

MNEMONIC AS AN INNOVATIVE APPROACH TO CREATIVE TEACHING OF SECONDARY SCHOOL CHEMISTRY

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ABSTRACT

Chemistry as a secondary school subject despite its importance and central role in science and development is often found difficult to understand by students. Chief among the contributing factors being the approaches used by chemistry teachers which tend to make chemistry concepts to be too abstract and uninteresting to students. Thus, most often, students tend to view concepts in chemistry as being too “volatile” as they often are unable to remember them. Thus, in order to ensure that chemistry teaching and learning become more interesting and for students to be able to remember learnt chemistry concepts, the use of mnemonics was suggested. This suggestion is based on the premise that learning and remembering of information becomes better when presented in forms that are personal, surprising or humorous and when various scientific facts and procedures to be learnt are well connected to more familiar words and phrases. Mnemonic is defined as a memory aid meant to assist in the learning and recall of information that might have been somewhat problematic to recall. Using some chemistry concepts, the paper identified some forms in which mnemonics can be used innovatively in teaching senior school chemistry. The paper then advocated for the creative usage of mnemonics in teaching chemistry to be included as a vital component of initial training and the retraining of secondary school chemistry teachers. [AJCE 4(2), Special Issue, May 2014]

INTRODUCTION

Science teaching in Nigeria dated back to 1867 when Nature Study and Hygiene were introduced as school subjects. These later became Biology, Chemistry and Physics [1-2]. Chemistry was thus among the three basic sciences introduced into Nigerian secondary schools by the colonial government. Central to the teaching of science and technology in schools is chemistry [3-4].

Chemistry as a branch of science deals with the study of the properties, and composition of matter, and how these undergo changes [5-6]. In Nigeria, chemistry as a subject is being taught starting from the post basic level of the educational system. At the basic level, chemistry is taught as an integral part of basic sciences. The importance of chemistry teaching in science and technological development cannot be overemphasized as chemistry is reputed as being central to the understanding of the other physical sciences owing to its confluence with and influences on the other natural sciences such as physics, biology and geology [7-8]. Edeh & Vikoo [9] had equally asserted that practically all forms of human endeavours and everything in science involves the application of chemistry.

The central role that chemistry plays among the sciences and technology can be discerned from the fact that to gain admissions into any programme in the (physical and biological) sciences, technology, engineering, agricultural and medical science programmes in any institution of higher learning in Nigeria requires at least a credit pass in chemistry [10].

Considering the central role that chemistry plays especially as regards the sciences at the senior secondary school level as well as its roles as parts of the core admission requirements to higher institutions across the African educational systems and especially in Nigeria, it would thus be expected that senior secondary school students' performance in the subject would be high.

Astonishingly, available reports of students' performance across West Africa reveal that senior secondary school students' results in public examinations in chemistry in Nigeria, Sierra Leone, Ghana, Liberia and Gambia had consistently been getting worse. Most often, at least 70% of candidates that registered for the examination have not been able to pass [11-15].

Various factors have been attributed to students' consistent abysmal performance in school science and mathematics subjects especially chemistry at the senior secondary level [16-18]. Chief among the contributing factors being the approaches used by chemistry teachers which tend to make chemistry concepts to be too abstract and uninteresting to students as well as the general perception of chemistry topics by students [19-20]. Another being that chemistry is generally perceived difficult to learn by students. Jimoh [20] as an example reported that senior secondary school chemistry students perceived 65% of the topics in the senior secondary chemistry curriculum difficult to comprehend. Thus most often, students tend to view concepts in chemistry as being too volatile as they often are unable to remember them [20-21].

