

IDENTIFICATION OF THE MATHEMATICS CONCEPTS THAT ARE RELEVANT IN THE STUDY OF CHEMISTRY AT THE SECONDARY SCHOOL LEVEL IN NIGERIA

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ABSTRACT: *This study focused on identification of mathematics concepts that are relevant in chemistry education at the secondary school level. The study is a descriptive research design and the area of the study was Abakaliki education zone of Ebonyi State, Nigeria. The sample comprised of 73 teachers (38 mathematics teachers and 35 chemistry teachers). Questionnaire was the instrument used for data collection. The questionnaire was made up of two sections for mathematics and chemistry teachers. Data collected were analyzed using mean and standard deviation. Based on the findings from the data analysis, recommendations were made and it includes; the chemistry teachers should be exposed to programmes that would enable them to acquire more knowledge on mathematical aspects of chemistry. Training programmes should be organized which will bring the chemistry and mathematics teachers together to share their views on certain concepts in mathematics among others.*

KEYWORDS: Identification, Mathematics, Concepts, Relevant, Chemistry.

INTRODUCTION

Science Teachers Association of Nigeria (STAN, 2011) defined chemistry as a branch of science that studies the properties of matter in terms of compositions, structures, transformations, interactions and energy implications of chemical changes. Chambers 21st Century Dictionary (2004) defined chemistry as the scientific study of the composition, properties and reactions of chemical elements and their compounds. Ababio (1998) sees chemistry as a branch of pure science, which deals with the composition, properties and uses of matter. Omiko (2014) observed that chemistry studies the principles controlling the reactions and the changes which matter undergoes.

Ezekannagha and Ifeakor (2002) observed that the study of chemistry also includes man's attempt to transform the Natural world in order to benefit from nature's complexities and hidden resources. Ezechukwu (2005) defined chemistry as a branch of science which deals with the study of Nature, composition and properties of matter and the changes matter will undergo under different conditions. Okeke and Ezekannagha (2002) observed that chemistry is the queen of the sciences: That is the subject that goes down to investigate the basic properties of substances in the physical universe. Omiko (2013) observed that all other branches of science borrow some knowledge or concepts from chemistry to interpret their principles or working mechanism.

From the definitions of chemistry as illustrated above, one can say that chemistry is interested in the study of composition of substances. What is a particular substance made up? How are they arranged in the substance? What holds the particles of the substance together? Chemistry is also interested in the changes that substances undergo either on their own or when they interact with one another. Chemistry also studies the energy contents of substances as well as

the changes in the energy contents of substances as well as the changes in the energies of substances undergoing transformations to other things, or in the course of their interactions with other substances.

Heys (1978) in Ezekannagha and Ifeakor (2002) listed three reasons why we should study chemistry, such reasons are:

- (a) To discover as much as we can about the behaviour of different kinds of matter.
- (b) To find out the reasons for this behaviour and so obtain a deeper understanding of its nature.
- (c) To put this knowledge gained into practical use that would lead to the development of man and his environment.

To acquire chemistry/chemical knowledge, one needs to understand the mathematical concepts that are relevant in the study of chemistry. Proper understanding of the mathematics concepts relevant in the study of chemistry will enable us to acquire the necessary skills required in the application of chemistry knowledge in solving human problems or as may be required in the production, of fertilizers for Agriculture, production of drugs for treatment of sicknesses in human beings, among others.

MATHEMATICS: Mathematics according to Hornby (2000), the Oxford Advanced Learner's Dictionary of Current English can be defined as science of numbers, quantity and space. Aghadiuno (2000) sees mathematics as the study of quantities and relations through the use of numbers and symbols. Mathematics is described as the language of science Uduma (2012). Thus, it is the foundation upon which the study of other sciences is based. Therefore, for excellence to be made in the study of other sciences, mathematics education should be given serious attention. The National Council of Teachers of Mathematics (NCTM, 1995) classified mathematics into Arithmetic, Algebra and geometry.

Onu (2003) maintained that mathematics is an indispensable tool in chemistry. Ejike (1999) asserted that sound and thorough understanding or knowledge of mathematical principles pre-determine future success in disciplines like Chemistry, Physics and other Sciences and Technology related courses. He further observed that studies in mathematics and in all disciplines in which mathematics is used as a tool requires thorough knowledge of basic arithmetic operations, manipulation of algebraic symbols and understanding what that manipulation means. However any student who is unable to perform arithmetic calculations and algebraic operations with reasonable speed and accuracy, and unable to understand which operations to use in solving a given problem and to interpret the result is handicapped.

