Students' Misconceptions about Bonding and Chemical Structure in Chemistry

Ephias Gudyanga[1], Tawanda Madambi [1],
[1]Midlands State University
Faculty of Education
Gweru, Zimbabwe

Abstract

This paper sought to find out the students' misconceptions about bonding and chemical structure in Chemistry at secondary school level. Simple descriptive survey was the main design. Participants were comprised of eighty (80) randomly sampled out Form 3 and Form 4 pupils. A 15 point Likert Scale (test) and a group interview were used as data collection instruments. There was a concordance in the sets of findings using descriptive statistics, inferential statistics and interviews showing that students had misconceptions in strengths of chemical bonds (89%, F_{4df}=11.35;$p<0.05$), shapes of molecules (75%; F_{1df}=10.39; $p<0.05$), coordinate bonding (68%, F_{2df}=14.56; $p<0.05$), molecular/ionic charges (61%, F_{2df}=11.33; $p<0.05$) and hydrogen bonding 60%, F_{4df}=10.49;$p<0.05$). It was recommended that ways of minimizing students' misconceptions could include use of conceptual chemical models, use of e-learning for example Cyber School. Learning environments should be more visual than conceptual. Science teachers should be equipped with the various strategies for teaching skills so as to improve teaching and learning in science.

Key words: Misconception, Bonding, Covalent, Ionic, Chemical, Structure.

Introduction and Background

Many students say that Chemistry is a difficult subject (Carter & Brickhouse, 1999).These perceived difficulties are part of the context in which students develop Chemistry concepts in their minds. Being able to recognize and work with student-held ideas and misconceptions is a key component for any Chemistry teacher to be successful. One of the main barriers that students encounter as they work to understand Chemistry are conceptions which they hold in their minds, the visual images they form in their short term memory and eventually the concepts they code into their long term memory for further retrieval and usage. Teachers can be astonished to learn that despite their best efforts, students do not grasp fundamental ideas covered in class. Even when some of the best students give the right answers (Mazur, 1997), they are often memorized words which are correctly used. When probed further, these students reveal their failure to understand the underlying conceptions fully (Mazur, 1997).

Thus, in our role as teachers, besides offering students information and helpful examples, we must also be able to guide them on the reasoning processes that lead to algorithms and conceptual generalizations. In many cases, students have developed an ability to provide correct solutions to examination problems and questions most of the time, not so much via correct reasoning and conceptual understanding, but rather because they have either come up with generalizations or are familiar with the often-featured questions, Mazur (1997). Further Chemistry learning, which lacks appropriate understanding of fundamental concepts from the beginning of their studies may have negative implications amongst the affected students. Therefore, it is necessary for students to understand the basic concepts in Chemistry as they learn it in secondary schools.

Chemistry, as a subject, is concerned with the properties and reactions of substances, (Johnstone, 1991). Substances are often understood in terms of aggregations of particles, and the nature of the bonding between those particles is used to explain many of the chemical and physical properties of the substances including such aspects as whether the substances are solids, liquids or gases at a given temperature and pressure. The theoretical content of Chemistry is best seen as a set of models. Gilbert (2003) claims that models play a major role in all science disciplines; nevertheless, they seem to be particularly problematic to Chemistry students. Students live and operate in the macroscopic world of matter. Unfortunately, they do not perceive Chemistry as related to their surroundings. Moreover, they do not easily follow shifts between the macroscopic and microscopic levels.

Ross and Munby (1991) found out that students had misconceptions in the topic acids and bases. For example, students considered that the acids tasted bitter and hot. Schmidit (1995) also found out that students did not have well developed conceptions about how to differentiate acids from bases. The effect of oxidation and reduction is also a difficult concept for students to conceptualize. Students believe that the oxygen that made the iron rust was from the water and that the rusted iron has the same weight as the original iron (Hesse & Andersen, 1992). In general, students have various misconceptions in different topics in Chemistry.

Chemical bonding is an abstract topic, something appearing far removed from the daily experiences of secondary school students. As students cannot see an atom, it is difficult for them to understand the concepts involved in the topic of chemical structure and bonding and there is great potential for the formation of student misconceptions (Taber, 2003). Teachers need to be aware of students' misconceptions of various ideas associated with chemical structure and bonding in order to develop teaching strategies to enable their own students to construct ideas of chemical bonding which are compatible with the scientific concepts.

