

# Towards Improving Quality of Education in Chemistry: An Investigation into Chemistry Teachers' Knowledge of Chemistry Curriculum

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**Abstract**—The 21<sup>st</sup> century world is a knowledge society and a lot of emphasis is placed on possession of knowledge and skills. 21<sup>st</sup> century teachers are therefore expected to possess, to a great extent, pedagogic content knowledge (PCK), discipline-based knowledge (D-bK) and curriculum content and context knowledge (CCCK). These aspects of knowledge are essential for teachers to deliver lessons effectively and efficiently to students. Deficiency in any of these aspects of knowledge is bound to bear on teachers' effectiveness, and consequently reflect on students' learning and learning outcome. Secondary school students' underachievement in chemistry has often been associated with teachers' poor knowledge of the teaching curriculum on which students' learning is based. This study set out to ascertain how knowledgeable teachers are about the chemistry curriculum which they implement in schools. The study shows that about 80% of teachers are knowledgeable about the various dimensions of the new chemistry curriculum. The author asserts that lack of knowledge of the curriculum on the part of teachers, which very often is given as one of the contributing factors to students' underachievement in chemistry may after all be unfounded. The paper made suggestions towards improving quality of education in chemistry.

**Index Terms**—Curriculum, Knowledge, learning outcomes, under-achievement

## I. INTRODUCTION

The downward trend in achievement of secondary school students in both public and school examination has remained a source of worry to many stakeholders in Nigerian education system. There are indications that much of the problems emanate from the classrooms. There are reports of inappropriate pedagogical approach adopted by teachers in the classroom, for instance, chemistry teachings are not supported by practical activities, not even mere demonstration in some cases (Adeyegbe, 1998; Nwofor, 1991; Ochu, 2007; Udo & Eshiet, 2007; Nwahunanya, 2011 and Ugwuanyi, 2011). Other reports include teachers' poor knowledge of the subject matter of chemistry, its curriculum, loss of interest in chemistry by students, their poor or negative attitude towards the subject, the ever-existing problem of shortage in the number of well-trained chemistry teachers, laboratory materials and equipment.

The problems are legion and constitute a significant factor besetting education in chemistry in secondary schools. These problems cannot be solved simultaneously, but gradually and systematically. Perhaps the place to start is the classroom,

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where investigation should be carried out to ascertain what goes on therein, with focus on the teacher. Teachers are the drivers of the education system and managers of the classrooms; they control what goes on in classrooms and teach the students based on their knowledge, understanding and interpretation of the curriculum philosophy, objectives, content and the recommended pedagogical approach to its implementation. Kerr (1968) refers to curriculum as the totality of planned and guided learning that is executed by the school either in groups or individually, inside or outside the school. Okorie (2010) describes the curriculum as a statutory and public document that expresses the desires and aspiration of people of a given period and articulates the desirable experiences, which the people intend for themselves, and their younger generation; the sequence and method of achieving such experiences usually spelt out as goals and objectives to be reached in a school process.

The 21<sup>st</sup> century world is a knowledge society and a lot of emphasis is placed on possession of knowledge and skills. 21<sup>st</sup> century teachers are therefore expected to possess, to a great extent, pedagogic content knowledge (PCK), discipline-based knowledge (D-bK) and curriculum content and context knowledge (CCCK). These aspects of knowledge are essential for teachers to deliver lessons effectively and efficiently to students. Deficiency in any of these aspects of knowledge is bound to bear on teachers' effectiveness, and consequently reflect on students' learning and learning outcome. Pearson Education (2003) sees knowledge as the information gained through learning or experience. Piaget (1971) explains that the foundations of knowledge are in action. This can be explained in terms of action towards acquisition of knowledge or in its utilization. Thus, an act based on the information gained by the individual through learning or experience expresses that individual's knowledge about the given subject or situation. Therefore, teachers' knowledge of the curriculum should be assessed and ascertained by how they act upon it, in terms of correct interpretation of its philosophy and objective, proper implementation of its content in line with the recommended approach to concept delivery and learning evaluation. Nnachi (2011) observed that crisis in education system results from teachers' inability to implement the curriculum, which perhaps is an indication that teachers are not conversant with the recommended pedagogical approach of the curriculum. The new NERDC curriculum has been in use in Nigerian senior secondary schools since September 2011, beginning with the SS1 curriculum component. The first set of senior secondary school graduates educated with this curriculum will be examined in June, 2014.