Anderson (1999) observed that mathematical aspects of chemistry provide various experiences to be learned under the condition, which allows for reflection and discussion of the meaning and implication of what is learnt. Omiko (2015) stated that it is not just enough for chemical symbols and equations to be used in the study of the sciences. Skills are also required on the part of the teacher in selecting the appropriate method, technique and teaching aid to fit the students' interest and understanding of the subject.

Mathematics according to Ernest (1991) is a symbolic language in which problem situations and the solutions found are expressed. The systems of mathematical symbols have a communicative function and an instrumental role. From the social or economic perspective, mathematics is a key element and an activity in day to day life which every human being practices in one form or the other.

Mathematical Concepts Relevant in the Study of Chemistry

The table below contains some of the mathematical concepts that are relevant in the study of chemistry at the secondary school level.

Table 1: Contains some of the Mathematical Concepts that are Relevant in the Study of Chemistry at the Secondary School Level

S/N	Mathematics Concepts (Topics)	Area of Chemistry Concepts where it is used in teaching.
1.	Arithmetic operations such as, Addition, Subtraction, Multiplication, division etc.	Relative molecular mass, molar mass, percentage composition, empirical formula, Temperature Conversion
2.	Algebraic process: Variation (a) Direction variation (b) Inverse Variation (c) Joint variation	Gas Laws Charles Law, Ideal Gas equation Boyle's Law, graham's law of diffusion The general gas equation.
3.	Logarithm	PH-value of a solution (acidity and alkalinity of solution, chemical kinetics.
4.	Equation involving fractions (Mathematical expressions)	Volumetric analysis, solubility, chemical equilibrium, vapour density, rate of chemical reactions, mass volume calculations, mole concept, Avogadro's law (Number).
5.	Simple equations	Oxidation number or state, Daltion's Law of partial pressure,
6.	Ratio	Gay-Lussac's Law, etc.

Source: Uduma (2012)

- (a) **Arithmetic:** This deals with numbers. When we add, subtract, multiply or divide some numbers or volumes, or masses of substances in chemistry we are carrying out arithmetic operations. The mathematics aspect of chemistry involving Arithmetic operations are, the calculations involving the relative molecular masses of compounds, molar masses of elements, percentage composition, empirical formula and temperature conversion, Ababio (2000).
- (b) **Variation:** This deals with the relationship between two or more quantities in which there is a change in the other. A quantity in the relationship, which never changes in value is called a constant variation.

Proper understanding of the above mathematics topics listed on table 1 will help the students in solving problems in chemistry. If the students lack the knowledge of those mathematics concepts, they will find it difficult in solving related chemistry problems. Onu (2003) and Hudson (1995) linked students' difficulty in understanding mole concept in chemistry to their inability to cope with mathematical concepts such as ratio and theoretical concepts such as atom and molecules. Many students avoid mathematics classes because of fear. The usefulness of mathematics in the field of human cannot be over emphasized. In chemistry education, besides being used to unearth the hidden treasures of chemical behaviour, it is employed to classify scientific thinking and communication of experimental results in chemistry.

Effective mathematics education is a very important factor in the growth, advancement and well being of the individual and the society in general. For individual members of any society to cope effectively with the demand and challenges of everyday life, respond competently to the difficulties involved in the pursuit of personal and group goals, and function confidently in ones environment, there is the need for the acquisition of meaningful and usable scientific knowledge, (Eze, 2003). Mogbo (2001) observed that the acquisition of relevant mathematics' knowledge is the gateway and key to the sciences, especially engineering and physical sciences.

However, it has been observed that there is unprecedented constant decrease in science, and science related courses enrolment in tertiary institutions, Omiko (2015). Abdurahman, (1997) contended that out of the 443, 695 candidates that enrolled for West African school Certificate (WASC/SSCE, from 1992-1998, only 16.54% or 73, 400 enrolled for physics. He maintained that the data for biology and chemistry were not different. Obodo (1993) and Omiko (2015) contended that these issues suggest that science and mathematics education at the secondary level is problematic.

