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EFFECTS OF MATHEMATICAL PROCESS ON SENIOR SECONDARY SCHOOL CHEMISTRY STUDENTS' ACADEMIC PERFORMANCE

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ABSTRACT

The study investigated the effects of mathematical process on chemistry students' academic performance in Acids, Bases and Salts. A quasi experimental research design using intact classes was employed in the study. Senior Secondary two (SS2) science students from Government Technical College, Runjin Sambo, Government Girls College, Mabera, and Government Technical College, Farfaru, all in Sokoto Metropolis of Sokoto State were used for the study. The face and content validity of the Performance Test in Acids, Bases and Salts (PTABS) was established by presenting the test questions to five (5) experts in the field of study at both university and secondary schools levels Data were collected with the help of the validated instrument developed by the researcher and a reliability index of 0.74 was established. Mean scores were used in answering the research questions while t-test was employed in testing the hypotheses. The findings revealed that there is a significant difference between the mean performances of Students taught Acids, Bases and Salts in chemistry using Mathematical processes and those taught using Discussion Method. No significant gender difference between the mean performances of students taught Acids, Bases and Salts in chemistry. Based on the findings, it was recommended that Mathematics processes should be employed in the teaching and learning of chemistry to enable students understand the connection between mathematics and chemistry.

INTRODUCTION

The senior secondary years are the years of later adolescence corresponding to the later part of secondary education, during which pupils are exposed to science related subjects such as Biology, Chemistry and Physics. It is a stage at which students' deal with abstraction, conceptual thinking, and generalization of facts, all of which require the use of mental processes. No doubt that Piaget (1967) described it as intellectual development level period between the ages of 12 years to adolescent. The Chemistry Curriculum for instance, deals with abstraction, conceptual thinking and generalization of facts, all of which requires the use of cognitive processes. Chemistry is the study of matter, its property, how and why substances combine or separate to form other substances, and how some substances interact with energy (Achimugu, 2009). In its paper Mathematics Pathway, the University of Tasmania (2018) stated that chemistry involves observation and numerical measurements of quantities such as length, volume, density, temperature, and the concentration of chemical solutions. Most of these quantities are associated with Mathematical skills. Frances Bacon (n. d.) articulated that Mathematical skills are the key to all sciences. Today the world largely depends on science and science in turn depends on mathematics.

While mathematics is a branch of knowledge that deals with measurement, numbers, and quantities. Its knowledge is essential to the effective learning of chemistry considering transfer of ideas into reality (Charles, Gladys, Arokoyu, Amadi, & Joseph 2017) as cited in Ogbisi, (2009). Its processes provides insight into all branches of Chemistry and can form the basis for students' ability to understand unfamiliar concepts, construct models and solve problems. With the knowledge of Mathematics processes, the child's reasoning ability becomes quite systematic and reasonably well integrated. The child thinks formally, logically and in abstraction. He is able to understand and transfer understanding from one situation to another and exhibits particular orientation to problem solving (Oloyede, 2012).

The Mathematics curriculum identifies seven key mathematical processes students engage in as they learn and use Math throughout the grade. These are problem solving, reasoning and proving, reflecting, selecting tools and computational strategies, connecting, representing, and communicating. Students will use these processes when learning concepts and procedures, practical skills and problem solving. The application of these processes in Chemistry would enable students understand other branches of Chemistry which involves mathematical expressions. Liza, (2010) Stated that some reason for poor performance in chemistry may be attributed to lack of appropriate knowledge of mathematical processes, poor teaching methods, inadequate facility, inadequate laboratory infrastructures for teaching chemistry, and student attitude. It is unfortunate however, that most students this days have erroneous impression about mathematics and dislike mathematical activities, many seem to fear, even hate mathematics (Fatema, 2015).

It is in view of this that the paper seeks to find out the effect of Mathematical processes on Senior Secondary School Chemistry Students performance in Chemistry (Acids, Bases & Salts) and its corresponding effects on gender.

Objectives of the Study

The study aimed at achieving the following objectives among senior secondary school Chemistry students. Specifically, this study sought:

1. to determine the difference between mean scores of students taught Acid, Base and Salt using Mathematical Processes and Discussion method.
2. to determine the difference between mean scores of male and female students taught Acid, Base and Salt using Mathematical Processes.

Research Questions

This study sought to provide answers to the following research questions:

1. Is there any difference between the mean scores of students taught Acid, Base and Salt using Mathematical Processes and Discussion method?
2. Is there any difference between the mean scores of male and female students taught Acid, Base and Salt using Mathematical Processes?

Hypotheses

Based on the research questions and objectives of this study, the following null hypotheses were formulated and tested.

1. There is no significant difference between the mean scores of students taught Acids, Bases and Salts using Mathematical Processes and Discussion method.
2. There is no significant difference between the mean scores of male and female students taught Acid, Base and Salt using Mathematical Processes.