BEST PRACTICES IN TEACHING AND LEARNING

To remedy this situation science educators have advocated for a wide array of options to enhance the meaningful teaching and learning of chemistry [2, 4, 7 and 9]. As an example, the US National Research Council of *the National Academies* [22] had advocated for the following four pedagogical practices as best practices of science teaching:

1. Engaging resilient preconceptions: that is, addressing students' initial understanding and preconceptions about topics; the assumption being that students do not come into the classroom as "tabula rasa.", rather learners have got some forms of entry behaviours prior to exposure to any course of instruction; such preconceived knowledge may sometimes

tend to limit what can be learnt by students. Thus the need for the identification, confrontation and resolution of students' preconceptions be identified, confronted, and resolved.

2. Organizing knowledge around core concepts: this implies the provision of a foundation of factual knowledge and conceptual understanding. The underlying principle is that a powerful way to increase understanding and retention is through organizing of information.
3. Supporting metacognition and student self-regulation. This involves teaching strategies that will help students take control of their learning. It is felt that teachers' best pedagogical practices should enable students to be made mindful of what they already know as well as what they do not know. A means of ascertaining this is through appropriate evaluation strategies such as the use of pre-test and demanding that students should summarize what they have learned.
4. Cooperative Learning: this involves allowing students to learn together.

A scrutiny of the suggested best practices in teaching and learning indicates that essentially, best practices in teaching and learning should aim at making learning interesting to learners as well as aiding assimilation and recall of learnt concept. There is no doubt that various innovative methods of teaching have been suggested which are felt to be capable of enhancing meaningful learning, such include concept mapping, peer tutoring, guided discovery and use of mnemonics [1, 2, 4, 23 and 24].

Considering the fact that one of the main problems encountered by students in learning chemistry is that of inability to organize taught concepts in such a way as to facilitate ease of recall, it is thus felt that one vital means of enhancing learning of chemistry is through a method

that would aid students' memory. This is where mnemonics comes in as a "best practice"; an innovative pedagogical approach to creative teaching and learning of chemistry

WHAT IS A MNEMONIC DEVICE

Psychologist World [26] explains that the word mnemonic (pronounced nee.MON.ik) is used (a) as a noun meaning a device, such as a formula or rhyme, that helps a person remember something or (b) as an adjective meaning aiding memory. Iza, & Gil [27] describes mnemonic as memory-enhancing pedagogical methods aimed at improving learning and information recall through the use of imagery. The Wikipedia defines mnemonics as any learning technique that aids information retention. The Awake! [28] explains that "a mnemonic is a strategy or device that helps us store information in the long-term memory and recall it when needed" (p.29). Iza & Gill's definition however appears to be the most suitable definition of mnemonics as an instructional strategy. All these simply implies that mnemonic or mnemonic device is any pedagogical device involving the use of imagery and associations to enhance learning and aid easy recall of learnt concepts.

The vital role of mnemonics as an effective pedagogical technique had long been established [24-29]. As an example, Butcher [30] explains that the mnemonic techniques had long been in use by the ancient Greeks and Romans to improve their memory. Congos [25] [citing a study by Miller (1967)] asserted that mnemonics increased recall and that students who regularly used mnemonic devices increased test scores by as much as 77%! Mastropieri, & Scruggs, [31] inform that mnemonics can be modified to fit a variety of learning content and especially beneficial to students with learning difficulties. Hayden [32] reported of medical students' use of mnemonics in committing anatomical terminologies to memory. According to

Mcalum & Seay [29], psychologists believe that mnemonic techniques are so effective in learning because they impose meaning and structure to material that otherwise would be unstructured or less meaningful. Among others, studies by Wang, Thomas, & Ouellette [24], Iza, & Gil [27], Hayden [32] and Mastropieri, & Scruggs [33] have justified the positive effects of the usage of mnemonic devices in facilitating learning as well as its effects on students' abilities to recall learnt facts.

THEORETICAL BASIS OF MNEMONICS AS A TEACHING METHOD

Shawn, Thomas & Coleman [34] inform that in many of the science classes students do have to recall enormous amounts of information in somewhat short period of time. They then suggest that mnemonics as aids for science students to be able to connect various scientific facts and procedures to more familiar words and phrases that would then enhance easy learning and recall of learnt scientific facts.

