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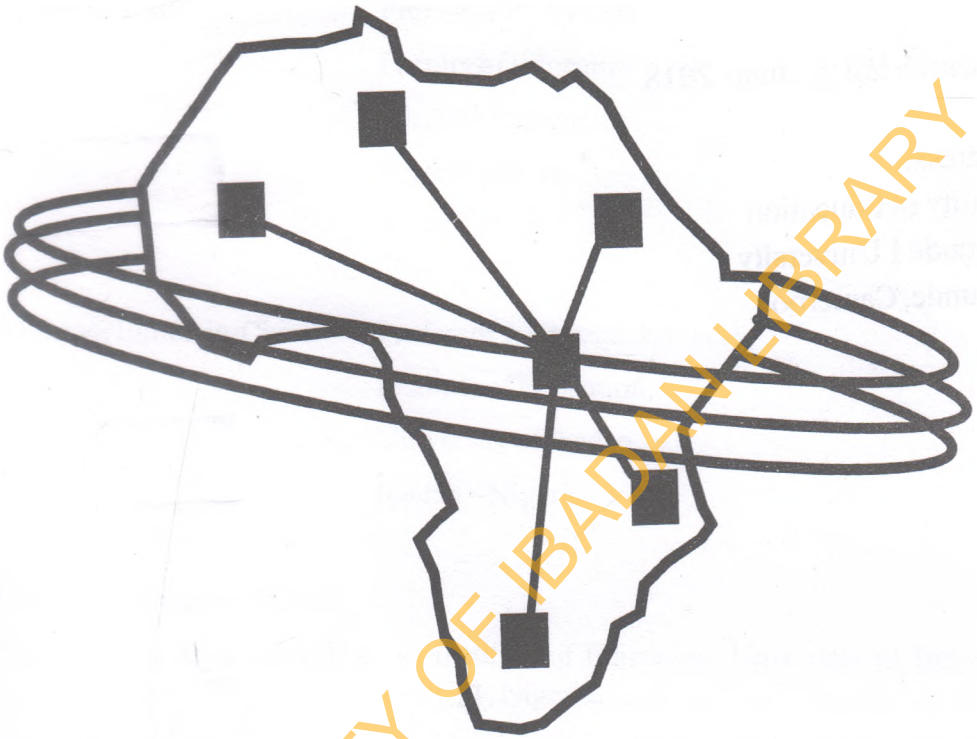

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TABLE OF CONTENTS

COGNITIVE ENTRY CHARACTERISTICS IN MATHEMATICS AND TEACHING EFFECTIVENESS AS CORRELATES OF STUDENTS' ACHIEVEMENT IN QUANTITATIVE CHEMISTRY IN RIVERS STATE, NIGERIA

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Georgina N. Obaitan

and

Joshua Oluwatoyin Adeleke

Abstract

Past studies have attributed poor performance of students to teachers' and students' characteristics. However, no study seems to have related these characteristics to students' achievement in quantitative chemistry. This study therefore investigated the extent to which cognitive entry characteristics in mathematics and teaching effectiveness correlated with students' achievement in quantitative chemistry. The study adopted descriptive research design. Simple random sampling was used to select 3 local government areas (LGA) in Rivers State, 10 schools from each LGA and a science class consisting of all chemistry students from each school. A total of 1652 students participated in the study. Instruments for data collection included: CEC in Mathematics Test, Students' Rating of TE and Quantitative Chemistry Achievement Test. Data was analysed using multiple regression. There was a positive and significant composite contribution of CEC in mathematics and TE to students' achievement in quantitative chemistry ($R = .27$, $R^2 = .074$, $F_{(2, 1649)} = 66.310$, $p < 0.5$). The CEC in mathematics contributed more ($\beta = .262$, $t = 11.065$, $p < .05$) than TE ($\beta = .066$, $t = 2.784$, $p < .05$). The study recommends that Chemistry students should be encouraged to improve on their CEC in mathematics needed to learn quantitative chemistry topics by revising their previous lessons. Chemistry teachers should be encouraged to attend seminars, conferences and workshops to improve on their teaching effectiveness.

KeyWords: Quantitative Chemistry, Chemistry teachers, Chemistry students, achievement and calculations.

Introduction

Chemistry, which is one of the main science subjects, is at the center of the development of nations because its knowledge is crucial to national development. Eke (2008) expresses that any nation aspiring to be scientifically and technologically developed must have an adequate level of chemistry education. Perhaps, this is why a credit pass in chemistry at the Senior Secondary School Certificate Examination (SSSCE) is compulsory for candidates that are aspiring to study most science courses such as chemistry, chemistry education, pharmacy, biochemistry, medicine, agricultural science, zoology, engineering among others. Unfortunately, an analysis of the results of the candidates who sat for the Senior Secondary School Certificate Examination in chemistry from 2002 to 2016 reveals that about 51% of the candidates were not able to obtain a credit pass. This implies that about 51% of these candidates were automatically disqualified from studying most science courses, which is bad for the scientific and technological development of Nigeria.

