform progress and intelligence. Dewey sees education as a process of living or life itself. Furthermore, ideal curriculum has to consider the interest and ability of the learner in order to make it meaningful to him/her. For Dewey the school aims at guiding individuals to grow out of existing condition. The school makes individual to be tentative at least in the beginning and maintain flexibility and moves to be guided towards a set of activities that lead to construction and reconstruction. Dewey's philosophy of reflective practice has implication for teaching in general and for Physics in particular. Teachers are perceived as guidance. They are expected to be intelligently aware of the capacities, needs and past experiences of learners. Their role is to reflect and think about a way out of learning problems surrounding chemistry curriculum. Teachers are required to select and construct learning experiences of the learner with care. They are demanded to create room for suggestion for learners to develop a plan, share experiences and organize experiences.

Theory of Academic Performance by Walberg (1984)

This theory is otherwise called Walberg theory of educational productivity and it was propounded by Walberg in 1984. The theory posits that psychological characteristics of individual students and their immediate psychological environments influence educational outcomes cognitively, behaviorally and attitudinally. According to Rugutt and Chemosit (2005), Walberg theory determined nine key variables that require optimization to increase students' academic performance in terms of cognitive, attitude and behaviour and these variables are categorized into three groups as: student aptitude, instruction and environment. Student aptitude include: Ability or prior Performance, as measured by the usual standardized tests, development, as indicated by chronological age or level of maturation, and motivation as indexed by personality tests or the student's willingness to persevere intensively on learning tasks. Instruction include: The amount of time students spent in learning and the quality of the instructional experience, including psychological and curricular aspects. And the environmental factors of educationally stimulating, psychological climates of the home, the classroom and social group, the peer group outside the school, and exposure to mass media (Xin &Jianjum, 2010; Matthew, 2002).

4 Review of Related Empirical Studies

Various studies wholly and partly related to the effect of chemistry-based puzzles on Performance have been conducted previously in addressing several issues. In the following paragraphs, a review of some of these studies are presented.

Adzape, Otor and Akpoghol (2020), investigated the effects of chemistry-based puzzles on senior secondary school chemistry students' interest and gender in chemical periodicity in Abuja. The design of the study was quasi-experimental; specifically, the pre-test, post-test non-equivalent control group design was adopted. A sample of 129 students from a population of 4369 was used in the study. Students were classified into experimental and control groups: Students in the experimental groups were instructed with chemistry-based puzzles while students in the control groups were instructed with the demonstration method. An interest questionnaire called Chemical Periodicity Concepts Interest Inventories (CPCII), constructed by the researchers and validated by experts from three universities in Nigeria, was used in the study. Reliability coefficient of the instrument was calculated and found to be 0.79. Three research questions and three hypotheses were raised in the study. The research questions were answered using Mean and Standard Deviation while hypotheses were tested at 0.05 confidence level using Analysis of Covariance (ANCOVA). Findings showed that students in the experimental group who were taught with Puzzle-Based Strategy (PBS) had higher interest in the topic 'chemical periodicity' than those in the control group who were taught with the Demonstration Method (DEM). There was no significant difference in the interest of students by gender. Interaction effect of gender and treatments on interest was not significant. It was recommended that teachers should incorporate puzzle-based instructional strategies in their teaching as a variety to curb boredom in the classroom due to monotony of the conventional methods among others.

Efe (2015) Enhancing Academic Achievement and Retention in Senior Secondary School Chemistry through Discussion and Lecture Methods: a case study of some selected secondary schools in Gboko, Benue State, Nigeria. The present study was initiated to determine how academic achievement and retention in chemistry is enhanced using the two instructional methods among SSII students and ascertained the differential performance of male and female students in chemistry with a view of improving student performance in chemistry. The study adopted a non-equivalent pretest, posttest control quasi-experimental design. A total of one hundred and eighteen senior secondary school II students in intact classes were chosen from three schools in Gboko Local Government Area of Benue State using purposive random sampling. The ages of the students ranged between 16-17 years. Data were collected using a 30- item multiple choice Chemistry Achievement Test (CAT), in organic chemistry. Students were assigned to a treatment and a control group. Three hypotheses were generated and tested

