Chapter 5
Are Our Students Learning and Understanding Chemistry as Intended? Investigating the Level of Prior Knowledge of UNIVEN Students for the Second Year Inorganic Chemistry Module

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1 Introduction

Chemistry is an example of what Neumann (2001) describes as a “big science”; it is a hard pure discipline. In the teaching of hard pure disciplines, the ‘oldest’ knowledge (the knowledge established since long) is presented at the lower levels of instruction, as it constitutes the basic knowledge, whereas more current or advanced knowledge is taught at more advanced levels, such as senior undergraduate level (Neumann 2001).

Learning chemistry, like any other science, is a cumulative process where the teaching and learning of new information/concepts builds on what students already know (Neumann 2001; Ozmen 2004; Emondson 2005; Zoller 1990). What the students learn depends on their interpretation, because they bring to lessons pre-existing (alternative) conceptions about scientific phenomena (Barke et al. 2009; Palmer 1999, 2001; Taber 2000 in Ozmen 2004). These alternative conceptions can influence the way in which meaning is constructed in students’ minds and at times interfere with the learning of correct scientific principles or concepts (Ozmen 2004). The term ‘misconceptions’ is used synonymously with pre-existing or alternate conceptions throughout this document, inasmuch as they are different from the established concepts as accepted in a given field.

Misconceptions can be defined as ideas students have about concepts, which are inconsistent with scientific conceptions (Ozmen 2004). They reflect the complex nature of the multiple causes of students’ erroneous conceptions. There is a difference between lack of knowledge or concept and misconception. A lack of concept or knowledge can be remedied with instructions and subsequent learning, while

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L. Mammino, J. Apotheker (eds.), *Research in Chemistry Education*,
https://doi.org/10.1007/978-3-030-59882-2_5

misconceptions need unlearning before new material can be learned. As such, methods for eliminating misconceptions and for remedying lack of concept may differ considerably (Hasan et al. 1999).

If students fail to acquire the appropriate knowledge, they may have difficulties participating in the disciplinary discourses (Biggs 1999). This will make it difficult for students to acquire problem-solving skills, ways of thinking and working in the discipline (Biggs 1999). Furthermore, after graduation, they may not be able to deal with the ever changing and complex challenges in the global and information-based society (Biggs 1999).

The process of students making their own meaning is the basis of the constructivist approach prevalent in science learning. This approach assumes that the knowledge and understanding of concepts arise from the variety of contacts with the physical and social world, or as a result of personal experience, interaction with teachers, other people or through the media (Gilbert and Zylberstajn 1985 in Ozmen 2004; Palmer 2001). Since misconceptions can interfere with quality chemistry learning, it is incumbent on teachers to determine ways of prevention or remediation (Schoon and Boone 1998). The teacher should strive to help students achieve good, chemically accurate understanding of the concepts.

The misconceptions can be deeply rooted in students' minds because they have been acquired over years and are, in their nature, difficult to change. They can, thus, form part of the students' core beliefs (Ozmen 2004). Factors such as teaching approach, assessment criteria, use of models, internet-based teaching (ICTs) and so forth, can also contribute to the creation of misconceptions in students' minds (Kind 2004; Nahum et al. 2004; Boo 1998).

The majority of students at the University of Venda are African and from rural areas (where educational institutions are under-resourced) and English is not their mother-tongue. A significant percentage of students, therefore, show poor English language proficiency and thus experience difficulties understanding lectures, let alone the textbooks and other chemistry literature, or the disciplinary terminology. These difficulties could lead to misconceptions. Furthermore, for these students, articulation gap is expected, which further increases the barriers to learning. Articulation gap is defined as the mismatch between the learning requirements of the current module and the skills and competencies acquired from the previous prerequisite module (Fischer and Scott 2011). It means that there is a difference between the skills and competencies that are required for the module and those possessed by the students. This may be due to the mismatch between the minimum requirements for the module and the academic preparedness needed for success in the course (ibid). The presence of articulation gap causes a discontinuity in the students' learning process as they move from a previous level to a more advanced one.

