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Misconceptions in chemical bonding and its remedial measure through constructivist strategies

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Abstract : Science educators have agreed that understanding of chemical bonding is the basis of chemistry education. In this field, many articles dealing with the problem of learning difficulties of students in the concept of mole, chemical equilibrium, solutions, electrochemistry and atomic structure can be found in the science education literature. Learning science is a cumulative process where new information is added to students' existing knowledge, constructing the knowledge based on what they already have. What students do with information which is presented to them depends largely on what they already think and believe. Constructivist approach seems to be effective in providing meaningful learning. According to this approach, this kind of learning can take place only when the learner relates the new information to his already existing knowledge. Knowledge cannot be transmitted to the learner's mind from a textbook or by the teacher. Instead, students construct their knowledge by making links between their ideas and new concepts through experience they acquire in school or society. Teacher, thus, must help students' correct alternative conceptions and assist meaningful learning. In this article we have concentrated the basic misconceptions of students to explain different types of chemical bonds and advocate some measures to eradicate the misconceptions related to chemical bonding.

Keywords : Misconceptions, chemical bonding, constructive approach.

Introduction

In learning chemistry misconceptions play a vital role, simply producing inadequate explanations to questions, the students face. Students construct their own concepts, consciously or subconsciously as explanations for the behavior, properties or theories they experience. According to them most of these explanations are correct because these explanations make sense in terms of their understanding of the behavior of the world around them[1]. In addition, misconceptions, once embedded in a learner's conceptual schemes, are extremely hard to remove[2].

Learning is the product of self organization and reorganization of existing ideas. Unfortunately, there is no universal strategy that will result in success with all students. Students are often unable to integrate facts and formulas although they can successfully solve mathematical problems[3]. For this reason, one of the main aims of chemistry education is to make a meaningful understanding of basic concepts of chemistry. Constructivist approach seems to be effective in providing meaningful learning. According to this approach, this kind of learning can take place only when the learner relates the new information to his already existing knowledge. Knowledge cannot be transmitted to the learner's mind from a textbook or by the teacher. Instead, students construct their knowledge by making links between their ideas and new concepts through experience they acquire in school or society. These types of experiences can result in assimilation in which new knowledge is incorporated into existing cognitive structure or they can lead to disequilibrium in which experiences cannot be reconciled within the existing structure, where cognitive structure is reorganized, occurs.

Thus, from this point of view, learning is a process of conceptual change. For this reason, effective teaching requires the teacher to consider the learners' conceptual knowledge that they have achieved from experience. In

practice, prior knowledge may be missing or may include wrong conceptions or the learner may fail to make the link between new knowledge and his existing structure[4]. Therefore, for effective teaching, the cognitive level of the learners and their conceptual development which means the extent of prior knowledge about the topic necessary for learning new knowledge should be considered. Furthermore, the subject that will be taught should not be too complex. However, this simplification should be done carefully otherwise it may cause students to develop wrong conceptions. Briefly, there should be a correlation between the scientific topics and to what extent the students comprehend this knowledge[5]. Generally, students' wrong ideas about a particular topic are called as misconceptions which prevent learning and very resistant to change. In chemistry, students hold several misconceptions in many areas such as mole concept[6], atomic structure[7], chemical equilibrium[8-10], solutions[11,12] and electrochemistry[13].

Concepts like bonding, structure, rate of reaction, and internal energy apply to all chemical systems[14]. The comprehension of these concepts has implications regarding understanding the whole chemical process, mainly chemical reactions and chemical properties of substances. Chemical reactions involve the breaking and forming of chemical bonds[15]. Therefore, chemical bonding is a key concept in chemistry[16].

In constructivist theory, the acquisition of knowledge is viewed as a constructive process that involves active generation and testing of alternative propositions[17]. Teaching chemistry focuses on providing students with opportunities in which they have cognitive conflict and they develop different ideas based on their experience. This can be promoted by recent developed teaching techniques like group discussion, seminar, symposium, panel discussion etc. where knowledge construction is occurred with exchange of views among friends and the teacher. In this way, students can control their learning process. Research studies showed that oral discussions develop students' critical thinking ability and understanding of the content[18].

Constructivist views also emphasize generative learning, questioning or inquiry strategies. An emphasis on constructivism and hands-on inquiry-oriented instruction to promote students' conceptual knowledge by building on prior understanding, active engagement with the subject content, and applications to real world situations has been advocated in science lessons. It is also emphasized on discovery, experimentation, and open-ended problems that have successfully applied in chemistry education. In this article we have tried to make a way out to transform misconception related to chemical bonding to real conception in light of constructivist approach oriented instruction.

Sources of misconceptions :

The word misconception refers to students' incorrect answers to a particular concept, students' ideas which cause wrong answers about a particular concept and students' beliefs about how the world works different than that of the scientists[19].

