European Journal of Educational Studies 3(3), 2011

EFFECT OF PRE-EXPOSURE OF STUDENTS TO BASIC MATHEMATICAL CONCEPTS ON THEIR PERFORMANCE IN QUANTITATIVE ASPECTS OF CHEMICAL REACTIONS

OLUWATAYO, JAMES AYODELE

Institute of Education, University of Ado-Ekiti, Nigeria

E-mail address for correspondence: ayotayor@yahoo.com

Abstract: The study investigated the effect of pre-exposure of students to basic mathematical concepts on their performance in quantitative aspects of chemical reactions. 90 SS2 students from two schools in two local government areas of Ekiti State were stratified into experimental (N=45) and control (N=45) groups. The experimental group was pre-exposed to basic mathematical concepts, followed by exposure to quantitative chemical reactions while control group was exposed to the same chemical concepts without pre-exposure to mathematical concepts. Both groups were pretested and posttested using a 30-item multiple choice Chemistry Achievement Test drawn from the concepts of mass-volume relationships, electrolysis, oxidation numbers and acid-base reactions, validated by the researcher. Data collected were analysed using means, standard deviation and t-test. Results showed that the experimental group performed significantly better in the posttest than the control group suggesting that pre-exposure of students to basic mathematical concepts facilitates better performance in quantitative aspects of chemical reactions.

Key words: Effect, pre-exposure, mathematical concepts, students' performance, chemical reaction

INTRODUCTION

The potency of mathematics as an anchor that holds the desirable achievement in the physical and biological sciences has been widely acknowledged. For instance, in chemical education, substantial studies have examined the relationship between mathematics and chemistry and found that mathematics forms the basic ingredients to the understanding of chemistry and the establishment of new facts (e.g. Abdullahi, 1982; Johnstone, 1984; Adesoji, 1985; Carter and Brickhouse, 1989; Bello, 1990; Schmidt, 1992; Kogut, 1993; Axalonu, 1995; Adeyeye, 1999; Olayiwola, 2001; Kehinde, 2005; Adesugba, 2006). Indeed, Axalonu (1995) pointed out that in every chemical experiment, starting from its design to the making of measurements and drawing of inferences, the chemists rely heavily on mathematical skills in order to achieve satisfactory results. It is generally believed that the higher the ability in Mathematics, the higher the likelihood of satisfactory performance in chemistry.

In the curriculum of chemistry at the Senior Secondary School level (see Comparative Education Study and Adaptation Centre, 1985), certain concepts such as the mole concept, gas laws, mass-volume relationships, electrolysis, redox reactions, acid-base reactions, rate of chemical reactions and others require adequate knowledge of basic mathematical concepts in order to cope with them, the factor which probably makes chemistry one of the most intellectually demanding subjects.

Ideally, it is expected from a theoretical viewpoint that chemistry students ought to have learned the concepts of ratios and proportions before being exposed to the mole concept or mass-volume relationships. Similarly, the students ought to have learned the concepts of variations (direct, inverse, joint) and change of subjects or formula before being exposed to gas laws or electrolysis and so on. On that premise, it might be possible for the students to apply the knowledge gained in the basic mathematics to solving related chemical problems. However, studies by Kehinde (2005), Adesugba (2006) and the West African Examinations Council (WAEC) Chief Examiner's Report (2006) showed that many secondary school students lack the conceptual and calculative skills for success in chemistry, the factor which has been responsible for the abysmal performance in the senior school certificate examination chemistry in the last decade where less than 50% of the examinees passed with credits and above in the subject.

Though earlier studies in this area (e.g. Johnstone, 1984; Carter and Brickhouse, 1989; Zoller, 1990; Kogut, 1993) have reported that many students find chemistry difficult because of its abstract nature and the mathematical skills required, the bulk of the blame has been placed on the teachers for failing to develop the needed mathematical skills in the students to tackle chemical problems with ease. It is intriguing that many chemistry teachers tactically skip some perceived difficult concepts in chemistry, especially the quantitative aspects of chemical reactions due to their inability to effectively teach them, the factor which has scared many students away from chemistry (Olayiwola, 2001; Ezekannagha, 2008). This situation seems to be unhealthy for the growth of science and technology in Nigeria since persistent failure of students may deny the nation of a crop of future chemists.

Nevertheless, the task involved in this study is to incorporate mathematical concepts into the teaching of quantitative aspects of chemical reactions and hence determine whether such an exercise would have any effect on students' performance in the chemical concepts.