Chemical structure and bonding is one of the key and basic fundamental concepts in Chemistry (Tan & Treagust, 2001). Understanding the subject of chemical bonding is crucial for students' further learning because it underlies most of the advancing subjects in Chemistry. The concepts regarding the topic chemical structure and bonding are essential for the understanding of many concepts and topics in Inorganic Chemistry, Organic Chemistry and Physical Chemistry. It is therefore necessary for students to construct the meanings of chemical bonding concepts properly.

The concepts associated with chemical structure and bonding, such as molecules, ions, covalent bonding, and ionic bonding (Boo, 2000; Miha, 2007; Taber, 2003) are abstract and students have misconceptions. To date, it seems there is no research done in Zimbabwe concerning student misconceptions about chemical structure and bonding in the teaching and learning of Chemistry.

This study is an attempt to identify students' misconceptions about chemical structure and bonding in Chemistry at Ordinary Level. More specifically, the purpose of the study was to gain a better understanding of the students' misconceptions, and to help teachers on how these students' misconceptions could be dealt with. The concepts in chemical structure and bonding are abstract, so there is great potential for the formation of alternative conceptions as students try to derive meaning from what is said by the teacher or what is written in the textbooks. Thus, teachers need to be aware of students' misconceptions of chemical bonding in order to develop teaching strategies to enable their own students to construct ideas of chemical bonding which are compatible with the scientific concepts.

Therefore it is against this background that this study looked at the students' misconceptions associated with chemical structure and bonding in the teaching and learning of Chemistry.

Research Question

The study was guided by the following main research question. What are the student misconceptions in chemical structure and bonding? The question was put across from an unbiased stance. We looked at it from the following Null perspective.

Null Hypotheses:

1. Students have no misconceptions of strengths of chemical bonds.
2. Students have no misconceptions of shapes of molecules
3. Students have no misconceptions of coordinate bonding
4. Students have no misconceptions of molecular and ionic charges
5. Students have no misconceptions of hydrogen bonding

Method

Procedure

A pilot study was carried out preceding the main study. One boarding secondary school in the Umguza district rural area was chosen. Twenty (20) pupils of the forty eight (48) in the selected class responded to the test to ascertain reliability. The principal researcher is an experienced academic who has vast chemistry experience, both as a teacher and examiner. Factor Analysis (Varimax Rotation and Kaiser Normalization) were used to determine the suitability of the questions which were to appear in the main study. Judging from the value of their factor loadings of 0.38 and above, and mean reliability ($r = 0.60$; $p < 0.01$), authors considered the test to be reliable and valid. A new scale of 15 items was generated for use. Questions checking on bonding and chemical structure were generated and mixed up to check for response acquiescence and or response set amongst the subjects.

The main study was conducted in four randomly selected secondary schools in Matebeleland North province of Zimbabwe. The majority {9 out of 14 (64%)} of the schools in the purposefully selected district had no chemical models. This prompted us to investigate on how conceptions on bonding and chemical structures at Ordinary Level were formed. The concepts of bonding and chemical structures are introduced at Ordinary Level. It is at this formative stage where and when one can judge the "correctness" of concept formation. We were therefore not interested in studying Advanced Level students.

The descriptive survey design was used because accurate information can be obtained from a large number of people with a small sample. Borg and Gall, (1996) argue that the use of a descriptive survey is usually associated with feasibility and accuracy. It was a convenient method of data collection and analysis as it allowed the information to be collected by means of a classroom test.

The population consisted of 680 Ordinary Level Chemistry students in 14 secondary schools.

Sample sizes larger than 30 and less than 500 are appropriate for most research (Strike and Posner, 1992). In this study the sample size consisted of 80 (eighty) students. From the schools in the district that offer Ordinary Level Physical Science and or Chemistry.

Form 3 and Form 4 Physical Science and or Chemistry students in four secondary schools in the district were the target group. Stratified random sampling was employed for selection of students whereby students were divided into two groups (Form 3 and Form 4) and then simple random choice without replacement was employed. Names were drawn from a box, 20 (twenty) students were selected from each school which consisted of 10 (ten) students from each form. In total, eighty (80) students were selected from the 4 (four) secondary schools.

Test items were 15. Here is a sample of 7 out of 15.