In an effort to unearth misconceptions held by students as they begin the 1st semester Inorganic Chemistry II course (course code: CHE 2521), this study analyses responses to a diagnostic test based on high school and 1st year chemistry syllabi. The approach was aimed at allowing the students to express their views on different chemistry subjects (National Research Council 1997). Since a qualitative research approach was chosen, questions and discussions are used to probe misconceptions (National Research Council 1997). Some misconceptions have been discovered by asking students to sketch or describe some object or scientific phenomenon (National Research Council 1997). The use of a diagnostic test based on the preceding modules and given at the beginning of the course can be another way of inducting students into the chemistry discipline. It gives the new students an idea of what sort of preparatory work or level of skills is required for enrolment into the course. The test will also give the teacher an idea of how well prepared the students are for the course. The literature reports that in all sciences, including chemistry, phenomena are associated with some form of students' misconceptions. The literature reports studies on students' misconceptions related to chemistry concepts, and investigates their possible causes also through blended learning and examinations (Ozmen 2004; Tan et al. 2002). The current study reports on possible misconceptions implied by the responses to the diagnostic test based on hybridization, electronegativity, octet rule, bonding, periodic table, electronic configuration, Lewis structures and resonance. These concepts were selected as those for which incorrect answers were encountered frequently and which, therefore, posed challenges for the majority of students enrolled for undergraduate chemistry modules.

2 Motivations for the Study

The following observations from interaction with students are some of the factors that have motivated the study:

- General fear/negative perceptions from the students, e.g. "Chemistry is difficult"
- Widely spread memorization, which leads to cheating in tests and examinations
- Poor conceptual understanding of scientific principles/concepts
- Lack of interest in pursuing post-graduate studies (concerns the majority of students)
- High failure rate (low class average marks)
- Lack of participation in class
- Answering questions that were not asked
- Frequent cheating in tests and examinations (by illegal material or copying from each other)
- Difficulties in constructing coherent scientific arguments
- Reproduction of materials from the notes, textbooks and model answers in tests and examinations.
- Desperate need for model answers, that students memorize
- Few students own textbooks

The above-mentioned points were perceived as out of the ordinary by the author and prompted the current study as a way of finding out the possible underlying students' learning issues.

3 Methodology

The subjects of the research were 80 students of the University of Venda, majoring in chemistry, in their second year during the 2015 academic year, and who had enrolled for the CHE 2521 module. A qualitative research was carried out to identify their level of preparedness and possible misconceptions. The instrument used was a set of nine discussion questions as part of diagnostic test. The test contained no multiple choice questions or questions requiring one-word answers, to minimize the chances of guessing. Furthermore, the instructions informed that the test would not count for formal assessment. The author believes that, under these circumstances, the students would gather that only their honest opinions and impressions were sought, without consequences for them. Due to the created atmosphere of lack of perceived personal incentives or direct consequences, the author was confident that the students would be free to give their honest opinions. The students with lack of knowledge on particular questions were expected to leave blank spaces or to indicate that they did not know the answer. The majority of students answered most of the questions and no totally blank answer sheet was returned. The absence of response to certain questions was interpreted as due to lack of knowledge of the given concept, since there would be no perceived reason or incentive to give misleading answers.

The responses recorded in the present work were selected from the answers to questions in the diagnostic test (see Appendix A). The answers were analysed to identify module-wide misconceptions held by students of that group. The misconceptions are identified by analysing the meaning and implications of the responses to each question. The misconceptions identified or hypothesised in this study are viewed as representative of the learning challenges faced by students enrolled for the CHE 2521 module. The concepts with most incorrect responses are deemed as ones for which misconceptions abound. Conversely, those associated with few incorrect responses are viewed as containing less or insignificant level of misconceptions. The author is also aware of the fact that the number of implied misconceptions does not necessarily say anything about the degree to which they impact on a student's learning. The incorrect responses to questions on certain concepts may be few, but of such a serious nature that they hamper learning to a greater degree.