Purpose of the Study

The major purpose of this study was to identify the mathematics concepts that are relevant in the study of chemistry at the secondary school level in Nigeria. Specifically, the study identified:

1. Chemistry topics (concepts) requiring mathematical knowledge.
2. Mathematics concepts relevant to the study of chemistry at the secondary school level/SSCE syllabus.
3. Relevance of mathematics in teaching and learning of chemistry concepts.
4. If the mathematics teachers cover the mathematics concepts within the school academic year.

Generally, the study will identify the areas or topics in mathematics that are applied in the study of chemistry.

Research Questions

The following research questions guided the study:

1. What are the chemistry concepts/topics at the secondary school level which require mathematics knowledge?
2. What are the mathematics concepts/topics that are relevant in the study of chemistry at the secondary school level?
3. How relevant are mathematics concepts in teaching and learning of chemistry at the secondary school level?
4. Do mathematics teachers in any way cover the relevant mathematics concepts in chemistry in their mathematics lessons?

METHODOLOGY

Design of the Study

This is a descriptive survey research design on the identification of the mathematics concepts relevant in the study of chemistry at the secondary school level. A descriptive survey design according to Abonyi (2006) is one of the cheapest and quick ways of obtaining facts and figures from systematically selected segments of a population with the purpose of ascertaining the general characteristics of the population.

Area and Scope of the Study

This study was conducted in Abakaliki Education Zone of Ebonyi State of Nigeria. The scope of the study covered those mathematics concepts that are relevant in teaching and learning of chemistry at the secondary school level. Such topics include: Charles, Law, equations involving fractions, PH-value of a solution, Arithmetic operation, ratio, Gay-lussac's law, simple equations, Dalton's law of partial pressure, Boyle's law, mole concept among others.

Population of the Study

The population of the study comprised all the mathematics and chemistry teachers in the 72 government owned secondary schools from Abakaliki Education Zone. The population comprised 38 mathematics teachers and 35 chemistry teachers, making a total of 73 teachers.

Sample and Sampling Techniques

The researchers used the 73 teachers (38 mathematics teachers and 35 chemistry teachers) as the sample for the study. The reason for using the total population as the sample for this study was because of its small size.

Instrument for Data Collection

The instrument used for data collection was a structured questionnaire based on the mathematics concepts relevant in the study of chemistry at the secondary school level.

The questionnaire comprised 34 items, which were formulated based on the research questions, using four-point likert scale of strongly agree (SA), Agree (A), Disagree (D) and strongly disagree (SD). The four (4) point likert scale was assigned numerical values as illustrated below.

Strongly Agree	(SA)	4 Points
Agree	(A)	3 points
Disagree	(D)	2 points
Strongly Disagree	(SD)	1 point

Validation of the Instrument

Five experts validated the instrument; Two Specialists in Mathematics education, two specialists in chemistry education and one specialist in measurement and Evaluation from

Ebonyi State University, Abakaliki. Their suggestions helped in restructuring the final draft of the instrument and no item was dropped from the 34 items.

Reliability of the Instrument

The 34 item instrument was administered to 25 mathematics teachers and 27 chemistry teachers in trial testing carried out by the researchers in schools in Onueke Education Zone which were not used for the final study. Data from their responses on the instrument were analyzed to determine the reliability of the instrument, using Cronbach Alpha. The result of the data analysis gave reliability co-efficient of 0.79. This high value of the reliability coefficient indicates that the instrument was reliable and will measure what it is suppose to measure.

Method of Data Collection

The questionnaire was administered to the 73 teachers, made up of 38 mathematics teachers and 35 chemistry teachers by the researchers. The researchers distributed the questionnaire instrument to the respondents who's filled the questionnaire and returned to the researchers on the spot. This made it possible for the researchers to obtain 100% return of the completed questionnaire.

Method of Data Analysis

The data collected were analyzed using frequency, mean and standard deviation.

Decision Rule

The mean was calculated using the following formula;

$$\bar{x} = \frac{\sum fx}{N}$$

Where	\bar{x}	=	Mean
	\sum	=	Summation
	X	=	Nominal values of the option
	N	=	Number of respondents
	f	=	frequency

Applying the formula for the four (4) point likert scale, we have,

$$\bar{x} = \frac{\sum fx}{N} = \frac{4 + 3 + 2 + 1}{4} = \frac{10}{4} = 2.5$$

Cut-off mean point is 2.5. However, any response having mean score of 2.5 and above is accepted, while any response with a mean score below 2.5 is rejected.