The West African Examination Council Chief Examiners' Reports (2004-2009) identified poor mathematical skills as one of the main reasons for the poor performance of students in chemistry. This agrees with the findings of Ahiakwo (2015), which reveals that senior secondary students' performance in quantitative chemistry (calculations in chemistry) was poor. Poor performance of students in quantitative chemistry is therefore likely to hinder students from obtaining good grades in chemistry. The question that arises therefore, is, what could be responsible for students' poor performance in quantitative chemistry? The study of Jegede (2007) reveals that about 96% of students fear chemistry because they feel it demands too much calculation. This implies that the mindset students bring into the chemistry learning environment could be crucial to their achievement. This agrees with the findings of Nakayama, Yamamoto and Santiago (2006). They conducted a study on the impact of learner attitude to learning and found that their disposition affected their achievement. It therefore appears that students' cognitive entry characteristics (CEC), which is one of the orientations students bring into the chemistry learning environment, is likely to influence their achievement in quantitative chemistry.

Bloom (1976) defines cognitive entry characteristics as the specific knowledge, abilities or skills which are essential prerequisites for the assimilation of a learning task. In this study, cognitive entry characteristics in mathematics refer to the prerequisite knowledge in mathematics needed to learn quantitative chemistry. Perhaps, if chemistry students come into the chemistry learning environment with the prerequisite knowledge in mathematics needed to learn quantitative chemistry, they may achieve high grades in quantitative chemistry. This is likely because mathematical skills are part of the cognitive entry characteristics needed for students to learn quantitative chemistry since it involves calculations based on mathematics. Bloom (1976) argues that cognitive entry

characteristics have strong influence on students' achievement and that if all the students in a class have adequate levels of cognitive entry characteristics, virtually all of them can attain a high degree of learning. The CEC in mathematics that students bring into the chemistry learning environment therefore seems to be crucial to students' achievement in quantitative chemistry.

Teaching effectiveness is another factor that is likely to influence students' achievement in quantitative chemistry. This is because teachers are form an indispensable part of the teaching and learning process since they are the ones that make sure that the students are effectively taught in order to achieve the aims and goals of the curriculum. In this study, teaching effectiveness is a set of classroom instructional behaviours adopted by chemistry teachers that will enable students attain a high degree of learning quantitative chemistry. Teaching effectiveness was measured in this study by the students' rating of their chemistry teacher in teaching quantitative chemistry.

It is expected that a teacher that teaches effectively should have the ability to make students to be interested in the subject and motivate them to learn. Such a teacher is expected to concentrate on the goals he or she or the curriculum has set and do whatever is possible to achieve these goals. For teachers to be able to achieve these goals, they must possess the necessary knowledge and skills required to teach the subject and properly use the knowledge and skills to effect learning in the students. Medley (1977) states that the possession of the required knowledge and skills by the teacher is referred to as 'teacher competence' while the ability of the teacher to properly use the knowledge and skills is referred to as 'teacher performance'. A teacher who possesses these qualities is likely to provide the students with good opportunity to learn which will likely help them attain a high degree of learning. This agrees with Bloom's theory of school learning that if students are provided with appropriate conditions for learning, they will attain a high degree of learning. It therefore appears that an excellent performance in quantitative chemistry could possibly be achieved through effective teaching by chemistry teachers.

Studies conducted on cognitive entry characteristics and teaching effectiveness appear not to have related them to achievement in quantitative chemistry. This study therefore investigated the extent to which cognitive entry characteristics in mathematics and teaching effectiveness correlated with students' achievement in quantitative chemistry.

Research Questions

The research questions for the study are listed below:

1. What is the composite contribution of students' cognitive entry characteristics in mathematics and teaching effectiveness to students' achievement in quantitative chemistry?

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Research Questions

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1. What is the composite contribution of students' cognitive entry characteristics in mathematics and teaching effectiveness to students' achievement in quantitative chemistry?

2. What are the relative contributions of students' cognitive entry characteristics in mathematics and teaching effectiveness to students' achievement in quantitative chemistry?

Methodology

*The study a*dopted a descriptive research design. Simple random sampling was used to select three Local Government Areas (LGAs) in Rivers State. Simple random sampling was again used to select 10 schools from each LGA making a total of 30 schools. A Senior Secondary 2 science class was randomly selected from each school and a total of 1,652 chemistry students participated in the study.