Different approaches for the elimination of misconceptions associated with various chemistry concepts are reported in the literature. It is further confirmed from literature that the methods developed in the framework of the constructivist learning theory are used to remove such misconceptions (Üce and Ceyhan 2019).

4 Results

The results of this study are based on the analysis of students' answers to the diagnostic test. For the sake of clarity, the responses to the test's individual questions are discussed in separate subsections. Representative responses to each of the questions are reported in tables and the inferences on students' preparation are outlined in the same subsection.

4.1 Responses and Misconceptions About Chemical Bonding

Representative responses to questions related to covalent bonding, ionic bonding and intermolecular forces (Question 1 (a) and (b)) are reported in Table 5.1.

The responses show that students have made a distinction between ionic (metals-nonmetals) and covalent bonding (between non-metals) which do not necessarily exist in nature (Nahum et al. 2004). For example, bonding in coordination compounds show characteristics of both ionic and covalent (ibid). There does not seem to be a clear understanding of the role of electrons in bonding. This is in agreement with the findings by Nicoll (2001), who verified that students confuse ionic, covalent and hydrogen bonds and cannot define covalent bond.

The responses also show that students do not understand bonds and intermolecular forces and cannot distinguish bonding the two. Even though they have come across bonding theory and concepts from a 1st year module, they have not been able to construct accurate conceptual frameworks. These results suggest that students passed the previous exams (high school and 1st year) through memorization. They also suggest that students may have passed those prior examinations through other means rather than understanding: they may have copied from other students during the exams or brought illegal materials into the examination rooms.

The literature suggests that misconceptions related to chemical bonding – like those mentioned above – can be eliminated by making students create models and use them while expressing concepts about chemical bonds (Üce 2015) and by

Table 5.1 Representative responses to a question about chemical bonding

Question: *Distinguish between the following:*	
	(a) Covalent and ionic bond
	(b) Intermolecular forces and bonds
#	**Responses**
1	Covalent bond occurs between non-metals
	Ionic bond occurs between non-metals and metals
2	Intermolecular forces hold electrons in an atom
	Bonds are strong forces of attraction between ionic molecules
3	Intermolecular forces are joining together of two molecular with attractive force
	Bonds are joining together of two molecules
4	Intermolecular forces between electrons which keep the electrons close to each other
	They bind two or more elements without the sharing of electrons
	Bonds are forces that attracts electrons of an atom
5	Intermolecular forces are those that attract electrons in an atom. They occur in the particles of an atom or compound. Intermolecular forces occur when there is a sharing of electrons

preparing guiding materials on ionic bonds based on the constructivist model (Kayalı and Tarhan 2004).

4.2 Responses and Misconceptions About Electronegativity

Representative responses to a question related to electronegativity are reported in Table 5.2.

Students seem to generally understand that electronegativity has to do with ability or force that facilitates the transfer of particles (e.g. electrons). They generally believe that electronegativity has to do with the ability that facilitates transfer of particles between substances. The misconceptions reveal themselves when this 'ability' is expressed in terms of a force, energy or a process. The transfer process refers to 'gaining and attracting' for some students and 'losing and repelling' for others. The particles appear to be electrons to some students and atoms to others. Substances between which particles are transferred are electrons, atoms or between the two (an electron and an atom). Some explanations (e.g., answer 15) have a 'social' connotation; this is an example of what Nahum et al. (2004) refers to as anthropomorphic explanations. Few other students seem to have no clue about what electronegativity is; this is indicated by answers such as 1, 3, 14, etc. Similar to Nicoll (2001)'s subjects, no student linked electronegativity to bonding (bond polarity in particular). However, students' responses were generally not far off from the