Methodology

Quasi experimental Research design involving pre-test and post-test was used for the study. The population of the study consisted of all senior secondary school students of science within Sokoto Metropolis, Sokoto State. Two (2) intact classes of 41 and 44 students from Government Technical College Runjin Sambo, Sokoto and Government Girls College Mabera, Sokoto were used as experimental groups respectively. While an intact class of 46 students from Government Technical College Farfaru was used as control group.

Research Instrument

The instrument used was developed by the researcher consists of 50 completing items, designed to measure seven mathematical process which includes: Problem solving, Reasoning and proving, Reflecting, Selecting Tools and Computational Strategy, Connecting, Representing, Communicating. The test items were later reduced to 40 items covering the area of interest, in attempt to determine the effect of mathematical processes strategy on senior secondary school chemistry students' performance in Acids, Bases and Salts. The instrument was Performance Test on Acids, Bases and Salts (PTABS).

Validation of the Instrument

The face and content validity of the Performance tests (PTABS) was established by presenting the test questions to five (5) experts in the field of study at both university and secondary schools levels**.** They critically examined the suitability and appropriateness of the items, match the ability of the students, the clarity and adequacy of language, and check the suitability of the distractors among other things. Their comments helped to eliminate inadequate test items. Comments made by the experts were taken into consideration and the necessary modification and correction were made before the production of the final copy that was administered.

Reliability of the Instrument

The instrument (PTABS) was subjected to pilot testing on SSII students outside the study area. The reliability of PTABS was determined by administering the test twice using test-retest method with two weeks' interval in line with Tuckman, (1975) recommendation. The results of the two tests were being correlated using Pearson Product Moment Correlation Co-efficient and a reliability index of 0.74 was obtained.

Results

Research questions were answered using descriptive statistics (mean, standard deviation and percentages) of the performance scores while t-test was used to determine the statistical significance of the research hypotheses at 0.05 level of significance.

Research Question One: Is there any difference in academic performance of students taught Acid, Base and Salt using Mathematical Processes strategy and discussion method?

Table 1: Mean, Standard Deviation and Mean Difference of Scores between Mathematical Processes strategy and Discussion Method.

Variable	N	Mean	SD	Mean Difference
Mathematical Processes strategy	85	25.39	8.10	4.78
Discussion method	46	20.61	5.52	

α=0.05 **Source: Field Work, 2019**

The data presented in Table 1. Shows that there was a difference in the performance of experimental group who were taught Acid, Base and Salt using Mathematical Processes and the control group taught the same concepts using discussion method. From the table, the Mathematical Processes strategy group had a mean score of 25.39 and standard deviation of 8.10. While the Discussion group had a mean score of 20.61 and standard deviation of 5.52. The mean difference is 4.78 in favor of Mathematical Processes strategy group. The significance of the mean difference obtained would be statistically established when the corresponding null hypothesis was tested.

Research Question Two. Is there any difference in academic performance of male and female students taught Acid, Base and Salt using Mathematical Processes strategy?

Table 2: Comparison of Mean and Standard Deviation of Male and Female Students taught Acid, Base and Salt using Mathematical Processes strategy.

Variable	N	Mean	SD	Mean Difference
Male	41	25.90	8.28	
				0.98
Female	44	24.92	8.00	

α=0.05 **Source: Field Work, 2019**

Table 2 showed that there was difference between the performance of male and female taught Acid, Base and Salt using Mathematical Processes strategy. It shows that Male in the experimental group had mean score of 25.90 and standard deviation 8.28 while their female counterparts had mean score of 24.92 and standard deviation 8.00. The difference in their mean achievement score is 0.98. The statistical significance of the mean difference would be observed when the corresponding null hypothesis was tested.

The following null hypotheses were tested using t-test statistic at 0.05 level of significance with the aid of Statistical Package for Social Sciences package. Null hypotheses 1, and 2 were tested using t-test statistics the performance scores as presented in the tables 3 and 4.

A null hypothesis is rejected or retained based on the alpha-value and p-value set. When alpha-value is equal or greater than p-value, the null hypotheses is rejected or otherwise retained.
HO_1: There is no significant difference between the academic performance of students taught Acid, Base and Salt using Mathematical Processes strategy and Discussion method.

Table 3 t-test analysis comparing the students' performance in Mathematical Processes strategy and Discussion method.

Variables	**N**	**Mean**	**Df**	**t-cal.**	**P-value**	**Decision**
Mathematical Processes	85	25.39	129	3.58	0.00	Rejected
discussion method	46	20.61				

α=0.05 Source: Field Work, 2019

The result in Table 3. Shows the t-test analysis of performance for experimental group (Mathematical Processes) and control group (Discussion method) in Acid, Base and Salt. From the table, p-value of 0.00 obtained was less than the alpha value of 0.05. This indicate that there

is significant difference in the academic performance of students taught using Mathematical Processes strategy and discussion method. Thus, the null hypothesis is rejected.
HO_2: There is no significant difference between the academic performance of male and female students taught Acid, Base and Salt using Mathematical Processes strategy?