which were tested at 0.05 level of significance. The data obtained were analyzed using descriptive statistics, t-test, spearman's correlation coefficient and analysis of variance (ANOVA). There was significant difference in students' performance when discussion and lecture strategies were used to teach chemistry (Fcal = 4.65 >Fcrit = 3.85 at P < 0.05). There was significant difference in the retention ability of students exposed to discussion and lecture method (rcal = 0.9786 >0.2353 at P < 0.05). There was significant difference in the performance of male and female students in the two groups (tcal = 3.621 >tcrit = 2.000 at P < 0.05). The overall results showed that discussion instructional strategy significantly improved students' performance in chemistry better than the lecture instructional strategy. The study concluded that discussion enhanced better achievement and productivity than the lecture method. It was recommended that discussion method should be used to teach organic chemistry in Nigerian Senior Secondary Schools.

Janet (2015) investigated the effects of chemistry-based puzzles on senior secondary school chemistry students' Performance, retention and interest in chemical periodicity. The quasi-experimental design with a pre -test and post- test was adopted in the study. A total of 129 students were used in four intact classes from four purposively sampled schools. Two schools were randomly assigned in the experimental group and two in the control group. Students in the experimental groups were instructed with chemistry-based puzzles while students in the control groups were instructed with the demonstration method. A detailed collection of chemistry-based puzzles were developed into lesson plans for use in the experimental group. This was done with the theory of social constructivism in mind and trained research assistants were used to deliver the course. A Performance test called Chemical Periodicity Concepts Performance Test (CPCAT) and an interest inventory called Chemical Periodicity Concepts Interest Inventories (CPCII), constructed by the researcher and validated by experts from three universities in Nigeria, were used in the study. Reliability coefficients of the two instruments were found to be 0.96 and 0.79 respectively.

Treatment in the two groups lasted for three weeks and a retention test was taken after an interval of four weeks. Nine research questions and nine hypotheses were raised and tested at 0.05 confidence level (significance level). The research questions were answered using mean and standard deviation while hypotheses were tested with Analysis of covariance (ANCOVA). Findings showed that students in the experimental group who were taught with Puzzle-Based Strategy (PBS) achieved slightly higher scores than those in the control group who were taught with the demonstration method. However further analysis with ANCOVA showed that there was no significant difference in Performance in the two groups. Interest of student's due to instructional strategy in the experimental group was significant. There were no significant difference in gender by

Performance, retention and interest. There was significant difference in students' retention, but there was no significant difference in students' retention by gender. Interaction effects of gender and treatments on Performance, retention and interest were not significant. The above study was related to the current study because it used chemistry Based-puzzles, performance, retention and interest as variables of the study.

Statement of the Problem

The consistent decline in the performance and retention of chemistry students in most secondary schools in Katsina state is the major problem that prompted this investigation. Chemistry is one of the key subjects required to meet up with increase in demand for science and technology. Therefore, if Katsina state students are to attain science and technological development, the problem of consistent decline in chemistry must be addressed. One of the problems that is attracting public concern and outcry among the students' today is the decline in the performance of science students in public examinations (shu'aibu, 2021). This observable decline has been blamed on a number of factors, including lack of using effective methodologies for teaching chemistry in secondary schools (Baraya, 2021). The continual and unabated poor performance of students suggests that the situation should no longer be glossed over. In an attempt to focus attention on chemistry learning, issues creating problems must be addressed. Various teaching strategies exist, yet poor teaching and learning of chemistry seems to continue unabated.