- Calcium chloride is a solid at room temperature and has a high melting point. Explain why calcium chloride has a high melting point.
- Sodium chloride melts at 800^0C. Tetrachloromethane CCI_4 is a liquid at room temperature, Explain how this difference arises.
- Write out the shapes, including the bond angles of the following
  - (a) the ion PH_4^+
  - (b) the molecule PH_5
- The molecule BF_3 and NF_3 have similar formulae but completely different shapes. Draw diagrams to show the shapes of the two molecules and carefully explain why they are different.
- Explain with an example how co-ordinate bond is formed.
- What is the charge of copper ion and explain why it is like that?
- What conditions are necessary for the formation of a hydrogen bond?

The test was self administered, and marked by researchers. In all cases a 100% test answer return was achieved. To validate findings the top 10 students and the least 10 students were group interviewed. All items were analysed one at a time. Degree of difficulty index and discriminating power index for each item were noted.

The eight classes provided 80 participants (N=80), with 48 (60%) being males and 32 (40%) being females. The average age was 16.2 years and a standard deviation (SD) of 0.85).

Instrumentation

The main instrument was a Likert scale test with 15 items triangulatedly designed to test student's understanding of concepts. Some concepts had to be repeated in different wording to test conceptualization or understanding.

Results and discussion

Research Question : What are the students' misconceptions in bonding and chemical structure?

Table 1: ***Students' misconceptions by percentages (N=80).***

Students' Misconceptions	Percentage of student with Misconceptions
The strength of bonds	89
The shape of the molecule	75
Identifying co-ordinate bonding	68
Charge in a molecule/ions	61
Hydrogen bonding	60

The Null hypothesis stated that there are no misconceptions formed by students in strengths of covalent bonds, ionic or molecular bonding. Students were asked to agree or disagree with the concept purporting to the fact that the electrons being shared are the ones responsible for keeping the two atoms together e.g. in a chlorine (Cl_2) molecule. Students were requested to justify their answers. SPSS/PC+ (Hull & Nie, 1984), was used to test the hypothesis. Analysis of Variance (ANOVA) test was carried out to verify this hypothesis.

Hypothesis 1: *Students have no misconceptions of strengths of chemical bonds*
Table 2 : ***ANOVA about misconceptions in bonding and chemical structures amongst students (N=80).***

Source of Variance	Mean Square	DF	Sum of squares	F-Ratio	Probability
Students'concepts &strengths of bonds	6.81	4	26.87	11.35**	P<0.05
Students' conceptions of shapes of molecules	14.98	1	14.98	10.39*	P<0.05
Students' conceptions of coordinate bonding	26.58	2	50.38	14.56*	P<0.05
Students' conceptions about molecule / ionic charges	15.78	2	15.78	11.33**	P<0.05
Students' conceptions about hydrogen bonding	5.87	4	24.45	10.49**	P<0.05

The Null hypothesis which says students have no misconceptions of strengths of chemical bonds is rejected. The students showed that at 5% significant level, they have misconceptions of the strengths involved between atoms and molecules. They failed to conceptualise the relationship between electron affinity for protons in the nucleus (F_{4df} = 11.35; p<.05), irrespective of total configurations of electrons and that of protons being equal.

There is some concordance in the 2 sets of results showing 89% of the students having misconceptions of strengths of chemical bonds F ratio(F_{4df} = 11.35; p<.05) leading to rejection of Null hypothesis. Hence, the students have misconceptions of strengths of chemical bonds.

During interview discussion, and item analysis, students thought that covalent bonds are the weakest. This is because covalent bonding involves the sharing of electrons whilst ionic bonding involves transfer of electron and form two ions of opposite charges which attract each other. Students assumed that all covalent bonds are weak. They believed that covalent bonds are weaker (Boo, 2000) than ionic bonds because students had the notion that covalent substances have low melting points. Taber (2003) argues that the description of covalent bond gives a lot of trouble to high school students. Some studies indicated that students have misconceptions and learning difficulties concerning atomic structure, chemical bonding and matter (Harrison & Treagust, 2001).

Many students do not distinguish between the properties of a substance and the properties assigned to a single, isolated atom (Harrison and Treagust 2001). From interview discussions with the participants, it was observed that students believed that the "particles" of a substance, called atoms or molecules, are very small portions of the 'continuous' substance. Any misconceptions that students harbor about the fundamental concepts of atoms and molecules will impede further learning (Griffiths & Preston, (1992).