This is in agreement with Ausubel [35] psychology of meaningful learning. In the preface to his book *Educational Psychology: A Cognitive View*, Ausubel [35] strongly asserted that "If I had to reduce all of educational psychology to just one principle, I would say this: The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly" (p. vi). This view is also supported by Novak [36], Novak & Cañas, [37] that meaningful learning requires the learner to assimilate new concepts and propositions into existing cognitive structures.

The difficulties experienced by science students in learning large chunks of scientific facts and recalling them is aptly summarized by Novak & Cañas [37] based on reviews of psychological foundations of learning and memory:

the human memory is not a single “vessel” to be filled, but rather a complex set of interrelated memory systems... all incoming information is organized and processed in the working memory by interaction with knowledge in long-term memory. The limiting feature here is that working memory can process only a relatively small number of psychological units (five to nine) at any one moment ... this means that relationships among two or three concepts are about the limit of working memory’s processing capacity. For example, if a person is presented with a list of 10-12 letters or numbers to memorize in a few seconds, most will recall only 5 to 9 of these. However, if the letters can be grouped to form a know word, or word-like unit, or the numbers can be related to a phone number or something known, then 10 or more letters or numbers can be recalled. In a related test, if we give learners 10-12 familiar but unrelated words to memorize in a few seconds, most will recall only 5-9 words. If the words are unfamiliar, such as technical terms introduced for the first time, the learner may do well to recall correctly two or three of these. Conversely, if the words are familiar and can be related to knowledge the learner has in her/his cognitive structure, e.g. months of the year, 12 or more may be easily recalled (pp 5-6).

This quotation, although used by Novak & Canas [37] to justify the use of concept mapping as a tool that facilitates meaningful learning, it needs be mentioned that it equally provides the rationale for the effective usage of mnemonics as a teaching method. As could be inferred from Ausubel [35] theory of learning and Novak and Canas’ [37] assertion of the value of using familiar words and concepts to facilitates meaningful learning of bulky facts and as well as to aid ease of recall, then mnemonics would serve as that scaffold providing the link between what is already familiar and easy to recall and that which is to be leant. This no doubt would enhance the utilization of the retention of the knowledge for long periods of time as long as that scaffold can be remembered [38].

Asides being an effective aid to learning and recalling of scientific facts, one other significant advantage of mnemonic devices is that they can be used in a wide array of situations involving learning of large pieces of information, “from behaviour to academics to careers to hobbies” [39]. While acknowledging that mnemonics are considered as cognitive strategies,

Spackman [40] and Scruggs & Mastropieri [41] lament that the use of mnemonics fell into disuse and are not taught in schools today. They then ascribe ignorance of the techniques being a possible factor responsible for lack of its usage.

Literatures abound with different classification scheme for mnemonics (25, 29, 34 & 40). According to McAlum, & Seay [29] mnemonics techniques can be classified into two: organizational and encoding. Congos [25] informs that there are several types of mnemonics and that what works best is dependent on the individual learner. He further identified nine basic types of mnemonics which were: Music, Name, Expression/Word, Model, Ode/Rhyme, Note Organization, Image, Connection, and Spelling Mnemonics. Shawn, Thomas, & Coleman [34] identified six types of mnemonics methods the method of loci, acrostics, acronyms, clustering, sayings, and rhymes.

USE OF MNEMONICS IN TEACHING SECONDARY SCHOOL CHEMISTRY

From a review of the psychological basis for the use of mnemonics in teaching, it could thus be asserted that to facilitate meaningful learning and to enhance recall of scientific facts, as well as to aid long term memory through the use of mnemonics, the tasks of chemistry teachers would be that of helping our students to relate the new concepts we are to teach with that that they are already familiar with or would find interesting and easy to remember. All that chemistry teachers would need to do is to assist students in remembering the new materials using mnemonic devices. As mentioned earlier, mnemonics enhance recall of stored information by providing a scaffold that links what the students are familiar with to that which they are to learn. This aids the students in making mental snapshots of the information to be learned [29].