Instrumentation

Three instruments were used to collect data for this study:

1. Cognitive Entry Characteristics in Mathematics Test (CECMT)
2. Students' Rating of Teaching Effectiveness in Quantitative Chemistry (SRTEQC)
3. Quantitative Chemistry Achievement Test (QCAT)

The Cognitive Entry Characteristics in Mathematics Test (CECMT) was constructed by the researchers based on the experiences of the researchers as chemistry and mathematics teachers. It is made up of two sections: sections A and B. Section A contains the demographic information of the students while section B contains the Cognitive Entry Characteristics in Mathematics Test which is made up of 15 items. Quantitative chemistry questions based on the Senior Secondary 2 curriculum [calculations in *Mass, mole, volume relationship, Acid-Base reactions, Redox reactions (oxidation numbers) and Electrolysis (Faraday's laws*)] were constructed, and administered to SS 2 chemistry students. From their responses and the experiences of the researchers, the cognitive entry characteristics in mathematics needed to solve each question were identified and listed. This list was used to develop a table of specification that was used as a guide to develop the items that formed the cognitive entry characteristics test in mathematics. The instrument was given to experts in mathematics education and chemistry education for their comments after which it was trial tested and validated using a sample of 130 Senior Secondary 2 Chemistry Students from co-educational public schools that were not part of the population that participated in the study. Kuder Richardson formula 20 (KR-20) was used to establish the construct validity and internal consistency of the instrument, which was found to be 0.8.

The Students' Rating of Teaching Effectiveness in Quantitative Chemistry instrument was developed by the researcher. It is made up of two sections: sections A and B. Section A contains the demographic data of the students while section B contains the Students' Rating of Teaching Effectiveness in Teaching Quantitative Chemistry. The instrument is

made up of 25 items and was given to the Chemistry students to rate the teaching effectiveness of their chemistry teachers in teaching quantitative chemistry. Open ended questions were administered to some senior secondary school chemistry students. Arrays of their responses were collated, from which items that formed the content of the structured rating scale emanated. The Likert response format was used. The instrument was trial tested and validated using a sample of 130 Senior Secondary 2 chemistry Students from co-educational public schools that were not part of the sample that participated in the study. Cronbach Alpha Coefficient was used to establish the construct validity and internal consistency of the instrument, which was found to be 0.90.

The Quantitative Chemistry Achievement Test was developed by the researcher based on the Senior Secondary 2 chemistry curriculum. It is made up of two sections: sections A and B. Section A contains the demographic information about the students while section B contains 25 Quantitative Chemistry Achievement Test items with four options answer format. A table of specification was developed by the researcher based on the quantitative chemistry topics in the Senior Secondary 2 curriculum [calculations in *Mass, mole, volume relationship, Acid-Base reactions, Redox reactions (oxidation numbers) and Electrolysis (Faraday's laws)*]. The table of specification was used as a guide to develop the items. The instrument was given to experts in chemistry education for their comments after which it was trial tested and validated using a sample of 130 Senior Secondary 2 chemistry students from co-educational public schools that were not part of the sample that participated in the study. Kuder Richardson formula 20 (KR-20) was used to establish the construct validity and internal consistency of the instrument and it was found to be 0.76.

The questionnaires and the different tests were administered to the chemistry students in the selected science classes.

Data Analysis

Multiple regression analysis was used to analyse the data.

Findings And Discussion

Research Question 1.

What is the composite contribution of students' cognitive entry characteristics in mathematics and teaching effectiveness to students' achievement in quantitative chemistry?

Table 1: Regression Analysis on the Composite Contr ibution of Teaching Effectiveness and Cognitive Entry Characteristics in Mathematics to Students' achievement in Quantitative Chemistry (Model Summary)

R = .27
R^2 = .074
Adj. R^2 = .073
Std. Error = 2.417

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	774.888	2	387.444	66.310	.000
	Residual	9634.944	1649	5.843		
	Total	10409.832	1651			

Table 1 presents the Regression analysis of the composite contribution of the independent variables (Cognitive Entry Characteristics in Mathematics and Teaching Effectiveness) to the dependent variable (students' achievement in Quantitative Chemistry). It was revealed that the multiple correlation coefficient (R) indicating the linear relationship between the independent variables (Cognitive Entry Characteristics in Mathematics and Teaching Effectiveness) and the dependent variable (students' achievement in Quantitative Chemistry) was 0.27, which is positive. The Adjusted R square was 0.073, meaning that the independent variables accounted for 7.3 percent of the variance in students' achievement in Quantitative Chemistry. Further verification of the significant composite contribution of the independent variables to students' achievement in Quantitative Chemistry using regression ANOVA produced $F_{(2,1649)} = 66.31$; $p < 0.05$. Since p value is less than 0.05, it can be concluded that there was a significant composite contribution of Cognitive Entry Characteristics in Mathematics and Teaching Effectiveness to students' achievement in Quantitative Chemistry .