From the octet rule, stable molecules can usually be drawn as overlapping atomic structures so that each atom has noble gas structure if electrons in the overlapping region are counted to both atoms. Although this pattern can be explained in terms of higher level chemical models such as molecular orbital, it is normally introduced at a high school level before such concepts are available (Taber, 2003). Thus, this description of covalent bond strength gives a lot of troubles to high school students. The octet rule does not explain why bonding pairs of electrons do not repel each other despite the same charge and how moving electrons can stay between two nuclei of atoms. Consequently, students cannot understand strengths of covalent bonding correctly. They just think that atoms share their valence electron to get an octet.

Taber (1998) highlighted that students would commonly identify and distinguish which electron in a covalent bond belonged to each of the bonded atoms. From the discussion interviews, participants, also considered the sharing of electrons as the 'force' holding the atoms in a molecule together instead of electrostatic attraction between the shared electrons and the nuclei involved. This finding is corroborated by Boo (2000) who found that some of her students held the misconception that a covalent bond is a pair of shared electrons. This misconception probably arises out of exposure to statements often found in textbooks such as the covalent bond is the pair of shared electrons in a covalent molecule.

Some students held the misconception that an ionic bond is electrostatic in nature but not the covalent bond. It seems that these students were unaware that all chemical bonds (including metallic bonds, Van der Waals bonds and hydrogen bonds) are electrostatic in nature. This misconception may have arisen because in discussing ionic bonding, textbooks tend to mention that ions formed as a result of electron transfer between metallic atom and the non-metallic atom and are held by an electrostatic attraction between these positively charged and negatively charged ions. At the same time, in discussing covalent bonding these textbooks either make no mention of what constitutes the covalent bond or they merely mention that the pair of shared electrons is the covalent bond.

According to Boo (2000), students believe that covalent bonds are weaker than ionic bonds because students had the notion that covalent substances generally have lower melting points and boiling points compared to ionic substances. This appears to be linked to the inadequate textbook treatment on the concepts of bonding and properties of covalent and ionic substances. In many textbooks, the discussion on bonding often does not include the explanation that ionic bonding results in the formation of a giant ionic lattice structure whereas covalent bonding usually results in the formation of simple or discrete molecular structures. The notion that melting (or boiling) a covalent substance with simple molecular structures does not involve breaking the covalent bond within the molecule but only involves breaking the relatively weaker bonds between molecules is often not pointed out in textbooks.

Hypothesis 2: *Students have no misconceptions about shapes of molecules*

The understanding of the concept of atomic orbital, the real meaning of the s, p, d, f designation and the direction of orbital are fundamental in learning about hybrid orbital and hybridization leading to shapes of molecules. Table 2 shows calculated Analysis of Variance or F-ratio of 10.39 at 1 degree of freedom versus critical table ANOVA showing that calculated ANOVA is statistically significant at 5% significant level, signifying that students have misconceptions of shapes of molecules.

Seventy – five percent (75%, Table 1) of the students had misconceptions about shapes of molecules, confusing the shape of the molecule with the shape of s and p orbital. Also, about 61% (Table 1) of the students had misconceptions on the charge of an atom or an ion. Students had difficulties to identify that the atom becomes positive or negative if it gains or loses electrons respectively. These findings appear common and are similar misconceptions as those found in western countries, (Chemistry Education: Research and Practise, 2004). A research done in Curtin University in Australia clearly showed that the concepts associated with chemical structure and bonding, such as molecules, ions, hydrogen bonds and giant lattice are abstract and are highly based on the sub-microscopic nature of Chemistry, most students have misconceptions (Taber, 2003). The errors which pupils made might have been caused by failure to understand the concept in the topic.

Chemistry includes how atoms are bonded together to form compounds and how formulas and structures of compounds are dictated by bonding forces. Some studies indicate that students have misconceptions and learning difficulties concerning atomic structure, chemical bonding and matter (Harrison & Treagust, 2001). The understanding of the concept of atomic orbital, the real meaning of the s, p, d, f designation and the direction of orbital are fundamental in learning about hybrid orbital and hybridization. Taber (2001) suggests that having learned to think about atomic structure in terms of electron shells may impede learning about orbital and that learning the details of shapes and designations of atomic orbital then acts as an impediment to thinking about molecular orbital and shapes. Students confuse molecular orbital with atomic orbital suggesting that bonding electrons in bonds, in molecules, in orbital they designated as s or p, or confusing sets of hybridized molecular orbital (e.g. sp^3 hybrids) with molecular orbital.