Despite the recognition and importance attached to chemistry there is a serious decline in students' performance in the subject. Reports by the Nations Examination bodies (WAEC and NECO) indicated that students' performance in chemistry is relatively poor over the years. The Chief Examiner's Report for the West African Senior School Certificate Examination (WASSCE 2021) pointed out that some of the reasons for candidates' poor performance in chemistry are; inability of the students to tackle most of the numerical questions; poor expressions and the use of nomenclature especially in organic compound and writing of formulae and incorrect balanced chemical equations. The poor performance of students in Chemistry at SSCE is attributed to a number of factors ranging from learners' attitude, teachers' attitude, and the curriculum, method of instruction and instructional materials, among others (Bunkure, 2013)
Objectives of the study

Objectives of the study

The study seeks to investigate the effect of chemistry-based puzzles on performance in Chemical Periodicity among senior secondary students in Katsina ZEQA. Specifically, the study following objectives.

1. Examine the effect of chemistry based puzzles on the students' academic performance in chemical periodicity.

2. Find out the mean academic performance in chemical periodicity of the male and female students exposed to chemistry-based puzzles.

Research Questions

The following research questions were be answered in this research:

1. What is the difference between mean academic performance score of the students' taught chemical periodicity using chemistry-based puzzles and those taught without it?
2. What is the difference between mean academic performance score of male and female students' taught chemical periodicity using chemistry based puzzles?

Research Hypotheses

The following hypotheses were formulated for the Study and were test at 0.05 level of significance.

$H0_1$: There is no significant difference between the mean academic performance score of students taught chemical periodicity using chemistry based puzzles and those taught without it.

$H0_2$: There is no significant difference between the mean academic performance score of the male and female students taught chemical periodicity using chemistry based puzzles.

Research Method

This study employed a quasi-experimental research design using the pre-test, post-test, post posttest control group. This design was considered suitable for this study because the variables under study can be manipulated.

Population of the Study: The population of this study Comprises of 15495 senior secondary SSII chemistry students in 25 schools within Katsina Zonal Education Quality Assurance. Katsina Zonal Education Quality Assurance is made up of three Local Government Area, Katsina, Kaita and Jibia Local Government Areas. With 8530 male student while 6965 female student. SSII students in the zone are generally within the age range of 13-21 years.

Instrumentation: Two instruments namely: Chemical Periodicity Test (CPT) and Chemistry Interest Questionnaire (CIQ) were used for the study.

Validity of the Instrument: To ascertain the validity of CPT, the CPT was validated by three experts with PhD Qualification: two from the Department of Chemistry and one from Department of English in Umaru Musa Yar'adua University. For both content as well as face validities.

Reliability of the Instruments: The scores obtained from the pilot test were used to determine the reliability coefficient of the CPT The study employed test-retest method for CPT on the scores obtained from the pilot test through split-half method by using odd and even numbers. The two test scores were analyzed using Pearson's Product Moment Correlation (PPMC).

Procedure for Data Collection: In order to collect data pretest was administered followed by treatment. Where the

experimental group was treated using chemistry-based puzzles while the control group treated using conventional method. Post test was administered a week after the application of the treatment. To measure retention post-post test was administered two weeks after posttest.

Procedure for Data Analysis

The data for this study was analyzed using descriptive and inferential statistics. Mean and Standard Deviation were used to answer research questions while T-test independent sample was used to test hypotheses at 0.05 significance level. The following are the research questions answered and hypotheses tested.

Results and Discussion

In order to be able to answer the research questions, the researcher made use of descriptive statistics (mean, mean rank and standard deviation).

Research Question One: What is the difference between mean academic performance sscore of the students taught chemical periodicity using chemistry-based puzzles and those with taught without it?

Table 1: Differences in the mean performance score of experimental and control group

Groups	N	Mean	Std. Dev.	Mean difference
Experimental	77	25.23	1.97	7.04
Control	72	18.19	2.88	

Table 1 Shows that the difference between mean academic performance score of student taught using chemistry based puzzles (M=25.23, SD=1.97) and those taught using lecture method (M=18.19, SD=2.88) is 7.04. Therefore, it seems that the student taught chemical periodicity using chemistry-based puzzles (Experimental Group) have performed better than those taught using lecture method (Control Group)

Research Question Two: What is the difference between mean academic performance score of male and female students' taught chemical periodicity using chemistry based puzzles?