Table 5.2 Representative responses to a question about electronegativity

Question*: Discuss electronegativity*	
#	**Responses**
1	Ability of an atom to react and move
2	It gives an indication on weather an element
3	It is the charge that an atom has
4	It is the energy of an atom
5	Ability of electron to attract an electron for itself
6	Ability of an atom to attract a lone pair of electrons
7	Measure of the ability of an atom in a molecule to move from one element to another
8	Measure of attraction of atom to attract another atom
9	A process in which an atom attracts an atom to itself
10	Energy required to remove an electron in an atom
11	Capability of an electron to attract other electrons to itself
12	Force of repulsion due to electrons
13	A number of electrons that are present in the element
14	Ability of an atom to bond
15	Measure of the ability of an atom to compete for an electron
16	Ability of an atom to donate or lose electron

correct answer. Good grasp of electron configuration is essential for understanding periodic properties, e.g. electronegativity of elements.

Demircioğlu et al. (2005) reported the misconceptions regarding trends on the periodic table (for example, those of electronegativity and ionisation energy). They used narration as a remedy for identified misconceptions. The narration scopes include associating chemistry concepts to daily life (e.g. items in supermarket); establishing social and technological structure in chemistry class properly; helping improve students' attitude in the class through presentations of scientific concepts in daily situations; and raising individuals with scientific literacy.

4.3 Responses and Misconceptions About Hybridization

Representative responses to a question about the hybridization of atomic orbitals are reported in Table 5.3.

The hybridization concept seems to be the least understood, and the majority of answers show a wide range of misconceptions coupled with total misunderstanding. It was rarely associated with bond formation, e.g. 'formation of new special bonds', 'overlapping of atoms or orbitals', 'fusion of elements', etc. These definitions suggest lack of understanding of concepts such as atoms, elements and orbitals. Most answers to this question were really off the mark, as indicated by definitions such as 4, 5, and 7 in Table 5.3. Incorrect conceptions and descriptions were varied, and most of them suggested unfamiliarity with general chemistry texts or literature; it is the case of answers 4, 5, 6 and 7 in Table 5.3. Reading the responses one gets the perception that students have not fully engaged with the material related to the concepts. It is as if they are using guess work, like in answer 11.

Table 5.3 Representative responses to a question about hybridization

Question*: Define Hybridization*	
#	**Responses**
1	Mixing of electrons on the orbitals form other orbitals
2	Mixing of atoms in order to get a more complex molecule
3	Mixing of atomic orbitals to give new atomic orbital
4	Reaction of hydrogen with other molecules, thus hydrogen is added
5	Addition of elements to an atom which makes it to change shape and characteristics and geometry
6	It is the state of the formation of many structures formed as a result of delocalization of the electrons in a molecule
7	It refers to the exchange of an electron from different atom bonded together
8	It refers to the overlapping of orbitals of different atoms
9	It is associated with the formation of new bonds. Bonds between atoms break in order to form *spd* bonds
10	It describes how atom overlap each other and the type of geometry formed
11	Elements fused to form newly hybridized elements

Some students seem to capture information about the concepts in the form of chunks, but do not know how the relevant pieces of information relate to each other; examples are answers 3 and 7. Some of the answers were not far off; for example, answers 1 and 2 and, even closer, answer 3. These answers may suggest that the students have the main idea, but got somewhat confused when expressing it; but they could also indicate lack of understanding of chemistry concepts such as atoms, orbitals, and molecules.

The above results are similar to those obtained by Hanson et al. (2012) when they investigated misconceptions regarding atomic orbitals and hybridization among undergraduate chemistry students. The diagnosed misconceptions emanated from poor conceptualization of the octet rule, the shapes of hybrid orbitals and the driving force of hybridization, among other factors. The implementation of deliberate use of a conceptual teaching approach, in line with the cognitive theory, is recommended, as it has been reported to improve conceptual understanding among undergraduate students.