Another misconception about atomic orbital is that the students perceive each orbital as a box (Huheey, 1998) as in box diagrams or orbital filling diagrams used for electron configuration of multi-electron atoms. Students define an orbital as a box that can be full or empty but filled by electrons (Huheey, 1998). This misconception may result from the presentation of the orbital filling diagrams used for electron configurations in Chemistry textbooks (Huheey, 1998, p. 31; McMurry & Fray, 1998).

The octet 'rule' is simple for the learners to visualize and use (Taber and Watts 1996). The octet 'rule' is often presented as an obligatory condition for proper bonding. Thus, students often adopt the anthropomorphic notion of atoms, wanting to possess octets or full outer shells and consider that chemical reactions occur in order to allow atoms to achieve this natural desire. This causes some students to have difficulties in accepting anything that is not clearly explicable in 'octet' terms, for example, hydrogen bonds or even covalent bonds or transition metal bonds not leading to 'octets' (Weinhold & Landis, 2005).
Robinson (1998) suggests that the octet rule can also be considered as another important obstacle in perceiving the hybridization topic, just as it has been found to be when studying chemical bonding. He stated that students use the octet rule as a basis for explaining chemical reactions and chemical bonding rather than using it as a guide to identify stable species and molecular shapes. Taber (2001) also suggests that the Octet Rule is a cause of a widespread epistemological learning block among Chemistry students.

In another identified misconception, students perceive that hybridization is an event in which orbitals transform to an energetically equivalent state. This misconception resulted from the student misunderstanding of the information of energetically equivalent hybrid during the hybridization. McMurry & Fray, (1998).present hybridization of the carbon atom just after the little hybridization The same thing continues during instruction and some teachers prefer teaching hybridization starting and ending with the hybridization of the carbon atom. This situation may cause the students to think that hybridization is a property belonging only to the carbon atom.

According to Zoller (1990) the misconceptions and misunderstanding when learning hybridization can develop among students because of the problems related to understanding the meaning of some of the prerequisite concepts. The understanding of the concept of atomic orbital, molecular shapes, the real meaning of the s, p, d, f designations and the directions of orbitals are fundamental in learning about hybrid orbitals and hybridization. Such understanding is essential to learning other concepts, such as covalent bonding, molecules and matter. Taber (2001) reported that when learners were first taught about orbitals, some seemed to take this term as a synonym for shells, and for orbits: so all three terms tended to be used interchangeably. He stated that students confused molecular orbitals with atomic orbitals: suggesting that bonding electrons in bonds in molecules were in orbitals they designated as s. or p. or confusing sets of rehybridized molecular orbitals (e.g. sp^3 hybrids) with molecular orbitals.

Hypothesis 3:*There is no misconception about identification of coordinate bonds.*

The Null hypothesis that there are no students who have misconceptions in identifying coordinate bonds was rejected as shown in Table 2 at probability level of 5% ($F_{2df0.05}$=14.56).

From the findings, 68% (Table 1) of the students had difficulties in identifying co-ordinate bonds. According to Boo (1998), co-ordinate bonding is a challenge to students. Coordinate or dative bonding is often another mystery to the students (Taber, 2003) who had the octet framework. A dative bonding is formed when an atom gives its pair of non-bonding electrons (one pair electrons) to a vacant orbital of another atom so that they can be stabilized in terms of energy. Typical examples are NH_4^+, H_3O^+ and O_3. However, there seems to be no incentive for the donor atom to share its electrons with another atom because it already fulfils the octet rule from the octet framework. In addition, electron-deficient compounds and the "expansion of the octet" in the third period (e.g., PCl_5, SF_6) cannot be understood by students operating with this conceptual framework (Taber, 2003).

However, the findings from this study identified the potential sources that generated students' misconceptions such as the terms and explanation used and given by the teacher as well as the textbooks. Yifrach (1999) presents a scientist's view, claiming that the way textbooks and teachers present dative bonding is deluding and misleading. It would also appear that the way the syllabus is structured, topics are not inter-linked and this might mislead students in understanding the key concepts.

The study reveals that ineffective communication between students and teachers might cause students misconceptions. According to Erduran (2003), lack of adequate explanations by teachers can lead to a mismatch between what is being taught and what is being learned. However, learning in Science requires more than just adding new concepts to the knowledge. It often requires realignment in thinking and construction of new ideas that may be in conflict with earlier ideas. Both terms, dative bonding and coordinate bonding, are used interchangeably.