Purpose of the Study

The purpose of the study was to determine the effect of pre-exposure of students to basic mathematical concepts on their performance in quantitative aspects of chemical reactions.

Research Questions

The following research questions were raised to guide the study:

1. What are the performances of the experimental and control groups in the pretest?
2. What are the performances of the experimental and control groups in the posttest?
3. Is there any difference between the performance of the experimental and control groups in the pretest?
4. Is there any difference between the performance of the experimental and control groups in the posttest?

Research Hypotheses

The following hypotheses were tested at 0.05 level of significance:

HO_1: There is no significant difference between the performance of the experimental and control groups in the pretest.

HO_2: There is no significant difference between the performance of the experimental and control groups in the posttest.

METHODOLOGY

Research Design

The study was a two-group pretest-posttest comparative experimental design as schematically explained below:

O_1 X_1 O_2 (Experimental group)

O_3 X_2 O_4 (Control group)

where O_1 and O_3 were pretest for the experimental and control groups respectively while O_2 and O_4 were posttest for the experimental and control groups respectively

X_1 = treatment on experimental group, pre-exposed to basic mathematical concepts before exposure to quantitative aspects of chemical reactions.

X_2 = treatment on the control group exposed to quantitative aspects of chemical reactions without pre-exposure to basic mathematical concepts.

Sample and Sampling Techniques

90 SS2 chemistry students randomly selected from two schools in two local government areas of Ekiti State were stratified into experimental (N=45) and control (N=45) groups. The selection of the two local government areas out of 16 in Ekiti State was randomly done while the selection of schools was purposively done based on the numerical strength of students offering chemistry.

Research Instrument

The instrument for collecting data was a 30-item multiple choice Chemistry Achievement Test (CAT) drawn from the concepts of mass-volume relationships, electrolysis, oxidation numbers and acid-base reactions, using a table of specification, based on three levels of cognition namely, knowledge, understanding and application.

Sample items include:

1. The oxidation number of chromium (Cr) in $Cr_2O_7^{2-}$ is

   (a) +7 (b) +6 (c) -7 (d) -6 (e) -2

2. In which of the following is the oxidation state of sulphur equals +2?

   (a) SO_2 (b) SO_3 (c) H_2SO_4 (d) $Na_2S_2O_3$ (e) Na_2SO_4

3. 0.10 mole of electrons is equivalent to _________

   (a) 950C (b) 1920C (c) 9650C (d) 96500C (e) 196200C

4. Determine the time required to complete the passage of 0.02 Faradays if a current of 2 amps were passed through a solution

   (a) 965S (b) 1930S (c) 2895S (d) 9650S (e) 96500C

5. What volume of 0.50 mol dm^{-3} H_2SO_4 will exactly neutralise $25cm^3$ of 0.10 mol dm^{-3} NaOH?

   (a) $50cm^3$ (b) $25cm^3$ (c) $12.5cm^3$ (d) $5.0cm^3$ (e) $2.50cm^3$

6. 0.30g impure copper turning reacted with 0.01 mol dm^{-3} Trioxonitrate (V) acid according to the equation.

   $3Cu_{(s)} + 8HNO_{3(aq)} \rightarrow 3Cu(NO_3)_{2(aq)} + 4H_2O_{(L)} + 2NO_{(q)}$,

   [Cu=64, O=16, N=14, H=1]

What is the percentage of pure copper in the sample?

(a) 20% (b) 40% (c) 60% (d) 80% (e) 90%

The duration of the test was 45 minutes.

Validity and Reliability of Instrument

Copies of the instrument were given to experienced chemistry teachers and experts in Tests and Measurement at the University of Ado-Ekiti, Nigeria to ascertain its face, construct and content validity criteria. The difficulty indices of the items ranged from 0.4 to 0.9 using upper and lower 27% (tetrachoric-α) while the discriminating indices of items ranged from 0.2 to 0.7. The internal consistency of the instrument was estimated at 0.67 using Kuder-Richardson-21.