4.4 Responses and Misconceptions About Resonance

Representative responses to a question related to resonance are reported in Table 5.4.

Some answers were not far off, such as answers 5 and 6; others were outright wrong or showed total confusion of terms, like answers 2 and 3. Again, these responses suggest lack of in-depth understanding of basic chemistry terms such as element, molecules, chemical formula, chemical structure, etc. On the other hand, some responses (including answers 1, 2 and 3) may also suggest that students may have an idea of what resonance is and can perhaps recognize it, but they do not have the appropriate vocabulary to describe it. Answer 4 suggests that students appear to use surface approach to learning and do not engage with concepts deeply enough, and this leads to widespread confusion of terms. One also gets the perception that students rarely consult reading materials or other sources such as textbook and chemistry literature. The description in answer 6 suggests that there is a difference

Table 5.4 Representative responses to a question about resonance

***Question**: Define resonance*	
#	**Responses**
1	Resonance shows direction of chemical reaction
2	It is the rearrangement of electrons in atoms
3	Resonance is a substance used to neutralize the charges or to remove charges of chemical solutions
4	The structural molecules which have more than two structural molecules
5	It is the same structural formula but differ in arrangement of elements
6	Different atoms or substances form bonds where the bonds rotate in the molecule or reaction to give different structures

in the way students make meaning from concepts; in other words, students have different frames of reference from those of the teacher, textbooks and literature. Thus, these responses show the need to put more focus on finding out how students make meaning of the chemistry concepts (Nahum et al. 2004).

Furthermore, the reported answers on resonance structures also highlight students' thinking in relation to chemical reactions, electrons and atomic arrangements, charges and bonds. Literature reports misconceptions associated with resonance structures as being related to misconceptions on concepts like reaction equilibrium, charges, stability, atomic and electron arrangement (Widarti et al. 2017). It is recommended that emphasis be placed on drawing Lewis structures, clearly distinguishing between isomers and resonance structures, and depicting resonance structures, in addition to implementing innovative constructivist teaching methods, e.g. using multiple representations, to eradicate identified misconceptions.

4.5 Responses and Misconceptions About the Periodic Table

Representative responses to a question related to the description of groups and periods of the periodic table are reported in Table 5.5.

Groups and periods in the periodic table represent the most basic terms and language used widely in chemistry. Seeing the confusion prevalent around these terms (e.g., answers 1, 2) is sad, because it means that students cannot clearly participate in, or follow some discourses and discussions related to the trends in the periodic table. Views such as those expressed in answers 3 and 1 show that students have no idea what these terms are about. Since students are unsure about these concepts, they may be taking chances by writing as many views as possible (even as contradictory as the views above) with the hope that one of them may be correct. This

Table 5.5 Representative responses to a question about the periodic table

***Question**: Describe groups and periods in the Periodic Table*	
#	**Responses**
1	Groups are rows across the periodic table. Vertical elements
2	Periods are columns on the periodic table. Horizontal elements.
3	Periods are vertical elements and are from left to right on the periodic table.
4	Groups of atoms arranged according to specific categories, e.g. metals are grouped together on the periodic table
5	Groups are classified according to stability. They are horizontally arranged and start from top to bottom
6	Groups are read from left to right in the periodic table.
7	Periods are all rows from 1 to 18.
8	Groups represent the outer shell electrons of atoms.
9	Periods represent the distance between the outer shell electrons and the nucleus of atoms.

shows that they are just guessing. Even more confusion is shown by responses 8 and 9. Some responses are not too far off, like answers 4 and 5.

The misconceptions associated with the meaning of groups and periods in the periodic table can be remedied by using analogy, e.g. how items in the supermarket are packed. The knowledge of electron configuration is essential for understanding groups and periods in the periodic table. Misconceptions on this are often revealed by the students' inability to identify the group and period to which a certain element belongs.

