ASSESSING SENIOR SECONDARY SCHOOL CHEMISTRY EXAMINATION QUESTIONS USING LEGITIMATION CODE THEORY IN PURSUIT FOR MEANINGFUL LEARNING

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Abstract

The study analyzed chemistry examination questions conducted by National Examination Council (NECO) in pursuit for meaningful learning. The study was motivated by the students' poor chemistry conceptual understanding and non-satisfactory performance in the undergraduate courses at universities. Legitimation code theory was used as analytical tool to examine the strength or otherwise of 2018 and 2019 chemistry questions conducted by NECO. Content analysis research method was used. The sample size of the study comprised of 250 NECO chemistry questions (133 for 2018 and 117 for 2019). Descriptive statistics: Frequency count and percentage was used as data analysis technique. The results of the study revealed that 84 %(2018) and 82.9%(2019) of the chemistry questions require abstract knowledge of chemistry concepts without relating to daily activities and only 16%(2018) and 17.1%(2019) questions required application of chemistry in daily activities. The results also revealed that 66.8%(2018) and 65%(2019) of the chemistry questions required either only one chemical term/formula/structure or even no chemical terminology to answer the questions. However, 33.1%(2018) and 35% (2019) questions required the use of many ideas from different topics before arriving at the answer. The study recommends that Legitimmation code theory should be applied in analyzing examination questions and hence educators and teachers should adopt it in order to improve the quality of their questions.

Keyword: Chemistry, Semantic gravity, Semantic density, Meaningful learning, NECO

The pursuit for meaningful learning has become a contemporary issue in science education particularly chemistry education. Meaningful learning refers to the situation where the concept that is learned (fact) is fully understood by the individual and that individual knows how the specific fact relates to other stored fact in the brain. It is a contrast of the much least desirable rote learning. Meaningful leaning underlies constructivist integration of thinking, feeling, and acting, leading to empowerment for commitment and responsibility (Novak, 2010). Meaningful learning supports independent thinking in the students (Novok, 2002). It helps individuals to internalize a new stimulus of any concept and later is reflected in the individual's ability to apply the new knowledge in real life situations (Kilic, & Cakmak, 2013). The problem of meaningful learning in chemistry education has become a topical issue (Grangea & Blackie, 2018). Blackie (2014) reported that this problem is even compounded further in that there is no intuitive conception of the molecular nature of matter. There are two major issues being considered when addressing the issue of meaningful learning and these includes the idea of conceptual understanding and that of conditions required for learning to occur (Grangea & Blackie, 2018).

Conceptual understanding is the students' ability to comprehend chemistry concepts and relate it to the daily activities. Harrison and Treagust,(2018) argued that chemistry students' lack of conceptual understanding is one of the factors that led to their failure in general chemistry courses at undergraduate levels in universities and other tertiary institutions. Previous studies also reported that lack of conceptual understanding is the challenging issue for chemistry education students (Potgieter, 2010, Potgieter and Davidowitz, 2010; Kilic, & Cakmak, 2013). Several contemporary approaches such as concept mapping (Cetin-Dindara, & Gebanb, 2013, Kilic & Cakmak, 2013), chemistry competency test (Potgieter and Davidowitz, 2010) , Use of Multiple tiers test (Umate, Eya & Okebannama, 2019; ; Kanli, 2015; Demirioglu, Demirioglu & Yadigaroglu, 2013) and Four modes Application Technique (Ahmad & Umate, 2018) have been used to improve students conceptual understanding in chemistry but yet the conceptual understanding proves to be low as indicated by the poor performance of the students in Senior Secondary Certificate examination.

Senior Secondary Certificate Examination (SSCE) is conducted in Nigeria by West African Examination Council (WAEC) and National Examination Council (NECO). Chemistry is one of the core science subject in which science students write SSCE examination either conducted by NECO or WAEC.

There have been some criticisms with regards to the students' performances in NECO examination. Osarenren (2013) argued that the regional examination body WAEC is more competitive and better than NECO. Some calls have been made for the cancellation of NECO for fear that the SSCE it administers is not as valid as that of the WAEC (Falaye & Afolabi, 2005). Kpolovie, Ololubeii, & Ekwebelemiii, (2011) reported that it is possible to identify candidates who scored an F9 on the WAEC SSCE and an A1 on the NECO SSCE in the same subject and in the same year, thus rising the concern about the credibility and validity of the NECO SSCE examination. Nnadozie (2014) reported that there is suspicion among Nigerians with respect to the students' high performance in NECO and mass failure in WAEC in almost all subjects and in the same year. It is on the basis of the aforementioned evidence that the present study analysed NECO chemistry questions using semantics of the Legitimation Code Theory (LCT). The aim is to find out whether the questions being asked encourage conceptual understanding which makes for meaningful learning or not.