Research Question 2.
What are the relative contributions of students' Cognitive Entry Characteristics in Mathematics and Teaching Effectiveness to students' achievement in Quantitative Chemistry?

Table 2: Relative Contributions of Cognitive Entry Characteristics in Mathematics and Teaching Effectiveness to Students' Achievement in Quantitative Chemistry

Model	Unstandardized Coefficients		Standardized Coefficients	T
	B	Std. Error	Beta	
(Constant)	3.799	.274		13.858
COGNITIVE ENTRY CHARACTERISTICS IN MATHEMATICS	.206	.019	.262	11.065
TEACHING EFFECTIVENESS	.008	.003	.066	2.784

Table 4.2 shows the beta weights indicating the relative contributions of the independent variables to students' achievement in Quantitative Chemistry. The two independent variables (students' Cognitive Entry Characteristics in Mathematics and Teaching Effectiveness) were found to have significant relative contributions to students' achievement in Quantitative Chemistry. However, the more potent contributor was cognitive entry characteristics in Mathematics ($\beta = 0.262$, $P < 0.05$); followed by teaching effectiveness in Quantitative Chemistry ($\beta = 0.066$, $P < 0.05$)

Discussion of Findings

The findings revealed that there was a significant composite contribution of cognitive entry characteristics in mathematics and teaching effectiveness to students' achievement in quantitative chemistry. This shows that cognitive entry characteristics in mathematics are fundamental to students' achievement in quantitative chemistry. This is because mathematical skills are imperative for students to attain a high degree of learning quantitative chemistry since it involves a lot of calculations based on the students' knowledge of mathematics. This finding corroborates that of Bloom (1976) who found that cognitive entry characteristics have strong influence on students' achievement. The finding confirms that the cognitive entry characteristics students bring into the chemistry learning environment is very crucial to their achievement in quantitative chemistry. The finding also agrees with the findings of some previous studies that cognitive entry characteristics have influence on students' achievement (Adeleke, 2008; Ajogbeje; Borisade, 2013 and Caliskan, 2014).

The findings also revealed that teaching effectiveness of chemistry teachers is essential to students' achievement in quantitative chemistry. This is because teachers form an indispensable part of the teaching and learning process since they are the ones that ensure that the students are effectively taught to enable them to achieve the aims and goals of the curriculum. An effective teacher can make students become interested in the subject and also motivate them to learn. The result of this study corroborates Ezeasor's (2003) findings which revealed that the mean score of the students taught with effective teaching was statistically and significantly better than students taught with ineffective teaching. The finding also agrees with the study of Kane, Rockoff and Staiger (2007) which showed that the differences in the teaching effectiveness between teachers increased students' achievement over a period of one year. This means that high achievement in quantitative chemistry can be achieved through effective teaching of chemistry teachers. However, the finding is contrary to that of the study of Akiri and Ugborugbo (2009) that found no statistically significant influence of teachers' classroom effectiveness on students' achievement.

The findings also revealed that cognitive entry characteristics in mathematics contributed more to students' achievement in quantitative chemistry. This finding buttresses the fact that cognitive entry characteristics are indeed fundamental to students' achievement in quantitative chemistry. The result supports the statement of Bloom (1976) that if all the students in a class have adequate levels of cognitive entry characteristics, virtually all of them can attain a high degree of learning. The finding also collaborates that of Adeleke (2008) which showed that cognitive entry characteristics needed for the learning of bearing in mathematics had a significant effect on students' achievement in bearing inthe subject.

Conclusion and Recommendations

Cognitive entry characteristics in mathematics and teaching effectiveness were found to be fundamental to students' achievement in quantitative chemistry. The issue of cognitive entry characteristics in mathematics and teaching effectiveness is central in achieving objectives of teaching quantitative chemistry. Hence, it is imperative to ensure that chemistry students and teachers alike acquire the necessary skills that will support learning. This is very essential for students to be able to attain a high degree of learning in quantitative chemistry.

Based on the above findings, the following recommendations were made that will ensure that chemistry students attain a high degree of learning in quantitative chemistry.

1. Chemistry teachers should ensure that their students have the necessary cognitive entry characteristics in mathematics before teaching any quantitative chemistry topic. They can also find out those lacking cognitive entry characteristics in mathematics through formative tests during the course of teaching and teach them as the teaching progresses.

2. Chemistry students should be encouraged to improve their mathematical abilities by revising topics they have been taught in mathematics that will enhance the cognitive entry characteristics in mathematics needed to learn topics in quantitative chemistry.

3. Chemistry teachers should be encouraged to enroll in in-service education programmes, attend seminars, conferences and workshops to improve their teaching effectiveness.

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