Hypothesis 4: *Students have no misconceptions about molecular or ionic charges*

The formation of ionic bonding is described with the need of atoms for the octet. During the transfer, the metal atom that lost electrons became a cation, and the nonmetal atom that gained electrons became an anion. Thus, two ions with opposite charges attracted each other and became 'a pair of ions', and the pair of ions is represented by a formula unit. From this perspective, students were asked to explain the lattice structure of sodium chloride where a sodium ion is surrounded by six chloride ions, students tended to think of one bonding as a strong covalent bond but other fine bonds as week intermolecular bonding. This is because only one electron can be transferred from a sodium atom to one chlorine atom resulting in forming one bond. The students assume that the number of ionic bonds formed and not just the ionic charges, 61% as depicted in Table 1 demonstrated misconception about ionic charges.

An ANOVA test (Table 2) showed (F_{2df} = 11.33; $p<0.05$) rejection of the Null hypothesis at 5% level of significance. Students have misconceptions of ionic or molecular charges.

The formation of ionic bonding is described with the need of atoms for the octet. According to Miha (2007) students explain that metal atom gives its valence electrons to the nonmetal atom to make their outer shell full. Thus, two ions with opposite charges attracted each other and became 'a pair of ions', and the pair of ions was represented by a formula unit (Taber, 2003).

From this perspective, sodium chloride solid is molecular in nature. So, in the lattice where a sodium ion is surrounded by six chloride ions, students tended to think of one bonding as a strong covalent bond but other fine bonds weak intermolecular bonding. This is because only one electron can be transferred from a sodium atom to one chlorine atom resulting in the formation of one bond. The students assume the number of ionic bonds formed and not just the ionic charges (Coll & Taylor, 2001).

In the interviews we found that many students adopted a molecular framework for ionic bonding. We found that many students believed that the atomic electronic configuration determines the number of ionic bonds formed. For example, a sodium atom can only donate one electron, so it can form only one bond. Bonds are only formed (Taber, 2003) between atoms that donate/accept electrons. For example, in sodium chloride, the chloride is bonded to the specific sodium atom that donated an electron to it.

Hypothesis 5: *Students have no misconceptions about hydrogen bonding.*

Intermolecular bonding is often not considered by students as a type of chemical bonding because it does not help atoms achieve full shells. Some students believed that it is absent even in polar molecular substances such as water, 60% of the students as shown in Table 1 and ($F_{4df=}10.49_{;}$ $p<0.05$) as shown in Table 2 had a misconception of hydrogen bonding, hence Null hypothesis was rejected. Students think that it is involved in C-H bonds thus between hydrogen and carbon atom. They perceive that any bond which involves hydrogen atom is a hydrogen bond, forgetting that hydrogen bond is formed between hydrogen atoms and a highly electro negative atom like oxygen and nitrogen.

According to Taber and Coll (2002), students have misconceptions about hydrogen bonding because the existence of bonding which does not lead to atoms having full electron shells is consequently something of a mystery to many students.

Intermolecular bonding is often not considered to count as a type of chemical bonding because it does not help atoms achieve full shells. Some students believed that it is absent even in polar molecular substances such as water (Coll & Taylor, 2010). Also when learning about hydrogen bonding, some students just assumed this is nothing more than covalent bonding involving hydrogen. A proper bond is considered as one that only allowed an atom to obtain a full shell or octet of electrons. This means it is either covalent or ionic (Taber 2003).

Some students thought that intermolecular bonding is stronger than intramolecular bonding and that intermolecular forces were influenced by gravity (Coll and Taylor, 2001). Students held another misconception that intramolecular covalent bonds (instead of intermolecular bonds) are broken when a substance changes phase (Boo, 1998).

Conclusions and Recommendations

Students have misconceptions about chemical structure and bonding. These misconceptions include the strengths of bonds; shapes of molecules, coordinate bonds, molecular or ionic charges, and hydrogen bonding. Terms and explanations used by teachers, presentation of concepts in textbooks and inadequate explanations by teachers could contribute to student's misconceptions. Some of the external factors that might mislead students understanding of the key concepts are the students' background, perhaps negative attitude of students towards the subject and students' prior knowledge. Ways of minimizing students' misconceptions could include, use of conceptual chemical models, use of e-learning, for example Cyber school which makes a teaching and learning environment more visual than conceptual so that students can better relate and apply. Science teachers should be equipped with the various strategies of teaching skills so as to improve the teaching and learning of science. They should be motivated and supported by school administrators, parents and the community at large. Current Chemistry textbooks should be revised to include the element of conceptual change. It is also recommended that relevant research results about student misconceptions be communicated to curriculum developers.

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