Table 2: Differences in the Mean performance of male and female students in experimental group

Groups	N	Mean	Std. Dev.	Mean difference
Male	44	25.07	2.18	0.39
Female	33	25.45	1.66	

From Table 2 it could be seen that the mean academic performance score of the males (M=25.07, SD=2.18) and females (M=25.45, SD=1.66) taught using chemistry-based puzzles is 0.39. This shows that the female students scores slightly better than their male counterparts.

Hypotheses Testing

In order to be able to test the stated hypotheses, the researcher used inferential statistics Independent samples t-test statistics to be specific. The use of this statistics was based on the nature of the data collected. Moreover, all the hypotheses were tested at 5% level of significance.

H_{O1}: There is no significant difference between the mean academic performance of students taught chemical periodicity using chemistry based puzzles and those taught some topic using lecture method.

Table 3: t-test Analysis of students' academic performance between experimental and control groups

Groups	N	Mean	Std. Dev.	Df	t value	P value	Remark
Experimental	77	25.23	1.97	147	17.118	0.00	Significant
Control	72	18.19	2.88				

From Table 3, it could be seen that the difference between the mean academic performance score of SSII students taught chemical periodicity using chemistry-based puzzles and those taught using lecture method is significant (t(147)=17.118, P<0.05). Therefore, the null hypothesis was rejected.

H_{O2}: There is no significant difference between the mean academic performance of the male and female students taught chemical periodicity using chemistry based puzzles.

Table 4: t-test Analysis of Male and Female Students Academic Performance

Groups	N	Mean	Std. Dev.	Df	t value	P value	Remark
Male	44	25.07	2.18	75	-0.85	0.339	Not Significant
Female	33	25.45	1.66				

Table 4 Shows that the difference between the mean performance score of the male (M=25.07, SD=2.18) and female (M=25.45, SD=1.66) SSII student taught chemical periodicity using chemistry based puzzles is not significant (t (75)=17.118, P>0.05. This shows that both male and female students have the same level of mean performance when taught using chemistry-based puzzles. Therefore, the null hypothesis is hereby accepted and retained.

Summary of the Findings

Based on the result presented, the major findings of the study are as follows:

1. There is significant difference between the mean academic performance of students taught chemical periodicity using chemistry based puzzles and those taught some topic using lecture method among senior secondary schools of Katsina ZEQA. *(t= 17.118, P=0.00 and df =147).*
2. There is no significant difference between the mean academic performance of the male and female students taught chemical periodicity using chemistry based puzzles among senior secondary schools in Katsina ZEQA. *(t = -0.85, df = 75, and P = 0.339).*

Conclusion

Based on the findings of this study, the following conclusions were drawn;

1. Puzzle-based teaching strategy was found to be more effective than the Lecture method on students' academic performance and retention in chemical periodicity.
2. There was no significant difference in the performance, retention and interest of male and female students taught with Puzzle-based Strategy.

Recommendations

Based on the findings of this study, the following are hereby recommended:

1. Chemistry teachers should expose students to chemistry-based puzzles in order to encourage active engagement and enhance students' academic performance.
2. Curriculum planners and curriculum development bodies in Nigeria like; NERDC should design program and policies that incorporate the use of chemistry-based puzzles in teaching and learning Chemistry.
3. The NTI and professional bodies such as STAN, should organize special training, workshops and seminars for Chemistry teachers on how to use chemistry-based puzzles.
4. The Chemical Society of Nigeria (CSN) should provide the stand to address the issues of persistent low interest, academic performance and retention ability in Chemistry among student in secondary schools as well as promotion of teachers' awareness of the use of chemistry-based puzzles and its impact on students.

Contributions to Knowledge

The result of this study has the following contributions to knowledge;

1. The study has provided empirical evidence in respect of the efficacy of chemistry-based puzzles as teaching models in facilitating students' performance in senior secondary chemistry. This suggests the need for teachers to lay less emphasis on the conventional methods of teaching which are teacher centered and emphasize the student centered methods.
2. The study offers students an opportunity to learn in a more relaxed environment and interact with their classmates in a social environment. This will make them to

appreciate chemistry and other science subjects better.

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