## II. PROBLEM

Secondary school students' underachievement in chemistry has often been associated with teachers' poor knowledge of the teaching curriculum on which students' learning is based. There is need to ascertain how knowledgeable teachers are about the chemistry curriculum which they implement in schools.

## III. RESEARCH QUESTIONS

1. What percentage of chemistry teachers are familiar with the new NERDC chemistry curriculum in use to educate secondary school students in chemistry?
2. What percentage of chemistry teachers are knowledgeable about the various dimensions of the new chemistry curriculum?

## IV. PURPOSE OF STUDY

The purpose of this study is to:

1. Ascertain to what extent teachers are knowledgeable about the new NERDC chemistry curriculum in use Nigerian secondary schools;
2. Determine if the pedagogical approach recommended is actually in use in implementing the curriculum in schools.

## V. METHOD

The study was carried out in Makurdi and Enugu in Benue and Enugu states of Nigeria respectively. The sample consisted of 20 senior secondary school chemistry teachers who participated in Train – the - Trainers workshop organised by Nigerian Educational Research and Development Council (NERDC) towards the implementation of the new secondary school chemistry curriculum in Nigerian schools.

The sample was drawn from all the six geo-political zones of Nigeria namely North – East, North-Central, North-West, South-East, South-South and South-West. An instrument, the 'Chemistry Curriculum Knowledge Test for Teachers (CCKTT)' was designed and used for the study. It consists of 12 statements about the following five dimensions of the curriculum: rationale, general structure, unique features, contents and its pedagogic approach; the teachers were required to indicate their degree of agreement or disagreement with the statements about the curriculum by a tick (✓) in the appropriate column. 8 of the 12 statements were positively cued while 4 were negatively cued. The instrument is a 4-point Likert-scale with the following options: Strongly Agree (SA) (4); Agree (A) (3); Disagree (D) (2); Strongly Disagree (SD) (1). For positively cued items, the responses were assigned values ranging from 4 to 1. For negatively cued items, the values were reversed. A score of 3 and above were taken that the respondents were in agreement with the opinion and therefore knowledgeable about the item; scores below 3 indicate disagreement with the item of the instrument and therefore not knowledgeable about the specific aspect of the curriculum in focus. A minimum score of 36 of maximum score of 48 is the benchmark for a respondent to be considered knowledgeable about the curriculum.

The instrument was face validated by three experts in chemical education for coverage of the items in the instrument in respect of their distribution to the various dimensions of the instrument; clarity of the statements to make the interpretation

of the scale easy; appropriateness of the rating scale; and suitability of the instrument for the study. All the experts agreed that the statements were clear; items in the instrument covered the 5 dimensions of the instrument; and the instrument were suitable for use in the study.

The instrument was pilot tested with sample made up of teachers randomly selected from Abia, Anambra, Benue, Enugu and Kogi States of Nigeria who were not used for this study. The data obtained using the instrument in the pilot study was used to determine the internal consistency of the instrument, using the Cronbach's Alpha reliability method. The reliability value of 0.87 was obtained. The instrument was administered to the sampled teachers during workshops and the return rate was 100%.

## VI. DATA ANALYSIS

Percentage, frequency and mean are used for data analysis.

## VII. RESULTS

The results are presented according to the research questions as follows:

### VIII. RESEARCH QUESTION 1

What percentage of chemistry teachers are familiar with the new NERDC chemistry curriculum in use to educate secondary school students in chemistry?