Experimental Procedures and Data Collection

Pretest was administered on the students two weeks before the experimental procedure to determine their entry behaviour. This was followed by the experimental treatment in which both the experimental and control groups were taught the concepts of mass-volume relationship, electrolysis, oxidation numbers and acid-base reactions for four weeks. However, the experimental group was first pre-exposed to basic mathematical concepts before exposing them to quantitative aspects of chemical reaction while the control group was not pre-exposed to basic mathematical concepts. For example, before teaching oxidation numbers, the experimental group was pre-exposed to the fundamental rules of operations (addition, subtraction, multiplication and division) and then linear equations. Similarly, before teaching electrolysis, the concepts of variations (direct, inverse, joint) and change of formula were taught and so on. After the experimental treatment, the items in the pretest were rearranged and re-administered to both the experimental and control groups and their responses marked, scored and collected for data analysis.

Data Analysis

Data were analysed using means, standard deviations and t-test, tested at 0.05 level of significance.

RESULTS

Question 1: What are the performances of the experimental and control groups in the pretest?

Data were analysed using means and percentages as presented in table 1.

Table 1*:* Means and standard deviations experimental and control groups in pretest

Variables	***N***	***Mean***	***SD***
Experimental	45	7.41	4.7
Control	45	8.13	4.2
Total	**90**		

Maximum score = 30

Table 1 shows that the mean scores of the experimental and control groups in the pretest were 7.41 and 8.13 respectively, while their corresponding standard deviations were 4.7 and 4.2 respectively. This implies that the scores of the experimental group in the pretest ranged from 2.71 (3) to 12.11 (12) while those of the control group ranged from 3.93 (4) to 12.33 (12). By comparison, the two groups were homogenous.

Question 2: What are the performances of the experimental and control groups in the posttest?

Data were analysed using means and percentages as presented in table 2.

Table 2: Means and standard deviations experimental

and control groups in pretest

Variables	***N***	***Mean***	***SD***
Experimental	45	17.3	3.8
Control	45	14.7	4.5
Total	**90**		

Maximum score = 30

Table 2 shows that the mean scores of the experimental and control groups in the post-test were 17.3 and 14.7 respectively while their corresponding standard deviations were 3.8 and 4.5 respectively. This implies that the scores of the experimental group ranged from 13.5 (14) to 21.1 (21) while those of the control group ranged from 10.2 (10) to 19.2 (19). By comparison, the experimental group performed better than the control group in the posttest.

Testing of Hypotheses

HO_1: There is no significant difference between the experimental and control group in the pretest.

Data were analysed using t-test as presented in the table 3.

Table 3: t-test comparison between performance of experimental

and control group in pretest

Variables	***N***	***Mean***	***SD***	***df***	t_{cal}	t_{tab}
Experimental	45	7.41	4.7	88	0.767	2.00
Control	45	8.13	4.2			

P>0.05 (not significant)

Table 3 shows that the t-test calculated was 0.767 while its corresponding table value at 0.05 level of significance was 2.00. Since $t_{calculated} < t_{table}$, it implies that there was no significant difference between the performance of the experimental and control groups in the pretest.

HO_2: There is no significant difference between the experimental and control group in the posttest.

Data were analysed using t-test as presented in the table 4.

Table 4: t-test comparison between performance of experimental and control group in posttest

Variables	*N*	*Mean*	*SD*	*df*	t_{cal}	t_{tab}
Experimental	45	17.3	3.8			
Control	45	14.7	4.5	88	2.96	2.00

$P<0.05$ (significant result)

Table 4 shows that the t-test calculated was 2.96 while its corresponding table value at 0.05 level of significance was 2.00. Since $t_{calculated}>t_{table}$, it implies that there was significant difference existed between the performance of the experimental and control groups in the posttest. The mean of the experimental group, 17.3>the mean score of the control group 14.7. This implies that the experimental group performed better than the control group in the posttest.

DISCUSSION

This study examined the question of whether pre-exposure of students to basic mathematical concepts would have effect on their performance in quantitative aspects of chemical reactions. Answering this question requires a preliminary examination of the students' entry behaviour and their subsequent performance in the posttest.

An examination of table 1 shows that the entry behaviour of the students in quantitative aspect of chemical reactions was poor as neither the experimental group nor the control group had the mean score nearer the average score of 15. Moreover, the spread of scores of the experimental group ranged from 3 to 12 while those of the control group ranged from 4 to 12. Furthermore, the result in table 3 shows no significant difference between the performance of the experimental and control groups in the pretest indicating an homogeneity of weak background in quantitative aspects of chemical reactions. These results tend to support the findings of Kehinde (2005), Adesugba (2006) and WAEC (2006) that many secondary school students lack calculative skills for success in chemistry.