Legitimation Code Theory (LCT) was developed by Maton (2009) and the theory states that the knowledge structure in humanities tends to be horizontal and that of natural sciences is hierarchical. The hierarchical knowledge structure requires condensation of knowledge appropriately at a much lower level (Maton, 2014). Legitimation Code Theory has emerged in the sociology of education as a powerful and illustrative 'toolkit' to analyze the organising principles of knowledge practices, their associated meaning-making systems, and the nature of knower dispositions (Maton, 2014). The key to LCT is the idea of making Educators who understand the forms of and relationship between knowledge, knowing, and knowers are better equipped to address teaching, learning, and assessment challenges, particularly in the increasingly diverse and complex 21st century educational contexts (Pott & Wolf, 2019).

LCT provides the tools for the investigation, analysis, and interpretation of 'knowledge practices' (Maton, 2014). The theory has rapidly emerged as an effective theoretically informed 'toolkit' offering a suite of dimensions through which to observe, analyze, interpret, and design teaching and learning practices(Pott & Wolf, 2019).

LCT is an analytical framework that is being used to explore a host of issues, practices and contexts in education and beyond (Maton, Hood, & Shay, 2013), both on its own and alongside complementary frameworks (Hood, 2010, 2013; Matruglio, Maton, & Martin, 2013). LCT provides a means for revealing the nature of the knowledge practices being expressed in discourse (Maton, 2014). This study used semantic dimension of LCT which comprised semantic gravity and semantic density.

Semantic gravity is the degree to which meaning relates to context and it can be stronger or weaker and it is related to the degree of abstraction (Maton, 2011). The semantic gravity is aimed at measuring abstractedness of chemical concepts in the questions If the question requires application of chemical concept(s) from one section of the curriculum to a specified example, the question will be coded as (SG^+), for instance, the following compounds are formed by covalent combination except (a) CH_4 (b) Cl_2 (c) H_2 (d) H_2O (e) MgO. This question is from one section of curriculum:, chemical combination. It requires the students to apply idea from knowledge of chemical combination to answer the question. When the question requires only recall of the concepts definition or rules: that question will be tag as SG^{++} , for ,example, Sudan III is used to test for (a) cellulose (b) fats and oil (c) glucose (d) starch. In this question, the students are expected to recall that Sudan III is used to test fats and oil. If the question requires the students' conceptual knowledge from different sections of the curriculum to be integrated to create a unified theory that is applicable to a broader context, the question will be coded as SG^- .For example, what is the oxidation number of nitrogen in $Al(NO_3)_3$. In this question, the students are expected to have the ideas of oxidation number rules, group of elements in the periodic table, mathematical ability e.t.c . Any question that required the students to integrate chemical concepts with general everyday knowledge to create meanings will be coded as SG^{--}. For instance, which of the following is used as an antiseptic in hospital operating room? (a) Acetylene (b) Ethers (c) Ethylene (d) Methanol (e) Phenol. Table 1 presents semantic gravity translation device

Table 1: Semantic Gravity Translation Device

Allocated code	Criteria
SG^{++}	The question requires application of chemical concept(s) from one section of curriculum to a specified example
SG^+	The question is located in a specific section of the curriculum and only requires recall of the concepts, definition or rules
SG^-	The concept is situated in the curriculum and are integrated with general everyday knowledge to create meanings that is applicable in any context
SG^{--}	The question requires concepts from different sections in the curriculum to be integrated to create a unified theory that is applicable to a broader context

Semantic density is 'the degree to which meaning is condensed within symbols (terms, concepts, phrases, expressions, gestures, calculations, etc.)' (Maton, 2011) and it is related to the degree of complexity. Semantic density is aimed at measuring the amount of chemical terms in a given question. If a question requires the students to first identify a problem before any interpretation or manipulation can be done in order to arrive at answer, the question will be coded as SD^{++} , for example, calculate the quantity of electricity in coulumbs used when a current of 2.7 ampere is passed through a solution of silver salt for 25 minuets 20 seconds? (a) 87.5 (b) 206 (c) 1350 (d) 4050 (e) 4104 . In this question , the chemical terms includes: silver symbol, writing balanced silver equation, Conversion of minuets to seconds e.t.c. If the question given has to be unpacked before interpretation in order to arrive at the answer, the question will be coded as SD^+. When only one term/structure is given and need to be interpreted or manipulated before arriving at answer such question will be coded as SD^- . But when no chemical terminology or concepts is required to answer a given question, for instance, In the periodic table, calcium and magnesium belong to (a) group 2 (b) Group 3 (c) group 4 (d) group 6. This type of question is coded as SD^{--} . Table 2 presents the translation device for semantic density