Table 4. t-test analysis comparing male and female students on Experimental Group (Mathematical Processes strategy)

Variables	N	Mean	Df	t-cal.	P-value	Decision
Male	41	25.90				
			83	0.56	0.58	Retained
Female	44	24.92				

α=0.05 Source: Field Work, 2019

The figures in Table 4. Shows the t-test analysis of performance male and female in experimental group (Mathematical Processes strategy) in Acid, Base and Salt. From the table, p-value of 0.58 obtained is greater than the alpha value of 0.05. This indicates that there is no significant difference in the performance of male and female students taught Acid, Base and Salt using Mathematical Processes strategy. Thus, the null hypothesis is retained.

The results of this study provided an empirical evidence of the efficacy of the Mathematical Processes in the teaching of chemistry. The experimental group produce higher mean performance scores than the control group taught the same content/concepts in chemistry using the discussion methods.

The finding of this study in table 1 revealed that there was significant difference between the performance of students in experimental (Mathematical Process) and control groups (Discussion). A significant difference implies rejection of the null hypothesis. Thus, the null hypothesis which states that there is no significant difference between the performances of students taught Acid, Base and Salt concept using Mathematical Processes and those taught discussion methods is hereby rejected. The significant difference is in support of experimental group. A significant high performance implies that Mathematical Processes was more effective than the discussion method of instruction.

This finding is in support of research findings of Ibrahim and Nur (2000), Bilgin (2006) and Samuel, (2015). Which revealed that there was significant difference in the understanding of science concept as expressed by students' performance in the experimental and control group respectively?

Reasons why the experimental group performed better than the control group may be attributed to form of the strategy employed which are more students centered. Thus, it focuses on science as a concept not only related to the problems but also scientific method to solve the problem. Therefore, students have to understand not only the concepts relevant with the problem that becomes the center of attention but also to gain learning experiences relevant to the skill on applying Mathematical strategy in solving science problems, and develop critical mindset. Provided variety of instructions for the students to navigate their learning process, these activities have therefore made the students in the experimental group performed better. Students gain learning experiences to develop high-level thinking skill, skill in analyzing and solving problems, as well as building self-reliance and competitiveness. The relative performance of the students in control group is an indication that the discussion method adopted in teaching science by science teachers is less effective.

From the findings in table 2 indicates that there is no significant difference between the performance of male and female students taught Acid, Base and Salt concept using Mathematical Processes and Discussion method. This implies retention of the null hypothesis. Thus, the null hypothesis which states that there is no significant difference between the performance of male and female students taught Acid, Base and Salt concept using Mathematical Processes is retained.

The research is in accord with the findings of Charles et. al., (2017). Ogunleye and Babajide (2011). The findings reveal that there was no significant difference in gender on investigating the effects of mathematics knowledge on chemistry students' academic performance. Ogunleye and Babajide (2011), reported insignificant difference on students' commitment to science and gender.

Generally, results of studies on gender related differences in performance in science are often contradicting (Mari 2006).

This result agrees with the findings of Bilgin (2006), Shuaibu and Mari (2003) and Charles et. al., (2017), they all reported independently better level performance by the experimental group than the control group in Process Based Instruction (PBI) and high acquisition of Process Based Instruction (PBI) irrespective of gender. Their study contradicts the earlier report by Shuaibu and Ameh (2001), who reported that male performed better in science than female.

CONCLUSION

The results of this study provided an empirical evidence of the efficacy of the Mathematical Process in the teaching and learning of chemistry. Findings of the study showed that there was a significant difference in the academic performance of students taught using Mathematical Process and discussion method. On the other hand, there was no significant gender difference in the mean academic performance of students of male and female students taught Acid, Base and Salt using Mathematical Process and so success in chemistry does not depend on the gender of the students.

RECOMMENDATIONS

Recommendations were made based on the findings:

1. Since the use of MPS in teaching has been found to enhance the quality of performance in chemistry, chemistry teachers should be encouraged to employ it more in the teaching of the science subjects. By so doing, the performance of students in the subjects could be increased. Since the PBI is effective in the improvement of student performance, service training, workshops, and seminars should be organized by Federal and State Ministries of Education to encourage science teachers in the use of PBI.
2. Both male and female students benefitted equally when taught Acids, Bases and Salts using MP. Based on this finding the female and male student should be encouraged to vigorously pursue most of the chemistry-based courses like engineering, medicine, etc. since most of the abstract concepts can now be explain using mathematical processes. It makes such concepts to be tangible and easily conceptualized.

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