Table 1, which presents a descriptive analysis of teachers' level of knowledge of specific dimensions of the curriculum, shows that 90% of teachers claim to be familiar with the new chemistry curriculum. This implies that they are at least aware of existence of a new curriculum that provides for the contents, performance objectives, teachers' and learners' activities, materials to facilitate teaching-learning and evaluation guides.

**Table: 1 Descriptive Analysis of Teachers' Level of Knowledge of Specific Dimensions of the curriculum (n = 20)**

Statement	Level of agreement /disagreement			
	SA	A	D	SD
<b>Familiarity with the curriculum</b>				
I am familiar with NERDC SSS Curriculum for Chemistry.	(4) 20%	(14) 70%	(1) 5%	(1) 5%
<b>1. General Structure of the curriculum</b>				
The NERDC SSS Curriculum for Chemistry provides for the contents, performance objectives, teachers' and learners' activities, teaching and learning materials; and evaluation guides.	(6) 30%	(14) 70%	–	–
<b>2. Unique Features of the curriculum</b>				
The NERDC SSS Curriculum for Chemistry is rigid and does not encourage teachers to enrich the contents with relevant materials and information from their immediate environment.	(1) 5%	(2) 10%	(9) 45%	(8) 40%

The NERDC SSS Curriculum for Chemistry adopts the spiral approach in the arrangement of concepts.	(6) 30%	(9) 45%	(3) 15%	(2) 10%
The NERDC SSS Curriculum for Chemistry uses the thematic approach in selecting its contents.	(3) 15%	(12) 60%	(2) 10%	(3) 15%
The NERDC SSS Curriculum for Chemistry shows chemistry and its inter-relationship with other subjects.	(10) 50%	(9) 45%	–	(1) 5%
<b>3. Content Dimension of the Curriculum</b>				
The NERDC SSS Curriculum for Chemistry omitted topics in Nuclear chemistry in its content .	(2) 10%	(8) 40%	(8) 40%	(2) 10%
The IUPAC Periodic Table is not recognized in the NERDC SSS Curriculum for Chemistry.	–	(2) 10%	(11) 55%	(7) 35%
The IUPAC nomenclature is used in naming compounds in the NERDC SSS Curriculum for Chemistry.	(9) 45%	(8) 40%	(3) 15%	–
<b>4. Pedagogic Approach Dimension of the Curriculum</b>				
The NERDC SSS Curriculum for Chemistry does not recognize the use of computer in teaching and learning of chemical concepts.	–	(3) 15%	(11) 55%	(6) 30%
The use of local materials in teaching and learning of chemistry is not recognized in the NERDC SSS Curriculum for Chemistry.	–	–	(12) 60%	(8) 40%
Evaluation technique employed in the NERDC SSS Curriculum for Chemistry does not reflect its contents.	–	(1) 5%	(10) 50%	(9) 45%

All numbers in parentheses are the frequencies

## IX. RESEARCH QUESTION 2

What percentage of chemistry teachers are knowledgeable about the various dimensions of the new chemistry curriculum?

Table 3 shows that about 80% of teachers are knowledgeable about the various dimensions of the new chemistry curriculum.

**Table 2: A summary of percent of teachers who are knowledgeable about the various dimensions of the chemistry curriculum (n=20)**

Dimensions of chemistry curriculum	Percent (%) of teachers who are knowledgeable
General structure	100
Unique structure	82.5
Content	48.33
Pedagogic approach	93
	Mean = 80.96