4.6 Responses and Misconceptions About the Lewis Structures

For this question, students were required to draw the structures; therefore, very little comments were given. However, the answers (drawings) revealed the following unexpected occurrences:

- Some Lewis structures with three and more atoms contained no central atoms when they should have had it
- Some structures violated the octet rule
- The lone pairs were situated on either side of the central atom and separated into single electrons.

The familiarity with the Lewis structures of molecules is fundamental to understanding covalent bonding. However, the familiarity with Lewis structures among students seems limited; in particular, the understanding of the key concepts to be applied when drawing a Lewis structures seems limited. The errors in the drawings also raise suspicions as to whether students consult reading materials such as textbooks and other sources. Sound knowledge of electronic configurations and the octet rule is essential for mastering Lewis structures. Luxford and Bretz (2014) also identified lack of understanding of the octet rule as a first step towards misconceptions relating to bonding representations like the Lewis structure.

4.7 Responses and Misconceptions About Electron Configuration

Representative responses to a question related to electron configurations are reported in Table 5.6.

The responses show that students associate electron configuration with inappropriate other concepts, e.g. oxidation number (answer 1). This clearly indicates confusion of terms, and limited understanding of basic aspects of atomic structure theory. Therefore, accurate treatment of basic atomic structure theory is necessary to overcome these misconceptions.

Table 5.6 Representative responses to a question about electron configuration

***Question**: Describe electron configuration*	
#	**Responses**
1	It tells us whether an atom is able to lose electrons quicker or easier or if it adds electrons
2	It tells if element has high reactivity, physical properties and stability

Table 5.7 Representative responses to a question about the oxidation number

***Question**: Describe oxidation number*	
#	**Responses**
1	Number of electrons lost
2	A measure of how high is the degree to react with oxygen
3	Number of electrons an atom has in a periodic table
4	Reason in which an atom loses or gain an electron
5	State in which an atom is oxidized
6	Total number of electrons an atoms has
7	Number left when a elements reacts with a oxygen
8	Number that has been reduced
9	The number an atom has in a compound
10	It's the gaining of electrons
11	The number added or donated to a substance
12	The number showing how an atom is oxidized
13	Oxidation number that represents oxidizing agent
14	Loss of electron of an element
15	It is the number presented by irons of an atom

4.8 Responses and Misconceptions About the Oxidation Number

Representative responses to a question related to the oxidation number are reported in Table 5.7.

The answers show a wide range of misconceptions. They give one the idea that students have only superficially engaged with the theory, but do not have a complete grasp of the concept. It seems they only remember some facts about the concepts, but cannot present full and coherent explanations. For instance, they are aware of electron transfer, but without knowing how it happens, and they recall that the oxidation number somehow relates to the number of electrons lost. There seems to also be confusion of terms, as issues totally unrelated to the oxidation number are included in the discussion, like in answers 2 and 3.

Shehu (2015) also identified similar misconceptions with regard to the determination of which species is oxidized or reduced and the determination of the oxidation state of the species involved in a reaction. The diagnosis of misconceptions needs to be followed by the planning of lessons which integrate new information in order to enhance unlearning of alternate conceptions while adopting new ways of thinking; setting up convincing laboratory experiences, and using more structural models or technology–based method, are recommended as remediation methods.

4.9 Responses and Misconceptions About the Octet Rule

Representative responses to a question related to the octet rule are reported in Table 5.8.

Students seem to have a general idea that the octet rule involves eight electrons, stability and bonding. However, they do not seem to know how the three features relate, as clearly highlighted by answers 2, 3, and others. Students seem to have a tough time linking terms/features that are essential in the octet rule. It is as if they remember only certain words and terms that are disjointed, likely as a result of memorization.

Misconceptions about the octet rule are found also in other contexts. For instance, Ozmen (2004) reports about students not linking the term octet to the number 8, as some students involved in his study believed that 'nitrogen atom can share five bonding pairs of electrons', leading to ten electrons around nitrogen atom instead of eight.