RESULTS

The results of the data analysis are presented in tables according to each research question.

Research Question 1

What are the chemistry concepts/topics at the secondary school level which require mathematics knowledge?

Table 2: Mean Response and Standard Deviation of Teachers on Chemistry Concepts/Topics that Require Mathematics Knowledge.

S/N	Items	SA	A	D	SD	\bar{x}	S.D	Decision
	The following chemistry topics require mathematics knowledge							
1.	Relative molecular mass	23	28	17	5	2.94	0.89	Accepted
2.	Molar masses of compounds	31	18	20	4	3.04	0.86	Accepted
3.	Percentage composition of elements	24	21	27	1	2.93	0.80	Accepted
4.	Empirical formula	19	33	18	3	2.93	0.93	Accepted
5.	Temperature conversion	22	19	21	11	2.71	0.99	Accepted
6.	Gas Laws	28	16	22	7	2.90	1.02	Accepted
7.	Laws of Electrolysis	20	27	18	8	2.80	1.00	Accepted
8.	Calculations involving PH. Value	29	11	24	9	2.82	0.82	Accepted
9.	Volumetric analysis	28	23	19	3	3.04	0.88	Accepted
10.	Chemical kinetics	26	27	17	3	3.04	0.90	Accepted
11.	Solubility	19	23	21	10	2.69	0.71	Accepted
12.	Chemical equation	24	27	21	1	3.01	0.89	Accepted
13.	Rates of chemical reactions	21	29	19	4	2.91	0.94	Accepted
14.	Mass-volume calculations	32	18	20	3	3.08	0.97	Accepted
	Grand Mean					2.91		Accepted

Based on the above results in table 2, all the items had mean scores above the 2.50 cut-off point. Based on this, all the items were accepted. The grand mean of 2.91 is also above the 2.50 meaning that the teachers agreed that those topics in chemistry require mathematics knowledge.

Research Question 2

What are the mathematics concepts/topics that are relevant in the study of chemistry at the secondary school level?

Table 3: Mean response of the teachers on the Mathematics Topics Relevant in the Study of Chemistry at the Secondary school Level.

S/N	Items	SA	A	D	SD	\bar{x}	S.D	Decision
	The following Mathematics topics are relevant in the study of chemistry at the secondary school level.							
15.	Arithmetic operations	18	28	26	1	2.86	0.90	Accepted
16.	Direct Variations	21	29	22	1	2.95	0.82	Accepted
17.	Inverse variation	17	27	23	6	2.75	0.75	Accepted
18.	Joint variation	23	27	19	4	2.94	0.83	Accepted
19.	Logarithm	20	20	28	5	2.75	0.88	Accepted
20.	Equations involving fractions	19	32	18	4	2.90	0.79	Accepted
21.	Ratio	24	27	16	6	2.94	0.98	Accepted
	Grand Mean					2.87		Accepted

Based on table 3 above, all the items had mean scores above the 2.50 cut-off-point, indicating that the mathematics concept/topics listed on the questionnaire are relevant in the study of chemistry at the secondary school level.

Research Question 3

How relevant are mathematics concepts in teaching and learning of chemistry at the secondary school level?

Table 4: Mean and Standard Deviation of the Respondents on how relevant Mathematics Concepts are in Teaching and Learning of Chemistry

S/N	Items	SA	A	D	SD	\bar{x}	S.D	Decision
22.	I teach all mathematics aspects of chemistry in the class	20	23	24	6	2.78	0.73	Accepted
23.	Application of the knowledge of mathematics is necessary in teaching chemistry concepts.	19	21	26	7	2.71	0.81	Accepted
24.	It is necessary to use mathematical equations in solving some problems in chemistry.	18	32	17	6	2.84	0.93	Accepted
25.	I consult mathematics teachers to help in explaining some mathematics concepts relevant in chemistry.	21	27	23	2	2.91	0.88	Accepted
26.	Chemistry is given three periods in a week so as to cover the syllabus.	16	24	28	5	2.69	0.92	Accepted
27.	I solve some of the mathematical aspects of chemistry problems and allow the students to do the same after introducing the topic	17	25	26	5	2.73	0.89	Accepted
	Grand Mean					2.77		Accepted

From the results on table 4, all the items had mean scores above 2.50. This indicates that the respondents considered the mathematical concepts relevant in the study of chemistry. This also shows that the respondents (chemistry and mathematics teachers) have the ability in teaching mathematical concepts in chemistry.