Table 3 shows that about 80% of teachers are knowledgeable about the various dimensions of the new chemistry curriculum. This is against the 90% of teachers who claimed to be familiar with the curriculum. A more detailed analysis of data in Tables 1 and 2 show that 100% of teachers know the general structure of the curriculum. They know that the NERDC SSS Curriculum for Chemistry provides for the contents, performance objectives, teachers' and learners' activities, teaching and learning materials; and evaluation guides. However, 10% of teachers are not familiar with the new curriculum. 15% of the teachers are not knowledgeable about the unique structure of the curriculum. They agreed or strongly agreed that the curriculum is rigid and does not encourage teachers to enrich the content. 45% of the teachers disagreed strongly or disagreed that the curriculum omitted some topics in Nuclear Chemistry. They are therefore not knowledgeable about this aspect in the curriculum. 25% of teachers disagreed or strongly disagreed that the curriculum used the spiral approach in the arrangement of concepts. This percentage is not knowledgeable about this aspect of the curriculum. 25% of teachers either disagreed or strongly disagreed that the thematic approach was used in selecting curriculum contents. 15% agreed or strongly agreed that the curriculum does not recognize the use of computer in the teaching and learning of chemical concepts. 100% of teachers disagreed or strongly disagreed with the statement that the use of local materials is not encouraged in the teaching and learning of chemistry. 90% of teachers either agreed or strongly disagreed that IUPAC Periodic Table was not recognized in the curriculum. 15% of teachers disagreed or strongly disagreed that the IUPAC nomenclature is used in naming compounds in the curriculum. 95% of teachers disagreed or strongly disagreed that the evaluation technique employed in the curriculum does not reflect its content. This percentage is therefore knowledgeable, only 5% of teachers are not knowledgeable about this aspect of the curriculum. 95% of teachers either agreed or strongly agreed that the curriculum shows chemistry and its interrelationship with other subjects. They are therefore are knowledgeable about this aspect of the curriculum.

## X. DISCUSSION

This discussion focuses more on the content dimension and unique feature of the curriculum, which as shown in Table 2 are the ones that teachers are less knowledgeable about. On page 13 of the curriculum, under the theme: The Chemical World, the topic Periodic Table provides that families of elements be placed according to groups' I-VIII, i.e., group 1-8. The periodic table is a chart in which elements, when placed in order of atomic number, fall into groups of similar elements. It is the most significant tool that chemists use for organizing and remembering chemical facts. In the 1860s, a number of scientists, most notably Dmitri Mendeleev (1834-1907), produced the periodic tables. In one form of the periodic table, Mendeleev gave the columns of the periodic table Roman numbers, and added the letters A for some columns and B for others. These numbers have been in use for many years, but in North America and Europe, chemists used the A and B in different ways. This older form of the table brought confusion.

To eliminate the confusion, the IUPAC proposed a convention that numbers the groups of elements from 1 through 18 with no A or B designations, going from left to right. Thus, by Mendeleev's numbering, the halogens are in group VIIA, but in the IUPAC numbering, they are in group 17 (Brown, LeMay, Bursten and Murphy, 2009; Sharp, 1992; Bettelheim and March, 1991). The IUPAC Periodic Table has Groups 1-18. Therefore, it could be said that the curriculum does not recognize the IUPAC Periodic Table, although the IUPAC nomenclature is used in naming compounds in the curriculum, e.g. Calcium Trioxocarbonate (IV) ( $\text{CaCO}_3$ ); Silver Trioxocarbonate (V). The standards of nomenclature in chemistry are proposed by the International Union of Pure and Applied Chemistry (IUPAC). Chemical nomenclature may be considered to be a language. As such, it is made up of words and it should obey the rules of syntax.

The NERDC curriculum uses a convention that numbers the groups from I through VIII, i.e. for example, group IA – alkali metals, group IIA – alkali earth, in line with that widely used in North America. Europeans use similar conventions that number groups from IA through VIIIA and then from IB through VIIIB. Many of the imported books from Europe and America have retained the older version of the table, although with information on the IUPAC stand on the table. Secondary school chemistry books written in Nigeria, have shown interest in the IUPAC table. There is need for the teaching and examination curricula in Nigeria to take a common stand on the issue.