Table 2: Semantic Density Translation Device

Allocated Code	Criteria
SD^{++}	The chemical problem or question must be first being identified before any interpretation or manipulation can be done in order to get solution/answer to the question. That is multiple steps are required.
SD^+	The given information needs to be manipulated –unpacked before it can be interpreted
SD^-	only one term/structure is given and needs to be interpreted in order to answer the question
SD^{--}	No chemical terminology or concepts are required to answer the question

The ideas of semantic gravity and semantic density have been used effectively in the context of teaching and learning subjects in various aspects of education. For example, nursing (McNamara, 2010), English (Macken-Horarik, 2011), physics (Georgiou, Maton, & Sharma, 2014), chemistry (Blackie, 2014; Grangea & Blackie, 2018). Uphahi, Isreal and Olorundare, 2017; Blackie, 2014 analyzed chemistry questions at the undergraduate level and found that most chemistry questions being asked were at comprehension and remembering levels. This will not encourage conceptual understanding and hence do not lead to meaningful learning. Grangea & Blackie (2018) also analysed exam questions in general chemistry at undergraduate level and revealed that the contextual manner in which questions were formulated in the course fails to shape the students learning towards developing a meaningful understanding of the core concepts covered in the curriculum. The purpose of this study, therefore, is to explore the structure, as well as the nature of the knowledge at play in the NECO chemistry examination questions using the LCT concept of semantic dimensions. The study has two aims: 1) To determine the complexity and abstractedness of the items of NECO chemistry examination questions to ensure conceptual understanding. 2) To find out whether science students pass chemistry better in NECO than WAEC because of simplicity of the questions or not.

Research Objectives

1. To determine the strength of semantic gravity of 2018 and 2019 NECO chemistry questions
2. To determine the strength of semantic density of 2018 and 2019 NECO chemistry questions

Research Questions

1. What is the strength of semantic gravity of 2018 and 2019 NECO chemistry questions
2. What is the strength of semantic density of 2018 and 2019 NECO chemistry questions

Research Method

The Content research design was used in this study. The sample size of the study comprised of 250 NECO chemistry questions (133 for 2018 and 117 for 2019). NECO chemistry question is made up of three papers namely I, II and III. Paper I is practical (which was not part of this study) while II and III are objectives and essay written together. This study concentrated on paper II and III of the chemistry questions. Paper III is made up of 60 objective questions which required the learners to select from the responses and paper II is made up of six assay questions which requires written responses or calculations. In assay questions, each sub-question was considered as single question while each objective question was taken as a single question. Semantic gravity and semantic density translation devices were developed and used as analytical tools.

In this study, the semantic gravity and density of each question from both objective and essay was first identified separately by different researchers. Inter rater reliability of 0.73 was obtained. Frequency count and percentages was used as data analysis techniques.

Results

Table 3: Distribution of 2018 Chemistry questions in NECO Based on Semantic Gravity

Allotted code	SG^{++}	SG^{+}	SG^{-}	SG^{--}
Frequency	54	54	17	4
Percentage	43.60	40.60	12.80	3.10

Table 3 shows the distribution of chemistry questions in NECO with respect to the semantic gravity. The result shows that out of 133 questions: 54(43.6%) items were with the weak semantic gravity (SG^{++}), 54(40.6%) were with the weakest semantic gravity (SG^{+}), 17(12.80%) items were with the strong semantic gravity (SG^{-}) and 4(3.10%) items were with the strongest semantic gravity (SG^{--})

Table 4: Distribution of 2018 Chemistry questions in NECO Based on Semantic Density

Allotted code	SD^{++}	SD^{+}	SD^{-}	SD^{--}
Frequency	10	34	69	20
Percentage	7.5	25.6	53.1	15.0

Table 4 displays the distribution of 2018 chemistry questions in NECO based on semantic density i.e the amount of chemical terms in a given item. The result indicates that out of 133 chemistry questions: 20(15.0%) items have weakest semantic density (SD^{--}), 69(53.1%) have weak semantic density (SD^{-}), 34(25.6%) have strong semantic density (SD^{+}) and 10(7.5%) have strongest semantic density (SD^{++}).