5 Conclusions

A qualitative research method using a diagnostic test as a tool of analysis was applied to test the level of preparedness and the presence of misconceptions for students enrolled for the 2nd year Inorganic Chemistry module (course code: CHE

Table 5.8 Representative responses to a question about the octet rule

***Question**: Describe the octet rule*	
#	**Responses**
1	Shows that an atom doesn't not need to show bonds because it is already stable.
2	It's the rule that mainly includes compounds with eight electrons
3	It requires eight bonds for stability
4	It occurs when there are eight electrons or bonds
5	The chemical substance must have maximum electrons of eight
6	It is the molecular which contacts the bonding of eight electrons
7	States that each atom involve in the bond formation must have a total of eight electrons at the end of a reaction.
8	Maximum of sharing eight electrons in a molecules

2521) at the University of Venda. The results revealed that misconceptions related to hybridization, electronegativity, octet rule, chemical bonding, groups and periods in periodic table, electronic configuration, Lewis structures, oxidation number and resonance abound. The concepts tested form part of high school and 1st year syllabi. In this way, students do not seem to be adequately prepared for the concepts in the 2nd year level module.

Students seem not to have formed and developed appropriate frames of references needed to deal with chemistry concepts. These are students who have successfully completed their 1st year general chemistry module, in which concepts included in the diagnostic test form part to the syllabus. There are reasons to believe that student engage in practices that make them effective at test-taking and examination-writing, without understanding the subject matter.

Close analysis of students' responses to the diagnostic test leads to a number of conclusions.

The students' responses suggest that surface learning is the common approach among the respondents. This leads to memorization of facts. Memorization without fully understanding the core meaning of concepts leads to forgetfulness, recalling of disjointed facts, and at times total confusion. The responses to most questions showed that students remember only part of the information and often fail to link or associate facts accurately, as the responses were largely incoherent and at times confusing.

The lack of adequate chemistry vocabulary is also apparent. This may be a direct result of not acquiring textbooks or not consulting other chemistry sources. It is further confirmed by the difficulty students have in engaging and discussing chemistry concepts. They are unable to use disciplinary terminology in their discussion. One gets the impression that students have a lack for words or vocabulary to express themselves. Therefore, end up using wrong words, thus failing to convey the message they intend to. Language proficiency also seems to be lacking as one reads more and more badly constructed sentences.

Close analysis of CHE 2521 promotion results for 2013, 2014 and 2015 showed pass rates over 50%. The fact that the majority of students end up passing the CHE 2521 module suggests something related to teaching approaches or assessment criteria. There may be misalignment between learning outcomes and assessment criteria (Gibbs 1999). It seems as if the level at which students are assessed (in tests, assignments and examinations) is lower than expected. The assessment may be testing recall, by requiring short or one word answer. This sort of assessment does not test true understanding of concepts. Students look to assessment criteria to determine what they need to pass the course (Gibbs 1999). If the assessment seeks for conceptual understanding by requiring students to make their thinking and understanding explicit, then the quality of learning may improve.

Appendix: The Diagnostic Test

CHE 2521(Diagnostic test; Inorganic chemistry)				
Instructions				
1. Answer all questions giving as much information as you can.				
2. Write neatly and legibly.				
3. The test will not count for marks.				
Questions				
1. Distinguish between the following:				
(a) Covalent and ionic bond (b) Intermolecular forces and bonds				
2. Discuss electronegativity and how it changes in the periodic Table.				
3. Define hybridization.				
4. Define resonance.				
5. Describe features of the Periodic Table:				
(a) periods (b) columns				
6. Draw the Lewis structure for the following compounds:				
(a) CO_3^{2-}	(b) NO_3^-	(c) XeF_6	(d) ICl_2^-	(e) BF_3
7. (a) Describe the electronic configuration of a substance. (b) What information can one gather from electronic configuration of a substance?				
8. Describe oxidation number.				
9. Describe the octet rule.				

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