Chemistry as a secondary school subject is replete with several contents to be learnt by students. Mnemonics come in very useful in teaching and in aiding students to learn and to recall. In the following section we will illustrate with examples (mostly from personal anecdotes as a chemistry teacher) how mnemonics can be used in teaching chemistry contents.

The first approach has to do with what the use of **Expression or Word** mnemonic. To make an expression or word mnemonic, the first letter of each item in a list is arranged to form a phrase or word. There is no doubt that the expression or word mnemonics are the most popular form of mnemonics [24, 28] and possibly the easiest to use. Personal experience and literature reveal that this type of mnemonic device is very appropriate in enhancing learning of complex and abstract information [24, 28].

The first twenty elements

The learning of the first elements according to their atomic number is an indispensable content to be learnt by every beginning chemistry student as it serves as the foundation upon which several concepts in chemistry is built on. To teach this content we have developed the mnemonics based on the first letter of the names of the elements (or perhaps more from their symbols), but for the elements such as sodium and potassium whose symbols were derived from their Latin names, the mnemonic device entails the usage of the first letter of their Latin names. The rationale for this is to ensure consistency with the learning of the symbols of these elements. The mnemonics also include what we termed two “error checkers” which are the actual names of the elements chlorine and calcium. If for any reason, chlorine and calcium do not stand placed in the 17th and 20th positions respectively, then there is an error.

Element	Atomic No	Mnemonic
Hydrogen	1	Hi
Helium	2	Helen
Lithium	3	Listen
Beryllium	4	Before
Boron	5	Boys
Carbon	6	Call
Nitrogen	7	Nita
Oxygen	8	Or
Fluorine	9	Florence
Neon	10	Never
Sodium	11	Nastically
Magnesium	12	Magnetize
Aluminum	13	All
Silicon	14	Silly
Phosphorous	15	People
Sulphur	16	Soldering
Chlorine	17	Chlorine
Argon	18	Around
Potassium	19	Killer
Calcium	20	Calcium

Activity series

The activity series is the arrangement of metals in the order of their reactivity. This is also another concept in chemistry that provides the framework for the understanding of various other related concepts. To teach the activity series, we make use of “the popular scientist” mnemonics. This is also an Expression or Word mnemonic. K, Na, Ca, Al, Zn, Fe, Pb, H, Cu, Mn, Ag, Hg

Mnemonics	Name of elements
Popular	potassium
Scientists	sodium
Can	calcium
Make	magnesium
A	aluminum
Zoo	zinc
In	iron
Low	lead
Humid	hydrogen
Country	copper
More	manganese
Successfully with	silver
Gold	gold

Interestingly these were the same mnemonics used in teaching me about the activity series which my teacher also claimed was used in teaching him and which I have been using in teaching my students!

Diatomic Molecules

Diatomic molecules are molecules formed when two atoms of the same or different elements bond to each other. Only seven elements naturally form diatomic molecules; these are hydrogen, nitrogen, oxygen, fluorine, chlorine, bromine and iodine. Their molecular formulas would be written as H₂, N₂, O₂, F₂, Cl₂, Br₂, and I₂. In the teaching of this content, we often use these mnemonics which is also another form of expression mnemonics:

Hi Nike Of Florida, Clearly Bridge Iodine. Attempts were also made to include an “error checker” (by making the mnemonic for Iodine to be the name of the element) as well as to ensure consistency of the mnemonics with the symbols of the elements. The suggested mnemonics of Wikkianswer.com (41): **Oh I Have Nice Closet For Brooms** have also been found useful.

Reduction-Oxidation (Redox) Reactions

The Wikipedia (42) explains that the key terms involved in redox reactions “are often confusing to students” (para 42). A probable reason being the fact that both reduction and oxidation reactions occur simultaneously in any redox reaction.