However, an examination of table 2 shows appreciable increase in the mean scores of both the experimental and the control groups in the posttest. The appreciable increase in the performance of the control group in the posttest could be inferred from the fact that they were also exposed to quantitative aspects of chemical reactions. In reality, it is impossible to detach mathematical concepts from the quantitative chemical reactions if properly taught by the teachers. The significant difference found between the performance of the experimental and control groups ($t_{cal}=2.96$, $t_{tab}=2.00$) in the posttest with the experimental group (mean=17.3) performing better than the control group (mean=14.7) is an indication that pre-exposure of the experimental group to basic mathematical concepts had favourable effect on their performance in quantitative aspects of chemical reactions and not by chance. These results support the earlier findings by Kogut (1993), Adeyeye (1999) and Adesugba (2006) that mathematics and chemistry go together and that the higher the ability in mathematics, the higher the performance in chemistry.

CONCLUSION

Based on the data analysed in this study, it could be concluded that pre-exposure of students to basic mathematical concepts had significant favourable effect on their performance in quantitative aspects of chemical reactions.

RECOMMENDATIONS

Based on the findings, the following recommendations were made:

1. Chemistry teachers should statutorily incorporate mathematical concepts into the teaching of quantitative aspects of chemical reactions to enable students form a strong linkage between mathematics and chemistry for better performance in chemistry.
2. Chemistry teachers should collaborate with their mathematics counterparts to teach applications of mathematical concepts to related chemical concepts for better understanding and higher confidence of students in problem-solving in chemistry.
3. Chemistry students should be encouraged to practice mathematical problems in chemistry to enable them handle numbers with ease.

REFERENCES

Abdullahi, A. (1982). Science teaching in Nigeria. Ilorin: Atoto Press Ltd. 27.

Adesoji, F. A. (1985). Effective use of self-learning device and programmed text in teaching mathematical model in chemistry. Unpublished M.Ed. Dissertation, University of Ife (*now* Obafemi Awolowo University, Ile-Ife).

Adesugba, F. (2006). Effect of mathematical background on students' achievement in chemistry. Unpublished B.Sc.(Ed.) project, University of Ado-Ekiti, Nigeria.

Adeyeye, E. I. (1999). Cognitive relationship between the academic performances of SSCE students in mathematics and chemistry in Ekiti State. *Journal of Educational Research and Evaluation*. 3(2):69—76.

Axalonu, H. O. (1995). Assessing the process skills in Titrimetric analysis in chemisty. A paper presented at the 36th annual conference of the Science Teachers Association of Nigeria (STAN), Maiduguri. August.

Bello,O. O. (1990). A preliminary study of chemistry students' errors in Stoichiometric problem. *Journal of Science Teachers Association of Nigeria*. 26(2): 67—73.

Carter, C. S. and Brichkouse, N.W. (1989). What makes chemistry difficult. *Journal of Chemical Education.* 66:223—225.

Comparative Education Study and Adaptation Centre (1985). Curriculum of senior secondary school chemistry. Lagos.

Ezekannagha, G. N. (2008). Chemistry teachers' competence on the use of concept mapping: a tool for teaching different concepts in chemistry. Proceedings of the 49th annual conference of Science Teachers Association of Nigeria (STAN). 23—26.

Johnstone, A. H. (1984). New stars for the teacher to steer by. *Journal of Chemical Education*. 61:847—849.

Kehinde, V. O. (2005). The effect of problem-solving instructional strategies on students' learning outcomes in the mole concept. Unpublished M.Ed. thesis, University of Ado-Ekiti, Nigeria.

Kogut, L.S. (1993). A general course for science and engineering majors with marginal academic preparation. *Journal of Chemical Education*. 70(7): 565—567.

Olayiwola, M. A. (2001). Teaching the problem of difficult concepts in chemistry: a diagnosis of facts. A paper presented at the Science Teacher Association of Nigeria (STAN) National Chemistry Workshop, Lokoja. 23rd—28th April.

Schmidt, H. (1992). Stoichiometric problem-solving in the high school chemistry. A paper presented at the annual meeting of the National Association for Research in Science Teaching; 65th. Botswana.

West African Examinations Council, Chief Examiner's Report (2006). Senior school certificate examinations in Nigeria. Lagos office, Nigeria.

Zoller, V. (1990). Student's misunderstanding and misconceptions in college freshmen chemistry (general and organic). *Journal of Research in Science Teaching*. 27:1053—1065.