10% of teachers are not familiar with the new curriculum, this figure appears small but significant considering the fact that there is a dearth of chemistry teachers in the school system. Oral interviews conducted by the researchers in the course of this study reveal that this 10% of teachers who are not familiar with the new curriculum and even those who are knowledgeable about the new curriculum depend on examination syllabi of such bodies as West African Examination Council (WAEC) for teaching curriculum. This means that the teachers only concentrate on those topics that the examiners are interested in. This also implies that the pedagogic approach of the NERDC curriculum is not adopted in schools. This explains the current practice in schools where few specific practical activities relating to School Certificate examinations are carried out only when the final certificate examinations are very close at hand. This is contrary to the recommendations of the NERDC curriculum. The NERDC curriculum recommends that 'Chemistry essentially is a practical science that is better studied and learnt with plenty of practical activities' (NERDC, 2012). Also recommended is the need to show the socio-cultural relevance of Chemistry by using locally available materials and for students' use to use ICT facilities particularly the Internet, as part of their learning experience, to obtain current and more information on specific chemical concepts.

One unique feature of the NERDC curriculum is that it encourages teachers to enrich the contents with relevant materials and information from their immediate environment. It adopted the thematic approach in selecting its contents while the spiral approach was adopted in the arrangement of concepts. NERDC (2012) explained that the contents of the new curriculum are arranged or organized in spiral form, such that only aspects of the recommended contents and concepts are studied at the various class levels. A spiral curriculum is one in which the contents keep repeating themselves at

different class levels, but the depth and breadth of the subject matter keep increasing as the class level increases and as the learners mature in terms of experience and background knowledge. The curriculum shows chemistry and its inter-relationship with other subjects.

The NERDC SSS Curriculum for Chemistry omitted some topics in Nuclear chemistry in its content. Such topics as *Types and nature of radiation, Half life as a measure of stability of the nucleus, Nuclear reactions: Fission and Fusion in nuclear reactors, Effects and application of radioactivity*, which are common topics for all candidates as stipulated in Section A of the West African Senior Certificate Examination (Chemistry) detailed syllabus. NERDC (2012) noted that these topics in Nuclear Chemistry were inadvertently omitted in the new curriculum, but are very crucial and should be taught. Teachers are advised to spread the topics across the various levels of senior secondary education in chemistry, following the spiral approach of organising the contents.

## **XI. IMPLICATIONS**

The findings of the study have both curricular and instructional implications to teachers, the chemistry curriculum itself and the school system. It has been shown that teachers do not adhere to the pedagogic approach recommended by the curriculum. Their reliance on the examination syllabi for teaching curriculum is not helping the school system or the society, which is hoping to achieve its science educational transformation agenda, use the new curriculum. The study shows that a high percentage of teachers (80%) are knowledgeable about the curriculum. Lack of knowledge of the curriculum which very often is give as one of the contributing factors to student's underachievement may after all be unfounded. What is clear however is teachers' mode of implementation of the curriculum does not follow the recommended pedagogic approach. This may work against the achievement of the curriculum objectives.

## **XII. RECOMMENDATIONS**

1. Sensitization of teachers to adhere to the recommended pedagogic approach should be embarked upon by NERDC in collaboration with the various States' Ministries of Education. This should be followed by close monitoring of what goes on in the classroom.
2. The examination bodies should reform their present examination, system to emphasis more of acquisition of practical skills than the one which encourages more of recall of theoretical knowledge, which appears to be the case.
3. School laboratories should be equipped to a reasonable extent. Teachers have always pointed to the fact that the laboratories are poorly equipped, and in many cases are non-existent. Also, laboratory attendants and technologists should be employed in school to partners with teachers in ensuring that the pedagogic approach of the new curriculum is adhered to.
4. The NERDC should go a top further to develop and publish books that illustrate how this subject should be taught in schools.

Experience has shown that teachers, especially new entrants into the teaching profession lack the necessary experience to handle practical activities in the school.

Management. "Teacher of the Year, 2002" California Education Authority, USA.

### XIII. CONCLUSION

The much emphasis placed on acquisition of certificate as evidence of learning appears to have been the reasons for teachers to jettison the recommend pedagogic approach of the curriculum. There might be other reasons. This calls for further investigation. This way, the objectives of the new curriculum in producing school graduates who are fairly scientifically literate could be achieved.

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