Research Question 4

Do mathematics teachers in any way cover the relevant mathematics concepts in chemistry in their mathematics lessons?

Table 5: Mean Response and Standard Deviation of the Respondents on how the Mathematics Teachers Cover those Mathematics Concepts that are Relevant in the Study of Chemistry.

S/N	Items	SA	A	D	SD	\bar{x}	S.D	Decision
28.	I cover all the mathematics concepts relevant in teaching/learning of chemistry	19	20	34	0	2.79	0.91	Accepted
29.	I cover stiochiometric topics in the class	17	23	19	14	2.58	0.79	Accepted
30.	Mathematics is given five periods a week	27	22	20	4	2.98	0.82	Accepted
31.	I evaluate the students at the end of each mathematics lesson.	32	18	16	7	0.02	0.67	Accepted
32.	I take time to see the students work on individual basis.	27	23	21	2	3.02	0.81	Accepted
33.	I allow the students to participate in the lesson by solving problems on the chalkboard	22	28	23	0	2.98	0.93	Accepted
34.	Students are given 3 to 4 assignments on each topic taught	27	28	14	4	3.06	0.73	Accepted
Grand Mean						2.91		Accepted

Based on the results on table 5, all the items had mean scores above 2.50. This implies that the respondents cover all the mathematics concepts relevant in the study of chemistry in their mathematics lessons.

Findings

From the results of the study, it was observed that the study of chemistry at the secondary school level requires mathematical knowledge. Based on the findings, the following chemistry concepts require the knowledge of mathematics; molar masses, relative molecular mass, percentage composition of elements or compounds, empirical formula, temperature conversion, gas laws, laws of electrolysis, PH-value-of solutions, chemical equilibrium, rates of chemical reaction, mass-volume calculations, oxidation number, volumetric analysis etc. This is in agreement with graham and Murray (1999), who said that modern mathematics is a vast field of knowledge with many sub-divisions.

The respondents (the teachers) agreed that the mathematics topics such as; Arithmetic operations, direct variation, inverse variation, joint variation, logarithm, equations involving fractions, simple equations and ratio are relevant in the study of chemistry at the secondary school level. This is in accordance with the words of Briet (2003), he observed that mathematics is a dynamic field constantly demanding willingness to make new observations to repeat experiments, consider new facts, and challenge earlier conclusions.

In answering the research question which asked, what are the chemistry topics which require mathematics knowledge? It was discovered that all the chemistry topics require the knowledge of mathematics. This is in line with Ejike (1999) who asserted that sound and

thorough knowledge of mathematical principles pre-determines future success in science disciplines such as Chemistry, Biology and Physics among others.

The result of data analysis based on research question 4, indicates that the mathematics teachers cover those mathematical concepts in their classes, which are relevant to the study of chemistry at the secondary school level. This agrees with Eze (2003) who stated that acquisition of relevant mathematics knowledge is the gate and key to the sciences especially engineering and physical sciences.

RECOMMENDATIONS

Based on the findings from the data analysis, the following recommendations were made.

- Chemistry teachers should be exposed to programmes that will help them acquire more knowledge on mathematical aspects of chemistry.
- In-service or re-training programmes should be organized which will bring the chemistry and mathematics teachers together to share the views and ideas on certain topics in mathematics and chemistry.
- Chemistry teachers should be allowed and sponsored to attend conferences, seminars and workshops to update their knowledge of calculations in chemistry.
- Government should provide recommended chemistry textbooks which deal practically on mathematical aspect of chemistry.

CONCLUSION

This study was conducted to identify the mathematics concepts relevant in the study of chemistry at the secondary school level. From the data analysis, the following mathematics concepts were identified to be relevant in the study of chemistry; relative molecular mass molar mass, percentage composition, empirical formula, temperature conversion, gas laws, laws of electrolysis, PH-value of solutions, chemical equilibrium, rates of chemical reaction, mass-volume calculations, volumetric analysis, oxidation numbers, balancing of chemical equation, and mole concept among others.

Based on the findings, the researchers conclude that mathematics plays significant roles in the teaching and learning of chemistry at the secondary school level. Chemistry cannot be taught successfully without the knowledge of mathematics, therefore chemistry teachers should regularly update their knowledge in calculations involving chemistry in their classroom activities.

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