In order to eliminate students' misconceptions, it is necessary to identify the sources of these misconceptions. During learning, the student tries to connect new knowledge into his knowledge already retained. If he holds misconceptions, these misconceptions interfere with subsequent learning. Therefore, new knowledge cannot be connected to his existing knowledge and misunderstanding of the concept occurs[20]. So, students' existing ideas are important factors affecting the development of misconceptions. There are several sources of misconception: one possible source of students' misconceptions is everyday knowledge. Teacher themselves also may cause misconceptions[21]. They may misunderstand the context. However, although instruction is accurate, students may misunderstand some concepts due to inadequate prerequisite knowledge. Another source of misconceptions might be textbooks[22].

Students' misconceptions in chemical bonding :

Nicoll[23], Tan and Treagust[24], Peterson, Treagust and Garnett[25], Taber[26] and Coll and Treagust[27] have pointed out the following students' misconception related to chemical bonding : (a) Confusing atoms and molecules, (b) Failing to consider octet rule, (c) Not relating polarity with electronegativity, (d) Not distinguishing between ionic and covalent bonding, (e) Failing to explain why bonding occurs, (f) Metals and non metals form molecules, (g) Atoms of a metal and non metal share electrons to form molecules, (h) A metal is covalently bonded to a non metal to form a molecule, (i) Metals and non metals form

strong covalent bonds, (j) Ionic compounds exist as molecules formed by covalent bonding, (k) Covalent bonds were broken when a substance changes state, (l) Equal sharing of electron pairs occurred in all covalent bonds, (k) The polarity of a bond was dependent on the number of valance electrons in each atom involved in the bond, (m) Ionic charge determined the polarity of the bond, (n) Nonpolar molecules formed when the atoms in the molecule had similar electronegativies, (o) Number of covalent bonds formed by a non metal was equal to the number of electrons in the valance shell, (p) Bond polarity determined the shape of a molecule, (q) The shape of a molecule was due to equal repulsion between the bonds only, (r) Only nonbonding electron pairs influenced the shape of a molecule, (s) Metals do not have any bonds since all atoms are the same, there is some interactions in metals but there is not proper bonding, (t) Metals have covalent and/or ionic bonding. These students do not think the existence of bonds other than covalent or ionic, (u) Metallic bonding occurs only in alloys, (v) Metallic and ionic bondings are weak bondings, (w) Intramolecular covalent bonding is weak bonding, (x) Continuous metallic or ionic lattices are molecular in nature, (y) The bonding in metals and ionic compounds involves intermolecular bonding, (z) Ionic bonding occurs by sharing of electrons and (aa) Metallic lattices contain neutral atoms.

In order to make chemistry education meaningful, these misconceptions have to remove from the mind of the learners.

Constructivist approach to address the misconceptions :

Teaching Learning process in science is a complex and slow process. Students have difficulty in understanding of the most of the concepts in chemistry and hold misconceptions[16]. Often, they have misconceptions about the natural phenomena before entering the classroom and these misconceptions prevent thoughtful learning. Therefore, instruction is very important part for the end of teacher; it should focus on students' ideas. Students should be encouraged to think, ask questions, test ideas and explain the facts. These can be achieved by constructivist approach. Constructivism is the combination of Piaget's cognitive and developmental theory and Vygotsky's interactional and cultural emphasis. From constructivist point of view, knowledge cannot be transferred into the student, instead students construct their own meanings from the words or visual images they hear or see. Knowledge is not passively received from the teacher or through the senses. It is actively built up by the learner. Constructivism focuses on the way in which learners construct useful knowledge. It may be through personally constructed or socially mediated. Learners construct, elaborate and test new knowledge until they become satisfied. Knowledge develops and continues to change with the activity of the learner. Then, learning occurs by changing and organizing cognitive knowledge. Cognitive reorganization takes place as learners try to overcome obstacles or contradictions during the activity they involved[28]. Based on this perspective, teaching is not providing information and checking whether students have acquired it or not. Teaching is creating situations in which students are actively involved in scientific activities and they make their own construction.

Constructivist teaching learning approaches because of being more actively involved, having more discussion, practical work, less note-taking, having more fun and greater understanding of concepts[29]. By examining interviews, it was seen that students were more active in the learning process. They could state their ideas whether they are wrong or right. They had opportunity to see and control their thinking. They constructed correct knowledge more confidently and became more confident in their understanding of science. Constructivist approach stresses on students' prior knowledge. It emphasizes giving students' opportunities in which they can reflect their knowledge and construct meaning by interacting with objects, events and people. In this way, the teacher may realize students' misconceptions and focus on activities to change them with the scientifically correct explanations.

Recommendations :

The constructivist approach makes a motivated environment for students to think about the scientific concepts and their conceptions. The role of the teacher is to facilitate and support their thinking for conceptual change. The teachers should use following instructional strategies to eliminate misconceptions effectively from the mind of the learners.