Definitions of Basic Concepts in REDOX reactions

1. Cations and Anions

Cations are positively (+) charged ions while anions are negatively (-) charged ions. This following mnemonics can be of help to students in remembering these definitions and in avoiding a mix up.

Cats have paws and Anegativeion

This is actually a combination of a form of imagery and association mnemonics. To remember the definitions of cations and anions, all the student would have to do is to remember that cats have paws (that is Cations are pawsitive, and that the letter t in cation looks like a + (plus) sign (Ca⁺ion). The cat also has a negative ion that is: An anion is a negative ion (**Anegativeion**). Usually in redox reactions all that the student needs to do is to get a concept right, once this is done, then the converse is true for the other concept.

2. Anode and Cathode

Anode is the electrode in which oxidation takes place while cathode is the electrode in which reduction takes place. We have found the mnemonics RED CAT and AN OX very useful in remembering the definitions. RED CAT to imply: **Reduction** at **cathode** and AN OX stands for: **Anode** for **oxidation**.

3. Oxidation and Reduction

To memorise the definitions of oxidations and reduction reactions in which it is common to mix up oxidation and reduction, the suggested short phrase by Wikipedia (n.d.): "**LEO the lion says GER**" has been found very useful. That is LEO stands for "Lose Electron" Oxidation"

and GER stands for "Gain Electron Reduction". The acronym "Oil Rig" is also another common useful mnemonics. This acronym stands for "**O**xidation is **l**osing", "**R**eduction is **g**aining".

4. Redox reactions

A redox reaction is a chemical reaction in which there is a change in oxidation state of atoms participating in the reaction. An atom (or ion) whose oxidation number increases in a redox reaction is said to be oxidized (and is called a reducing agent). It is accomplished by loss of one or more electrons. The atom whose oxidation number decreases gains (receives) one or more electrons and is said to be reduced. This relation can be remembered by the following mnemonics.

To teach this concept and to aid memorization, we have found it useful to firstly reduce the definition into simpler sentences: oxidation involves an increase in oxidation number by loss of electrons while reduction involves a decrease in oxidation number by decrease in oxidation number. We have developed the mnemonics IONLEO is in DONGER.

These mnemonics stand for: **I**ncrease in **O**xidation **N**umber by **L**oss of **E**lectrons (**O**xidation reaction definition) and **D**ecrease in **O**xidation **N**umber by **G**ain of **E**lectrons (**R**eduction reaction definition).

CONCLUSION AND RECOMMENDATIONS

Personal anecdotes and research reports have indicated the effectiveness of mnemonics in aiding learning and recall using different subjects and different topics [24, 26, 27 and 33]. Students often report that mnemonics devices not only aid recall of facts and principles but also make learning interesting.

Despite the potentials of mnemonics devices in aiding learning and memory, the use of mnemonics is hardly a part of the methodology taught to teachers-in-training in most teacher education programs. It is also noted that although there a wide array of suggestions as to the use of mnemonics in teaching and aiding memory. A recent internet search of the word mnemonics using Google search engine returned about 1,600,008 results! And these are from all imaginable areas. Despite the vastness of the use of mnemonics, there seems to be a dearth of researches to empirically document the effects of their usages in science teaching generally and especially in chemistry teaching on students' (cognitive and non-cognitive) learning outcomes.

It would thus be necessary that researchers in the fields of science education, chemistry teaching and learning, educational evaluation, and educational psychology would need to focus attention on empirically documenting the impacts of the use of mnemonics devices on students' learning outcomes in various areas of chemistry and at various levels. In addition, it would also be worthwhile to investigate various possible learner characteristics as they relate to the effects of the use of mnemonics n learning outcomes.

Teacher education programs would in the same vein incorporate the use of mnemonic devices as one of the teaching methods to be taught in chemistry methodology courses. It would also be important to include the use of mnemonic devices as parts of the contents of chemistry teacher retraining programs.

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