Table 5: Distribution of 2019 Chemistry questions in NECO Based on Semantic Gravity

Allotted code	SG^{++}	SG^{+}	SG^{-}	SG^{--}
Frequency	51	47	11	9
Percentage	43.2	39.8	9.4	7.6

Table 5 shows the distribution chemistry questions in NECO with respect to the semantic gravity. The result shows that out 118 questions: 51(43.2%) items were with the weak semantic gravity ((SG^{++}), 47(39.7%) were with the weakest semantic gravity (SG^{+}), 11(9.4) items were with the strong semantic gravity (SG^{-}) and 9(7.6%) items were with the strongest semantic gravity (SG^{--})

Table 6: Distribution of 2019 Chemistry questions in NECO Based on Semantic Density

Allotted code	SD^{++}	SD^{+}	SD^{-}	SD^{--}
Frequency	10	32	34	42
Percentage	8.5	27.1	28.8	35.6

Table 6 displays the distribution of 2019 chemistry questions in NECO based on semantic density i.e the amount of chemical terms in a given the item. The result indicates that out of 118 chemistry questions: 42(35.6) items have weakest semantic density (SD^{--}), 34(28.8) have weak semantic density (SD^{-}),, 32(27.1) have strong semantic density (SD^{+}) and 10(8.5) have strongest semantic density (SD^{++})..

Discussion of the Results

The aim of any summative evaluation is to determine the level of understanding reached by the students at the end of a given program about a specific curriculum. In order to achieve this objective, there is need to assess the students over wide range of abstraction and complexity.

The result of this study revealed that majority of NECO chemistry questions have weak semantic gravity 84 %(2018) and 82.9 %(2019). Only few questions have strong semantic gravity 16 %(2018) and 17.1 %(2019). Majority of the questions focused on the application of one concept / phenomenon to a specific example. For instance, chlorine atom and chlorine ion have same (a) chemical properties (b) electron charge (c) electronic configuration (d) number of protons. To answer this question, only knowledge of atomic structure is needed which is a single concept. The present finding is consistent with the findings of some studies in the literature who found that vast majority of chemistry assessment has narrow or weak range of semantic gravity (Blak, 2014; Grangea & Blackie, 2018). This could be the plausible reason that students consistently struggle in trying to understand chemical concepts at undergraduate program and other tertiary institutions. The students' ability to abstract concepts from the context in which it is taught and display in a more comprehensive understanding that would be applicable to a broader context, is not being assessed in any question that has weak semantic gravity (Grangea & Blackie, 2018)

Another important finding emanating from this study is that majority of the questions have narrow semantic density i.e the complexity level of the questions. Majority of NECO chemistry questions have weak or narrow range of semantic density 66.8 %(2018) and 65 %(2019). Only few questions, 33.1 %(2018) and (35% (2019 have strong semantic density. The questions with weak semantic density are those that either requires only one chemical concept or even no chemical terminologies in order to arrive at the answer. This could lead to students' inability to transfer what they have learnt from one section of the curriculum to the another. The present finding of this study is in agreement with finding of (Blakie, 2014; Uphahi, Isreal & Olorundare, 2017;Grangea & Blackie, 2018) who reported that most of chemistry questions have narrow range of semantic density and argued that this is one of the reasons why students find chemistry concepts difficult. This in turn makes the students to lack meaningful learning in chemistry and other related disciplines that require chemistry knowledge as pre-requisite.

Conclusion

Analysis of NECO chemistry questions for the years 2018 and 2019 revealed that there is need for adjustment of chemistry questions in terms of complexity and abstraction if meaningful learning and conceptual understanding has to be assured. It is only if the students understand chemistry meaningfully that the learnt idea can be manipulated innovatively in meeting the demand of today's world. The results of this study also disclosed that most of the questions have narrow or weak semantic gravity and density. This means that most of the questions framed in this examination fail to shape the students learning towards developing a meaningful understanding of the core concepts covered in the curriculum. This could be one of the reasons that students consistently perform non-satisfactorily in the examination. Moreover, even those passed with good grade; struggle to engage with these concepts when framed in different forms.

Recommendation

1. The study recommends that examination bodies such as WAEC, NECO etc should make effort in ensuring that the complexity and abstraction levels of the items should be improved.
2. Chemistry educators and teachers should make sure that the semantic gravity and density of end of terms exam chemistry questions are adequately good so that students can use what they have learnt in different situations
3. The semantic dimension of Legitimmation code theory should be applied in analyzing examination questions and hence educators and teachers should adopt it in order to improve the quality 0f their questions.

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