(i) While teaching chemical bonding, first metallic bonding should be introduced and then ionic and covalent bonds should be taught. Studying metallic bonds, students use their knowledge of ionic

and covalent bonding in explaining metallic bonding.

(ii) During instruction, first general notion of bonding should be given in detail and electrical interactions should be emphasized.

(iii) The electron sea model, band theory for metals, a model based on electron transfer should be introduced before the student.

(iv) The octet rule, the molecular orbital theory, the valance bond approach and ligand field theory for covalent substances with model construction by the student should be encouraged in classroom.

(v) The shape of Na and Cl ions when constructing diagram of sodium chloride should be clearly visualized in classroom.

(vi) The teachers should be careful when using visual representations such as dotted lines or spheres that cause confusion among students.

(vii) The chemistry teachers should be experienced in the analysis of textbooks.

(viii) Teacher should make a relationship between the theoretical model and experimental facts by using students' common experience.

(ix) Curriculum programs should be based on the constructivist perspective and textbooks should be improved so that students' misconceptions can be minimized.

Conclusion :

There has been continuous demand for constructivist strategies of teaching during the past decade due to better ways of teaching which eliminates misconceptions successfully from the mind of the learners. National Curriculum Framework, 2005 has also emphasis on constructive approaches of teaching. But unfortunately we could not able to implement such strategies in our education system effectively. To make chemistry education meaningful the teacher has to follow constructivist approach for the betterment of our future backbone.

References

1. D. R. Mulford and W. R. Robinson, *J. Chem. Edu.*, 2002, **79** , 739.
2. C. J. Songer and J. J. Mintzes, *J. Res. Sci. Teach.*, 1994, **31**, 621.
3. R. E. Yager, "The Science Teacher", 1991, September, 53.
4. K. S. Taber, *Educational Studies*, 2001, **27**, 159.
5. K. S. Taber, *Phy. Edu.*, 2000, **35**, 320.
6. J. R. Staver and A. T. Lumpe, *J. Res. Sci. Teach.*, 1995, **32**, 177.
7. A. Chakraborty and B. C. Mondal, *Ind. Stream Res. J.*, 2012, **2**, 76.
8. E. Gussarsky and M. Gorodetsky, *J. Res. Sci. Teach.*, 1988, **25**, 319.
9. M. Camacho and R. Good, *J. Res. Sci. Teach.*, 1989, **26**, 251.
10. J. Q. Pardo and J. J. Solaz-Patolez, *J. Res. Sci. Teach.*, 1995, **32**, 939.
11. J. V. Ebenezer and G. L. Ericson, *Sci. Edu.*, 1996, **80**, 181.
12. M. R. Abraham, V. M. Williamson and S. L. Westbrook, *J. Res. Sci. Teach.*, 1994, **31**, 147.
13. P. J. Garnet and D. F. Treagust, *J. Res. Sci. Teach.*, 1992, **29**, 121.
14. P. Fensham, "Concept Formation", in D. J. Daniels (ed.), "New Movements in the Study and Teaching of Chemistry", London, Temple Smith, 1975, pp. 199-217.
15. K. Taber and R. Coll, "Bonding", in J. K. Gilbert, O. D. Jong, R. Justy, D. F. Treagust and J. H. Van Driel (eds.), 2002, pp. 213-234.
16. T. Levy-Nahum, A. Hofstein, R. Mamlok-Naaman and Z. Bar-Dov, *Chem. Edu. Res. Pract.*, 2004, **5**, 301.
17. W. W. Cobern, *Sci. Edu.*, 1996, **80**, 579.
18. K. Hogan, B. K. Nastas and M. Pressley, *Cognition & Instruction*, 2000, **17**, 379.
19. D. I. Dykstra, C. F. Boyle and I. A. Monorch, *Sci. Edu.*, 1992, **76**, 615.
20. M. B. Nakhleh, *J. Chem. Edu.*, 1992, **69**, 191.
21. M. Sarikaya, *International Edu. J,*, 2007, **8**, 40.
22. J. M. de Posada, *Sci. Edu.*, 1999, **83**, 423.
23. G. Nicoll, *International J. Sci. Edu.*, 2001, **23**, 707.
24. K. D. Tan and D. F. Treagust, *School Sci. Rev.*, 1999, **81**, 75.
25. R. F. Peterson, D. F. Treagust and P Garnett, *J. Res. Sci. Teach.*, 1989, **26**, 301.
26. K. S. Taber, *Sci. Edu.*, 2003, **87**, 732.
27. R. K. Coll and D. F. Treagust, *J. Res. Sci. Teach.*, 2003, **40**, 464.
28. M. P. Driscoll, "Psychology of Learning for Instruction", Paramount Publishing, Inc, 1994.
29. B. C. Mondal, *Sikshachintan,* 2012, **6**, 69.